Shri Swami Vivekanand Shikshan Sanstha's

Vivekanand College Kolhapur (Autonomous)

Department of Statistics

M. Sc. I-Statistics

Semester I & II

Syllabus to be implemented from
Academic year 2023-24
(As per NEP 2020)

Teaching and Evaluation scheme

One/Two- Years PG Programme

Department/Subject Specific Core or Major (DSC)

First Year Semester- I & II (M.Sc. Statistics)

Semester	Course Code	Course Title	No. of Credits
I	DSC17STA11	Distribution Theory	**04**
	DSC17STA12	Estimation Theory	**04**
	DSC17STA13	Statistical Computing	**02**
	RMD17STA11	Research Methodology	**04**
	DSC17STA19	Practical I	**04**
	DSE17STA11	1.Mathematical Statistics	**04**
	DSE17STA12	2.Real Analysis	**04**
	DSE17STA13	3.Linear Algebra	**04**
		Credit	**22**
II	DSC17STA21	Linear model and Regression Analysis	**04**
	DSC17STA22	Theory of Testing of Hypothesis	**04**
	DSC17STA23	Multivariate Analysis	**02**
	DSC17STA29	Practical II	**04**
	FPR17STA21	FP/OJT	**04**
	DSE17STA21	1. Probability Theory	**04**
	DSE17STA22	2.Reliability theory	**04**
		Credits	**22**

Objectives:

1.The students are expected to understand the principles, concepts, and recent developments in the Statistics.

2. To enhance student sense of enthusiasm for Statistics and to involve them in an intellectually stimulating experience of learning in a supportive environment.

3. The practical course is framed in relevance with the theory courses to improve the understanding of the various concepts in Statistics.

Program Outcomes (PO):

On successful completion of the program students will able to:

PO1: Understand the principles and concepts in the statistical theory at an advanced level which take into account recent advances in the subject.

PO2: Acquire the strong foundation of statistical concepts which will benefit them to become good Statistician.

PO3: Use acquired statistical methodologies and modelling techniques to address real-life problems.

PO4: Gain the knowledge of software which has the wide range of opportunities in the Quality control, Planning and development, IT sector, industries, Business, Government and private sector etc.

PO5: Qualify various National / State level competitive exams like ISS, DSO, CSIR-UGC NET, SET, GATE, MPSC, UPSC, Banking etc.

Program Specific Outcomes (PSO):

On successful completion of the program students will able to:

PSO1: Enhance sense of enthusiasm for Statistics and to involve them in an intellectually stimulating experience of learning in a supportive environment.

PSO2: Handle and analyse small as well as large databases with computer skills.

PSO3: Understand, implement and develop statistical models.

PSO4: Describe complex statistical ideas to non-statisticians and to present the results of their analyses in written, oral forms and can make practical suggestions for improvement.

PSO5: Apply statistical techniques to optimize and monitor real life phenomena related to industry and business analytics etc.

1) Nature of the theory question papers (4 credits):

a) There shall be 7 questions each carrying 16 marks.

b) Question No.1 is compulsory.

i) It consists of 8 multiple choice questions for 1 mark each. (8 marks)

ii) short note type questions (attempt any 2 out of 3) (8 marks)

c) Students have to attempt any 4 questions from question No. 2 to 7.

d) Question No. 2 to 7 shall contain 2 to 4 sub-questions.

2) Nature of the theory question papers (2 credits):

a) There shall be 4 questions.

b) Question No.1 is compulsory.

i) It consists of 4 multiple choice questions for 1 mark each. (4 marks)

ii) short note type questions (attempt any 1 out of 2) (4 marks)

c) Question No. 2 to 4 shall be of 16 marks each.

d) Students have to attempt any 2 questions from question No. 2 to 4.

e) Question No. 2 to 4 shall contain 2 to 4 sub-questions.

3)Nature of Practical examination: -

Sr. No.	Component	Max marks
1	Practical examination: Examination will be of 3 hour duration. There shall be 8 questions each of 12 marks, of which a student has to attempt any 5 questions.	60
2	Day-to-day practical performance and journal	20
3	Viva: Viva will be based on all practicals	20
Total		100

4)Each of the following courses have the same question paper in all examinations of M.Sc. Statistics and M.Sc. Applied Statistics.

Semester I	Semester II
Distribution Theory	Linear model and Regression Analysis
Estimation Theory	Theory of Testing of Hypothesis
Statistical Computing	Multivariate Analysis
Research Methodology	

M.Sc. I Statistics (Sem I)
DSC17STA11: DISTRIBUTION THEORY

Course Outcomes: At the end of the course students will be able to:
CO1: Recognize and learn concept of mixture of distribution and their decomposition.
CO2: Execute transformation of univariate random variables and different moment inequalities.
CO3: Describe the concept of central and non-central distributions.
CO4: Learn the concept of order statistics.

