M.A./M. Sc. COURSE IN STATISTICS

TWO-YEAR FULL-TIME PROGRAMME
SEMESTERS I to IV

SCHEME OF EXAMINATION AND COURSE CONTENTS

Department of Statistics
Faculty of Mathematical Sciences
University of Delhi
Delhi-110007

2008

M.A. /M. Sc. STATISTICS
SCHEME OF EXAMINATION

Examination 2009 and onwards
First Year: Semester I (July to December)

		Duration (hrs.)	Max. Marks	Credits
Paper 101 :	Analysis	3	70	4
Paper 102 :	Probability Theory	3	70	4
Paper 103 :	Statistical Methodology	3	70	4
Paper 104 :	Survey Sampling	3	70	4
Paper 105 :	Practical-I comprising the following two parts: Part A: Statistical Computing-I; Part B: Data Analysis-I (based on papers 103 and 104)	4	100	4
	Internal Assessment-I*		120	__
		Total	500	20

Examination 2010 and onwards
First Year: Semester II (January to May)

		Duration (hrs.)	Max. Marks	Credits
Paper 201 :	Linear Algebra	3	70	4
Paper 202 :	Stochastic Processes	3	70	4
Paper 203 :	Statistical Inference-I	3	70	4
Paper 204 :	Design of Experiments	3	70	4
Paper 205 :	Practical-II comprising the following two parts: Part A: Statistical Computing-II; Part B: Data Analysis-II (based on papers 203 and 204)	4	100	4
	Internal Assessment-II*		120	__
		Total	500	20

Examination 2010 and onwards
Second Year: Semester III (July to December)

		Duration (hrs.)	Max. Marks	Credits
Paper 301 :	Statistical Inference-II	3	70	4
Paper 302 :	Multivariate Analysis	3	70	4
Paper 303 :	Generalized Linear Models	3	70	4
Paper 304 :	One optional paper out of the following: (i) Bio-Statistics; (ii) Operational Research; (iii) Nonparametric Inference; (iv) Actuarial Statistics; (v) An elective from outside the Department	3	70	4
Paper 305 :	Practical-III comprising the following two parts: Part A: Problem Solving Using C Language-I (based on papers 301, 302 and 303); Part B: Problem Solving Using SPSS-I (based on papers 301, 302 and 303)	4	100	4
	Internal Assessment-III*		120	__
		Total	500	20

Examination 2011 and onwards

Second Year: Semester IV (January to May)

Paper	401 :	Econometrics and Time Series Analysis	3	70	4
Paper	402 :	Demography, Statistical Quality Control and Reliability	3	70	4
Paper	403 :	Any two of the following options:	3	70	4
Paper	404 :		3	70	4

(i) Applied Stochastic Processes
(ii) Order Statistics
(iii) Bayesian Inference
(iv) Advanced Survey Sampling Theory
(v) Advanced Theory of Experimental Designs
(vi) Advanced Statistical Computing and Data Mining
(vii) An elective from outside the Department

Paper	405:	Practical-IV comprising the following two parts: Part A: Problem Solving Using C Language-II (based on papers 401 and 402) Part B: Problem Solving Using SPSS-II (based on papers 401 and 402)	4	100	4
		Internal Assessment-IV*		120	—
			Total	500	20

Grand total of Semester I, Semester II, Semester III and Semester IV = 2000
Grand total of credits over Semester I, Semester II, Semester III and Semester IV = 80

Note 1: Each paper will carry 100 marks including 30 marks earmarked for Internal Assessment.*

Note 2: It is recommended that four lectures per week will be devoted to each of papers 101 to 104, 201 to 204, 301 to 304 and 401 to 404. It is further recommended that each part of practical papers 105, 205, 305 and 405 will be assigned 4 periods per week.

Note 3: Each of the papers 105, 205, 305 and 405 consists of two parts (A and B) with the following subdivision of 50 marks for each part:
Written 30 marks, Oral 10 marks, Record Book 10 marks. Examination in respect of each part will be of 2 hours duration.

*** Internal Assessment for M.A./M. Sc. (Semesters I to IV)**

Internal Assessment-I **:** consists in evaluation of students in papers 101 to 104 in the course of Semester I, each paper being assigned 30 marks.

Internal Assessment-II **:** consists in evaluation of students in papers 201 to 204 in the course of Semester II, each paper being assigned 30 marks.

Internal Assessment-III : consists in evaluation of students in papers 301 to 304 in the course of Semester III, each paper being assigned 30 marks.

Internal Assessment-IV : consists in evaluation of students in papers 401 to 404 in the course of Semester IV, each paper being assigned 30 marks.

The format and modus operandi for the above Internal Assessments will be decided and announced by the Department at the beginning of a semester.

Pass Percentage, Promotion and Division Criteria and Span Period

PASS PERCENTAGE

Minimum marks for passing the examination in each semester shall be 40% in each paper and 45% in aggregate of a semester.

However, a candidate who has secured the minimum marks to pass in each paper but has not secured the minimum marks to pass in aggregate may reappear in any of the paper/s of his choice in the concerned semester in order to be able to secure the minimum marks prescribed to pass the semester in aggregate.

Note: Examination for courses shall be conducted only in the respective odd and even semesters as per the Scheme of Examinations. Regular as well as Ex-Students shall be permitted to appear/re-appear/improve in courses of odd semesters only at the end of odd semesters and courses of even semesters only at the end of even semesters.

No student would be allowed to avail of more than 3 chances to pass any paper inclusive of the first attempt.

PROMOTION CRITERIA

A. **Semester to Semester:** Students shall be required to fulfill the promotion criteria from the first year to the second year of the Course. Within the same year, students shall be allowed to be promoted from a semester to the next semester, provided he/she has passed at least half the papers of the current semester.

B. **First year to Second year:** Admission to the second year of the M.A./M. Sc. Course shall be open to only those students who have successfully passed at least 75% papers out of the papers offered for the first year of the M.A./M. Sc. Course comprising Semester I and Semester II taken together. However, he/she will have to clear the remaining papers while studying in the second year of the M.A. / M. Sc. Course.

DIVISION CRITERIA

Successful candidates will be classified on the basis of the combined results of first year and second year examinations as follows:

Candidates securing 60% and above	:	I Division
Candidates securing 50% and above but less than 60%	:	II Division
Candidates securing 45% and above but less than 50%	:	Pass

SPAN PERIOD

No students shall be admitted as a candidate for the examination for any of the Years/Semesters after the lapse of 4 years from the date of admission to the first year of the M.A./M. Sc. Programme.

M.A./M. Sc. STATISTICS

Semester I: Examination 2009 and onwards

Paper 101: Analysis

Monotone functions and functions of bounded variation. Absolute continuity of functions, standard properties. Uniform convergence of sequence of functions and series of functions. Cauchy's criterion and Weirstrass M-test. Condititions for termwise differentiation and termwise integration (statements only). Power series and radius of convergence.

Riemann-Stieltjes integration. Statement of the standard properties and problems based on them. Multiple integrals and their evaluation by repeated integration. Change of variable in multiple integration. Beta and gamma functions. Differentiation under integral sign. Leibnitz rule. Dirichlet integral, Liouville's extension.

Maxima-minima of functions of several variables, Constrained maxima-minima of functions.

Analytic function, Cauchy-Riemann equations. Statement of Cauchy theorem and of Cauchy integral formula with applications,Taylor's series. Singularities, Laurent series. Residue and contour integration.

