Rayat Shikshan Sanstha's

Yashavantrao Chavan Institute of Science, Satara
(Autonomous)

Post-graduate Programme

M. Sc. in Statistics

Syllabi of the course

Choice based credit system syllabus

(To be implemented from academic year 2021-22)

Preamble

The goal of syllabus to make the study of Statistics popular and interesting among the students for job achievements as well as higher studies.

The syllabus is prepared after discussion at length with number of faculty members of the subject and experts from industries and research fields. The units of the syllabus are well defined, taking into consideration the level and capacity of students.

Eligibility: B. Sc. with Statistics as principal subject.

General Objectives of the Course:

1. The students are expected to understand the principles, concepts and recent developments in theStatistics.
2. To enhance student sense of enthusiasm for Statistics and to involve them in an intellectually stimulating experience of learning in a supportiveenvironment.
3. The practical course is framed in relevance with the theory courses to improve the understanding of the various concepts inStatistics.

Otherfeatures:

1. **Library:**

Reference and Textbooks, Journals and Periodicals, Reference Books for Advanced Books for Advanced studies.

2. **Specific equipment's in laboratory:**

60 Computers, LCD Projector, Visualizer, Smart board etc.

61 Laboratory Software's:

1. SAS 2. SPSS 3. R-Software.
4. MINITAB 5. Python

1. **Title:** M. Sc.(Statistics)

2. **Year of Implementation:** The syllabus will be implemented from June, 2021-22 onwards.

3. **Duration:** TwoYears

4. **Pattern:** M. Sc. Statistics program has semester pattern and Choice Based Credit System. The program consists of 96credits.

5. **Medium of instruction:**English

6. **Structure ofcourse:**

Notations:

A six-character code is given to each paper. In MST "M" stands for M.Sc., "S" stands for Statistics, "T" stands for Theory and "P" stands for practical. The first digit following MST is Semester Number. The second digit "0" stands for the core theory course, the digit "1" stands for a practical paper and the third digit indicates the serial number of paper in that semester.

M.Sc. PartI

Semester – I

CourseCode	Title of the course	Instruction Hrs/week	Marks- End Semester Exam	Marks- Internal Assessment	Credits
MST 101	Real Analysis	4	60	40	4
MST 102	Linear Algebra	4	60	40	4
MST 103	Population Studies	4	60	40	4
MST 104	Estimation Theory	4	60	40	4
MST 105	Optimization Technique - I	4	60	40	4
MSP116	Practical-I	12	60	40	4
Total Credits of Sem-I					**24**

M.Sc. (Statistics) Semester – II

CourseCode	Title of the course	Instruction Hrs/week	Marks- End Semester Exam	Marks- Internal Assessment	Credits
MST 201	Probability Theory	4	60	40	4
MST 202	Theory of Testing of Hypotheses	4	60	40	4
MST 203	Regression Analysis	4	60	40	4
MST 204	Linear Model and Design of Experiment	4	60	40	4
MST 205	Sampling Theory	4	60	40	4
MSP 216	Practical-II	12	60	40	4
Total Credits of Sem-II					**24**

7. Equivalence

Semester I

CourseCode	Title of the course	CourseCode	Title of the course
MST 101	Real Analysis	MST 101	Real Analysis
MST 102	Linear Algebra	MST 102	Linear Algebra
MST 103	Distribution Theory	MST 103	Population Studies
MST 104	Estimation Theory	MST 104	Estimation Theory
MST 105	Optimization Technique - I	MST 105	Optimization Technique - I
MSP 116	Practical-I	MSP 116	Practical-I

Semester II

CourseCode	Title of the course	CourseCode	Title of the course
MST 201	Probability Theory	MST 201	Probability Theory
MST 202	Theory of Testing of Hypotheses	MST 202	Theory of Testing of Hypotheses
MST 203	Multivariate Analysis	MST 203	Regression Analysis
MST 204	Linear Model and Design of Experiment	MST 204	Linear Model and Design of Experiment
MST 205	Sampling Theory	MST 205	Sampling Theory
MSP 216	Practical-II	MSP 216	Practical-II

8. Syllabus

MST 101: REAL ANALYSIS

Course Objective: Students should to understand the basic properties of the field of real numbers, series of realnumbers and convergence, continuity, differentiability of real valued functions.