Unit and Credit	DSC17STA11: DISTRIBUTION THEORY	No. of hours per unit / credits
Unit I	Review of Random experiment and its sample space, events, random variables, discrete random variables, continuous random variables. Cumulative distribution function (CDF), properties of CDF, computation of probabilities of events using CDF, quantiles, absolutely continuous and discrete distributions, mixtures of probability distributions, decomposition of mixture CDF into discrete and continuous CDFs, expectation and variance of mixture distributions. Transformations of univariate random variables, probability integral transformation	15
Unit II	Concepts of location, scale and shape parameters of distributions with examples. Symmetric distributions and their properties. Moment inequalities (with proof): Basic, Holder, Markov, Minkowski, Jensen, Tchebysheff and their applications, Random vectors, joint distributions, Independence, variance-covariance matrix, joint MGF. Conditional expectation and variances, Transformations of bivariate random variables, Convolutions, compound distributions.	15
Unit III	Bivariate Normal distribution, Multivariate normal distribution: two definitions and their equivalence, singular and nonsingular normal distribution, characteristic function, moments, marginal and conditional distributions. Maximum likelihood estimators of the parameters of the multivariate normal distribution and their sampling distributions. Marshall-Olkin bivariate exponential distribution, Bivariate Poisson distribution.	15
Unit IV	Sampling distributions of statistics from univariate normal random samples: central and non-central chi-square, t and F distributions. Distributions of linear and quadratic forms involving normal random variables, Fisher Cochran and related theorems: only statements and applications. Order Statistics: Distribution of an order statistics, joint distributions of two order statistics, distribution of spacings, normalized spacings with illustration to exponential case, distribution of sample median and sample range.	15

Books Recommended:

1) Rohatagi V. K. & Saleh A. K. Md. E. (2001): Introduction to Probability Theory and Mathematical Statistics- John Wiley and sons Inc.
2) Johnson N. L. &Kotz. S. (1996): Distributions in Statistics Vol-I, II and III, JohnWiley and Sons New york.
3) S. Kotz, N. Balakrishnan, N. L. Johnson: Continuous Multivariate Distributions - Second Edition, Wiley.
4) Casella & Berger (2002): Statistical Inference - Duxbury advanced series.IInd edition
5)C. R. Rao (1995): Linear Statistical Inference and Its Applications (Wiley Eastern) Second Edition
6.) Dasgupta, A. (2010): Fundamentals of Probability: A First Course (Springer)

DSC17STA12: ESTIMATION THEORY

Course Outcomes: At the end of the course students will be able to:
CO1: Describe the notion of a parametric models, point estimation of the parameters of those models.
CO2: Construct the sufficient statistic, minimal sufficient statistic, m.l.e., moment estimator of the parameter.
CO3: Discuss the concept of MVUE, MVBUE, UMVUE.
CO4: Describe the concept of Bayesian inference and their real life applications.

Unit and Credit	DSC17STA12: ESTIMATION THEORY	No. of hoursper unit / credits
Unit I	Sufficiency principle, factorization theorem, minimal sufficiency, minimal sufficient partition, construction of minimal sufficient statistics, minimal sufficient statistic for exponential family, power series family, curved exponential family, Pitman family. Completeness, bounded completeness, ancillary statistics, Basu's theorem and applications.	15
Unit II	Problem of point estimation, unbiased estimators, minimum variance unbiased estimator, Rao- Blackwell theorem and Lehmann-Scheffe theorem and their uses. Necessary and sufficient condition for MVUE and their applications. Fisher information and information matrix, Cramer- Rao inequality, Chapmann-Robinson bounds, Bhattacharya bounds, their applications.	15
Unit III	Method of maximum likelihood (MLE) and small sample properties of MLE, method of scoring and application to estimation in multinomial distribution. MLE in non-regular families. Other methods of estimation: method of moments, minimum Chi square. U-Statistics: one and two sample; U-Statistics theorem for one sample and two sample (statements only).	15
Unit IV	Consistency of an estimator, weak and strong consistency, joint and Marginal consistency, invariance property under continuous transformations, methods of Constructing	15

	consistent estimators, asymptotic relative efficiency. Consistent and Asymptotic Normal (CAN) Estimators: Definition of CAN estimator for real and vector valued parameters, invariance of CAN property under non-vanishing differentiable transformation. Methods of constructing CAN estimators: Method of Moments, method of percentiles, comparison of CAN estimators. CAN and BAN estimators in one parameter exponential family of distributions, BAN estimators,	

Books Recommended:

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

DSC17STA13: STATISTICAL COMPUTING

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

CO1: Construct formulas, including the use of built-in functions and analysis tool pack.
CO2: Learn Lookup functions, pivot table and pivot chart
CO3: Develop the fundamentals of statistical analysis in R environment.
CO4: Learn different control statements and test procedures.