Fourier and Laplace transforms.

References:

1. Apostol, T.M. (1975). Mathematical Analysis, Addison- Wesley.
2. Bartle, R.G. (1976). Elements of Real Analysis, John Wiley & Sons.
3. Berbarian, S.K. (1998). Fundamentals of Real Analysis, Springer-Verlag.
4. Conway, J.B. (1978). Functions of one Complex Variable, Springer-Verlag.
5. Priestley, H.A. (1985). Complex Analysis, Clarenton Press Oxford.
6. Rudin, W. (1985). Principles of Mathematical Analysis, McGraw Hill.

Paper 102: Probability Theory

Classes of sets, field, sigma field, minimal sigma field, Borel field, sequence of sets, limits of a sequence of sets, measure, probability measure, Integration with respect to measure.

Basic, Markov's, Holder's, Minkowski's and Jensen's inequalities.

Random variables, convergence of a sequence of random variables-convergence in probability, almost surely, in the r^{th} mean and in distribution, their relationship, Helly-Bray theorem, monotone convergence theorem, Fatou's lemma, dominated convergence theorem, three-series criterion.

Characteristic function, uniqueness theorem, continuity theorem, inversion formula.

Laws of large numbers, Chebyshev's and Khinchine's WLLN, necessary and sufficient condition for the WLLN, Kolmogorov and Hajek-Renyi inequalities, strong law of large numbers and Kolmogorov's theorem.

Central limit theorem, Lindeberg and Levy and Liapunov forms of CLT. Statement of Lindeberg and Feller's CLT and examples.

Definition and examples of Markov dependence, exchangeable sequences, m-dependent sequences, stationary sequences.

References:

1. Ash, Robert B. (2000). Probability and Measure Theory, Second Edition, Academic Press, New York.
2. Bhat, B.R. (1999). Modern Probability Theory, 3rd Edition, New Age International Publishers.
3. Billingsley, P. (1986). Probability and Measure, 2nd Edition, John Wiley & Sons.
4. Capinski, M. and Zastawniah (2001). Probability through problems, Springer.
5. Chung, K. L. (1974). A Course in Probability Theory, 2nd Edition, Academic Press, New York.
6. Feller, W. (1968). An Introduction to Probability Theory and its Applications, 3rd Edition, Vol. 1, John Wiley & Sons.
7. Goon, A.M., Gupta, M.K. and Dasgupta. B. (1985). An Outline of Statstical Theory, Vol. I, World Press.
8. Laha, R. G. and Rohatgi, V. K. (1979). Probability Theory, John Wiley & Sons.
9. Loeve, M. (1978). Probability Theory, 4th Edition, Springer-Verlag.
10. Rohatgi, V. K. and Saleh, A.K. Md. E. (2005). An Introduction to Probability and Statistics, Second Edn., John Wiley.

Paper 103: Statistical Methodology

Brief review of basic distribution theory. Symmetric Distributions, truncated and compound distributions, mixture of distributions, Power series distribution, exponential family of distributions, Characterization of distributions (Geometric, negative exponential, normal, gamma), non-central chi-square, t and F distributions and their properties, Concept of censoring. Approximating distributions, Delta method and its applications. Approximating distributions of sample moments, limiting moment generating function, Poisson approximation to negative binomial distribution. Order statistics - their distributions and properties. Joint and marginal distributions of order statistics. Extreme values and their asymptotic distributions (statement only) with applications. Tolerance intervals, coverage of $(X_{(r)}, X_{(s)})$. General theory of regression, fitting of polynomial regression by orthogonal methods, multiple regression, examination of regression equation. Robust procedures, robustness of sample mean, sample standard deviation, chi-square test and Student's t-test. Sample size determination for testing and estimation procedures (complete and censored data) for normal, exponential, Weibull and gamma distributions. .

References:

1. Arnold, B.C., Balakrishnan, N., and Nagaraja, H.N. (1992). A First Course in Order Statistics, John Wiley & Sons.
2. David, H.A., and Nagaraja, H.N. (2003). Order Statistics, Third Edition, John Wiley and Sons.
3. Dudewicz, E.J. and Mishra, S.N. (1988). Modern Mathematical Statistics, Wiley, International Students' Edition.
4. Huber, P.J. (1981). Robust Statistics, John Wiley and Sons.
5. Johnson, N.L., Kotz, S. and Balakrishnan, N. (2000). Discrete Univariate Distributions, John Wiley.
6. Johnson, N.L., Kotz, S. and Balakrishnan, N. (2000). Continuous Univariate Distributions, John Wiley.
7. Rao, C.R. (1973). Linear Statistical Inference and Its Applications (Second Edition), John Wiley and Sons.
8. Rohatgi, V.K. (1984). Statistical Inference, John Wiley and Sons.
9. Rohatgi, V.K. and Saleh, A. K. Md. E. (2005). An Introduction to Probability and Statistics, Second Edition, John Wiley and Sons.

Paper 104: Survey Sampling

Basic ideas and distinctive features of sampling; Probability sampling designs, sampling schemes, inclusion probabilities and estimation; Fixed (Design-based) and Superpopulation (model-based) approaches; Review of important results in simple and stratified random sampling; Sampling with varying probabilities (unequal probability sampling) with or without replacement – pps, πps and non-πps sampling procedures and estimation based on them; Non-negative variance estimation; Two-way stratification, post-stratification, controlled sampling; Estimation based on auxiliary data (involving one or more auxiliary variables) under design-based and model-based approaches; Double (two-phase) sampling with special reference to the selection with unequal probabilities in at least one of the phases; systematic sampling and its application to structured populations; Cluster sampling (with varying sizes of clusters); Two-stage sampling (with varying sizes of first-stage units).

Non-sampling errors with special reference to non-response, Warner's and Simmons' randomized response techniques for one qualitative sensitive characteristic.

References:

1. Cassel, C.M., Sarndal, C-E and Wretman, J.H. (1977). Foundations of Inference in Survey Sampling, Wiley Inter-Science, New York
2. Chaudhari, A. and Vos, J.W.E. (1988). Unified Theory and Strategies of Survey Sampling , North –Holland, Amsterdam.
3. Chaudhari, A. and Stenger, H. (2005). Survey Sampling Theory and methods, 2nd Edn., Chapman and Hall.
4. Cochran, W.G. (1977). Sampling Techniques, John Wiley & Sons, New York

5. Hedayat, A.S., and Sinha, B.K. (1991). Design and Inference in Finite Population Sampling, Wiley, New York.
6. Levy, P.S. and Lemeshow, S. (2008). Sampling of Populations-Methods and Applications, Wiley.
7. Mukhopadhyay, Parimal (1997). Theory and Methods of Survey Sampling, Prentice Hall of India, New Delhi.
8. Murthy, M.N. (1967). Sampling Theory and Methods, Statistical Publishing Society, Calcutta.
9. Raj, D. and Chandhok, P. (1998). Sample Survey Theory. Narosa Publishing House.
10. Sarndal, C-E., Swensson, B. and Wretman, J.H. (1992). Model Assisted Survey Sampling, Springer-Verlag, New York.
11. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. (1984). Sampling Theory of Surveys with Applications, Iowa State University Press, Iowa, USA.
12. Thompson, Steven K. (2002). Sampling, John Wiley and Sons, New York.

Paper 105: Practical-I

Part-A: Statistical Computing-I

Review of programming in C; Representation of numbers, Errors. Bitwise operators, Manipulations, Operators, Fields. The C Preprocessor, Macros, Conditional Compilation, Command-line Arguments.

