MAHATMA GANDHI UNIVERSITY

PRIYADARSINI HILLS

KOTTAYAM-686560

RESTRUCTURED SYLLABUS

FOR

POST-GRADUATE PROGRAM

IN

M.Sc STATISTICS

MAHATMA GANDHI UNIVERSITY
KOTTAYAM

REGULATIONS FOR CREDIT AND SEMESTER SYSTEM

Duration

The duration of PG program shall be 4 semesters. The duration of each semester shall be 90 working days. Odd semesters extend from June to October and even semesters from December to April. There will be one month semester breaks each in November and May. A student may be permitted to complete the program, on valid reasons, with in a period of 8 continuous semesters from the date of commencement of the first semester of the programs.

Program Structure

The program includes two types of courses namely Program Core courses and Program Elective Courses. In the fourth semester the colleges can choose 4 electives that will suit the needs of students there, from the electives specified in the syllabus. There shall also be a Program Project with dissertation to be undertaken by all students. Every Program conducted under Credit Semester System shall be monitored by the College Council.

Viva Voce

Comprehensive Viva-voce shall be conducted at the end semester of the program and it shall cover questions from all courses in the program.

Project work

Project work shall be completed by working outside the regular teaching hours under the supervision of a teacher in the concerned department. There should be an internal assessment and external assessment for the project work. The external evaluation of the Project work is followed by presentation of work including dissertation and Viva-Voce.

Examinations

There shall be University examination at the end of each semester. Project evaluation and Viva -Voce shall be conducted at the end of the program only. Project evaluation and Viva-Voce shall be conducted by two external examiners and one internal examiner.

There shall be one end-semester examination of 3 hours duration in each lecture based course and practical course. The examinations for which computers are essential should be conducted in the computer lab supervised by an external examiner appointed by the university.

Evaluation and Grading

Evaluation: The evaluation scheme for each course shall contain two parts; (a) internal evaluation and (b) external evaluation. 25% weightage shall be given to internal evaluation and the remaining 75% to external evaluation and the ratio and weightage between internal and external is 1:3. Both internal and external evaluation shall be carried out using direct grading system.

Internal evaluation: The internal evaluation shall be based on predetermined transparent system involving periodic written tests, assignments, seminars and attendance in respect of theory courses and based on written tests, lab skill/records/viva and attendance in respect of practical courses. The weightages assigned to various components for internal evaluation are as follows.

Components of Internal Evaluation

Component	**Weightage**
i) Assignment--------	1
ii) Seminar ----------	1
iii) Attendance --------	1
iv) Two Test papers—	2

Letter Grade	Performance	Grade Point(G)	Grade Range
A	Excellent	4	3.5 to 4.00
B	Very Good	3	2.5 to 3.49
C	Good	2	1.5 to 2.49
D	Average	1	0.5 to 1.49
E	Poor	0	0.0 to 0.49

Grades for Attendance

% of attendance	Grade
>90%	A
Between 85 and 90	B
Between 80 and below 85	C
Between 75 and below 80	D
< 75	E

To ensure transparency of the evaluation process, the internal assessment grade awarded to the students in each course in a semester shall be published on the notice board at least one week before the commencement of external examination. There shall not be any chance for improvement for internal grade.

A separate minimum of C Grade for internal and external are required for a pass for a course. For a pass in a program a separate minimum grade C is required for all the courses and must score a minimum CGPA of 1.50 or an overall grade of C and above. Each course is evaluated by assigning a letter grade (A, B, C, D or E) to that course by the method of direct grading. The internal (weightage =1) and external (weightage =3) components of a course

are separately graded and then combined to get the grade of the course after taking into account their weightages.

A student who fails to secure a minimum grade for a pass in a course will be permitted to write the examination along with the next batch. There will be no supplementary examination.

Assignments:

Every student shall submit one assignment as an internal component for every course. The Topic for the assignment shall be allotted within the 6th week of instruction.