Unit 1: Set of real numbers, countable and uncountable sets, countability of rationals 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 2: Sequence of real numbers, convergence, divergence, Cauchy sequence, Convergence of bounded monotone sequence. Limit inferior and limit superior of the sequences. Series of numbers, tests for convergence (without proof) test for absolute convergence, convergence of sequences of non-negativeterms. (15)

Unit 3: 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 ofdistributions. (15)

Unit 4: 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)

Course Outcomes: Students are able to

1. Define and recognize the basic properties of the field of real numbers.
2. Define and recognize the series of real numbers and convergence.
3. Apply the theorem in a correct mathematical way.
4. Define and recognize the real functions and its limits.
5. Define and recognize the differentiability of real functions and its related theorems

BOOKS RECOMMENDED:

1. S. C. Malik & S. Arora, Mathematical Analysis, Wiley Eastern Limited-IInd edition, 1991.
2. R. R. Goldberg, Methods of Real Analysis, Blais dell Publishing company, Newyork, U.S.A, 1964.
3. G.R. Bartle, Element of Real Analysis, Wiley, 2nd edition, 1976.
4. G.R. Bartle & D. R. Sherbert, Introduction to Real Analysis-John, Wiley & Son Inc, 2000.
5. Royden, Principles of Real Analysis, Mac million, 1988.
6. Widder, Advanced Calculus, Dover Publication, 1989.
7. Apostol, Mathematical Analysis, Narosa Publishing House, T. M., 1985.

MST 102: LINEAR ALGEBRA

Course Objectives: Students should to understand

1. The basic concepts of linear algebra and to solve systems of linear equations.
2. Vectors and basic vector operations, eigenvalues and eigenvectors, quadratic forms etc.

Unit 1: Vector space, subspace, linear dependence and independence, basis, dimension of a vector space, example of vector spaces. Null space, Gram- Schmidt orthogonalisation process, Orthonormal basis, 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,partitionedmatrices. (15)

Unit 2: 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 solutionandexamples. (15)

Unit 3: 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 anditsapplications. (15)

Unit 4: 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)

Course Outcomes: Students are able to

1. Carry out matrix operations, including inverses and determinants.
2. Demonstrate understanding of the concepts of vector space and subspace.
3. Demonstrate understanding of linear independence, span, and basis.
4. Determine eigenvalues and eigenvectors and solve eigenvalue problems.
5. Apply principles of matrix algebra to linear transformations.
6. Solve systems of linear equations using multiple methods, including Gaussian elimination and matrix inversion.

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.

MST 103: POPULATION STUDIES

Course objectives: Students should to

1. Understand the need of population studies, vital statistics and concept of mortality and fertility.
2. Demonstrate understanding through data the concept of demography, Age- sex structure and migration.

Unit 1: Introduction and Sources of Population Data,Population trends, global variation in population size and growth, Definition, Scope and Evolution of Demography, **Basic Concepts and Measures:** Universe and Variables, Rates, Ratios and Proportions, Person-Years of Life, Basic Demographic Equation, Measures and Components of population change, Demographic Transition Theory, Demographic Dividends, Second Demographic Transition, Demographic Momentum or Population Momentum. (15)

Unit 2: Demographic Data Sources: Introduction, Censuses, Vital Statistics, Sample Surveys, Sample Registration System, Service Statistics, **Population Age-Sex Structures**: Quality of Data and Adjustments Concept and Significance of Age in Demographic Analysis, Sex Composition, Errors in Demographic DataWhipple's Index, Myers' Blended Index, Digit Preference Quotients for Birth Intervals, UN Joint Score or Accuracy Index Based on Age Data in 5-year Age Groups, Smoothening of Age Distributions, Use of Polynomial and Other Curves, Adjustments for Very Young and Old Ages. (15)