Stacks and their implementation; Infix, Postfix and Prefix notations. Queues, Link list, Dynamic Storage Management. Trees– Binary trees, representations, traversal, operations and Applications. Graphs– Introduction, representation. Sorting– Introduction, bubble sort, selection sort, insertion sort, quick sort including analysis.

Random numbers: Pseudo-Random number generation, tests. Generation of non-uniform random deviates– general methods, generation from specific distributions. Simulation- Random Walk, Monte-Carlo integration, Applications.

References:

1. Gottfried, Byron S. (1998). Programming with C, Tata McGraw Hill Publishing Co.Ltd., New Delhi.
2. Kernighan, Brain W. and Ritchie, Dennis M. (1989). The C Programming Language, Prentice Hall of India Pvt.Ltd., New Delhi.
3. Knuth, Donald E. (2002). The Art of Computer Programming, Vol. 2/Seminumerical Algorithms, Pearson Education (Asia).
4. Ross, S.M. (2002). Simulation, Academic press.
5. Rubinstein, R.Y. (1981). Simulation and the Monte Carlo Method, John Wiley & Sons.
6. Tenenbaum, Aaron M., Langsam, Yedidyah, and Augenstein, Moshe J. (2004). Data Structures using C, Pearson Education, Delhi, India.

Part B: Data Analysis-I

Computer-based data analysis of problems from the following areas:
Statistical Methodology and Survey Sampling.

Semester II: Examination 2010 and onwards

Paper 201: Linear Algebra

Examples of vector spaces, vector spaces and subspace, independence in vector spaces, existence of a Basis, the row and column spaces of a matrix, sum and intersection of subspaces.

Linear Transformations and Matrices, Kernel, Image, and Isomorphism, change of bases, Similarity, Rank and Nullity.

Inner Product spaces, orthonormal sets and the Gram-Schmidt Process, the Method of Least Squares.

Basic theory of Eigenvectors and Eigenvalues, algebraic and geometric multiplicity of eigen value, diagonalization of matrices, application to system of linear differential equations.

Generalized Inverses of matrices, Moore-Penrose generalized inverse.

Real quadratic forms, reduction and classification of quadratic forms, index and signature, triangular reduction of a reduction of a pair of forms, singular value decomposition, extrema of quadratic forms.

Jordan canonical form, vector and matrix decomposition.

References:

1. Biswas, S. (1997). A Text Book of Matrix Algebra, 2nd Edition, New Age International Publishers.
2. Golub, G.H. and Van Loan, C.F. (1989). Matrix Computations, 2nd edition, John Hopkins University Press, Baltimore-London.
3. Nashed, M. (1976). Generalized Inverses and Applications, Academic Press, New York.
4. Rao, C.R. (1973). Linear Statistical Inferences and its Applications, 2nd edition, John Wiley and Sons.
5. Robinson, D.J.S. (1991). A Course in Linear Algebra with Applications, World Scientific, Singapore.
6. Searle, S.R. (1982). Matrix Algebra useful for Statistics, John Wiley and Sons.
7. Strang, G. (1980). Linear Algebra and its Application, 2nd edition, Academic Press, London-New York.

Paper 202: Stochastic Processes

Poisson process, Brownian motion process, Thermal noise, Markov-shot noise, Two-valued processes. Model for system reliability.

Mean value function and covariance kernel of the Wiener and Poisson processes. Increment process of a Poisson process, Stationary and evolutionary processes.

Compound distributions, Total progeny in branching processes.

Recurrent events, Delayed recurrent events, Renewal processes. Distribution and Asymptotic Distribution of Renewal Processes. Stopping time. Wald's equation. Elementary Renewal Theorem. Delayed and Equilibrium Renewal Processes. Application to the theory of success runs. More general patterns for recurrent events.

One-dimensional, two-dimensional and three-dimensional random walks. Duality in random walk. Gambler's ruin problem.

Classification of Markov chains. Higher transition probabilities in Markov classification of states and chains. Limit theorems. Irreducible ergodic chain.

Martingales, Boob- Decomposition, Martingale convergence theorems, Optional stopping theorem.

References:

1. Bhat, B.R. (2000). Stochastic Models- Analysis and Applications, New Age International Publishers.
2 Feller, William (1968). An Introduction to Probability Theory and its Applications, Vol. 1 (Third Ed.), John Wiley.
3. Hoel, P.G., Port, S.C. and Stone C.J. (1972). Introduction to Stochastic Processes, Houghton Miffin & Co.
4. Karlin, S. and Taylor, H.M. (1975). A first course in Stochastic Processes, Second Ed. Academic Press
5. Medhi, J. (1994). Stochastic Processes, 2nd Edition, Wiley Eastern Ltd.
6. Parzen, Emanuel (1962). Stochastic Processes, Holden-Day Inc.
7. Prabhu, N.U. (2007). Stochastic Processes: Basic Theory and its Applications, World Scientific.
8. Ross, Sheldon M. (1983). Stochastic Processes, John Wiley and Sons, Inc.
9. Takacs, Lajos (1967). Combinatorial Methods in the Theory of Stochastic Processes, John Wiley and Sons, Inc.
10. Williams, D. (1991). Probability with Martingales, Cambridge University Press.

Paper 203: Statistical Inference –I

Minimal sufficiency and ancillarity, Exponential families and Pitman families, Invariance property of Sufficiency under one-one transformations of sample and parameter spaces. Fisher Information for one and several parameters models. Lower bounds to variance of estimators, necessary and sufficient conditions for MVUE.

Neyman-Pearson fundamental lemma and its applications, UMP tests for simple null hypothesis against one-sided alternatives and for one-sided null against one-sided alternatives in one parameter exponential family. Extension of these results to Pitman family when only upper or lower end depends on the parameters and to distributions with MLR property, Non-existence of UMP tests for simple null against two-sided alternatives in one parameter exponential family. Families of distributions with monotone likelihood ratio and UMP tests.

Interval estimation, confidence level, construction of shortest expected length confidence interval, Uniformly most accurate one-sided confidence Interval and its relation to UMP tests for one-sided null against one-sided alternative hypotheses.

References:

1. Bartoszynski, R. and Bugaj, M.N. (2007). Probability and Statistical Inference, John Wiley & Sons.
2. Ferguson, T.S. (1967). Mathematical Statistics, Academic Press.
3. Kale, B.K. (1999). A First Course on Parametric Inference, Narosa Publishing House.
4. Lehmann, E.L. (1986). Theory of Point Estimation, John Wiley & Sons.
5. Lehmann, E.L. (1986). Testing Statistical Hypotheses, John Wiley & Sons.
6. Rao, C.R. (1973). Linear Statistical Inference and Its Applications, Second Edition, Wiley Eastern Ltd., New Delhi.
7. Rohatgi, V.K. and Saleh, A.K. Md. E. (2005). An Introduction to Probability and Statistics, Second Edition, John Wiley.
8. Zacks, S. (1971). Theory of Statistical Inference, John Wiley & Sons.

Paper 204: Design of Experiments

Review of linear estimation and basic designs. ANOVA: Fixed effect models (2-way classification with unequal and proportional number of observations per cell), Random and Mixed effect models (2-way classification with m (>1) observations per cell).

Incomplete Block Designs. Concepts of Connectedness, Orthogonality and Balance. Intrablock analysis of General Incomplete Block design. B.I.B designs with and without recovery of interblock information.