Seminar Lectures

Every PG student shall deliver one seminar lecture as an internal component for every course. The seminar lecture is expected to train the students in self-study, collection of relevant matter from the books and Internet resources, editing, document writing, typing and presentation.

Class Tests

Every student shall undergo at least two class tests as an internal component for every course. The weighted average shall be taken for awarding the grade for class tests.

Attendance

The attendance of students for each course shall be another component of internal assessment. The minimum requirement of aggregate attendance during a semester for appearing the end semester examination shall be 75%. Condonation of shortage of attendance to a maximum of 10 days in a semester subject to a maximum of two times during the whole period of post graduate program may be granted by the University.

If a student represents his/her institution, University, State or Nation in Sports, NCC, NSS or Cultural or any other officially sponsored activities such as college union / university union activities, he/she shall be eligible to claim the attendance for the actual number of days participated subject to a maximum of 10 days in a Semester based on the specific recommendations of the Head of the Department and Principal of the College concerned. A student who does not satisfy the requirements of attendance shall not be permitted to take the end Semester examinations.

Mahatma Gandhi University, Kottayam, Kerala

Revised Syllabus of M.Sc. Statistics Program
Under Credit and Semester System (CSS) 2012

Course Code	Course Title	Credits	Teaching Hours
	Semester-I (Total credits-20)		
ST1C01	Distribution Theory	4	5
ST1C02	Analytical Tools for Statistics	4	5
ST1C03	Probability Theory	4	5
ST1C04	Mathematical Methods for Statistics	4	5
ST1C05	Statistical Computational Techniques	4	5
	Semester-II (Total credits-20)		
ST2C06	Multivariate Distributions	4	5
ST2C07	Advanced Probability Theory	4	5
ST2C08	Statistical Estimation Theory	4	5
ST2C09	Stochastic Processes	4	5
ST2C10	Statistical Computing-1	4	5
	Semester-III (Total credits-20)		
ST3C11	Sampling Theory	4	5
ST3C12	Statistical Testing of Hypotheses	4	5
ST3C13	Design and Analysis of Experiments	4	5
ST3C14	Multivariate Analysis	4	5
ST3C15	Statistical Computing-2	4	5
	Semester-IV (Total credits-20)		
ST4C16	Statistical Quality Control	3	5
ST4E--	Elective-1	3	5
ST4E--	Elective-2	3	5
ST4E--	Elective-3	3	5
ST4E--	Elective-4	3	5
ST4CD	Dissertation/Project		3
ST4CV	Viva-Voce		2

Total credits for the programme-80 credits

List of Electives Offered

1. E01: Econometric Methods
2. E02: Operations Research
3. E03: Statistical Reliability Analysis
4. E04: Population Dynamics
5. E05: Statistical Decision Theory
6. E06: Advanced Distribution Theory
7. E07: Time Series Analysis
8. E08: Statistical Computing-3

SYLLABI OF COURSES OFFERED IN SEMESTER I

ST1 C01: DISTRIBUTION THEORY

UNIT I

Quick review of basic concepts in distribution theory:- generating functions and properties, pgf, mgf, cumulant generating function and characteristic functions, factorial moments and recurrence relation, Discrete Distributions:- Power series, Binomial, Geometric, Poisson, Negative binomial and Hyper geometric.

UNIT II

Continuous Distributions:- Rectangular, Exponential, Weibull, Beta, Gamma, Pareto, Normal, Lognormal, Cauchy, Laplace, Logistic.

UNIT III

Functions of Random variables and their distributions using transformations of variables techniques. Distributions of sums, products and ratios of independent r.v.s, compound, truncated and mixture distributions.

UNIT IV

Sampling distributions:- Chi-square, t and F distributions (central only) Order statistics and their distributions:- joint and marginal distributions of sample median, range and mid – range (Exponential, Uniform, Logistic)

Text Books:

1. Hogg R.V and Craig A.T (1989) Introduction to Mathematical Statistics, Macmillian publishing company.
2. Arnold B.C, Balakrishnan N and Nagaraja H.N (1992) A first Course in Order Statistics.
3. Gupta S.C and Kapoor V.K (2000) Fundamentals of Mathematical Statistics, S. Chand & Co, New Delhi.