Unit 3: Basic Measures of Fertility: Introduction, Concepts, Types of Analysis: Period and Cohort Measures, Crude birth rate (CBR), General fertility rate (GFR), Age-specific fertility rate (ASFR), Total fertility rate (TFR), Child–Woman ratio (CWR), Specific fertility rates, Gross reproduction rate, Levels, Trends and Patterns of Fertility, Davis and Blake Intermediate Determinants of Fertility, Bongaarts' Model of Proximate Determinants of Fertility, Coale's Indices, Cohort Rates, Parity progression ratio (PPR), Birth intervals, Lexis diagram. (15)

Unit 4: Basic Measures of Mortality and Life Table Construction: Introduction, Crude Death Rate (CDR), Age-Specific Death Rate (ASDR), Useful Measures of Mortality, Life Tables, **Migration**: Importance of Migration and Concepts, Measures, Estimations of Migration Rates from Place of Birth Data, Estimation of Intercensal Migration from Place of Birth Data from Two Censuses, Estimation of Survival Ratio, Estimation of Migration from Place of Last Residence Data, Limitations, Accuracy of Data, Estimation of Migration from Place of Residence at a Fixed Prior Date, Estimation of Net Migration from Vital Statistics Data. (15)

Course Outcomes: Students are able to

1. Understand the Sources of Population Data, Population trends, Basic concepts and Measures of Demography.
2. Compute Population Age-Sex Structures.
3. Compute and understand Measures of Fertility.
4. Compute and understand Measures of Mortality
5. Construct the Life Table.

BOOKS RECOMMENDED:

1. Asha A. Bhende and Tara Kanitkar, Principles of Population Studies, Sixteenth Revised Edition, Himalaya Publishing House, Mumbai(2003).
2. Jacob S. Siegel and David a. Swanson, The Methods and Materials of Demography, Second Edition, Elsevier Science, USA(2004).
3. Hinde, Demographic Methods, Andrew London: Arnold (1998).
4. K.B. Pathak, and F. Ram, Techniques of Demographic Analysis, Mumbai: Himalaya Publishing House, (1998).
5. United Nations, Methods of Measuring Internal Migration, Manual VI, UN, New York (1974).
6. Coale, Ansley J. and Paul, Demney, Regional Model Life Tables and Stable Populations, Academic Press, New York (1983).
7. United Nations, Model Life Tables for Developing Countries, NewYork (1982).

MST 104: ESTIMATION THEORY

Course Objectives: Students should to

1. Derive suitable point estimators of the parameters of the distribution of a random variable and give a measure of their precision.
2. Learn computational skills to implement various statistical inferential approaches.

Unit 1: 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 2: 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 3: 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 4: The concept of prior distributions, various types of priors, non-informative, Jeffrey's, least favorable prior, posterior distribution; Posterior distribution conjugate family and standard examples of such families. Bayes estimation under squared error and absolute error loss functions. (15)

Course Outcomes: Students are able to

1. Understand the notion of a parametric models, point estimation of the parameters of those models.
2. Obtain the sufficient statistic, minimal sufficient statistic, m.l.e., moment estimator of the parameter.
3. Understand the concept of MVUE, MVBUE, UMVUE.
4. Describe the concept of Bayesian inference and their real life applications.

BOOKS RECOMMENDED:

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

MST 105: OPTIMIZATION TECHNIQUES - I

Course Objectives: Students should to

1. Develop the optimization techniques that will be useful in the personal and professional life.
2. Learn the mathematical formulation of complex decision-making problems and arrives at optimal or near-optimal solutions using different techniques of operations research.