Elimination of heterogeneity in two directions.

Symmetrical factorial experiments (s^m, where s is a prime or a prime power), Confounding in s^m factorial experiments, s^{k-p} fractional factorial where s is a prime or a prime power. Split-plot experiments.

Finite fields. Finite Geometries- Projective geometry and Euclidean geometry. Construction of complete set of mutually orthogonal latin squares.

Construction of B.I.B.D. using finite Abelian groups, MOLS, finite geometry and method of differences.

References:

1. Chakrabarti, M.C. (1962). Mathematics of Design and Analysis of Experiments, Asia Publishing House, Bombay.

2. Das, M.N. and Giri, N.C. (1986). Design and Analysis of Experiments, Wiley Eastern Limited.
3. Dean, A. and Voss, D. (1999). Design and Analysis of Experiments, Springer. First Indian Reprint 2006.
4. Dey, A. (1986). Theory of Block Designs, John Wiley & Sons.
5. Hinkelmann, K. and Kempthorne, O. (2005). Design and Analysis of Experiments, Vol. 2: Advanced Experimental Design, John Wiley & Sons.
6. John, P.W.M. (1971). Statistical Design and Analysis of Experiments, Macmillan Co., New York.
7. Kshirsagar, A.M. (1983). A Course in Linear Models, Marcel Dekker, Inc., N.Y.
8. Montgomery, D.C. (2005). Design and Analysis of Experiments, Sixth Edition, John Wiley & Sons.
9. Raghavarao, D. (1970). Construction and Combinatorial Problems in Design of Experiments, John Wiley & Sons.

Paper 205: Practical-II

Part A: Statistical Computing-II

Mathematical and Statistical problem solving using software package: Introduction, Plots in 2-D and 3-D. Numerical Methods: Vector and matrix operations, Interpolation. Numerical root finding, Matrix factorization. Eigenvalue and eigenvectors, Differentiation, Integration.

Generation of discrete and continuous random variables, Histograms and quantile-based plots. Parameter estimation– MLE, method of moments. Monte Carlo methods– Introduction, for Statistical inference, Bootstrap methods. Regression and curve fitting.

References:

1. Gentle, J.E., Härdle W. and Mori Y., (2004). Handbook of computational statistics — Concepts and methods, Springer-Verlag.
2. Knuth, Donald E. (2002). The Art of Computer Programming, Vol. 2/Seminumerical Algorithms, Pearson Education (Asia).
3. Monahan, J.M. (2001). Numerical Methods in Statistics, Cambridge.
4. Ross, S.M. (2002). Simulation, Academic press.
5. Rubinstein, R.Y. (1981). Simulation and the Monte Carlo Method, John Wiley & Sons.

Part B: Data Analysis-II

Computer-based data analysis of problems from the following areas:
Statistical Inference-I and Design of Experiments.

Semester III: Examination 2010 and onwards

Paper 301: Statistical Inference-II

Consistency and asymptotic relative efficiency of estimators. Consistent asymptotic normal (CAN) estimator. Method of maximum likelihood, CAN estimator for one parameter Cramer family, Cramer-Huzurbazar theorem. Solutions of likelihood equations, method of scoring. Fisher lower bound to asymptotic variance. MLE in Pitman family and double exponential distribution, MLE in censored and truncated distributions.

Similar tests, Neyman structure, UMPU tests for composite hypotheses, Invariance tests and UMP invariant tests, Likelihood ratio test, Asymptotic distribution of LRT statistic, Consistency of large sample test, Asymptotic power of large sample test.

Sequential tests-SPRT and its properties, Wald's fundamental identity, OC and ASN functions. Sequential estimation.

Non- parametric methods-estimation and confidence interval, U-statistics and their asymptotic properties, UMVU estimator, non parametric tests-single sample location, location-cum-symmetry, randomness and goodness of fit problems; Rank order statistics, Linear rank statistics, Asymptotic relative efficiency.

References:

1. Ferguson, T.S. (1967). Mathematical Statistics, Academic Press.
2. Gibbons, J.D. and Chakraborti, S. (1992). Nonparametric Statistical Inference, Marcel Dekker.
3. Kale, B.K. (1999). A First Course on Parametric Inference, Narosa Publishing House.
4. Lehmann, E.L. (1986). Theory of Point Estimation, John Wiley & Sons.
5. Lehmann, E.L. (1986). Testing Statistical Hypotheses, John Wiley & Sons.
6. Randles, R.H. and Wolfe, D.S. (1979). Introduction to the Theory of Non-parametric Statistics, John Wiley & Sons.
7. Rao, C.R. (1973). Linear Statistical Inference and Its Applications, Second Ed., Wiley Eastern Ltd.,
8. Rohatgi, V.K. and Saleh, A.K. Md.E. (2005). An Introduction to Probability and Statistics, Second Edition, John Wiley.
9. Sinha, S. K. (1986). Probability and Life Testing, Wiley Eastern Ltd.
10. Zacks, S. (1971). Theory of Statistical Inference, John Wiley & Sons.

Paper 302: Multivariate Analysis

Multivariate normal distribution, its properties and characterization. Random sampling from a multivariate normal distribution. Maximum likelihood estimators of parameters. Distribution of sample mean vector. Inference concerning the mean vector when the covariance matrix is known. Matrix normal distribution. Multivariate central limit theorem.

Wishart matrix – its distribution and properties. Distribution of sample generalized variance.

Hotelling's T^2 statistic – its distribution and properties. Applications in tests on mean vector for one and more multivariate normal populations and also on symmetry of organs. Mahalanobis' D^2.

Likelihood ratio test criteria for testing (1) independence of sets of variables, (2) equality of covariance matrices, (3) identity of several multivariate normal populations, (4) equality of a covariance matrix to a given matrix, (5) equality of a mean vector and a covariance matrix to a given vector and a given matrix.

Distribution of the matrix of sample regression coefficients and the matrix of residual sum of squares and cross products. Rao's U-statistic, its distribution and applications.

Classification and discrimination procedures for discrimination between two multivariate normal populations – sample discriminant function, tests associated with discriminant functions, classification into more than two multivariate normal populations.

Principal components, canonical variables and canonical correlations. Elements of factor analysis and cluster analysis.

Multivariate linear regression model – estimation of parameters and their properties. Multivariate analysis of variance [MANOVA] of one-way classified data. Wilk's lambda criterion.

References:

1. Anderson, T.W. (2003). An Introduction to Multivariate Statistical Analysis, Third Edition, John Wiley & Sons.
2. Arnold, Steven F. (1981). The Theory of Linear Models and Multivariate Analysis, John Wiley & Sons.
3. Giri, N.C. (1977). Multivariate Statistical Inference, Academic Press.
4. Johnson, R.A. and Wichern, D.W. (2007). Applied Multivariate Statistical Analysis, Sixth Edition, Pearson & Prentice- Hall.
5. Kshirsagar, A.M. (1972). Multivariate Analysis, Marcel Dekker.
6. Lawley, D.N. and Maxwell, A.E. (1971). Factor Analysis as a Statistical Method, Second Edition, London Butterworths.
7. Muirhead, R.J. (1982). Aspects of Multivariate Statistical Theory, John Wiley & Sons.
8. Rao, C.R. (1973). Linear Statistical Inference and its Applications, Second Edition, John Wiley & Sons.
9. Rencher, A.C. (2002). Methods of Multivariate Analysis, Second Edition, John Wiley & Sons.
10. Sharma, S. (1996). Applied Multivariate Techniques, John Wiley & Sons.
11. Srivastava, M.S. and Khatri, C.G. (1979). An Introduction to Multivariate Statistics, North Holland.