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. Kotz S, Balakrishnan N and Johnson N.L (2000) Continuous Multivariate distributions, John Wiley and sons.
4. Rohatgi V.K (1988) An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.
5. Mukhopadhaya P (1996) Mathematical Statistics, The New Central Book Agency.

ST1 C02: ANALYTICAL TOOLS FOR STATISTICS

UNIT I

Vector spaces, subspaces, linear independence of vectors, basis and dimension of a vector space, inner product and orthogonal vectors, Gram-Schmidt orthogonalization process, orthonormal basis, rank of a matrix, null space, partitioned matrices.

UNIT II

Linear equations, rank nullity theorem, characteristic roots and vectors, Cayley-Hamilton theorem, characteristic subspaces of a matrix, nature of characteristic roots of some special types of matrices, algebraic and geometric multiplicity of a characteristic root, generalized inverse, properties of g-inverse, Moore-Penrose inverse and its computations.

UNIT III

Quadratic forms, congruent transformations, congruence of symmetric matrices, canonical reduction and orthogonal reduction of real quadratic forms, nature of quadratic forms, simultaneous reduction of quadratic forms, similarity and spectral decomposition.

UNIT IV

Linear programming:- convex sets and associated theorems, introduction to linear programming problems (LPP), graphical solution, feasible, basic feasible and optimal basic feasible solutions to an LPP, theoretical development of simplex method, big-M method, two-phase simplex method, dual of linear programming, theorems of duality, dual-simplex method.

Text Books:

1. Shanti Narayan (1991) A text of book of matrices, S. Chand & Company, New Delhi
2. Graybill F. A. (1983) Matrices with applications in statistics, 2nd Ed. Wadsworth.
3. Biswas S. (1997) A text book of linear algebra, New age international.
4. Kanti Swaroop, Gupta P.K., et al, (1985) Operations Research, Sultan Chand & Sons.

Reference Books:

1. Rao C.R. (2002) Linear statistical inference and its applications, Second edition, Wiley Eastern.
2. Rao A.R. and Bhimasankaram P (1992) Linear Algebra, Tata McGraw Hill Publishing Company Ltd.
3. Sharma J.K. (2001) Operations Research: Theory and Applications, McMillan, New Delhi.

ST1 C03: PROBABILITY THEORY

UNIT I

Sequences and limit of sets, field, sigma field, measurable space, minimal sigma field, Borel field of R and of R^n, Random variables, vector random variables and limit of random variables.

UNIT II

Probability space, monotone and continuity property of probability measure , independence of finite number and sequence of events, Borel - Cantelli Lemma, Borel 0-1 law, conditional probability and Baye's Theorem for a finite number of events.

UNIT III

Distribution function:- properties - decomposition theorem, correspondence theorem (without proof), distribution function of vector random variables, mathematical expectation and properties, moments, basic, Markov, Jensen, Cr-inequalities.

UNIT IV

Convergence of random variables, convergence in probability, almost sure convergence, convergence in distribution, and convergence in r^{th} mean, properties and relations among them, independence of finite and sequence of random variables, weak and complete convergence of distributions, Helly-Bray lemma (statement only), Helly-Bray theorem (statement only).

Reference Books:

1. Bhat B.R (1981) Modern Probability theory, Wiley Eastern LTD, New Delhi.
2. Rohatgi V.K (1990) An introduction to probability theory and Mathematical statistics, Wiley Eastern ltd.
3. Billingsley P (1985) Probability and Measure, Wiley Eastern ltd.
4. Ash R.B (1972) Real Analysis and Probability, Academic press.
5. Laha R.G and Rohatgi V.K (1979) Probability theory, Van Nostrand.
6. Loeve M (1963) Probability Theory, Van Nostrand, Princeton.

