M.Sc. (STATISTICS): COURSE STRUCTURE
(with effect from 2015 ADMISSION ONWARDS)

Objectives

The present course is intended to provide a platform for talented students to undergo higher studies in the subject as well as to train them to suit for the needs of the society. Apart from teaching core Statistics subjects, the students are also trained to handle real life problems through the practical classes. As a part of the course the students are taught some programming languages and also exposed to various statistical softwares such as SPSS, MATLAB, SAS etc.

Eligibility

B.Sc. degree in Mathematics or Statistics main with at least 55% marks for the optional subjects taken together.

Duration of the Course **:** Four Semesters

Examination **:** Credit and Semester

Intake **:** 20

SEMESTER – I

Course Code	Title of Paper	Core/ Elective	Credits	Continuous evaluation marks	External Evaluation Marks	Total marks
STA 2101	Mathematical Methods for Statistics	C	4	50	50	100
STA 2102	Probability Theory I	C	4	50	50	100
STA 2103	Probability Distributions	C	4	50	50	100
STA 2104	Sampling Theory & Methods	C	4	50	50	100
STA 2105	Elective I	E	4	50	50	100

SEMESTER – II

Course Code	Title of Paper	Core/ Elective	Credits	Continuous evaluation marks	External Evaluation Marks	Total marks
STA 2201	Statistical Inference I	C	4	50	50	100
STA 2202	Probability Theory II	C	4	50	50	100
STA 2203	Stochastic Processes	C	4	50	50	100
STA 2204	Practical - I and Viva Voce	C	2	100	-	100
STA 2205	Elective II	E	4	50	50	100

SEMESTER – III

Course Code	Title of Paper	Core/ Elective	Credits	Continuous evaluation marks	External Evaluation Marks	Total marks
STA 2301	Statistical Inference II	C	4	50	50	100
STA 2302	Multivariate Analysis	C	4	50	50	100
STA 2303	Applied Regression Analysis	C	4	50	50	100
STA 2304	Practical - II using SPSS/ MATLAB , and Viva Voce	C	2	100	-	100
STA 2305	Elective III	E	4	50	50	100

SEMESTER - IV

Course Code	Title of Paper	Core/ Elective	Credits	Continuous evaluation marks	External Evaluation Marks	Total marks
STA 2401	Design and Analysis of Experiments	C	4	50	50	100
STA 2402	Statistical Quality Assurance	C	4	50	50	100
STA 2403	Practical – III using SAS/R , Project work and Viva Voce	C	4	50 (practical) + 100 (project)	50*	200
STA 2404	Elective IV	E	4	50	50	100

* The Viva Voce examination in STA 2403 is to be conducted externally with at least one external examiner (50 marks). The project in STA 2304 shall be evaluated internally in Semester III with 50 marks. The project evaluation based on a dissertation of STA 2403 shall be done in semester IV internally with 100 marks

List of Elective Papers:

1. Actuarial Statistics
2. Advanced Distribution Theory
3. Advanced Probability Theory
4. Advanced Stochastic Processes
5. Applied Multivariate Statistical Analysis
6. Applied Statistics for National Development
7. Complex Analysis and Integral Transforms
8. Demographic Techniques
9. Directional Data Analysis
10. Inference for Stochastic Processes
11. Operations Research
12. Reliability Modelling and Analysis
13. Statistical Computing
14. Statistical Decision Theory
15. Statistical Forecasting
16. Statistical Genetics
17. Stochastic Finance
18. Survival Analysis
19. Time Series Analysis

STA 2101: MATHEMATICAL METHODS FOR STATISTICS

1. Functions:- limits, continuity, uniform continuity, inverse functions, convex functions, monotone functions, functions of bounded variation, total variation (definitions only) and important theorems (without proof); Riemann-Stieltjes Integral:- definition, linear properties, integration by parts, change of variable in a Riemann-Stieltjes integral, reduction to a Riemann integral, step functions as integrators, reduction of a Riemann-Stieltjes integral to a finite sum, Eulers summation formula, monotonically increasing integrators, Riemann's condition, comparison theorems, integrators of bounded variation, sufficient conditions for existence of Riemann-Stieltjes integrals, Mean value theorems of Riemann-Stieltjes integrals, integral as a function of the interval, second mean value theorem for Riemann-Stieltjes integrals.

2. Sequences of functions:- Pointwise convergence of sequence of functions, Uniform convergence and continuity, Cauchy condition for uniform convergence, Uniform convergence of infinite series of functions, Uniform convergence and Riemann-Stieltjes Integration, Uniform convergence and differentiation, Multivariable Calculus:- limit and continuity of multivariable functions, Derivatives of a multivariable function - total derivative, directional derivatives, differentiation of composite functions, Taylor's Theorem for a multivariable function, inverse and implicit functions, optima of a multivariable function, method of Lagrange multipliers.

3. Matrices:- Rank of a matrix, elementary transformations of a matrix, reduction to normal form, elementary matrices, elementary transformations and elementary matrices, employment of only row (column) transformations, rank of a product, a convenient method for computing the Inverse of a non-singular matrix, Generalized Inverse Matrices:- Definition and existence, an algorithm, Solving linear equations - consistent equations, obtaining solutions, properties of solutions, Penrose inverse, Symmetric matrices - properties of generalized inverse.

4. Quadratic forms:- definition, Quadratic forms in the real field:- reduction in the real field, canonical forms, classification of quadratic forms and its characteristic properties, necessary and sufficient conditions for a definite form, gram matrices, Characteristic roots and characteristic vectors of a matrix:- determination of characteristic roots and vectors, characteristic sup-spaces of a matrix, nature of characteristic roots of some special types of matrices, algebraic and geometric multiplicity of a characteristic roots, Cayley-Hamilton theorem, Orthogonal and unitary reductions of quadratic forms:- orthogonal reduction of real symmetric matrices, unitary reduction of Hermitian matrices, simultaneous reduction of a pair of quadratic forms, Spectral decomposition of a matrix.

Text Books:

1. Khuri, A.T. (1993) Advanced Calculus with Applications in Statistics, John Wiley & Sons, Inc., USA, Chapters - 3 and 7
2. Apostol, T.M. (1996) Mathematical Analysis, Narosa Publshing House, New Delhi, Second Edition, Chapters - 6, 7, 9.

3. Shanti Narayan (1991) A text of book of matrices, S. Chand & Company, New Delhi, Chapters - 3, 6, 7, 10, 11.
4. Searle, S.R. (1971) Linear models, John Wiley & Sons, Inc., Chapter - 1.

Reference Books:

1. Gupta, S.L. and Gupta, N.R. (2003) Principles of Real Analysis, Second edition, Pearson Education (Singapore) Pte. Ltd.
2. Widder, D.A. (1996) Advanced Calculus, Second Edition, Prentice Hall, Inc., New Delhi.
3. Nanda, S. and Saxena, V.P. (2000) Real Analysis, Allied Publishers Ltd.
4. Graybill, F.A. (1969) Introduction to matrices with applications in statistics, Wadsworth Publishing Company, USA.
5. Rao, C.R. (2002) Linear statistical inference and its applications, Second edition, Chapter 1b, 1c.

STA 2102: PROBABILITY THEORY - I

1. Random variables: Algebra of sets, Fields, Sigma fields, Inverse function, Measurable functions, Random variables, Induced sigma fields, Limits of random variables.

2. Probability: General measure space, Lebesgue measure, Lebesgue-Stieltjes measure, Counting measure and their simple properties, Discrete probability space, General probability space as normed measure space, Induced probability space, Extension of probability measures. Distribution function of a random variable, Decomposition of distribution functions, Distribution function of random vectors.

3. Intgegration with respect to measure (Introduction only), Expectation and moments: Definition and properties, Moment generating functions, Moment inequalities: C_r-, Holder, Jenson and basic inequalities, Product spaces and Fubini's theorem (idea and statement only), Independence: Definitions, Multiplication properties, Zero-one laws.

4. Convergence: Modes of convergence, Convergence in probability, in distribution, in rth mean, almost sure convergence and their inter-relationships, Convergence theorem for expectation such as Monotone convergence theorem, Fatou's lemma, Dominated convergence theorem (some remarks on the corresponding theorems for general integrals with respect to measure).