Paper 303: Generalized Linear Models

Logistic and Poisson regression: logistic regression model for dichotomous data with single and multiple explanatory variables, ML estimation, large sample tests about parameters, Goodness-of-Fit tests (Concept of deviance), analysis of deviance, Lack-of-Fit tests in Logistic regression. Concept of overdispersion in logistic regression. Introduction to Poisson regression, MLE for Poisson regression, Applications in Poisson regressions.

Log linear models for contingency tables: interpretation of parameters, ML estimation of parameters, likelihood ratio tests for various hypotheses including independence, marginal and conditional independence, partial association.

Family of Generalized Linear Models: Exponential family of distributions, Formal structure for the class of GLMs, Likelihood equations, Quasi likelihood, Link functions, Important distributions for GLMs, Power class link function.

References:

1. Agresti, A. (2002). Categorical Data Analysis, Second Edition, Wiley.
2. Christensen, R. (1997). Log-linear Models and Logistic Regression, Second Edition, Springer.
3. Collett, D. (2003). Modeling Binary Data, Second Edition, Chapman and Hall, London.
4. Dobson, A.J. and Barnett, A.G. (2008). Introduction to Generalized Linear Models, Third Edition, Chapman and Hall/CRC. London.
5. Green, P.J. and Silverman, B.W. (1994). Nonparametric Regression and Generalized Linear Models, Chapman and Hall, New York.
6. Hastie, T.J. and Tibshirani, R.J. (1990). Generalized Additive Models. Second Edition, Chapman and Hall, New York.
7. Hosmer, D.W. and Lemeshow, S. (2000). Applied Logistic Regression, Second Edition. Wiley, New York.
8. Lindsey, J. K. (1997). Applying generalized linear models, Springer-Verlag, New York.
9. McCullagh, P. and Nelder, J.A. (1989). Generalized Linear Models, Second Edition, Chapman and Hall.
10. McCulloch, C.E. and Searle, S.R. (2001). Generalized, Linear and Mixed Models, John Wiley & Sons, Inc. New York.
11. Myers, R.H., Montgomery, D.C and Vining, G.G. (2002). Generalized Linear Models with Applications in Engineering and the Sciences, John Wiley & Sons.

Paper 304: Any one of the following optional papers:

(i) Bio-Statistics

Functions of survival time, survival distributions and their applications viz. exponential, gamma, weibull, Rayleigh, lognormal, death density function for a distribution having bath-tub shape hazard function. Tests of goodness of fit for survival distributions (WE test for exponential distribution, W-test for lognormal distribution, Chi-square test for uncensored observations).

Parametric methods for comparing two survival distributions viz. L.R test, Cox's F-test. P-value, Analysis of Epidemiologic and Clinical Data: Studying association between a disease and a characteristic: (a) Types of studies in Epidemiology and Clinical Research (i) Prospective study (ii) Retrospective study (iii) Cross-sectional data, (b) Dichotomous Response and Dichotomous Risk Factor: 2X2 Tables (c) Expressing relationship between a risk factor and a disease (d) Inference for relative risk and odds ratio for 2X2 table, Sensitivity, specificity and predictivities, Cox proportional hazard model.

Type I, Type II and progressive or random censoring with biological examples, Estimation of mean survival time and variance of the estimator for type I and type II censored data with numerical examples. Non-parametric methods for estimating survival function and variance of the estimator viz. Acturial and Kaplan –Meier methods.

Competing risk theory, Indices for measure-ment of probability of death under competing risks and their inter-relations. Estimation of probabilities of death under competing risks by maximum likelihood and modified minimum Chi-square methods. Theory of independent and dependent risks. Bivariate normal dependent risk model. Conditional death density functions.

Stochastic epidemic models: Simple and general epidemic models (by use of random variable technique).

Basic biological concepts in genetics, Mendels law, Hardy- Weinberg equilibirium, random mating, distribution of allele frequency (dominant/co-dominant cases), Approach to equilibirium for X-linked genes, natural selection, mutation, genetic drift, equilibirium when both natural selection and mutation are operative, detection and estimation of linkage in heredity.

Planning and design of clinical trials, Phase I, II, and III trials. Consideration in planning a clinical trial, designs for comparative trials. Sample size determination in fixed sample designs.

References:

1. Biswas, S. (1995). Applied Stochastic Processes. A Biostatistical and Population Oriented Approach, Wiley Eastern Ltd.
2. Collett, D. (2003). Modelling Survival Data in Medical Research, Chapman & Hall/CRC.
3. Cox, D.R. and Oakes, D. (1984). Analysis of Survival Data, Chapman and Hall.
4. Elandt Johnson R.C. (1971). Probability Models and Statistical Methods in Genetics, John Wiley & Sons.
5. Ewens, W. J. (1979). Mathematics of Population Genetics, Springer Verlag.
6. Ewens, W. J. and Grant, G.R. (2001). Statistical methods in Bio informatics: An Introduction, Springer.
7. Friedman, L.M., Furburg, C. and DeMets, D.L. (1998). Fundamentals of Clinical Trials, Springer Verlag.
8. Gross, A. J. And Clark V.A. (1975). Survival Distribution; Reliability Applications in Biomedical Sciences, John Wiley & Sons.
9. Indrayan, A. (2008). Medical Biostatistics, Second Edition, Chapman & Hall/CRC.
10. Lee, Elisa, T. (1992). Statistical Methods for Survival Data Analysis, John Wiley & Sons.
11. Li, C.C. (1976). First Course of Population Genetics, Boxwood Press.

12. Miller, R.G. (1981). Survival Analysis, John Wiley & Sons.
13. Robert F. Woolson (1987). Statistical Methods for the analysis of biomedical data, John Wiley & Sons.

(ii) Operational Research

Definition and scope of Operational Research, phases in Operational Research, different types of models, their construction and general methods of solution.

Simulation**:** Pseudorandom Number Generation, using random numbers to evaluate integrals. Generating discrete random variables: Inverse Transform Method, Acceptance-Rejection Technique, Composition Approach. Generating continuous random variables: Inverse Transform Algorithm, Rejection Method. Generating a Poisson process.

Programming**:** Linear programming. Nonlinear programming, Unconstrained problems and Kuhn-Tucker Conditions, Quadratic programming-Beale’s and Wolfe’s methods. Introduction to Dynamic programming: Bellman’s principle of optimality, general formulation, Computational methods and application of Dynamic programming.

Theory of Network – PERT, CPM.

Queueing Theory**:** Steady state analysis of M/M/1, M/M/C queues. Method of stages for steady state solution of $M/E_r/1$ and $E_r/M/1$ queues. Simple design and control problems in queueing theory.

Inventory Management**:** Characteristics of inventory systems. Classification of items. Deterministic inventory systems with and without lead-time. All units and incremental discounts. Single period stochastic models.

Introduction to Decision Analysis: Pay-off table for one-off decisions and discussion of decision criteria, Decision trees.