ST1 C04: MATHEMATICAL METHODS FOR STATISTICS

UNIT I

Sequences and series, convergence, continuity, uniform continuity, differentiability. Functions of several variables: maxima and minima, Method of Lagrangian multipliers, Riemann integral, Laplace transform and its applications to differential equations.

UNIT II

Measurable space and sets, Measure and measure space, finite and σ finite measures. Counting measure, Lebesgue measure, Lebesgue- stieltjes measure and general measure, Measurable functions.

UNIT III

Lebesgue integral. General definition of integral of a measurable function and its elementary properties. Fatou's lemma. monotone convergence theorem, Lebesgue dominated convergence theorem.

UNIT IV

Algebra of complex numbers, Analytic functions, Cauchy-Riemann equations, contour integral, Cauchy's theorem (without proof), Cauchy's integral formula, Liouville's theorem, Maximum modulus principle, Zeroes of a function, singular point, different types of singularities, residues at a pole.

Text Books:

1. Apostol T.M. (1996) Mathematical Analysis, second Edition, Narosa Publishing House, New Delhi.
2. Churchill R.V (1975) Complex variables and applications, McGraw Hill.

Reference Books:

1. Andre's I. Khuri (1993) Advanced Calculus with applications in statistics. Wiley & sons.
2. Malik S.C & Arora S (2006) Mathematical analysis, second edition, New age international.
3. Pandey H.D, Goyal J. K & Gupta K.P (2003) Complex variables and integral transforms Pragathi Prakashan, Meerut.

ST1 C05: STATISTICAL COMPUTATIONAL TECHNIQUES

UNIT I

Solution to algebraic and transcendental equations:- Bisection Method, Iteration method, Regula -falsi method, Newton-Raphson method. Solution to Simultaneous linear equations:- Gauss elimination method, Gauss-Jordan methods, Jacobi's method, Gauss-Seidel method, solution to non-linear equations – Newton Raphson method.

UNIT II

Interpolation - Newtons forward interpolation formula, Lagrange's interpolation formula, Numerical integration- General Quadrature formula, Newton-Cotes formula, Trapeizoidal, Simpson's (1/3), Simpson's (3/8) and Weddle's formula, Romberg integration and errors in numerical integration formulas.

UNIT III

Monte Carlo methods, Random Number Generation- Basic principles of Random number generation, inversion method, accept-reject method, Random number generation from Uniform, Exponential, Cauchy, Normal, Beta, Gamma densities, Random number generation from Binomial, Poisson and Geometric.

UNIT IV

Introduction to statistical software R, Data objects in R, Manipulating vectors, matrices, lists, importing of files, data frame, and computations of descriptive statistics measures. R-Graphics- Histogram, Box-plot, Stem and leaf plot, Scatter plot, Plot options; Multiple plots in a single graphic window, frequency table, Plotting of probability distributions and sampling distributions, Controlling Loops- For, repeat, while, if , if else etc. Implementation of numerical methods in unit I, unit II and Unit III using R.

Reference Books:

1. Sastry S.S. (1998) Introductory methods of numerical analysis. Third edition, Printice Hall, New Delhi.
2. Mohanan J.F (2001) Numerical methods of statistics, Cambridge University Press.
3. Srimanta Pal (2009) Numerical Methods- Principles, Analysis and Algorithms. Oxford University Press.
4. Alain F. Zuur, Elena N. Ieno, and Erik Meesters (2009) A Beginner's Guide to R, Springer, ISBN: 978-0-387-93836-3.
5. Michael J. Crawley (2005) Statistics: An Introduction using R, Wiley, ISBN 0-470-02297-3.
6. Phil Spector (2008) Data Manipulation with R, Springer, New York, ISBN 978-0-387-74730-9.