Text Books:

1. Bhat, B.R. (2011) Modern Probability Theory, Second edition, Wiley Eastern, Chapters - 1, 2, 3, 4, 5, 6, 9.
2. Billingsley, P. (1986) Probability and Measure, Second Edition, John Wiley.

Reference Books:

1. Feller, W. (1966) An Introduction to Probability Theory and Its Applications, Volume II, Wiley Eastern.
2. Rao, C.R. (1973) Linear Statistical Inference and Its Applications, Wiley.
3. Rohatgi, V.K. and A.K.E. Salah (2001) Introduction to Probability and Statistics, John Wiley and Sons.
4. Basu, A.K. (1999) Measure Theory and Probability, Prentice-Hall.

STA 2103: PROBABILITY DISTRIBUTIONS

1. Discrete Distributions : Modified power series family - properties, moment generating functions, recurrence relations for raw, central and factorial moments, recurrence relation for cumulants, Binomial, Negative binomial, Logarithmic series and Lagrangian distributions and their properties as special cases of the results from modified power series family, hypergeometric distribution and its properties.

2. Continuous distribution: Pearson family – identifications of the different types, Beta, Gamma, Pareto and Normal Special cases of the Pearson family and their properties. Exponential family of distributions, Compound, truncated and mixture distributions.

3. Sampling distributions: Sampling distributions of the mean and variance from normal population, independence of mean and variance, Chi-square, students t and F distribution and their non-central forms. Order statistics and their distributions, Conditional distribution of order statistics, distribution of sample range.

4. Bivariate distributions: Multinominal, bivariate normal, bivariate exponential distribution of Gumbel, Marshall and Olkin and Block and Basu, Dirichlet distribution.

Text Books:

1. Rohatgi V.K (1976) An introduction to Probability Theory and Mathematical Statistics, Wiley Eastern
2. Arnold B.C, Balakrishnan N and Nagaraja H.N (1992). A first course in order statistics
3. Galambos J, and Kotz's (1978): Characterization of Probability distributions, Springer -Verlag.
4. Ord J.K. (1972) Families of frequency distributions Griffin

Reference Books:

1. Johnson N.L, Kotz S and Kemp A.W (1992) Univariate discrete distributions, John Wiley.
2. Johnson N.L, Kotz S and Balakrishnan N (1991) Continuous univariate distributions I & II, John Wiley.
3. Johnson N.L, Kotz S and Balakrishnan N (1995) Multivariate Distribution, John Wiley.

STA 2104: SAMPLING THEORY AND METHODS

1. Basic concepts:- Population, sample, sampling design, interpenetrating subsampling; Simple Random Sampling (SRS):- SRS with replacement, SRS without replacement, confidence interval, estimation of population proportion, determination of sample size, comparison between SRSWR and SRSWOR; Stratified Random Sampling:- estimation of population mean and total, optimum allocation, other types of allocation, comparison with SRS.

2. Estimation of gain due to stratification over SRS, construction of strata, number of strata, Ratio estimator:- Bias and mean square error, estimation of variance, confidence interval, comparison with mean per unit estimator, optimum property of ratio estimator, unbiased ratio type estimator, ratio estimator in stratified random sampling; Difference estimator and Regression estimator:- Difference estimator, regression estimator, comparison of regression estimator with mean per unit and ratio estimator, regression estimator in stratified random sampling.

3. Systematic sampling:- estimation of population mean and variance, comparison of systematic sampling with SRS and stratified random sampling, circular systematic sampling; Cluster sampling:- estimation of population mean, estimation of efficiency by a cluster sample, variance function, determination of optimum cluster size, clusters of varying sizes; Probability proportional to size with replacement sampling:- estimation of population mean and total, selection of a ppswr sample; Varying probability without replacement sampling I:- properties of a sampling design, Horvitz-Thomson estimator.

4. Varying probability without replacement sampling II:- Midzuno-Sen-Lahiri sampling strategy, Desraj, Murthy's; Mutistage sampling:- estimation population total with SRS sampling at both stages, multiphase sampling (outline only); Errors in surveys:- effect of unit nonresponse in the estimate, procedures for unit nonresponse; quota sampling, network sampling; Adaptive sampling:- introduction and estimators under adaptive sampling.

Text Books:

1. Mukhopadhay, P (2009) Theory and methods of survey sampling, Second edition, PHI Learning Pvt Ltd., New Delhi, Relevant sections of Chapters 1-16.
2. Sampath, S. (2001) Sampling theory and methods, Alpha Science International Ltd., India, Chapter 10.

Reference Books:

1. Cochran, W.G. (1999) Sampling Techniques, Third edition, John Wiley & Sons.
2. Des Raj (1976) Sampling Theory, McGraw Hill.
3. Murthy, M.N. (1977) Sampling Theory and Methods, Statistical Publishing Society, Calcutta.
4. Singh, D. and Chaudharay, F.S. (1986) Theory and Analysis of Sample Survey Designs, Wiley Eastern.
5. Hansen, M.H., Hurwitz, W.N. and Madow, W.G. (1953) Sample Survey Methods and Theory, Volume II, John Wiley.

STA 2201: STATISTICAL INFERENCE - I

1. Point estimation: Sufficiency and minimal sufficiency, Exponential family of distributions, Pitman family, Factorization criterion, Likelihood equivalence, Unbiased estimation, Completeness, Ancillary statistics and Basu's Theorem, UMVUE estimators and their characterizations, Rao-Blackwell Theorem, Lehmann-Scheffe Theorem, UMVUE estimation of parametric functions from standard distributions.

2. Fisher information measure and its properties, Fisher information matrix, Lower bound to the variance of an unbiased estimates, Cramer-Rao, Chapman-Robbin's and Bhattacharya bounds, BLUE of parametric functions, Efficiency, Consistency, Weak and strong consistency, Marginal and joint consistent estimators, Equivariance, Pitman estimators

3. Methods of estimation: Methods of moments, Maximum likelihood, Minimum chi square and its modification, Least square estimation, Properties of maximum likelihood estimators, Cramer-Huzurbazar Theorem, Likelihood equation - multiple roots, Iterative methods, E.M Algorithm.

4. Basic elements of Bayesian Inference, Loss function, Prior distribution, Bayes Theorem, Posterior distributions, Bayes risk, Bayes principle, Bayes estimators, Minimax estimators, Metropolis-Hastings algorithm, Gibbs sampler, MCMC method.

Text Books:

1. E.L.Lehmann (1998) Theory of Point Estimation, John Wiley and Sons.
2. V.K.Rohatgi and A.K.L. Saleh (2001) An Introduction to Probability and Mathematical Statistics, Wiley.
3. B.K. Kale (1999) A First Course in Parametric Inference, Narosa Publishing Company.
4. Robert C.P. and Casella, G (1999) Monte Carlo Statistical Methods, Springer Verlag.

Reference Books:

1. Rao, C.R. (1973) Linear Statistical Inference and its Applications, Wiley.
2. Casella, G and Berger, R.L (2002) Statistical Inference, Second Edition, Thompson-Duxbury Press.
3. Mukhopadhay, P. (1999) Mathematical Statistics, New Central Book Agency Pvt. Ltd.

STA 2202: PROBABILITY THEORY - II

1. Characteristic functions**:** Definition and simple properties, Inversion formula, Uniqueness theorem, Characteristic function and moments, Bochner's Theorem (Statement only), Convergence of distribution function: Weak convergence, Convergence of distribution functions and characteristic functions, Convergence of moments.

2. Laws of Large Numbers**:** Covergence of series of independent random variables, Kolmogorov's inequality, Three series theorem, Weak law of large numbers (Kninchine's and Kolmogorov's), Kolmogorov's strong law of large numbers, Glivenko-Cantelli theorem, Kolmogorov's law of iterated logarithms (without proof).

3. Limit Theorems**:** Central limit theorems for i.i.d random variables, Lindberg-Levy and Liaponov's CLT, Lindberg-Feller CLT, Infinitely divisible distributions--definition, elementary properties and examples, Canonical representation (without proof).