References:

1. Gross, D., Shortle J.F., Thompson J.M. and Harris, C.M. (2008). Fundamentals of Queueing Theory, John Wiley & Sons.
2. Hadley, G. and Whitin, T.M. (1963). Analysis of Inventory Systems, Prentice Hall.
3. Hadley, G. (2002). Linear Programming, Narosa Publishing House.
4. Hadley, G. (1964). Non-Linear and Dynamic Programming, Addison-Wesley Publishing Company.
5. Hillier, F.S. and Lieberman, G.J. (2001). Introduction to Operations Research, Seventh Edition, Irwin.
6. Ross, S. M. (2006). Simulation, Fourth Edition, Academic Press.
7. Taha, H. A. (2006). Operations Research: An Introduction, Eighth Edition, Prentice Hall.
8. Wagner, B.M. (1975). Principles of OR, Englewood Cliffs, N.J. Prentice-Hall
9. Waters, Donald and Waters, C.D.J. (2003). Inventory Control and Management, John Wiley & Sons.

(iii) Nonparametric Inference

Review of order statistics, Distribution-free statistics over a class, Counting statistics, ranking statistics, Statistics utilizing counting and ranking, Asymptotic distribution of U-statistics, Confidence interval for population quantile and scale parameter, point estimation, Estimators associated with distribution free test statistics, Exact small-sample and asymptotic properties of the Hodges-Lehmann location estimators, Nonparametric density estimation, Nonparametric regression estimation. Tests based on length of the longest run, runs up and down, Kolmogorov-Smirnov two-sample statistic, rank order statistics: Correlation between ranks and variate values, One sample, paired sample and two sample problems, distribution properties of linear rank statistics, tests for equality of k independent samples: Kruskal-Wallis one way ANOVA test, Measures of Association for bivariate samples: Kendall's Tau coefficient, Spearman's coefficient of Rank correlation, relations between R and T; E (R), τ and ρ. Measures of association in multiple classifications: Friedman's two-way ANOVA by ranks in a k x n table, the Coefficient of Concordance of k sets of rankings of n objects, the Coefficient of Concordance of k sets of incomplete rankings. Concept of power and robustness, elements of bootstrapping.

References:

1. David, H.A. and Nagaraja, H. N. (2003). Order Statistics, Third Edition, John Wiley & Sons.
2. Gibbons, J.D. and Chakraborti, S. (1992). Nonparametric Statistical Inference, Third Edition, Marcel Dekker.
3. Hettmansperger, T.P. (1984). Statistical inference Based on Ranks, John Wiley & Sons.
4. Randles, R.H. and Wolfe, D.A. (1979). Introduction to the Theory of Nonparametric Statistics, John Wiley & Sons.
5. Rohatgi, V.K. and Saleh, A.K. Md. E. (2005). An Introduction to Probability and Statistics, Second Edition, John Wiley & Sons.

(iv) Actuarial Statistics

Section I- Probability Models and Life Tables

Utility theory, insurance and utility theory, models for individual claims and their sums, survival function, curtate future lifetime, force of mortality.

Life table and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables.

Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions evaluation for special mortality laws.

Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical evaluations.

Distribution of aggregate claims, compound Poisson distribution and its applications.

Section II- Insurance and Annuities

Principles of compound interest. Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding.

Life insurance: Insurance payable at the moment of death and at the end of the year of death-level benefit insurance, endowment insurance, diferred insurance and varying benefit insurance, recursions, commutation functions.

Life annuities: Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursions, complete annuities-immediate and apportionable annuities-due.

Net premiums: Continuous and discrete premiums, true monthly payment premiums, apporionable premiums, commutation functions, accumulation type benefits.

Payment premiums, apportionable premiums, commutation functions, accumulation type benefits.

Net premium reserves: Continuous and discrete net premium reserve, reserves on a semicontinuous basis, reserves based on true monthly premiums, reserves on an apportionable or discounted continuous basis, reserves at fractional durations, allocations of loss to policy years, recursive formulas and differential equations for reserves, commutation functions.

Some practical considerations: Premiums that include expenses-general expenses types of expenses, per policy expenses.

Claim amount distributions, approximating the individual model, stop-loss insurance.

References:

1. Atkinson, M.E. and Dickson, D.C.M. (2000). An Introduction to Actuarial Studies, Elgar Publishing.
2. Bedford, T. and Cooke, R. (2001). Probabilistic risk analysis, Cambridge.
3. Bowers, N. L., Gerber, H. U., Hickman, J. C., Jones D.A. and Nesbitt, C. J. (1986). 'Actuarial Mathematics', Society of Actuaries, Ithaca, Illinois, U.S.A., Second Edition (1997).
4. Medina, P. K. and Merino, S. (2003). A discrete introduction: Mathematical finance and Probability, Birkhauser.
5. Neill, A. (1977). Life Contingencies, Heineman.
6. Philip, M. et. al (1999). Modern Actuarial Theory and Practice, Chapman and Hall.
7. Rolski, T., Schmidli, H., Schmidt, V. and Teugels, J. (1998). Stochastic Processes for Insurance and Finance, Wiley.
8. Spurgeon, E.T. (1972). Life Contingencies, Cambridge University Press.
9. Relevant Publications of the Actuarial Education Co., 31, Bath Street, Abingdon, Oxfordshire OX143FF (U.K.)

(v) An elective from outside the Department (Course content as per the elective offered by the concerned Department).

Paper 305: Practical – III

Part A: Problem Solving using C language -I

Developing programs in C-language to analyse data from the following areas: Statistical Inference-II, Multivariate Analysis and Generalized Linear Models.

Part B: Problem Solving using SPSS-I

Based on

(i) knowledge of Software

(ii) application of Software for data analysis in the following areas: Statistical Inference-II, Multivariate Analysis and Generalized Linear Models.

Semester IV: Examination 2011 and onwards

Paper 401: Econometrics and Time Series Analysis

Time series as discrete parameter stochastic process. Auto covariance and auto correlation functions and their properties.

Detailed study of the stationary processes : Moving average (MA), Auto regressive (AR), ARMA and ARIMA models. Box-Jenkins models. Discussion (without proof) of estimation of mean, auto covariance and auto correlation functions under large sample theory. Choice of AR and MA periods. Estimation of ARIMA model parameters. Smoothing spectral analysis of weakly stationary process. Periodo gram and correlogram analysis. Filter and transfer functions. Problems associated with estimation of spectral densities.

Forecasting: Exponential and adaptive Smoothing methods

Econometrics: Review of G.L.M. and generalized least squares estimation, GLM with stochastic regressors. Instrumental variables, estimation, consistency property, asymptotic variance of instrumental variable estimators.

Bayesian analysis of G.L.M. with informative and non informative prior distributions. Bayes estimation and testing of hypotheses of the regression coefficients.

Distributed lag models: Finite polynomial lags, determination of the degree of polynomial. Infinite distributed lags, adaptive expectations and partial adjustment models, determination of lag length. Methods of estimation.

Simultaneous equations models: Identification problem. Restrictions on structural parameters-rank and order conditions. Restrictions on variances and covariances. Estimation in simultaneous equations models. Recursive systems, 2SLS estimators, Limited information estimators, k-class estimators, Instrumental variable method of estimation. 3-SLS estimation.