Unit and Credit	DSC17STA13: STATISTICAL COMPUTING	No. of hoursper unit / credits
Unit I	MSEXCEL: Introduction to MSEXCEL. Cell formatting, conditional formatting, Data manipulation using EXCEL: sort and filter, find and replace, text to columns, remove duplicate, data validation, consolidate, what-if-analysis. Working with Multiple Worksheets and Workbooks. Built-in mathematical and statistical functions for obtaining descriptive statistic, computing PMF/PDF, CDF and quantiles of the well-known distributions, rand and randbetween function, Logical functions: if, and, or, not. Lookup functions: hlookup, vlookup, Formula Errors, Creating and Working with Charts, Database functions, Text functions, Date and time functions, Excel add-ins: analysis tool pack, Pivot tables and charts.	15

Unit II	R-software: Introduction to R, data types and objects, operators, data input, data import and export, built in functions for descriptive statistics, random sampling and computation of pdf, cdf and quantiles of well-known distribution. Strings and Dates in R. apply family of functions. Saving work in R. Matrix algebra, graphical procedures, frequencies and cross tabulation, built in functions: lm, t.test, prop.test, wilcox.test, ks.test, var.test, chisq.test, aov. Control statements. Programming, user defined functions, Rpackages. R-studio.	15

Books Recommended:

1.Gardener, M. (2012). Beginning R: the statistical programming language. John Wiley & Sons.
2. Held, B., Moriarty, B., & Richardson, T. (2019). Microsoft Excel Functions and Formulas with Excel 2019/Office 365. Mercury Learning and Information.
3. Herkenhoff, L., & Fogli, J. (2013). Applied statistics for business and management using Microsoft Excel. New York: Springer.
4. Purohit, S. G., Gore, S. D., & Deshmukh, S. R. (2015). Statistics using R. Alpha Science International.

DSE17STA11: Mathematical Statistics

Course Outcomes: At the end of the course students will be able to:
CO1: Define and recognize the basic properties of the field of real numbers.
CO2: Define and recognize the series of real numbers and convergence.
CO3: Demonstrate understanding of the concepts of vector space and subspace, linear independence, span, and basis.
CO4: Apply principles of matrix algebra to linear transformations and solve systems of linear equations using multiple methods.

Unit and Credit	**DSE17STA11: Mathematical Statistics**	**No. of hoursper unit / credits**
Unit I	Sequences of real numbers, convergence, divergence, monotone, bounded and unbounded sequences, Cauchy sequence, Convergence of bounded monotone sequence. Limit points, Limit inferior and limit superior of the sequences and their properties. Subsequences and properties associated with them. Series of numbers, tests for convergence (without proof) test for absolute convergence, convergence of series of non-negative terms.	15
Unit II	Real valued functions, continuous functions, Uniform continuity of functions and sequences of functions,	15

	Uniform convergence of series of functions with special emphasis on power series, radius of convergence. Riemann, Riemann-Steltjes Integrals and their common properties. integrability of functions, Fundamental theorem on calculus, mean value theorem, their applications in finding functional of probability distributions. Maxima, minima of functions of several variables. Constrained maxima, minima, Lagrange's method, Taylor's theorem (without proof), Multiple and Improper integrals, their applications in multivariate probability distributions. Theorem on differentiation under integral sign and Leibnitz rule (statements only) with applications.	
Unit III	Vectors, linear dependence and independence of vectors, vector space, subspace, basis, dimension of a vector space, example of vector spaces. Gram-Schmidt orthogonalization process, Orthonormal basis, orthogonal projection of a vector, Linear transformations, algebra of matrices, types of matrices, row and column spaces of a matrix, elementary operations and elementary matrices, rank and inverse of a matrix, null space and nullity, partitioned matrices. Cayley-Hamilton theorem and its applications.	15
Unit IV	Generalized inverse, Vector and Matrix differentiation, Spectral decomposition of a real symmetric matrix, singular value decomposition, Choleskey decomposition, real quadratic forms, reduction and classification, index and signature, extrema of a quadratic form, simultaneous reduction of two quadratic forms.	15

Books Recommended:

1. S. C. Malik & S. Arora (1991): Mathematical Analysis, Wiley Eastern Limited-IInd edition.
2. R. R. Goldberg (1964): Methods of Real Analysis, Blais dell Publishing company, Newyork, U.S.A.
3. G.R. Bartle (1976): Element of Real Analysis, Wiley, 2nd edition, 1976.
4. G.R. Bartle & D. R. Sherbert (2000): Introduction to Real Analysis-John, Wiley & Son Inc, 2000.
5. F.A. Graybill, An Introduction to Linear Statistical Models Vol 1, Mc Graw-Hill Book Company Inc,1961.
6. G. Hadely, Linear Algebra, Narosa Publishing House, 1962.
7. D. Harville, Matrix Algebra from Statistics Perspective, Springer, 1997.
8. A. R. Rao and P. Bhimasankaram, Linear Algebra, Hindustan Book Agency, Second dition, 2000.