4. Conditioning: Conditional expectation and its properties, Conditional probabilities, Randon-Nikodym Theorem (Statement only) and its applications. Martingales, Submartingales, Martingale convergence theorem, Decomposition of submaritingales.

Text Books:

1. Bhat, B.R. (2011) Modern Probability Theory, Second edition, Wiley Eastern, Chapters 7, 8, 10, 11, 12.
2. Laha. R.G. and Rohatgi V.K. (1979) Probability Theory, John Wiley, Relevant sections of Chapters 2, 4, 6.

Reference Books:

1. Billingsley, P. (1986) Probability and Measure, Second edition, John Wiley
2. Feller, W. (1976) An Introduction to Probability Theory and its Applications, Volume II Wiley Eastern.
3. Hoffmann - Jorgensen J. (1994) Probability with a view towards Statistics, Chapman & Hall.
4. Loeve M. (1977) Probability Theory, Volume I, Fourth edition, Springer-Verlag
5. Loeve, M. (1978) Probability Theory, Volume II, Fourth edition, Springer-Verlag.
6. Rohatgi, V.K. and Salah, A.K.E. (2001) An Introduction to Probability and Statistics, John Wiley & Sons.
7. Sidney I. Resnick (1999) A Probability Path, Bikhanser.

STA 2203: STOCHASTIC PROCESSES

1. Markov Chains: Definition, Examples and classification, Discrete renewal equation and basic limit theorem, Absorption probabilities, Criteria for recurrence.

2. Continuous time Markov chains, Examples, General pure birth process, Poisson process, Birth and death process, Finite state continuous time Markov chains.

3. Galton-Watson branching processes, Generating function, Extinction probabilities, Continuous time branching processes, Extinction probabilities, Branching processes with general variable life time.

4. Renewal equation, Renewal theorem, Applications, Generalizations and variations of renewal processes, Applications of renewal theory, Brownian motion.

Text Books:

1. Karlin, S. and Taylor, H.M. (1975) A First Course in Stochastic Processes, second edition, Academic Press, Relevant sections of Chapters 1, 2, 3, 4, 5 and 8.
2. Bhat, B.R. (2002) Stochastic Processes, second edition, New Age Publication.

Reference Books:

1. Feller, W. (1965, 1968), An Introduction to Probability Theory and its Applications, Volume I and II, Wiley Eastern.
2. Bhat, U.N. (1984) Elements of Applied Stochastic Processes, John Wiley.
3. Cinlar, E. (1975) Introduction to Stochastic Processes, Prentice Hall.
4. Cox, D.R. (1962) Renewal Theory, Methuen.
5. Ross, S. (1996) Stochastic Processes, Second edition, John Wiley.
6. Medhi, J. (1994) Stochastic Processes, Second edition, Wiley Eastern.
7. Basu, A.K. (2002) Elements of Stochastic Processes, Narosa Publications.
8. Bhat, U.N. and Gregory Miller (2003) Elements of Applied Stochastic Process, John Wiley.

STA 2204: PRACTICAL - I

Based on topics covered in STA 2104, STA 2201, STA 2203 and STA 2205.

STA 2205: ELECTIVE - II

STA 2301: STATISTICAL INFERENCE – II

1. Tests of hypotheses, Formulation of problem, Null and alternative hypotheses, Size of a test, Two kinds of errors, Simple and composite hypotheses, Randomized and non-randomized tests, Power of a test, M.P test, Neyman-Pearson lemma and its generalization, Monotone likelihood ratio property, UMP tests, Unbiased tests and UMPU tests, Unbiased critical regions and similar regions, Neyman structure, UMPU tests in multiparametric exponential families of distributions.

2. Confidence interval estimation, Relationship between confidence interval estimation and testing of hypothesis, UMA and UMAU confidence intervals, Shortest confidence intervals, Construction of confidence intervals using pivots, Large sample confidence interval based on maximum likelihood estimator, central limit theorem and Chebyshev's inequality, Bayesian credible regions.

3. Likelihood ratio tests and their properties, Testing mean and variance of a normal population, Testing equality of means and variances of two normal populations, Sequential probability ratio tests, Construction of sequential probability ratio tests, Wald's identity, OC and ASN functions, Properties of SPRT.

4. Non-parametric inference: Goodness of fit tests- Chi square test and Kolmogorov Smirnov test for one and two sample problems, Sign test, Signed rank test, Wald-Wolfowitz run test, Median test, Man-Whitney U-test, Non-parametric confidence intervals, Bootstrapping confidence intervals, P-P Plot and Q-Q plot, Kendall's tau, Tests for independence and homogeneity.

Text Books:

1. Lehmann, E.L. (1998) Testing Statistical Hypothesis, John Wiley.
2. Wald, A. (1947) Sequential Analysis, Doves
3. Gibbons, J.K. (1971) Non-Parametric Statistical Inference, McGraw Hill
4. Rohatgi, V.K. and Salah, A.K.E. (2001) An Introduction to Probability and Statistics, John Wiley and Sons.
5. Kale, B.K. (1999) A First Course in Parametric Inference, Narosa Publications.

Reference Books:

1. Rao, C.R. (1973) Linear Statistical Inference and its Applications, Wiley.
2. Casella, G and Berger, R.L (2002) Statistical Inference, Second Edition, Thompson-Duxbury Press.

STA 2302: MULTIVARIATE ANALYSIS

1. Notion of multivariate distributions, Multivariate normal distribution, Marginal and conditional distributions, Characteristic function, Estimation of mean vector and covariance matrix.

2. Distribution of rectangular co-ordinates, Wishart distribution and its properties, Distribution of simple, partial and multiple correlations based on samples from normal population, Hotelling's T^2 and Mahalanobis D^2 statistics, Properties of T^2 and D^2, Multivariate Fisher Behren's problem.

3. Testing independence of sets of variates, Testing equality of covariance matrices and means, Sphericity tests, testing the hypothesis that a covariance matrix equal to given matrix, Mean and covariance equal to a given vector and given matrix.

4. Classification problem - standards of good classification, procedures of classification into one of two populations with known probability distributions, classification into one of two known multivariate normal populations (including with parameters are estimated), classification into one of several populations; Principal component analysis- Definition, properties and ML estimation; Canonical variables, Canonical correlation.

Text Books:

1. Anderson, T.W. (1984) An Introduction to Multivariate Statistical Analysis, John Wiley.
2. Kshirasagar, A.M. (1972) Multivariate Analysis, Marcel-Dekker.

Reference Books:

1. Seber, G.A.F. (1977) Multivariate Observations, Wiley.
2. Giri, N., Multivariate Statistical Inference, Academic Publishers.
3. Morrison, D.F. (1976) Multivariate Statistical Methods, John Wiley.
4. Rao, C.R. (1973) Linear Statistical Inference and the Application, Wiley.
5. Rancher, A.C. (1995) Methods of Multivariate Analysis, John Wiley.
6. Johnson, R.A. and Wichern, D.W. (1990) Applied Multivariate Statistical Analysis, Prentice Hall.

STA 2303: APPLIED REGRESSION ANALYSIS

1. Linear Regression Model, Least squares estimation, Gauss Markov Theorem, Properties of the estimates, Distribution Theory, Maximum likelihood estimation, Estimation with linear restrictions, Generalised least squares; Hypothesis testing - likelihood ratio test, F-test; Confidence intervals.

2. Residual analysis, Departures from underlying assumptions, Effect of outliers, Collinearity, Non-constant variance and serial correlation, Departures from normality, Diagnostics and remedies.

3. Polynomial regression in one and several variables, Orthogonal polynomials, Indicator variables, Subset selection of explanatory variables, stepwise regression and Mallows C_p -statistics, Introduction to non-parametric regression.

4. Introduction to nonlinear regression, Least squares in the nonlinear case and estimation of parameters, Models for binary response variables, estimation and diagnosis methods for logistic and Poisson regressions. Prediction and residual analysis, Generalized Linear Models – estimation and diagnostics.