References:

1. Johnston, J. (1984). Econometric Methods, Mc Graw Hill Kogakusha Ltd.

2. Judge, G.C., Hill, R,C. Griffiths, W.E., Lutkepohl, H. and Lee, T-C. (1988). Introduction to the Theory and Practice of Econometrics, Second Edition, John Wiley & Sons.
3. Kendall, M.G. and Stuart, A. (1968). The Advanced Theory of Statistics (Vol. III), Second Edition, Charles Griffin.
4. Kmenta, J. (1986). Elements of Econometrics, Second Edition, Mac millan.
5. Medhi, J. (1994). Stochastic Processes, Second Edition, Wiley Eastern, New Delhi
6. Montgomery, D.C. and Johnson, L.A. (1976). Forecasting and Time Series Analysis, Mc Graw Hill, New York .
7. Peter J. Brockwell and Richard A. Daris (2002). Introduction to time Series and Forecasting, Second Edition. Springer-Verlag, New York, Inc. (Springer Texts in Statistics).

Paper 402: Demography, Statistical Quality Control and Reliability

Demography: Measures of mortality, description of life table, construction of complete and abridged life tables, maximum likelihood, MVU and CAN estimators of life table parameters.

Measures of fertility, models for population growth, intrinsic growth rate, stable population analysis, population projection by component method and using Leslie matrix.

Quality control and Sampling Inspection: Basic concepts of process monitoring and control, General theory and review of control charts, O.C and ARL of control charts, CUSUM charts using V-mask and decision intervals, economic design of x- bar chart.

Review of sampling inspection techniques, single, double, multiple and sequential sampling plans and their properties, methods for estimating (n, c) using large sample and Bayesian techniques, curtailed and semi-curtailed sampling plans, Dodge's continuous sampling inspection plans for inspection by variables for one-sided and two-sided specifications.

Reliability: Reliability concepts and measures, components and systems, reliability function, hazard rate, common life distributions viz. exponential, gamma, Weibull, lognormal, Rayleigh, piece-wise exponential etc., Reliability and expected survivability of series, parallel, mixed, maintained and non-maintained systems with and without redundancy, preventive maintenance policy, preliminary concepts of coherent systems.

References:

1. Bain, L. J and Engelhardt, M. (1991). Statistical Analysis of Reliability and Life Testing Models, Marcel Dekker.
2. Barlow, R. E. And Proschan, F (1985). Statistical Theory of Reliability and Life Testing, Holt, Rinehart and Winston.
3. Biswas, S. (1988). Stochastic Processes in Demography and Applications, Wiley Eastern Ltd.
4. Biswas, S. (1996). Statistics of Quality Control, Sampling Inspection and Reliability, New Age International Publishers.
5. Chiang, C.L. (1968). Introduction to Stochastic Processes in Bio statistics, John Wiley.
6. Keyfitz, N. (1971). Applied Mathematical Demography, Springer Verlag.

7. Lawless, J. F. (1982). Statistical Models and Methods of Life Time Data, John Wiley & Sons.
8. Montgomery, D. C. (2005). Introduction to Statistical Quality Control, 5th Edn., John Wiley & Sons.
9. Spiegelman, M. (1969). Introduction to Demographic Analysis, Harvard University Press.
10. Wetherill, G. B. (1977). Sampling Inspection and Quality Control, Halsted Press.

Papers 403 and 404: Any two of the following options:

(i) Applied Stochastic Processes

Markov processes in continuous time. Poisson process, Kolmogorov equations. Forward and backward equations for homogeneous case. Random variable technique, Homogeneous birth & death processes. Divergent birth process. The effect of immigration. The general birth and death process. Multiplicative processes. Simple non-homogeneous processes. Polya process. The effect of immigration for non-homogeneous case. Queueing processes. Equilibrium theory. Queues with many servers. First passage times. Diffusion. Backward Kolmogorov diffusion equation. Fokker-Planck equation. Application to population growth. Epidemic and Counter models. Supplementary variables. Embedded Markov processes. Some multi-dimensional prey and predator and non-Markovian processes, Renewal processes-ordinary, modified, equilibrium. Renewal functions. Integral equation of renewal theory. Distribution of the number of renewals. The elementary renewal theorem.

References:

1. Bailey, Norman T.J. (1964). The Elements of Stochastic Processes, John Wiley and Sons.
2. Bartlett, M.S. (1966). An Introduction to Stochastic Processes, Cambridge University Press.
3. Cox. D. R. and Miller, H. D. (1965). The theory of Stochastic Processes, Mathuen & C0., London.
4. Hoel, P.G., Port, S.C. and Stone, C.J. (1972). Introduction to Stochastic Processes, Houghton Miffein Company.
5. Karlin, S. and Taylor, H.M. (1975). A First Course in Stochastic Processes (Second Ed.), Academic Press.
6. Ross, S. M. (1983). Stochastic Processes. John Wiley & Sons.

(ii) Order Statistics

Basic distribution theory. Order statistics for a discrete parent. Distribution-free confidence intervals for quantiles and distribution-free tolerance intervals. Conditional distributions, Order Statistics as a Markov chain. Order statistics for independently and not identically distributed (i.ni.d.) variates. Moments of order statistics. Large sample approximations to mean and variance of order statistics. Asymptotic distributions of order statistics. Recurrence relations and identities for moments of order statistics. Distibution-free bounds for moments of order statistics and of the range.

Random division of an interval and its applications. Concomitants. Order statistics from a sample containing a single outlier. Application to estimation and hypothesis testing.

Rank order statistics related to the simple random walk. Dwass' technique. Ballot theorem, its generalization, extension and application to fluctuations of sums of random variables.

References:

1. Arnold, B.C. and Balakrishnan, N. (1989). Relations, Bounds and Approximations for Order Statistics, Vol. 53, Springer-Verlag.
2. Arnold, B. C., Balakrishnan, N. and Nagaraja H. N. (1992). A First Course in Order Statistics, John Wiley & Sons.
3. David, H. A. and Nagaraja, H. N. (2003). Order Statistics, Third Edition, John Wiley & Sons.
4. Dwass, M. (1967). Simple random walk and rank order statistics. Ann. Math. Statist. 38, 1042-1053.
5. Gibbons, J.D. and Chakraborti, S. (1992). Nonparametric Statistical Inference, Third Edition, Marcel Dekker.
6. Takacs, L. (1967). Combinatorial Methods in the Theory of Stochastic Processes, John Wiley & Sons.

(iii) Bayesian Inference

Subjective interpretation of probability in terms of fair odds; Subjective prior distribution of a parameter; Bayes theorem and computation of posterior distribution.

Natural conjugate family of priors for a model. Conjugate families for exponential family models, and models admitting sufficient statistics of fixed dimension. Mixtures from conjugate family, Jeffreys' invariant prior. Maximum entropy priors.

Utility function, expected utility hypothesis, construction of utility function, St. Petersburg Paradox. Loss functions: (i) bilinear, (ii) squared error, (iii) 0-1 loss, and (iv) Linex. Elements of Bayes Decision Theory, Bayes Principle, normal and extensive form of analyses.

Generalized maximum likelihood estimation. Bayes estimation under various loss functions. Evaluation of the estimate in terms of the posterior risk, Preposterior analysis and determination of optimal fixed sample size. Linear Bayes estimates. Empirical and Hierarchical Bayes Methods of Estimation.

Bayesian interval estimation: Credible intervals, HPD intervals, Comparison with classical confidence intervals.

Bayesian testing of hypotheses, specification of the appropriate form of the prior distribution for a Bayesian testing of hypothesis. Prior and posterior odds. Bayes factor for various types of testing hypothesis problems. Lindley's method for Significance tests, two sample testing problem for the parameters of a normal population. Finite action problem and hypothisis testing under "O-K_i" loss, function. Large sample approximation for the posterior distribution. Lindley's approximation of Bayesian integrals.