7. Maria L. Rizzo (2008) Statistical computing with R, Chapman & Hall/CRC, Boca Raton, ISBN 1-584-88545-9.
8. Fishman G.S. (1996) Monte Carlo: Concepts, Algorithms, and Applications (Springer).
9. Purohit S.G., Gore S.D. and Deshmukh S.R. (2008) Statistics Using R. Narosa Publishing House, New Delhi.

SYLLABI OF COURSES OFFERED IN SEMESTER II

ST2 C06 MULTIVARIATE DISTRIBUTIONS

UNIT I

Bivariate normal distribution- marginal and conditional distributions, characteristic function. Bivariate exponential distribution of Marshall and Olkin - marginal distribution, characterstic function and lack of memory property. Multinomial distribution.

UNIT II

Multivariate distributions-Multivariate normal distribution (both singular and non-singular)- marginal and conditional distributions, properties and characterizations, estimation of mean and dispersion matrix. Independence of sample mean and sample dispersion matrix.

UNIT III

Jacobians of matrix transformations Y= AXB, Y=AXA', X= TT'. Matrix variate gamma and beta distributions, Wishart distribution, distribution of generalized variance.

UNIT IV

Quadratic forms of normal variables and vectors - Distribution of quadratic forms in normal variables (both scalar and vector quadratic forms), Cochran's theorem, Independence of quadratic forms. Simple, partial, and multiple correlation coefficients and their inter-relationships, tests, null and non-null distribution of simple and partial cases, null distribution of multiple correlation.

Reference Books:

Anderson T.W.(1984) An introduction to multivariate statistical analysis, second edn, John Wiley.

Seber G.A.F. (1983) Multivariate Observations, John Wiley.

Giri N.(1984) Multivariate statistical inference,Academic publishers.

Johnson And Kotz (1981) Distribution of Statistics- Multivariate, John Wiley.

Rao.C.R(1973) Linear statistical inference and its applications (2^{nd} Ed) Wiley Eastern ltd.

ST2 C07: ADVANCED PROBABILITY THEORY

UNIT I

Signed measure, Hahn and Jordan Decomposition theorems. Statement and applications of Radon – Nikodym Theorem (without proof), Lebesgue decomposition, Fubini's theorem (without proof), Probability space induced by a random variable, by a random vector, conditional expectation of a random variable, martingales, submartingles, super martingales, simple Properties of Martingales.

UNIT II

Characteristic function of a random variable, properties, uniform continuity and non-negative definiteness, statement of Bochner's Theorem, continuity and inversion theorems of characteristic functions, convex combinations of characteristic functions and distribution functions, characteristic function of a vector random variable.

UNIT III

Law of Large numbers, Weak Law of Large numbers of Bernoulli, Chebychev, Poisson and Khinchine, Kolmogrov strong law of large numbers for independent random variables- for i.i.d random variables, necessary and sufficient condition for weak law of large numbers.

UNIT IV

Central limit theorem, Demoivre-Laplace CLT, Lindberg -Levy and Liaponov CLT, Lindberg- Feller CLT (Without proof), domain of attraction and stable distributions.

Reference Books:

1. Bhat B.R (1981) Modern Probability theory, Wiley Eastern Ltd, New Delhi.
2. Rohatgi V.K (1990) An introduction to probability theory and Mathematical statistics, Wiley Eastern ltd.
3. Billingsley P (1985) Probability and Measure, Wiley Eastern Ltd.
4. Ash R.B (1972) Real Analysis and Probability, Academic press.
5. Laha R.G and Rohatgi V.K (1979) Probability theory, Van Nostrand.
6. Luckas E (1970) Characteristic functions, 2nd Edition, Hofna NewYork.
7. Parthasarathy K.R (1973) Introduction to Probability and Measure, Mac Millian.

ST2 C08: STATISTICAL ESTIMATION THEORY

UNIT I

Criteria for estimators - unbiasedness, consistency and efficiency, minimum variance, Fisher information, Cramer – Rao inequality, Bhattacharyya's bounds.