Text Books:

1. Seber, A.F. and Lee, A.J. (2003) Linear Regression Analysis, John Wiley, Relevant sections from chapters 3, 4, 5, 6, 7, 9, 10.
2. Montegomery, D.C., Peck, E.A. and Vining, G.G. (2001) Introduction to Regression Analysis, Third edition. Wiley.
3. B.Abraham and Ledotter, J. (1983) Statistical Methods for Forecasting, John Wiley & Sons.

Reference Books:

1. Searle, S.R. (1971) Linear models, John Wiley & Sons, Inc.
2. N.Draper and H. Smith (1986) Applied Regression Analysis – John Wiley & Sons.
3. Fox, J. (1984) Linear Statistical Models and Related methods, John Wiley, Chapter 5.
4. Christensen, R. (2001) Advanced Linear Modeling, Chapter 7.

STA 2304: PRACTICAL - II USING SPSS/MATLAB

Based on topics covered in STA 2301, STA 2302, STA 2303 and STA 2305.

STA 2305 ELECTIVE - III

STA 2401: DESIGN AND ANALYSIS OF EXPERIMENTS

1. Randomization, Replication and local control, One way and two way classifications with equal and unequal number of observations per cell with and without interaction, Fixed effects and Random effects model. Model adequacy checking, CRD, RBD and Latin Square designs, Analysis of co-variance for completely randomized and randomized block designs. Analysis of experiments with missing observations.

2. Incomplete Block Designs: Balanced Incomplete Block designs, Construction of BIB Designs, Analysis with recovery of inter-block information and intra-block information. Partially balanced incomplete block designs, Analysis of partially balanced incomplete block designs with two associate classes, Lattice designs.

3. 2^n Factorial experiments. Analysis of 2^n factorial experiments. Total confounding of 2^n designs in 2^P blocks. Partial confounding in 2^P blocks. Fractional factorial designs, Resolution of a design, 3^n factorial designs. Split plot desgin and strip plot design(out line only).

4. Response surface designs - orthogonality, rotatability blocking and analysis - Method of Steepest accent, Models properties and Analysis.

Text Books:

1. Montgomery, D.C. (2001)) Design and Analysis of Experiments, John Wiley.
2. Das M N and Giri N.C. (1979) Design and Analysis of Experiments, second edition, Wiley.
3. Hinkleman and Kempthrone, C. (1994) Design and Analysis of Experiments Volume I, John Wiley.

Reference Books:

1. Joshi D.D. (1987) Linear Estimation and Design of Experiments, Wiley Eastern.
2. Chakrabarti, M.C. (1964) Design of experiments, ISI, Calcutta.

STA 2402: STATISTICAL QUALITY ASSURANCE

1. Quality and quality assurance, Methods of quality assurance, Introduction to TQM and ISO 9000 standards, statistical quality control: Acceptance sampling for attributes, Single sampling, Double sampling, Multiple and sequential sampling plans, Measuring the performance of these plans.

2. Control charts, Basic ideas, designing of control charts for the number of non-conformities and fraction non-conformities, mean charts, Median charts, Extreme value charts, R-charts, and S-charts, ARL, Economic design of Shewarts control charts.

3. Acceptance sampling by variables, Sampling plans for a single specification limit with known and unknown variance, Sampling plans with double specification limits, Comparison of sampling plans by variable and attributes, Continuous sampling plans I, II and III.

4. Process capability studies, Statistical aspect of six sigma philosophy, Control charts with memory - CUSUM charts, EWMA-mean charts, OC and ARL for control charts, The Taguchi Method: The Taguchi philosophy of Quality, Loss functions, SN ratios, Performance measures, Experimental design in Taguchi Methods: Orthogonal arrays and linear graph, Estimation of effects, Parameter Design.

Text Books:

1. Montgomery, R.C. (1985). Introduction to Statistical Quality Control, Fourth edition, Wiley.
2. Mittag, H.J. & Rinne, H. (1993) Statistical Methods for Quality Assurance, Chapman & Hall, Chapters 1, 3 and 4.
3. The ISO 9000 book, Second Edition, Rabbit, J T and Bergle, PA Quality resources, Chapter-I
4. Schilling, E.G. (1982) Acceptance Sampling in Quality Control, Marcel Dekker.
5. Amitava Mitra - Fundamentals of Quality Control and Improvement – Pearson Education Asia 2001 – Chapter 12 (relevant parts)

Reference Books:

1. Duncan, A.J. (1986) Quality control and Industrial Statistics.
2. Grant E.L. and Leaven Worth, R.S. (1980) Statistical Quality Control, McGraw Hill.
3. Chin-Knei Cho (1987) Quality Programming, John Wiley.

STA 2403: PRACTICALS - III USING SAS/R AND VIVA-VOCE

Practicals should be based on topics covered in STA 2401, STA 2402, and two electives chosen.

LIST OF ELECTIVES

1. ACTUARIAL STATISTICS

1. Insurance Business – Introduction, Insurance Companies as Business Organizations, Concept of Risk; Future Lifetime Distribution and Life Tables – Future Lifetime Random Variable, Curtate Future Lifetime, Life Tables, Assumptions for Fractional Ages, Select and Ultimate Life Tables.

2. Actuarial Present Values or Benefit in Life Insurance Products – Compound Interest and Discount Factor, Benefit Payable at the Moment of Death, Benefit Payable at the End of Year of Death, Relation between A and $\bar{A}$.

3. Annuities – Annuities Certain, Continuous Life Annuities, Discrete Life Annuities, Life Annuities with *m*thly Payments; Premiums – Loss at Issue Random Variable, Fully Continuous Premiums, Fully Discrete Premiums, True *m*thly Payment Premiums, Gross Premiums.

4. Reserves – Fully Continuous Reserves, Fully Discrete Reserves; Multiple Life Contracts – Joint Life Status, Last Survivor Status.

Text Books:

1. Deshmukh, S.R. (2009) Actuarial Statistics – An Introduction using R, University Press (India) Pvt Ltd., Hyderabad, Chapters 1, 4, 5, 6, 7, 8 and 9.

Reference Books:

1. Promislow, S.D (2006) Fundamentals of Actuarial Mathematics, John Wiley, Chapters 2-11 & 14.
2. Neill, A. (1977) Life Contingencies, Heinemann, London.
3. Newton L.Bowers, Jr, Hans U.Gerber, James C.Hickman, Donald A. Jones and Cecil J. Nesbitt (1997) Actuarial Mathematics, The Society of Actuaries.
4. King, G. Institute of Actuaries Text Book. Part 11, Second edition, Charles and Edwin Layton, London.
5. Donald D.W.A. (1970) Compound Interest and Annuities, Heinemann, London.
6. Jordan, C.W. Jr. (1967) Life Contingencies, Second edition, Chicago Society of Actuaries.
7. Hooker, P.F. and Longley Cook, L.W. (1953) Life and Other Contingencies, Volume I and Volume II (1957) Cambridge University Press.
8. Spurgeen, E.T. Life Contingencies, Third edition, Cambridge University Press.
9. Benjamin, B. and Pollard, J.H. (1980) Analysis of Mortality and Other Actuarial Statistics, 2nd edition, Heinemann, London.
10. Freeman, H. (1960) Finite Differences for Actuarial Students, Cambridge University Press.
11. Biandt-Johnson, R.C. and Johnson, N.L. (1980) Survival Models and Data Analysis, John Wiley.

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2. ADVANCED DISTRIBUTION THEORY

1. Stopped sum distributions: Poisson stopped sum, Neyman type A, Poission-binomial, Poisson-negative binomial, Legrangian Poisson distributions, Distributions of order Poisson, negative binomial, Logarithmic series, Binomial.

2. Bivariate discrete distributions: bivariate power series distributions, bivariate Poisson, negative binomial and logarithmic series distributions, properties of these distributions, bivariate hypergeometric distribution and its properties.

3. Bivariate continuous models, bivariate Pearson system, Farlie Morgenstern distribution; distributions with specified conditionals, bivariate Pareto of I, II, III and IV kind, multivariate Liouville distributions.

4. Record values - definition, properties, distribution of *n*th record, record values from exponential, Weibull and logistic; Moments relationships, characterizations.