DSE17STA12: REAL ANALYSIS

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

CO1: Define and recognize the basic properties of the field of real numbers.

CO2: Define and recognize the series of real numbers and convergence.

CO3: Apply the theorem in a correct mathematical way.

CO4: Define and recognize the real functions and its limits and differentiability of real functions and its related theorems.

Unit and Credit	DSE17STA12: REAL ANALYSIS	No. of hoursper unit / credits
Unit I	Set of real numbers, countable and uncountable sets, countability of rational numbers and uncountability of the interval (0,1) Supremum and Infimum of bounded sets, limit point of a set, open, closed, dense and compact sets. Bolzano-Weierstrass and Heine-Borel Theorems (Statements only). Applications of the theorems	15
Unit II	Sequence of real numbers, convergence, divergence, Cauchy sequence, Convergence of bounded monotone sequence. Limit inferior and limit superior of the sequences. Series of numbers, testsfor convergence (without proof) test for absolute convergence, convergence of sequences of non-negative terms.	15
Unit III	Real valued function, continuous function, Uniform continuity of sequence of functions,Uniform convergence of series of functions with special emphasis on power series, radius of convergence. Riemann, Riemann -Steltjes Integrals and their common properties. Integration by parts, Fundamental theorem on calculus, mean value theorem, their applications in finding functional of distributions.	15
Unit IV	Vector and Matrix differentiation, Maxima, minima of functions of several variables. Constrained maxima, minima, Lagrange's method, Taylor's theorem (without proof), implicit function theorem and their applications. Multiple integrals, Change of variables, Improper integrals, Applications in multivariate distributions. Theorem on differentiation under integral sign (without proof), Leibnitz rule (statement only) and applications.	15

Books Recommended:

1. S. C. Malik & S. Arora (1991): Mathematical Analysis, Wiley Eastern Limited-IInd edition.
2. R. R. Goldberg (1964): Methods of Real Analysis, Blais dell Publishing company, Newyork, U.S.A.
3. G.R. Bartle (1976): Element of Real Analysis, Wiley, 2nd edition, 1976.

4. G.R. Bartle & D. R. Sherbert (2000): Introduction to Real Analysis-John, Wiley & Son Inc, 2000.
5. Royden(1988): Principles of Real Analysis, Mac million.
6. Widder(1989): Advanced Calculus, Dover Publication, 1989.
7. Apostol (1985): Mathematical Analysis, Narosa Publishing House, T. M., 1985.

DSE17STA13: LINEAR ALGEBRA

Course Outcomes: At the end of the course students will be able to:
CO1: Solve matrix operations, including inverses and determinants.

CO2: Demonstrate understanding of the concepts of vector space and subspace, linear independence, span, and basis.

CO3: Describe eigenvalues and eigenvectors and solve eigenvalue problems.

CO4: Apply principles of matrix algebra to linear transformations and solve systems of linear equations using multiple methods.

Unit and Credit	DSE17STA13: LINEAR ALGEBRA	No. of hoursper unit / credits
Unit I	Vector space, subspace, linear dependence and independence, basis, dimension of a vector space, example of vector spaces. Null space, Gram- Schmidt orthogonalization process, Orthonormal basis, canonical forms, diagonal forms, Jordan forms, orthogonal projection of a vector, Linear transformations, algebra of matrices, row and column spaces of a matrix, elementary operations and elementary matrices, rank and inverse of a matrix, Null space and nullity, partitioned matrices	15
Unit II	Permutation matrix, reducible/ irreducible matrix, primitive / imprimitive matrix, idempotent matrix, Kronecker product, Generalized inverse, Moore-Penrose generalized inverse, Solution of a system of homogenous and non-homogenous linear equations, theorem related to existence of solution and examples.	15
Unit III	Characteristic roots and vectors of a matrix, algebraic and geometric multiplicities of a characteristic root, right and left characteristic vectors, orthogonal property of characteristic vectors, Caley-Hamilton Theorem and its applications.	15
Unit IV	Spectral decomposition of a real symmetric matrix, singular value decomposition, Choleskey decomposition, real quadratic forms, reduction and classification, index and signature, extreme of a quadratic form, simultaneous reduction of two quadratic forms.	15

Books Recommended:

1. F.A. Graybill, An Introduction to Linear Statistical Models Vol 1, Mc Graw-Hill

Book Company Inc,1961.
2. G. Hadely, Linear Algebra, Narosa Publishing House, 1962.
3. D. Harville, Matrix Algebra from Statistics Perspective, Springer, 1997.
4. A. R. Rao and P. Bhimasankaram, Linear Algebra, Hindustan Book Agency, Second dition, 2000.
5. C. R. Rao, Linear Statistical Inference and Its Applications, Wiley, Second Edition, 2001.
6. J. Schott, Matrix Analysis for Statistics, Wiley, Third edition, 2016.
7. S. B. Searl, Matrix Algebra Useful for Statistics, Wiley, 2006.
8. Kshirsagar A.M (1983): Course in linear Models-Marcel Dekker.

RMD17STA11: Research Methodology

Course Outcomes: At the end of the course students will be able to:
CO1: Understand the concept of research, research process, and research ethics.
CO2: Understand and apply various sampling methods for data collection and estimate the parameters.
CO3: Understand the concept of simulation and able to simulate real life processes
CO4: Apply numerical methods to solve systems of linear equations and definite integrals.

Unit and Credit	**RMD17STA11: Research Methodology**	**No. of hoursper unit / credits**
Unit I	Meaning of research, objectives of research, motivation in research, types of research, research approaches, significance of research, research methods vs. methodology, research and Scientific method, research process, criteria of good research, defining research problem, research design, Research Ethics, publication of research, Plagiarism, Intellectual property rights, Patents and its filing procedures.	15
Unit II	Sampling techniques: review of simple random sampling stratified random sampling, systematic random sampling, cluster sampling, two phase sampling, ratio and regression method of estimation. Probability proportional to size sampling: Cumulative total method, Lahiri's method, Hansen-Horwitz estimator and its properties, Horwitz-Thompson estimator, Des Raj estimators for a general sample size. Non-sampling errors, techniques for handling non-response: Hansen–Horwitz and Demings model for the effect of call-backs. Randomized response techniques, dichotomous population, Warners model, MLE in Warners model, unrelated question model.	15
Unit III	Concept and need of simulation, random number generator, true random number and pseudo random number generators, requisites of a good random number generator. Tests for	15

	randomness. Congruential method of generating uniform random numbers. Algorithms for generating random numbers from well-known univariate discrete and continuous distributions, generating random vectors from multinomial, bivariate normal, and bivariate exponential distributions, generating random numbers from mixture of distributions (related results without proofs). Acceptance-Rejection Technique. Use of random numbers to evaluate integrals, to study the systems involving random variables, to estimate event probabilities and to find expected value of random variables. Use of random numbers for performance evaluation of estimators and statistical tests.	
Unit IV	Resampling methods: Bootstrap methods, estimation of bias and standard errors, estimation of sampling distribution, confidence intervals. Jackknife method: estimation of bias and standard errors, bias reduction method. Numerical methods for solution to system of linear equations: Jacobi and Gauss-Seidel methods with convergence analysis. Numerical methods for finding roots of nonlinear equation: Newton-Raphson method, bisection method; Newton-Raphson for system of non- linear equations. Numerical integration: quadrature formula, trapezoidal rule and Simpson's rules for single integral.	15

Books Recommended:

1. Atkinson, K. E. (1989). *An introduction to numerical analysis*, John Wiley and Sons.

2. Chaudhuri, A., & Stenger, H. (2005). *Survey sampling: theory and methods*. CRC Press.

3. Cochran, W. G. (1977). *Sampling techniques*. John Wiley & Sons.

4. Kennedy, W. J., & Gentle, J. E. (2021). *Statistical computing*. Routledge.

5. Kothari, C. R. (2004). *Research methodology: Methods and techniques*. New Age International.

6. Morgan, B. J. (1984). *Elements of simulation* (Vol. 4). CRC Press.

7. Mukhopadhyay, P. (2008). *Theory and methods of survey sampling*. PHI Learning Pvt. Ltd..

8. Ross, S. M. (2022). *Simulation*. Academic Press.

9. Singh, D., & Chaudhary, F. S. (1986). *Theory and analysis of sample survey designs*. John Wiley & Sons.

10. Sukhatme P. V., Sukhatme S. & Ashok C (1984). *Sampling Theory of surveys and applications.* Iowa university press and Indian society of agricultural statistics, New Delhi.