Unit 1: a) Linear programming problem (LPP): Theorems related to the development of Simplex algorithm, theorems related to a basic feasible solution ; Reduction of a feasible solution to a basic feasible solution, Improvement of a basic feasible solution, Existence of unbounded solution, Optimality conditions and other related theorems (statements only), Examples based on these theorems. Revised Simplex Method.
b) Artificial variable technique: Two phasemethod, redundancy. (15)

Unit 2: a) Concept of Duality, related theorems, complementary slackness property and development of dual simplex algorithm.
b) Sensitivity Analysis: Changes in the cost vector, requirement vector and non-basic activity vector; addition of new variables and addition ofnewconstraints. (15)

Unit 3: a) Theory of games: two person zero sum games, minimax and maximin principles, Saddle point, mixed strategies; rules of dominance, solution of 2 x 2 game by algebraic method, Graphical method, Reduction of the game problem as LPP, Minimax and Maximin theorem.
b) Dynamic Programming: The Recursion Equation Approach, Computational Procedure, Characteristics of Dynamic Programming, Solution of L.P.P. by Dynamic Programming. (15)

Unit 4: a) Integer Linear Programming Problem (ILPP): The concept of cutting plane, cuttingplane method for all ILPP and mixed ILLP, Branch and Bound method.
b) Quadratic programming: Kuhn-Tucker conditions, methods due toBeale,Wolfe. (15)

Course Outcomes: Students are able to

1. Understand basics and formulation of linear programming problems and appreciate their limitations; solve linear programming problems using graphical method.
2. Apply simplex method to solve real life problems.
3. Solve artificial variable technique, duality theory, revised simplex method, sensitivity analysis.
4. Understand the concept of Game theory and dynamic programming to solve their problems and understand their real life applications.

BOOKS RECOMMENDED:

1. G Hadley, Linear Programming, Addison Wesley, 1969.
2. Taha H. A., Operation Research An Introduction, Macmillan, 1971.
3. Kanti Swaroop & M. M. Gupta, Operations Research, Sultan Chand & P. Gupta, 1985.
4. D. S. Hira, Operation Research, Sultan Chand & Co.ltd,2010
5. J. K. Sharma., Operation Research Theory and Applications, Macmillan, 2003.

MST 116: PRACTICAL–I

Course Objective: Students should to understand and implement theory in real life problems.

1. Linear dependence and independence ofvectors.
2. Gram-Schmidt orthogonalization method.
3. Solving systems ofequations.
4. Inverse and g-inverse of amatrix.
5. Applications of Caley-Hamiltontheorem.
6. Inverse of a Partitionedmatrix.
7. Characteristics roots and vectors and theirapplications.
8. Classifications and reduction of quadraticforms.
9. Construction of population pyramid.
10. Calculation of Mortality and Fertility rate.
11. Construction of UMVUE.
12. Methods of Estimation: MML and MLE.
13. Methods ofScoring.
14. Practical's on Bayesian inference.
15. Solution to LPP using simplex method.
16. Revised Simplex method and Dual Simplex Method.
17. Game Theory.
18. Quadratic Programming
19. Integer Programming.
20. Dynamic Programming

Course Outcomes: Students are able to

1. Solve problem of matrix and understand application of Caley-Hamilton theorem.
2. Understand estimation methods.
3. Solve problem of optimization by using appropriate methods.

BOOKS RECOMMENDED:

1. F. A. Graybill, An Introduction to Linear Statistical Models Vol 1, Mc Graw-Hill Book Company Inc, 1961.
2. S. B. Searl, Matrix Algebra Useful for Statistics, Wiley, 2006.
3. P. Mukhopadhyay, Mathematical Statistics, Books and Allied (p) Ltd., 2015.
4. V. K. Rohatgi, and A. K. MD. E. Saleh, Introduction to Probability Theory and Mathematical Statistics, John Wiley & sons, 3rd Edition. 2015.
5. J. K. Sharma., Operation Research Theory and Applications, Macmillan, 2003.

MST 201: PROBABILITY THEORY

Course Objectives: Students should to understand

1. Concept of sets, field, probability measure and probability space.
2. Measurable function, random variable, related theorem and properties.
3. Concept of convergence and related theorem.
4. Concept of Weak and Strong laws of large numbers, related theorem and applications.