Reference Books:

1. Johnson, N.L., Kotz, S. and Kemp, A.W. (1992) Univariate discrete distributions, second edition, Wiley.
2. Kocherlakota, S. and Kocharlakota, K. (1992) Bivariate Discrete Distributions, Marcel-Dekker.
3. Johnson, N.L., Kotz, S. and Balakrishnan, N. (1997) Discrete multivariate distributions, second edition, Wiley.
4. Kotz, S. , Balakrishnan, N. and Johnson, N.L. (2000) Continuous multivariate distributions, Volume I, John Wiley and Sons.
5. Arnold, B.C., Balakrishnan, N. and Nagaraja, H.N. (1998) Records, John Wiley and Sons.

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3. ADVANCED PROBABILITY THEORY

1. Review of Elementary Probability theory, Basic properties of expectations, Sequences of integrals, Lebesgue-Stieltjes integrals, Weak convergence - Theorems.

2. Complete convergence: Kolmogorov's three-series and two series theorems, Decomposition of normal distribution, Levy metric, Zolotarev and Lindeberg-Feller Theorems; Berry-Esseen Theorem.

3. More on Infinitely divisible distributions, Convergence under UAN, Convergence to special distributions, Cauchy functional equation, Stable distributions.

4. Conditional expectations (general case), Random-Nikodyn theorem, Martingales, Doob's decomposition, L^P-spaces Martingales, Martingale limit theorems, Exchangeability, Definite's theorem.

Text Books:

1. Galambos J (1988) Advanced Probability Theory, Marcel Dekker, New York.

Reference Books:

1. Ash R. B (2000) Probability and Measure Theory, Second edition. Academic Press.
2. Billingsley P (1985) Probability and Measure, Second edition, John Wiley and Sons, NewYork.
3. Laha R.G. and Rohatgi, V.K. (1979) Probability Theory, John Wiley and Sons, NewYork.

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4. ADVANCED STOCHASTIC PROCESSES

1. Point Process: Preliminary ideas and definitions, product densities and characteristic functional, stationary point processes, renewal processes, doubly stochastic processes.

2. Stationary processes: Definitions and examples, mean square distance, mean square error prediction, properties of covariance function, orthogonal processes, Ergodic theorems.

3. Brownian motion processes.

4. Inference for Markov processes: Estimation of parameters and testing of hypothesis for Markov claims. Birth and death process. Galton-Watson branching process.

Text Books:

1. Karlin, S and Taylor, H. M. (1975) A First Course in Stochastic Processes, Academic Press, Relevant Sections from Chapter 6 & 9.
2. Karlin, S. and Taylor, H. M. (1981) A Second Course in Stochastic Processes, Academic Press, Relevant Sections from Chapter 18.
3. Basawa, I.V, and Prakasa Rao, B.L.S. (1980) Statistical Inference for Stochastic Processes, Academic Press.
4. Deley, D. (1988) An Introduction to the Theory of Point Processes, Springer Verlag.

Reference Books:

1. Ross, S.M. (1989) Stochastic Processes, John Wiley
2. Saaty, P.A.P. (1961) Elements of Queuing Theory and Applications, Mcgraw Hill
3. Gross, D. and Haris, C.M. (1974) Fundamentals of Queuing theory, John Wiley.
4. Bhat, U.N. (1984) Elements of Applied Stochastic Processes, John Wiley.
5. Prabhu, N.U. (1984) Introduction to Stochastic Processes, Mac Millan
6. Cinlar, E. (1984) Introduction to Stochastic Processes, Prentice Hall
7. Parzen, E. (1972) Stochastic Processes, Holden – Day.

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5. APPLIED MULTIVARIATE STATISTICAL ANALYSIS

1. Principal components Analysis:- population principal components, summarizing sample variation by principal components, graphing the principal components, large sample inference, monitoring quality with principal components; Canonical correlation analysis:- canonical variates and canonical correlations, interpreting the population canonical variables, the sample canonical variates and sample canonical correlations,

2. Factor analysis:- orthogonal factor model; methods of estimation, factor rotation, factor scores, perspectives and a strategy for factor analysis.

3. Cluster analysis:- similarity measures, hierarchical clustering methods, non hierarchical clustering methods; Distance methods:- multidimensional scaling, correspondence analysis.

4. Comparison of several multivariate population means (one-way MANOVA), simultaneous confidence intervals for treatment effects, profile analysis, two-way multivariate analysis of variance; Multivariate multiple regression, path analysis.

Text Books:

1. Johnson, R.A. and Wichern, D.W. (1990) Applied Multivariate Statistical Analysis, Pearson education, Relevant sections from Chapters 6, 8, 9, 10 & 12.
2. Dillon, W.R. and Goldstein, M (1984) Multivariate Analysis, John Wiley, Relevant sections from Chapter 12.

Reference Books:

1. Seber G.A.F. (1983) Multivariate Observations, Wiley.
2. Tabachnick, B.G. and Fidell, L.S. (1996) Using multivariate statistics, Third edition, Harper Collins College Publishers.
3. Gnandesikan, R., Methods of Statistical Data Analysis of Multivariate Observations, Wiley.
4. Jambu, M and Lebeaux M.O., Cluster Analysis and Data Analysis.
5. Lebart, Lmorinean, A. and Warwick K.M., Multivariate Descriptive Statistical Analysis, John Wiley.
6. Davison, Multidimensional Scaling, John Wiley.
7. Morrison D.F., Multivariate Statistical Methods, McGraw Hill.
8. Rencher, A.C. (1995) Methods of Multivariate Analysis, John Wiley.

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6. APPLIED STATISTICS FOR NATIONAL DEVELOPMENT

1. Demographic methods:- Sources of demographic data - census, register, adhoc survey, hospital records, demographic profiles of Indian census; Measurement of mortality and life tables - crude, death rates, infant mortality rates, death date by cause, standardized death rate; Complete life tables – its main features, mortality rate and probability of dying, use of survival tables; Measurement of fertility - crude birth rate, general fertility rate, total fertility rate, gross reproduction rate, net reproduction rate; Population growth in developing and developed countries; Population projection using Leslie metric; Labour force projection.

2. Economic statistics:- Index number - its definition, price relatives and quantity or volume relatives, link and chain relatives, consumer price index; Demand analysis - static laws of demand and supply, price elasticity of demand, analysis of income and allied size distribution - Pareto distribution, graphical test, fitting of Pareto's law, log normal distribution and its properties, Lorenz curve and estimation of elasticity; Gini coefficient.

3. Economic development, growth in per capita income and distributive justice, indices of development; Human Development Index, Estimation of national income - product approach, income approach and expenditure approach; Measuring inequality in incomes, poverty measurement - measures of incidence and intensity combined; Time Series:-components of time series, determination of trend, analysis of seasonal fluctuations, construction of seasonal indices, measurement of cyclic movement, random component in time series, smoothing methods,

4. Introduction to Indian and International Statistical System - role, function activities of Central and State Statistical Organizations; Organization of large scale sample surveys; Role of National sample survey organization; General and special data dissemination systems; Principal publications containing such statistics on the topics - population, agriculture industry, trade, price, labour and employment transport and communications, and finance; Educational and Psychological statistics:- Scaling individual test items, scaling of scores on a test, different types of scores and scaling, scaling of ranking and rating in terms of normal curve, Reliability of test scores, Rulon and Kuder Richardson methods, Reliability of a test, validity, comparison between reliability and validity, Intelligence coefficient.