Predictive density function, prediction for regression models, Decisive prediction, point and internal predictors, machine tool problem.

References:

1. Aitchison, J. and Dunsmore, I.R. (1975). Statistical Prediction Analysis, Cambridge University Press.
2. Bansal, A. K. (2007). Bayesian Parametric Inference, Narosa Publishing House, New Delhi.
3. Berger, J.O. (1985). Statistical Decision Theory and Bayesian Analysis, Springer Verlag, New York.
4. Box, G.E.P. and Tiao, G.C. (1973). Bayesian Inference in Statistical Analysis, Addison & Wesley.
5. De. Groot, M.H. (1970). Optimal Statistical Decisions, McGraw Hill.
6. Leonard, T. and Hsu, J.S.J. (1999). Bayesian Methods, Cambridge University Press.
7. Lee, P. M. (1997). Bayesian Statistics: An Introduction, Arnold Press.
8. Robert, C.P. (2001). The Bayesian Choice: A Decision Theoretic Motivation, Second Edition, Springer Verlag, New York.

(iv) Advanced Survey Sampling Theory

Admissibility of estimators; Non-existence of UMV estimators; Estimation of median; Sampling on two or more successive occasions (Repetitive surveys); Resampling techniques for variance estimation- independent and dependent random groups, the Jackknife and the Bootstrap; Small-area estimation; Design-based conditional approach, Double sampling for stratification; Non-sampling errors; Non-response and missing data, Randomized response techniques for one quantitative sensitive characteristic.

Prediction of non-observed residuum under fixed (design-based) and super population (model-based) approaches; Model-assisted sampling strategies, different types of superpopulation models with optimal strategies based on them; Robustness against model failures.

References:

1. Cassel, C.M., Sarndal, C-E and Wretman, J.H. (1977). Foundations of Inference in Survey Sampling, Wiley Inter- Science.
2. Chaudhari, A. and Stenger, H. (2005). Survey sampling Theory and Methods, 2nd Edn., Chapman and Hall.
3. Hedayat, A.S. and Sinha, B.K. (1991). Design and Inference in Finite Population Sampling, Wiley Inter-Science.
4. Levy, P.S. And Lemeshow, S. (2008). Sampling of Populations-Methods and Applications, Wiley.
5. Mukhopadhyay, P. (1996). Inferential Problems in Survey Sampling, New Age International (P) Ltd.
6. Muhopadhyay, P. (2007). Survey Sampling, Nerosa Publishing House, New Delhi.
7. Sarndal, C-E, Swensson, B. and Wretman, J.H. (1992). Model Assisted Survey Sampling, Springer-Verlag.

8. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. (1984). Sampling Theory of Surveys with Applications, Iowa State university Press, Iowa, USA.
9. Wolter, K.M.(2007). Introduction to Variance Estimation, Springer-Verlag.

(v) Advanced Theory of Experimental Designs

Partially balanced incomplete block designs. Resolvable and affine resolvable designs. Dual and linked block designs. Lattice Designs. Construction of PBIB designs. Cross-over designs. General Theory of Fractional Factorial Experiments. Optimal designs- Various optimality criteria. Symmetric and asymmetric orthogonal arrays and their constructions. Robust Parameter designs. Response surface designs- orthogonality, rotatability and blocking. Weighing designs. Mixture Experiments.

References:

1. Chakrabarti, M.C. (1962). Mathematics of Design and Analysis of experiments, Asia Publishing House.
2. Cornell, John A. (2002). Experiments with Mixtures, John Wiley & Sons.
3. Das, M. N. and Giri, N. C. (1986). Design and Analysis of Experiments, Wiley Eastern Limited.
4. Dey, A. (1986). Theory of Block Designs, John Wiley & Sons.
5. Dey, A. and Mukerjee, R. (1999). Fractional Factorial Plans, John Wiley & Sons.
6. Hedayat, A. S., Sloane, N. J.A. and Stufken, J. (1999). Orthogonal Arrays: Theory and Applications, Springer.
7. Hinkelmann, K. and Kempthorne, O. (2005). Design and Analysis of Experiments, Vol. 2: Advanced Experimental Design, John Wiley & Sons.
8. Jones, B. and Kenward, M.G. (2003). Design and Analysis of Cross-over Trials. Chapman & Hall/CRC Press.
9. Montgomery, D. C. (2005). Design and Analysis of Experiments, Sixth Edition, John Wiley & Sons.
10. Myers, R. H. and Montgomery, D. C. (2002). Response Surface Methodology: Process and Product Optimization using Designed Experiments, John Wiley & Sons.
11. Raghavarao, D. (1970). Construction and Combinatorial Problems in Design of Experiments, John Wiley & Sons.
12. Wu, C. F. J. and Hamada, M. (2000). Experiments: Planning, Analysis and Parameter Design Optimization, John Wiley & Sons.

(vi) Advanced Statistical Computing and Data Mining

Random number generation: Review; Simulating multivariate distributions; Simulating stochastic processes. Variance reduction. Stochastic differential equations: introduction, Numerical solutions. Markov Chain Monte Carlo methods–Gibbs sampling; Introduction to simulated annealing. EM algorithm and applications. Smoothing with kernels: density estimation, choice of kernels.

Review of classification methods from multivariate analysis; classification and decision trees. Clustering methods from both statistical and data mining viewpoints; Vector quantization. Unsupervised learning; Supervised learning; Artificial neural networks: Introduction, multilayer perceptron network, self-organizing feature map and radial basis function network. Structural risk minimization, Introduction to support vector machine. Overview of current applications.

References:

1. Bishop, C.M. (1995). Neural Networks for pattern Recognition, Oxford University Press.
2. Duda, R.O., Hart, P.E. and Strok, D.G. Pattern Classification, 2^{nd} Edition, John Wiley & Sons.
3. Gentle, J.E., Härdle W. and Mori Y., (2004). Handbook of computational statistics — Concepts and methods, Springer-Verlag.
4. Han, J. and Kamber, M. (2000). Data Mining: Concepts and Techniques, Morgan Kaufmann.
5. Hand, David, Mannila, Heikki, and Smyth, Padhraic, (2001). Principles of Data Mining, MIT Press.
6. Haykin, S. Neural Networks-A Comprehensive Foundation, 2^{nd} Edition, Prentics Hall.
7. McLachlan, G.J. and Krishnan, T. (1997). The EM Algorithms and Extensions, Wiley.
8. Nakhaeizadeh, G. and Taylor G.C. (1997). Machine Learning and Statistics, John Wiley & Sons.
9. Pooch, Udo W. and Wall, James A. (1993). Discrete Event Simulation (A practical approach), CRC Press.
10. Rubinstein, R.Y. (1981). Simulation and the Monte Carlo Method, John Wiley & Sons.
11. Simonoff, J.S. (1996). Smoothing Methods in Statistics, Springer.

(vii) An elective from outside the Department (Course content as per the elective offered by the concerned Department).

Paper 405:- Practical – IV

Part A: Problem Solving using C language -II

Developing programs in C-language to analyse data from the following areas: Econometrics, Demography, Statistical Quality Control, Reliability Theory, Survival Analysis, Time Series and Forecasting.

Part B: Problem Solving using SPSS-II

Based on

(i) knowledge of Software

(ii) application of Software for data analysis in the following areas:
Econometrics, Demography, Statistical Quality Control, Reliability Theory, Survival Analysis, Time Series and Forecasting.