Unit 1: 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 2: 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 3: 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, 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. (15)

Unit 4: a) Weak and Strong laws of large numbers, Kolmogorov's three series theorem for almost sure convergence (Statement only), Liaponove's, Lindeberg- Feller Theorems on CLT (Statement only). Applications of the above results.

b) Moment inequalities:- Markov, Chebychev, Holder, Minkowski and Jensen inequalities with their applications. Basic inequality Liapunov's. (15)

Course Outcomes: Students are able to

1. Learn the basic concepts of Sets, Sequence, Measurable function and limit.
2. Implementation of theoretical concept in example.
3. Recognize the measure theory, random variable, distribution function, limit of sequence variables.
4. Understand the concept of convergence and applications with example.
5. Understand the central limit theorem and large-sample approximations for common statistics.

BOOKS RECOMMENDED:

1. B. R. Bhat, Modern Probability Theory, New age international (P) limited, IIIrd edition, 1981.
2. Alan Karr, Probability Theory, Springer Verlag, 1993.
3. Billingsley P., Probability &Measure, John Wiley and sons, 1986.
4. Athreya K. B. and Lahiri S., Probability Theory vol 1, Trim series, (Hindustan BookAgency), 2006.
5. Feller, Introduction to Probability and its Applications vol. II, W. Wiley Eastern Ltd., 1969.
6. Loeve, M., Probability Theory, Springer Verlag, 1978.

MST202: THEORY OF TESTING OF HYPOTHESES

Course Objectives: Students should to

1. Understand the development of null and alternative hypotheses.
2. Know types of errors, most powerful test and concept of p- value.
3. Perform test of hypothesis as well as obtain MP, UMP tests.
4. Understand the concept of confidence interval, parametric and non-parametric tests.

Unit 1: 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 2: 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 3: Problem of confidence intervals, relation with testing of hypotheses problem, shortest length confidence intervals, UMA and UMAU confidence intervals. (15)

Unit 4: 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. (15)

Course Outcomes: Students are able to

1. Formulate null and alternative hypotheses, compute probabilities of types of error, MP tests and MLR property.
2. Understand UMP and UMPU test with their applications.
3. Obtain asymptotic confidence interval of a parameter and its relation with testing of hypothesis problem.
4. Apply small, large sample size tests and non-parametric tests in real life problems.

BOOKS RECOMMENDED:

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

MST 203: REGRESSION ANALYSIS

Course Objectives: Students should to develop

1. The deeper understanding of the linear and non-linear regression model and its limitations.
2. The regression model and apply for specific perspective data in appropriate manner.

Unit 1: Multiple regression model. Least square estimate and their Properties. Hypothesis testing, general linear hypothesis testing. Dummy variable. Residuals and their properties, Residual diagnostics. Transformation of variables: VST and Box-Cox Power transformation. Variable Selection Procedure: R – square, adjusted R-square, Mallows' Cp, forward, backward selection methods. AIC, BIC., Autocorrelation & Durbin – Watson test. (15)

Unit 2: Multicollinearity and Ridge regression. Robust Regression: Influential observation, leverage, outlier. Methods of detection of outlier and Influential observation. Estimation in presence of outlier: M estimator. Breakdown point, efficiency. Nonlinear regression models: Parameter estimation in a linear system. Transformation to a linear model. Statistical inference in nonlinear regression. (15)

Unit 3: Polynomial models in one and two variables, orthogonal polynomials, smoothing splines: linear, quadratic, cubic, cubic-B.Non parametric regression: Kernel regression, locally weighted regression. Generalized linear models, Link function, ML and Quasi-likelihood estimation. Large sample tests about parameters, goodness of fit. Deviance analysis. Residual analysis : raw, Pearson, deviance, Anscombe, quantile. AIC, BIC.

(15)

Unit 4: Logistic regression: logit, probit and cloglog model for single and multiple variables. ML estimation, Large sample test about parameter. Hosmer-Lemeshow test. ROC curve. Logistic regression for Nominal response. Proportional odds model. Poisson Regression: ML estimation using power link function. Testing significance of coefficients. Goodness of fit. Over dispersion, NB-2 model.