Reference Books:

1. Basic Statistics Relating to Indian Economy (CSO), 1990 - Current Indian Statistics
2. Cox PR (1957) Demography, Cambridge University Press
3. Croxton F E and Crowder D J (1967) Applied General statistics, Prentice - Hall India.
4. Guide to current Indian Official Statistics CSO, Govt. of India, New Delhi
5. Guide to official Statistics (CSO) -1990
6. Kendall, M.G. and Stuart, A. (1966). The Advanced Theory of Statistics, Charles Griffin
7. Keyfitz, N. (1977) Applied Mathematical Demography - Springer Verlag
8. Mukhopadhyay, P Applied Statistics, Books and Allied (P) Ltd
9. Pollard, A H, Yusuf , F and Pollard, G.N. (1998) Demographic Techniques

10. Saluja M.P, Indian Official Statistical Systems, Statistics Publishing Society, Calcutta
11. Sen, A. (1997) : Poverty and inequality
12. Statistical System in Indian (CSO) 1995
13. UNESCO : Principles for Vital Statistics system, Series M-12

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7. COMPLEX ANALYSIS AND INTEGRAL TRANSFORMS

1. Complex numbers:- definition, algebraic properties, Analytic function:- functions of a complex variable, limits, continuity, Cauchy-Riemann equations, sufficient conditions, analytic functions, harmonic functions, Integrals:- contours, contour integrals, Cauchy-Goursat theorem (without proof), Cauchy integral formula, derivatives of analytic functions.

2. Series:- convergence of sequence and series, Taylor series, Laurent series, absolute and uniform convergence of power series, Residues and poles:- residues, residue theorem, residues and poles, zeroes and poles of order m, evaluation of improper integrals, improper integrals involving Sines and Cosines.

3. Laplace Transform:- definition, properties, Laplace transforms of derivatives, Laplace transforms of integrals, Inverse Laplace transform, properties, inverse Laplace transforms of derivatives, inverse Laplace transforms of integrals, convolution of two functions, Applications of Laplace transforms.

4. Other Transforms:- Fourier transforms, Fourier sine and consine transforms, relationship of Fourier and Laplace transforms, properties, convolution, Hankel transforms, properties, some useful results for Bessel functions, Mellin transform, properties, inverse Mellin transform, properties.

Text Books:

1. Churchill, R.V. and Brown, J.W. ((1990) Complex variables and applications, Fifth edition, McGraw-Hill Publishing Company, New Delhi, Chapters 1, 2, 4, 5 & 6.
2. Raisinghania, M.D. (1995) Integral transforms, Second edition, S.Chand & Company Ltd., New Delhi, Chapters 1-4, 6 & 7.

Reference Books:

1. Spiegel, M.R. (1981) Theory and problems of Complex Variables, Schaum's outline series, McGraw-Hill Book Company, Singapore.
2. Raisinghania, M.D. (1995) Laplace and Fourier Transforms, First edition, S.Chand & Company Ltd., New Delhi.

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8. DEMOGRAPHIC TECHNIQUES

1. Sources of demographic Statistics, Basic demographic measures: Ratios, Proportions and percentages, Population Pyramids, Sex ratio Crude rates, Specific rates, Labour force participation rates, Density of population, Probability of dying.

2. Life tables: Construction of a life table, Graphs of l_x, q_x, d_x, Functions L_x, T_x and E_x. Abridged life tables Mortality: Rates and Ratios, Infant mortality, Maternal mortality, Expected number of deaths, Direct and Indirect Standardization, Compound analysis, Morbidity.

3. Fertility: Measures of Fertility, Reproductivity formulae, Rates of natural increase, Fertility Schedules, Differential fertility, Stable populations, Calculation of the age distribution of a stable population, Model Stable Populations.

4. Population estimates, Population Projections: Component method, Mortality basis for projections, Fertility basis for projections, Migration basis for projections, Ageing of the population, Estimation of demographic measures from incomplete data.

Text Books:

1. Pollard, A.H. Yusuf, F. and Pollard, G.N. (1990). Demographic Techniques, Pergamon Press, Chapters 1-8, 12.

Reference Books:

1. Keyfitz, N. (1977) Applied Mathematical Demography A Wiley-Interscience Publication.
2. Keyfilz, N. (1968) Introduction to the Mathematic of Population Ready, Mass: Addition-Wesley.
3. Keyfilz, N. and Caswell, H. (2005) Applied Mathematical Demography, Third edition, Springer.

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9. DIRECTIONAL DATA ANALYSIS

1. Graphical representation of data, Frequency distribution, Measures of location, circular variance and concentration, Correction for mean grouping, Measures of skewness and kurtosis.

2. Circular models, distribution theory, independence, convolution, moments, distributions of an arc, mixtures, lattice distributions, wrapped normal, Cauchy, Poisson distributions, Von Mises, Fisher distribution characteristic functions, Polar distributions, isotropic random walk on the circle.

3. Point estimation, Cramer Rao type bound, sufficiency, Methods of estimation, testing hypothesis from parametric models. Neyman-Pearson and likelihood ratio principles.

4. Non-parametric methods: Tests for randomness, goodness of fit, Rayleigh's test. Durand and Greenwood's test, Range test, Kuper's test, Watson's test, Uniform score tests, Runs test, Rank sum test, Tests for dispersion.

Text Books:

1. Mardia, K.V. (1972) Statistics of Directional data, Academic Press.
2. Batschelet, E. (1981) Circular Statistics in Biology, Academic Press.
3. Watson, G.S (1983) Statistics on Spheres, Wiley.

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10. INFERENCE FOR STOCHASTIC PROCESSES

1. Brief review of basic principles of methods of statistical inference, Inference for the Galton-Watson process, The Markov branching process, Estimation and prediction in Auto regressive process.

2. Inference in discrete Markov chains: Maximum likelihood estimation, Asymptotic properties of estimators, Asymptotic distribution of serial correlation, Tests of hypothesis tests of independence based on serial correlation Bayesian analysis, Inference for an absorbing chain Inverse likelihood estimation of states, Macro model, grouped Markov chains, Estimation in countable state-space Markov chain.
3. Inference in continuous time Markov chains: Inference in finite Markov chains, queueing models, pure birth and death process, Homogeneous and non-homogeneous Poisson processes, Inference for renewal process in relation to reliability applications.

4. Large sample theory for discrete parameter stochastic process, Estimation, Consistency, Asymptotic normality, Efficiency, Robustness, Maximum likelihood estimation for some optimal asymptotic tests.

Text Books:

1. Basava, I.V. and Prakasa Rao, B.L.S. (1980) Statistical Inference for Stochastic Processes Academic Press Chapters 1-7.

Reference Books:

1. Billingsley, P. (1961) Statistical Inference for Markov Processes, University of Chicago Press.
2. Chung K.L. (1967) Markov Chain with Stationary Transition Probabilities 2nd edition, Springer-Varlag
3. Karr, A.R. (1991) Point Processes and Their Statistical Inference, Marcel Dickker
4. Keiding, N. (1974) Estimation in the Birth Process, Biometrika, 61, 71-80.
5. Keiding, N.(1975) Maximum Likelihood Estimation in the Birth and Death Process, Annals of Statistics, 3, 363-372.

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11. OPERATIONS RESEARCH

1. Linear programming:- convex sets and associated theorems, graphical method, definition of linear programming problem, properties of a solution to the linear programming problem, generating extreme-point solutions, simplex computational procedure, artificial variables technique - big M method, two phase method; Revised simplex method; Duality problems of linear programming:- unsymmetric primal-dual problems, symmetric primal-dual problems, Degeneracy and anticycling procedures:- perturbation techniques.

2. Transportation problems:- general transportation problem, Finding initial basic feasible solution, test for optimality, degeneracy in transportation problem, unbalanced transportation problem, maximization transportation problem, Assignment problem:- mathematical formulation of the problem, the assignment method (Hungarian method), Non-linear programming problem (NLPP):- general non-linear programming problem, Constrained optimization with equality constraints - necessary conditions for a generalized NLPP, sufficient conditions for a general NLPP with one constraint, sufficient conditions for a general problem with $m(<n)$ constraints, Constrained optimization with inequality constraints - Kuhn-Tucker conditions for general NLPP with $m(<n)$ constraints.

3. Inventory models:- Deterministic inventory models - general inventory model, Static economic-order quantity (EOQ) models - classic EOQ model, EOQ with price breaks, multi-item EOQ with storage limitation, Probabilistic inventory models:- Continuous review models - "probabilitized" EOQ model, probabilistic EOQ model, Single-period models - No setup model (Newsvendor model), setup model (s-S policy).