DSC17STA19: PRACTICAL -I

Practical Number	Practical Name
1	Sketching of pdf and CDF for Discrete distribution
2	Sketching of pdf and CDF for Continuous distribution
3	Mixture of distribution
4	Applications of Bivariate Normal distribution & Multivariate Normal distribution.
5	Sufficient, minimal sufficient, and complete sufficient statistics
6	UMVUE and lower bunds for variances of unbiased estimators
7	Maximum likelihood and method of moments estimation
8	Method of Scoring and method of minimum chi-square estimation
9	Construction of Consistent CAN & BAN Estimators.
10	Confidence interval based on CAN & BAN.
11	Practical on MSEXCEL
12	Practical on R- Software
13	Sampling Techniques I
14	Sampling Techniques II
15	Applications of Simulation techniques
16	Numerical Methods and Resampling Techniques
17	2 to 3 practical's on elective Paper

(Each practical should consist of problems to be solved using at least two of the following software: EXCEL/ R/python)

Semester II

DSC17STA21: Linear Models and Regression Analysis.

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

CO1: Understand General linear model, Gauss Markov theorem, variances and covariance's of BLUEs.

CO2: Understand and apply multiple regression models in real life situations.

CO3: Understand concept of multicollinearity and non-linear regression.

CO4: Understand concept of Robust regression, Logistic regression and Poisson regression.

Unit and Credit	**DSC17STA21: Linear Models and Regression Analysis.**	**No. of hours per unit / credits**
Unit I	General linear model: definition, assumptions, concept of estimability, least squares estimation, BLUE, estimation space, error space, Guass Markov theorem, variances and covariances of BLUEs, Distribution of quadratic forms for normal variables: related theorems (without proof), Tests of hypotheses in general linear models. Description of the ANOVA and linear regression models as the particular cases of the general linear model.	15
Unit II	Multiple regression model, Least squares estimate (LSE), Properties of LSE, Hypothesis testing, confidence and prediction intervals, General linear hypothesis testing. Dummy variables and their use in regression analysis. Model adequacy checking. Transformations to correct model inadequacies: VST and Box-Cox power transformation.	15
Unit III	Multicollinearity: Consequences, detection and remedies, ridge regression. Autocorrelation: sources, consequences, detection (Durbin-Watson test) and remedies. Parameter estimation using Cochrane-Orcutt method. Variable Selection Procedures: Rsquare, adjusted R-square, Mallows' Cp, forward, backward and stepwise selection methods, AIC, BIC. Robust Regression: need for robust regression, M-estimators, properties of robust estimators: breakdown and efficiency. Asymptotic distribution of M-estimator (Statement only).	15
Unit IV	Generalized linear models: concept of generalized linear model, Link function, ML estimation, large sample tests about parameters, goodness of fit, analysis of deviance. Residual analysis, types of residuals: raw, Pearson, deviance, Anscombe, quantile; residual plots. Variable selection: AIC and BIC. Logistic regression: logit, probit and cloglog models for dichotomous data, ML estimation, Odds ratio and its interpretation, hypothesis tests about model parameters. Hosmer-Lemeshow test, multilevel	15

	logistic regression, Logistic regression for Nominal response. Poisson regression.	

Books Recommended:

1. Birkes, D., & Dodge, Y. (2011). Alternative methods of regression. John Wiley & Sons.
2. Cook, R. D., & Weisberg, S. (1982). Residuals and influence in regression. New York: Chapman and Hall.
3. Draper, N. R., & Smith, H. (1998). Applied regression analysis. John Wiley & Sons.
4. Huber,P.J.andRonchetti,E.M (2011)Robust Statistics,Wiley,2ndEdition.

5. Kutner, M. H., Nachtsheim, C. J., Neter, J., & Wasserman, W. (2004). Applied linear regression models. New York: McGraw-Hill/Irwin.
6. Montgomery, D. C., Peck, E. A., & Vining, G. G. (2021). Introduction to linear regression analysis. 5th Ed. John Wiley & Sons.
7. Seber,G.A.,Wild,C.J.(2003).Non linear Regression,Wiley.
8. Weisberg, S. (1985). Applied Linear Regression, John Wiley & Sons. New York.

DSC17STA22: THEORY OF TESTING OF HYPOTHESIS

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

CO1: Formulate null and alternative hypotheses, compute probabilities of types of error, MP tests and MLR property.

CO2: Understand UMP and UMPU test with their applications.

CO3: Construct asymptotic confidence interval of a parameter and its relation with testing of hypothesis problem.

CO4: Execute small, large sample size tests and non-parametric tests in real life problems.