(15)

Course Outcomes: Students are able to

1. Understand and apply multiple regression models in real life situations.
2. Understand concept of multicolinearity and non-linear regression.
3. Do residual analysis and will able to understand and apply the logistic regression.
4. Understand and apply the Poisson regression.

BOOKS RECOMMENDED:

1. D. C. Montgomery, E. A. Peck and G. G. Vining, Introduction to Linear Regression Analysis, Wiley, 2003.

2. D. W. Hosmer, and S. Lemeshow, Applied Logistic Regression, Wiley, 1989.

3. G. E. F. Seber, and C. J. Wild, Nonlinear Regression, Wiley, 1989.

4. C.E. McCulloch, & S.R. Searle, Generalized linear and mixed models, Wiley series in probability and statistics, New York, 2003.

5. P. McCullagh, and J. A. Nelder, Generalized Linear Models, Chapman & Hall., 1989.

6. J. Hilbe, Negative binomial regression, Cambridge University Press, 2nd Edition, 2011.

MST204: LINEAR MODELS AND DESIGN OF EXPERIMENTS

Course Objectives: Students should to understand

1. The concept of linear model for experimental design
2. The connections between design choice and the resulting statistical analysis.
3. The statistical aspects of experimental design as a whole within the structure provided by general linear models.

Unit 1: 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.
Generalized linear mixed model: Structure of the model. Random effects. Marginal versus conditional models. Estimation by generalized equation and conditional likelihood.

(20)

Unit 2: Analysis of variance: one way classification, two way classification without interaction and with interaction with equal number of observations per cell, Estimation and tests of hypotheses, multiple comparison procedures: Three types of errors, Tukey, Sheffe and Bonferroni procedure. (15)

Unit 3: Analysis of Covariance: estimation of parameters, related tests of hypothesis. General theory and application of one way and two way setup (10)

Unit 4: Two way classification with unequal number of observations per cell without interaction model, estimable parametric functions and their BLUEs, tests of hypotheses. Incomplete block design, concepts of connectedness, balancedness, and orthogonality, BIBD: Definition, properties and analysis, Symmetric BIBD. (15)

Course Outcomes: Students are able to

1. Understand General linear model, Guass Markov theorem, variances and covariance's of BLUEs.
2. Recognize one way classification, two way classifications without interaction and with interaction.
3. Apply this theory to the analysis of specific models in designing statistical experiments.

BOOKS RECOMMENDED:

1. A. M. Kshirsagar, Course in Linear Models, Marcel Dekker,1983.
2. D. D. Joshi, Linear Estimation and Analysis of Experiments, Wiley Estern Ltd, 1987.
3. M. N. Das and N.C. Giri, Design and analysis of experiments, New Age International(P)Limited Publishers, 2nd edition,1986.
4. S. R. Searle, Linear Models, John Wiley & Sons. New York, 1971.
5. M. C. Chakravarti, Mathematics of Design of Experiments, Asia Publishing House, Bombay, 1962.
6. Dey Aloke, Incomplete block design, Hindustan Book Agency, 2010.
7. A. M. Dean and D. Voss, Design and Analysis of Experiments, Springer, 1999.

MST 205: SAMPLING THEORY

Course Objectives: Students should to

1. Learn scientific view to conduct the survey in proper way to collect the data about specific perspective.
2. Learn variety of probability and nonprobability sampling methods for selecting a sample from a population.

Unit 1: Review of concept Simple random sampling with replacement (SRSWR) and Simple random sampling without replacement (SRSWOR), results related to SRSWR and SRSWOR, estimation of sample size. Stratified sampling: Stratification, allocation and estimation problems, comparison with SRS**,** post stratification, construction of strata, deep stratification, method of collapsed strata, Review of concept of Systematic sampling: linear systematic sampling and circular systematic sampling, Comparison with SRS andStratified sampling. (15)

Unit 2: PPSWR methods: Cumulative total method, Lahiri's method related estimation Problems and PPSWOR methods and related estimation of a finite population mean (Horwitz-Thompson and Des Raj estimators for a general sample size and Murthy's estimator for a sample of size 2, Midzuno sampling, Rao-Hartley-Cochran sampling Strategy. (15)