4. Queuing systems:- elements of a queuing model, roles of exponential distribution, pure birth and death models (relationship between the exponential and Poisson distributions) - pure birth model, pure death model, generalized Poisson queuing model, Specialized Poisson queues - steady-state measures of performance, Single server models-(M/M/1):(GD/∞/,∞), waiting time distribution for (M/M/1):(FCFS/∞/,∞), (M/M/1):(GD/N/,∞), Multiple-server models-(M/M/c):(GD/∞/,∞), (M/M/c):(GD/N/,∞), (M/M/∞):(GD/∞/,∞)-self service models, machine servicing model.

Text Books:

1. Gass S.I. (1985) Linear Programming - methods and applications, Fifth edition, Mc Graw Hill, USA, Chapters 2-7.
2. Kanti Swarup, Gupta, P.K. and Man Mohan (2001) Operations Research, Ninth edition, Sultan Chand & Sons, Chapters 3, 4, 10, 11 & 24.
3. Taha H.A. (2007) Operations Research - An introduction, Eighth edition, Prentice-Hall of India Ltd., Chapters 11, 14 & 15.

Reference Books:

1. Ravindran A, Philips D.T and Soleberg J.J. (1997) Operation Research - Principles and Practice, John Wiley & Sons.
2. Sinha, S.M. (2006) Mathematical programming theory and methods, Elsevier, a division of Reed Elsevier India Pvt. Ltd., New Delhi.
3. Paneerselvam, R. (2008) Operations Research, Second edition, Prentice Hall of India Pvt. Ltd., New Delhi.

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12. RELIABILITY MODELING AND ANALYSIS

1. Basic concepts in reliability: Failure rate, mean, variance and percentile residual life, identities connecting them; Notions of ageing - IFR, IFRA, NBU, NBUE, DMRL, HNBUE, NBUC etc and their mutual implications; TTT transforms and characterization of ageing classes.

2. Non monotonic failure rates and mean residual life functions, Study of life time models viz. exponential, Weibull, lognormal, generalized Pareto, gamma with reference to basic concepts and ageing characteristics; Bath tub and upside down bath tub failure rate distributions.

3. Discrete time failure models:- Definition of basic functions and their properties; Ageing classes and their mutual implications, Reliability systems with dependents components:-Parallel and series systems, k out of n systems, ageing properties with dependent and independents components, concepts and measures of dependence in reliability - RCSI, LCSD, PF_2, WPQD.

4. Reliability estimation using MLE - exponential, Weibull and gamma distributions based on censored and non censored samples; UMVUE estimation of reliability function; Bayesian reliability estimation of exponential and Weibull models.

Text Books:

1. Lai, C.D and Xie, M. (2006) Stochastic ageing and dependence in reliability (Relevant topics) Springer.
2. Sinha S K (1986) Reliability and Life Testing, Wiley Eastern.

Reference Books:

1. Barlow, R.E. and Proschan, F. (1975) Statisical Theory of Reliability and Life Testing, Holt, Reinhart and Winston.
2. Marshall, A.W. and Olkin, I. (2007) Life Distributions, Springer
3. Galambos, J. and Kotz, S. (1978) Characterization of Probability distributions, Springer
4. Lawless, J.F. (2003) Statistical Models and Methods for Life Data, Wiley.

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13. STATISTICAL COMPUTING

1. Computer programming in C:- simple computer programs, numeric constants and variables, arithmetic expressions, input and output in C programs, conditional statements, implementing loops in programs, defining and manipulating arrays, logical expressions and more control statements.

2. Functions, processing character strings, enumerated data types and stacks, structure, pointer data type and its applications, recursion, files in C.

3. Random variable generation:- uniform simulation, General techniques for simulating continuous random variables - inverse transformation method, rejection method, hazard rate method, Special techniques for simulating continuous random variables - Normal distribution, gamma distribution, beta distribution, Simulating from discrete distributions - alias methods.

4. Solution of algebraic and transcendental equations:- bisection method, iteration method, method of false position, Newton-Raphson method, solution of systems of nonlinear equation - method of iteration, Newton-Raphson method, Solution of linear systems:- matrix inverse method, Gaussian elimination method - Gauss method, Gauss-Jordan method, modification of the Gauss method to compute the inverse, method of factorization.

Text Books:

1. Rajaraman, V. (1994) Computer programming in C, Prentice Hall of India, New Delhi, Chapters - 4-11, 13-17, 19 & 21.
2. Sheldon M. Ross (2003) Introduction to probability models, Eighth edition, Academic press, Chapter 11.
3. Sastry, S.S. (1998) Introductory methods of numerical analysis, Third edition, Prentice Hall, New Delhi, Chapters - 2 & 6.

Reference Books:

1. Gotifried, B.S. (1996) Programming with C, Schaum's Series, Tata McGraw Hill.
2. Mullishi Hank, Cooper, H.L. (1992) The spirit of C - An introduction to modern programming, Jaico Publishing House.
3. Kundu, D. and Basu, A. (2004) Statistical computing – existing methods and recent developments, Narosa publishing house, New Delhi.
4. Monahan, J.F. (2001) Numerical methods of statistics, Cambridge University Press.
5. Aitkinson, K.E. (1989) An introduction to numerical analysis, John Wiley & Sons, Singapore.
6. Jain, M.K., Iyengar, S.R.K. and Jain, R.K. (1985) Numerical methods for scientific and engineering computation, Wiley Eastern Ltd., New Delhi.

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14. STATISTICAL DECISION THEORY

1. Basic elements of a decision problem, Randomized and non-randomized decision rules, Estimation and testing of hypothesis as decision problems, Bayes approach to inference and decision, Loss functions, Prior and posterior distributions, Prior - Posterior analysis for Bernoulli, Poisson and normal processes, Decision principles and Baye's risk.

2. Utility theory, axioms, construction of utility functions, sufficiency, equivalence of Classical and Bayesian sufficiency, complete and essentially complete classes of decision rules.

3. Minimax analysis, Basic elements of game theory, General techniques of solving games, Finite games, Supporting and separating hyperplane theorems, Minimax theorem, Minimax estimation for normal and Poisson means.

4. Admissibility of Bayes and minimax rules, General theorems on admissibility, Robustness of Bayes rules, Invariant decision rules, Location parameter problems, Confidence and credible sets.

Text Books:

1. James O. Berger (1980) Statistical Decision Theory and Bayesian Analysis, Springer Verlag
2. M.H. DeGroot (1970) Optimal Statistical Decisions, John Wiley
3. H. Raiffa and R. Schlaifer (2000) Applied Statistical Decision Theory, Wiley Classics

Reference Books:

1. Zellener (1971) An Introduction to Bayesian inference in Econometrics, Wiley
2. Hayes J, G and Winkler R I (1976) Probability, Statistics and Decision, Dower
3. Anthony O' Hagan (1994) Kendall's Advanced theory of Statistics vol. 2B, Bayesian Inference John Wiley.

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15. STATISTICAL FORECASTING

1. The regression model and its applications in Forecasting: Regression models, Estimation, Testing and prediction in linear regression models, Model selection Techniques, Multicollenearity, indicator variables, General principle of Statistical Model building, Serial correlation among the variable. Weighted least squares.

2. Forecasting in constant mean model, Locally constant mean model and simple exponential smoothing - Regression models with time as independent variable Discounted least squares and general exponential smoothing. Locally constant linear trend model and double exponential smoothing, Triple exponential smoothing, Prediction intervals.

3. Seasonal time series, Globaly and locally seasonal models. Winters' seasonal forecast procedures, Seasonal adjustments.

4. Stochastic time series models: Stochastic difference equation models, Autoregressive and moving average models and their properties, Non-Stationary models, ARIMA models and Forecasting.

Text Books:

1. Abraham B and Ledolter, J (1983) Statistical Methods for Forecasting, John Wiley and Sons, New York.

Reference Books:

1. Pankratz, A. (1983) Forecasting with univariate Box-Jenkins models, John Wiley Sons, New York
2. Makridakis, S. and Wheelwright, S.C. Forecasting Methods and Applications, John Wiley and Sons
3. Box, G. E. P. and Jenkins, G. M. (1976) Time Series Analysis: Forecasting and Control, Holden day.
4. Brockwell, P.J. and Davis, R.A. (2002) Introduction to Time Series and Forecasting, second edition, Springer

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16. STATISTICAL GENETICS

1. Introduction, Mendel's Laws, Linkage and Crossing cover, Linkage Maps, Statistical Analysis for Segregation and Linkage: Single Factor Segregation, Two factor segregation, Defection of Linkage, Estimation of Linkage.