Unit and Credit	DSC17STA22: THEORY OF TESTING OF HYPOTHESIS	No. of hours per unit / credits
Unit I	Problem of testing of Hypothesis, Simple and composite hypotheses. Randomized and non- randomized tests, Most powerful test, Neyman-Pearson Lemma and its applications. Determination of minimum sample size to achieve the desired strengths.Monotone likelihood ratio property, UMP test, power function of a test, existence of UMP.Tests for one-sided alternatives.Concept of p- value.	15
Unit II	UMP tests for two sided alternatives examples, their existence and non- existence. Generalized Neyman Pearson lemma, unbiased test, UMPU test and their existence in the case of exponential families (Statements of the theorems only). Similar tests, test with Neyman structure.	15
Unit III	Problem of confidence intervals, relation with testing of hypotheses problem, shortest length confidence intervals, UMA and UMAU confidence intervals. Asymptotic Confidence Intervals based on CAN estimators, Variance stabilizing transformations (VST), confidence interval based on VST, Asymptotic Confidence regions.	15

Unit IV	Likelihood ratio test and its application to standard distribution. Goodness of fit tests based on Chi-square distribution and application to contingency tables. Spearman's Rank Correlation Test; Kendall's Rank Correlation Test; Kruskal-Wallis Test; Fridman's Two-way analysis of variance by ranks. Wald test, Rao's Score test, Bartlett's test for homogeneity of variances, Consistent test	15

Books Recommended:

1. V. K. Rohatgi, and A. K. MD. E. Saleh (2015): Introduction to Probability Theory and Mathematical Statistics,John Wiley & sons, 3rd Edition.
2. B. K. Kale, and K. Muralidharan (2015), Parametric Inference: An Introduction, Alpha Science InternationalLtd.
3. E. J. Dudewicz and S. N. Mishra (1988): Modern Mathematical Statistics, John Wiley and Sons.
4. E. L. Lehmann (1983): Theory of Point Estimation, John Wiley & sons.
5. T. S. Ferguson, Mathematical Statistics (1967): A decision theoretical approach, Academic press.
7. S. Zacks (1971): Theory of Statistical Inference, John Wileyand Sons, New York.
8. R. H. Randles (1979): and D. A. Wolfe, Introduction to theory of nonparametric Statistics, Wiley.
9. J. D. Gibbons and S. Chakraborti(2010): Nonparametric Statistical Inference, CRC Press, Fifth Edition.

DSC17STA23: Multivariate Analysis

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

CO1: Review of multivariate normal distribution and their real life applications.

CO2: Understand Wishart distribution, Hotelling T2 and Mahalanobis D2 statistic.

CO3: Implement dimension reduction techniques using software on real life problems.

CO4: Demonstrate knowledge of the basic ideas behind discriminant and clustering analysis techniques with applications.

Unit and Credit	**DSC17STA23: Multivariate Analysis**	**No. of hours per unit / credits**
Unit I	Review of Multivariate Normal distribution Hotelling's T^2 Statistic and its null distribution. Applications of T^2 statistics and its relationship with Mahalanobis' D^2 statistic. Confidence region for the mean vector, Wishart matrix and its distribution, properties of Wishart distribution, distribution of generalized variance.	15
Unit II	Discrimination and classification. Fisher's discriminant function and likelihood ratio procedure, minimum ECM rule, Rao's U statistics and its use in tests associated with discriminant function, classification with three populations. Cluster analysis, Heirarchical methods: Single, Complete, average linkage method and non-heirarchical clustering	15

	method-k means clustering. Canonical correlation analysis, Introduction to principal component analysis and related results, Introduction to factor analysis and estimation.	

Books Recommended:

1.Kshirsagar A. M. (1972): Multivariate Analysis. Marcel-Dekker.
2. Johnson, R.A. and Wichern. D.W (2002): Applied multivariate Analysis. 5thAd.Prentice – Hall.
3. Anderson T. W. (1984): An introduction to Multivariate statistical Analysis2nd Ed. John Wiely.
4. Morrison D.F. (1976): Multivariate Statistical Methods McGraw-Hill.

DSE17STA21: PROBABILITY THEORY

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

CO1: Memorize the basic concepts of Sets, Sequence, Measurable function and limit.

CO2: Recognize the measure theory, random variable, distribution function, limit of sequencevariables.

CO3: Explain the concept of convergence and applications with example.

CO4: Implement the central limit theorem and large-sample approximations for common statistics

Unit and Credit	**DSE17STA21: PROBABILITY THEORY**	**No. of hoursper unit / credits**
Unit I	Classes of sets: Sequence of sets: limsup, liminf and limit of sequence of sets field, σ- field, σ- field generated by a class of sets, Borel σ- field. Probability measure, Probability space, properties of a probability measure, continuity, mixture of probability measures. Lebesgue and Lebesgue-Steltjes measures on R. Independence of events.	15
Unit II	Measurable function, random variable, distribution function of a random variable, simple random variable, elementary random variable, liminf, limsup and limit of sequence of random variables. Method of obtaining a random variable as a limit of sequence of simple random variables. Integration of a measurable function with respect to a measure, expectation of a random variable, independence. Characteristic function, simple properties. Inversion theorem and uniqueness property (Statement only).	15
Unit III	Monotone convergence theorem, Fatous Lemma, Dominated Convergence theorem, Borel- Cantelli Lemma, (Statements only), and their applications. Convergence of sequence of random variables, Convergence in distribution,	15