Unit 3: Use of supplementary information for estimation: ratio and regression estimators and their properties. Unbiased and almost unbiased ratio type estimators, Double sampling. Cluster sampling. Two –stage sampling with equal number of Second stage units, multistage-sampling. Stratification estimator, Multiphase sampling. (15)

Unit 4: Non-sampling errors: Response and non-response errors. Hansen–Hurwitz and Deming's model for the effect of call-backs. Random response techniques, dichotomous population, Warners model, MLE in Warners model, unrelated question model, polychotomous population: use of binary and vector response, binary response and unrelated questions, Multiattribute situations. (15)

Course Outcomes: Students are able to

1. Understand the basic concept of random sampling and different methods of sampling.
2. Apply unequal probability sampling designs viz. PPSWR, PPSWOR including Lahiri's method and Murthy's estimator for survey.
3. Implement Cluster sampling, Two –stage sampling, Multistage sampling, Ratio and Regression estimation in real life problems.
4. Recognize non-sampling error, Response and non-response errors. Apply different model and technique to overcome errors.

BOOKS RECOMMENDED:

1. Parimal Mukhopadhyay, Theory and methods of survey sampling, Prentice Hall of India private limited, 2nd Edition, 2008.
2. P. V. Sukhatme, S. Sukhatme & C Ashok, Sampling Theory of surveys and applications, Iowa university press and Indian society of agricultural statistics, New Delhi, 1984.
3. Chaudhuri and H. Stenger, Survey Sampling: Theory and Methods, chapman and hall/CRC, 2nd edition, 2005.
4. Des Raj and Chandhok. P., Sample Survey Theory, Narosapublication, 1998.
5. William G. Cochran, Sampling Techniques, John and Wieley sons Inc, IIIrd edition 1977.
6. M. N. Murthy, Sampling Theory of Methods, Statistical Publishing Society, Calcutta, 1977.

7. D. Singh and F. S. Chaudhary, Theory and Analysis of Sample Survey Designs, Wiley Eastern Limited, 1986.
8. S. Singh, Advance Sampling Theory and Applications (Volume I and II), Kluwer Academic Publishers, 2003.

MST 216-PRACTICAL–II:

Course Objective: Students should to understand and implement theory in real life problems.

1. Exploratory data analysis.
2. Multiple Linear Regression Model.
3. Multicollinearity and Nonlinearregression.
4. LogisticRegression.
5. PoissonRegression.
6. MP, UMP, and UMPUTests
7. Likelihood ratiotests.
8. ConfidenceIntervals.
9. Non-parametricTests.
10. Linear Estimation: Estimation and Hypothesistesting.
11. ANOVA: One way and two way orthogonal data withoutinteraction.
12. ANOVA: Two way orthogonal data withinteraction.
13. Two way non-orthogonal data withoutinteraction
14. Analysis ofBIBD.
15. Analysis of general blockdesign.
16. Basic samplingdesigns.
17. Ratio, regression, Horvitz-Thompson method ofestimations.
18. Stratified, Systematic and clusterSampling.
19. Multi-stagesampling
20. Non-samplingerrors.

Course Outcomes: Students are able tounderstand

1. Concepts of multivariate analysis techniques through example.
2. Testing of hypothesis process and different test.
3. One way and two way ANOVA.

BOOKS RECOMMENDED:

1. B. K. Kale and K. Muralidharan, Parametric Inference: An Introduction, Alpha Science International Ltd.,2015.
2. V. K. Rohatgi and A. K. MD. E. Saleh , Introduction to Probability Theory and Mathematical Statistics, John Wiley & sons, 3rd Edition.2015.
3. T. W. Anderson, An Introduction to Multivariate Statistical Analysis, John Wiely, 2nd Ed.1984.
4. D. D. Joshi, Linear Estimation and Analysis of Experiments, Wiley Estern Ltd, 1987.
5. Parimal Mukhopadhyay, Theory and methods of survey sampling, Prentice Hall of India private limited, 2nd Edition, 2008.

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