2. Random mating: Hardy-Weinberg law of equilibrium. Single Locus, Sex-linked genes, Autopraploids, Forces affecting gene frequency, Fisher's fundamental theorem, inbreeding: Mutation and migration different approaches, concepts and definition, Path Coefficients, Stochastic Process of gene-frequency change, Diffusion approach, Transition matrix approach.

3. Genetic components of variance: Relationship between phenotype and genotype, Different approaches, Genetic components of covariance between Track; Linkage effects, Sex-linked genes, Maternal effect, Epistatic interaction, Genotype X Environment interaction.

4. Heritability, Estimation of Heritability, Precision of Heritability estimates, Repeatability, Estimates of Genetic correlation, Generalized Heritability Relation between phenotypic selection and genotypic selection, Intensity of selection correlated, Response to selection. Selection for improving several characters.

Text Books:

1. Narain, P. (1990). Statistical Genetics, Wiley, Chapters 1-5, 7, 8, 9, 10, 14.

Reference Books:

1. Liu, B.H. (1998). Statistical Genomics, CRC Press, New York.
2. Falconer, D.S. (1970). Introduction to Genetics, Oliver & Boyd.

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17. STOCHASTIC FINANCE

1. Basic concepts of financial markets. Forward contracts, futures contracts, options-call and put options, European option and American options. Hedgers, speculators, arbitrageurs. Interest rates, compounding, present value analysis, risk free interest rates. Returns, gross returns and log returns. Portfolio theory – trading off expected return and risk, one risky asset and one risk free asset. Two risky assets, estimated expected return. Optimal mix of portfolio CAPM, capital market line, betas and security market line.

2. Options, pricing via arbitrage, law of one price. Risk neutral valuation. Binomial model- single and multiperiod binomial model, martingale measure. Modeling returns: lognormal model, random walk model, geometric Brownian motion process. Ito lemma (without proof). Arbitrage theorem. The Black-Scholes formula. Properties of the Black-Scholes option cost, the delta hedging arbitrage strategy. Some derivatives, their interpretations and applications.

3. Volatility and estimating the volatility parameter. Implied volatility. Pricing American options. Pricing of a European option using Monte-Carlo and pricing an American option using finite difference methods. Call options on dividend-paying securities. Pricing American put options, Modeling the prices by adding jumps to geometric Brownian motion. Valuing investments by expected utility. Modeling security market: Self-financing portfolio and no arbitrage, price process models, division rule, product rule

4. Financial Time Series – Special features of financial series, Linear time series models: AR(1), AR(p), ARMA(p,q) processes, the first and second order moments, estimation and forecasting methods. Models for Conditional heteroscedasticity: ARCH(1), ARCH(p), GARCH(p,q) models and their estimation. Comparison of ARMA and GARCH processes.

Reference Books:

1. Sheldon M. Ross (2003): "An elementary introduction to Mathematical Finance", Cambridge University Press.
2. David Ruppert (2004) "Statistics and Finance an Introduction" – Springer International Eddition.
3. Masaaki Kijima (2003) "Stochastic process with applications to finance", Chapman Hall.
4. Ruey S. Tsay (2005) "Analysis of Time Series III ed", John Wiley & Sons
5. John C. Hull (2008) "Options, Futures and other derivatives", Pearson Education India.

6. Christian Gourieroux and Joann Jasiak (2005): "Financial Econometrics", New Age International (P) Ltd.
7. Cuthbertson K and Nitzsche D (2001): "Financial Engineering - Derivatives and Risk Management", John Wiley & Sons Ltd.

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18. SURVIVAL ANALYSIS

1. Basic Quantities and Models - Survival function, Hazard function, Mean residual life function and Median life, Common Parametric Models for Survival Data; Censoring and Truncation - Right Censoring, Left or Interval Censoring, Truncation, Likelihood Construction for Censored and Truncated Data, Counting Processes.

2. Nonparametric Estimation of Basic Quantities for Right Censored and Left Censored Data - Estimators of the Survival and Cumulative Hazard Functions for Right Censored Data, Pointwise Confidence Intervals and Confidence Bands for the Survival Function (without derivation), Point and Interval Estimates of the Mean and Median Survival Time, Estimators of the Survival Function for Left-Truncated and Right-Truncated Data; Estimation of the Survival Function for Left, Double and Interval Censoring, Right-Truncated Data and in the Cohort Life Table, Estimating the Hazard Function, Excess Mortality; Hypothesis Testing - One-Sample Tests, Tests for Two or More Samples, Test for Trend, Renyi Type Tests.

3. Semiparametric Proportional Hazards Regression with Fixed Covariates - Coding Covariates, Partial Likelihoods for Distinct-Event Time Data, Partial Likelihoods when Ties are present, Local Tests, Discretizing a Continuous Covariate, Model Building using the Proportional Hazards Model, Estimation for the Survival Function; Introduction to Time-Dependent Covariates; Regression Diagnostics - Cox-Snell Residuals for assessing the fit of a Cox Model, Graphical Checks of the Proportional Hazards Assumption, Deviance Residuals, Checking the Influence of Individual Observations.

4. Inference for Parametric Regression Models - Exponential, Weibull and Log Logistics; Multiple Modes of Failure – Basic Characteristics and Model Specification, Likelihood Function Formulation, Nonparametric Methods.

Text Books:

1. Klein J.P. and Moeschberger M.L. (2003) Survival Analysis - Techniques for censored and truncated data, Second Edition, Springer-Verlag , New York, Chapters 2, 3, 4, 5, 6, 7, 8, 9, 11 and 12.
2. Lawless J.F (2003) Statistical Models and Methods for Lifetime Data, Second Editon, John Wiley & Sons, Relevant Sections of the Chapters 9.

Reference Books:

1. Kalbfleisch J.D and Prentice, R.L. (2002) The Statistical Analysis of Failure Time Data, Second Edition, John Wiley & Sons Inc.

2. Hosmer Jr. D.W and Lemeshow S (1999) Applied Survival Analysis - Regression Modelling of Time to event Data, John Wiley & Sons. Inc.
3. Nelson. W (1982) Applied Life Data Analysis.
4. Miller, R.G. (1981) Survival Analysis, John Wiley.

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19. TIME SERIES ANALYSIS

1. Time series as a discrete parameter stochastic process, Auto - Covariance, Auto-correlation and their properties. Exploratory time series analysis, Test for trend and seasonality, Exponential and moving average smoothing, Holt – Winter smoothing, Forecasting based on smoothing.

2. Wold representation of linear stationary processes, Detailed study of the linear time series models: Autoregressive, Moving Average, Autoregressive Moving Average and Autoregressive Integrated Moving Average models.

3. Estimation of ARMA models: Yule-Walker estimation for AR Processes, Maximum likelihood and least squares estimation for ARMA Processes, Discussion (without proof) of estimation of mean, Auto-covariance and auto-correlation function under large samples theory, Residual analysis and diagnostic checking. Forecasting using ARIMA models.

4. Analysis of seasonal models: parsimonious models for seasonal time series, General multiplicative seasonal models, forecasting, identification, estimation and diagnosis methods for seasonal time series. Spectral analysis of weakly stationary process. Herglotzic Theorem. Periodogram and correlogram analysis.

Text Books:

1. Box, G.E.P and Jenkins G.M. (1970) Time Series Analysis, Forecasting and Control, Holden-Day.
2. Brockwell, P.J and Davis R.A. (1987) Time Series: Theory and Methods, Springer-Verlag.
3. Abraham, B. and Ledolter, J.C. (1983) Statistical Methods for Forecasting, Wiley

Reference Books:

1. Anderson, T.W (1971) Statistical Analysis of Time Series, Wiley.
2. Fuller, W.A. (1978) Introduction to Statistical Time Series, John Wiley.
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