	Almost sure convergence, a characterizing property, convergence in probability, uniqueness of limit, Yule Slutsky results and preservation under continuous transform. Convergence in r^{th} mean, interrelationships (Statements only), their illustration with examples	
Unit IV	Characteristic function: definition and properties of characteristic function, inversion formula (without proof), characteristic function and moments. Laws of large numbers: Convergence of distribution functions, convergence of series of independent random variables, Kolmogorov inequalities and almost sure convergence, weak law of large numbers (without Proof) for iid and non-iid random variables, Strong law of large numbers (without Proof). Central limit Theorem (CLT) (without proof): Lindeberg-Levy, Liaponove's and Lindeberg-Feller forms and applications.	15

Books Recommended:

1. Bhat B. R. (1981): Modern Probability Theory –IIIrd edition: New age international limited.
2. Alan Karr, (1993) : Probability Theory – Springer Verlag.
3. Billingsley P. (1986): Probability & Measure –John Wiley and sons
4. Athreya K. B. and Lahiri S. (2006). Probability Theory, (Hindustan Book Agency).
5. Feller, W. (1969). Introduction to Probability and its Applications vol.II (Wiley Eastern Ltd.)
6. Loeve, M. (1978). Probability Theory (Springer Verlag). Fourth edition
7. Rohatgi, V.K. and Saleh, A. K. MD. E. (2015). Introduction to Probability Theory andMathematical Statistics -3rd Edition, John Wiley & sons.

DSE17STA22: RELIBILITY THEORY

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

CO1: Understand different types of systems and evaluate the reliability of such systems

CO2: Construct the reliability block diagrams and structure functions of coherent system using minimal path and cut sets

CO3: Understand the concepts of ageing of systems and classify them based on ageing properties

CO4: Learn reliability estimation for statistical testing.

Unit and Credit	DSE17STA22: RELIBILITY THEORY	No. of hoursper unit / credits
Unit I	Structure function, dual of a structure, cuts and paths, components & systems, coherent systems, redundancy, Pivotal decomposition, Associated random variables and their properties. Birnbaum's measure of structural importance. Reliability concepts and measures, reliability of coherent systems, bounds on system reliability, structural and reliability importance of components. Modular decomposition.	15
Unit II	Life time distributions, survival functions, failure rate function, cumulative hazard function, residual life time, survival function of residual life time, mean residual life time, Computation of these functions for Common life time distributions: exponential, Weibull, Gamma, Makeham, Pareto, Rayleigh.	15
Unit III	Notion of ageing: IFR, DFR, IFRA, DFRA, DMRL, NBU, NWU, NBUE, NWUE classes, ageing properties of common life time distributions, closure properties under formation of coherent structures, convolutions and mixtures of these classes. Damage model, cumulative damage model, univariate shock models and life distributions arising from shock models, bivariate exponential distribution.	15
Unit IV	Reliability estimation based on failure times in variously censored life tests and in tests with replacement of failed items; stress-strength reliability and its estimation. Maintenance and replacement policies; availability of repairable systems; modelling of a repairable system by a non-homogeneous Poisson process. Reliability growth models; probability plotting techniques; Hollander-Proschan and Deshpande tests for exponentiality; tests for HPP vs. NHPP with repairable systems.	15

Books Recommended:

1)Barlow R.E. and Proschan F. (1975): Statistical Theory of Reliability & Life testing, Holt, Reinhart and Winston.

2) Lawless J.F.(1982): Statistical Models & Methods of Life Tome Data, John Wiley.

3) Miller R.C. (1981): Survival Analysis. John Wiley

4) Bain L.J (1978): Statistical Analysis of Reliability & Life Testing, Models, Marcel Dekker.
5) Martz H.F. and Waller R.A (1982): Bayesian Reliability Analysis, John Wiley.

DSC17STA29: PRACTICAL -II

Course Outcomes: At the end of the course students will be able to understand and implement theory in real life problems.

Practical Number	Practical Name
1	Linear Estimation: Estimation and Hypothesis testing
2	Multiple linear regression
3	Variable selection, Multicollinearity and Autocorrelation
4	Logistic Regression & Poisson Regression
5	MP, UMP, and UMPU Tests
6	Likelihood ratio tests
7	Confidence Intervals
8	Non-parametric Tests
9	Exploratory data analysis.
10	Application of Hotelling's T^2 statistics
11	Discriminant Analysis
12	Principle component analysis and Factor Analysis.
13	At least two practical's on elective paper

(Each practical should consist of problems to be solved using at least two of the following software: EXCEL/ R/python)

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