UNIT II

Sufficiency, completeness, bounded completeness, Fisher-Neymann factorization theorem, minimal sufficiency, exponential families, Rao- Black well theorem, Lehmann – Scheffe theorem, ancillary statistics, Basu's theorem.

UNIT III

Methods of estimation: method of moments, method of maximum likelihood & their properties, Fisher's scoring method, method of minimum chi-square and method of modified minimum chi-square, confidence intervals, shortest confidence intervals.

UNIT IV

Elements of decision theory, statistical decision problem, loss and risk functions, decision rule, estimation and testing as particular cases, prior and posterior distributions, Bayes estimator, admissible decision rules, non-randomized and randomized decision rules, bootstrap and Jackknife techniques (basic concepts only).

Reference Books:

1. Lehmann E.L. (1983) Theory of point estimation – Wiley, New York.

2. Rohatgi V.K. (1988) An introduction to probability theory and mathematical statistics, Wiley Eastern.

3. Hogg R. V. and Craig A. T. (1989) Introduction to Mathematical Statistics, Macmillan Publishing Company.

4. Kale B. K. (1999) A First Course on Parametric Inference, Narosa Publishing House.

5. Lindgren B.W (1976) Statistical Decision Theory (3rd Edition), Collier Macmillian, New York.

6. Rao C.R (1974) Linear Statistical Inference and its Applications, John Wiley, New York.

ST2 C09: STOCHASTIC PROCESSES

UNIT I

Introduction to stochastic processes:- classification of stochastic processes according to state space and time space, wide sense and strict sense stationary processes, processes with stationary independent increments, Markov process, Markov chains-transition probability matrices, Chapman-Kolmogorov equation, first passage probabilities, generating functions, classification of states, criteria for recurrent and transient states, mean recurrence time, mean ergodic theorem, the basic limit theorem of Markov chains (statement only), reducible and irreducible Markov chains, stationary distributions, limiting probabilities and absorption probabilities.

UNIT II

Random walk, gambler's ruin problem; Galton-Watson branching process, generating function relations, mean and variance functions, extinction probabilities, criteria for extinction.

UNIT III

Continuous time Markov chains, Poisson processes, pure birth processes and the Yule processes, birth and death processes, Kolmogorov forward and backward differential equations, linear growth process with immigration, steady-state solutions of Markovian queuing models--M/M/1, M/M/1 with limited waiting space, M/M/s, M/M/s with limited waiting space and M/G/1.

UNIT IV

Renewal processes– concepts, examples, Poisson process viewed as a renewal process, renewal equation, elementary renewal theorem, asymptotic expansion of renewal function, central limit theorem for renewals, key renewal theorem (statement only), delayed renewal processes.

Text Books:

1. Ross S.M. (2007) Introduction to Probability Models, Ninth edition, Academic Press.
2. Bhat B.R. (2002) Stochastic Processes, second edition, New Age Publication.

Reference Books:

1. Feller W. (1968) Introduction to Probability Theory and its Applications, Vols. I & II, John Wiley, New York.

2. Karlin S. and Taylor H.M. (1975) A First Course in Stochastic Processes, Second edition, Academic Press, New-York.

3. Cinlar E. (1975) Introduction to Stochastic Processes, Prentice Hall, New Jersey.
4. Medhi J. (1996) Stochastic Processes. Second Editions, Wiley Eastern, New-Delhi.

5. Basu A.K. (2003) Introduction to Stochastic Processes, Narosa, New-Delhi.

6. Bhat U.N. and Miller G. (2003) Elements of Applied Stochastic Processes. (Third edition), John Wiley, New York.

ST2 C10: STATISTICAL COMPUTING-1

Applications of topics covered in the following papers

1. ST1 C01: Distribution Theory
2. ST2 C06: Multivariate Distributions
3. ST2 C08: Statistical Estimation Theory
4. ST2 C09: Stochastic Processes

Here 6 numerical questions each having a weight of 10 are to be asked. The student is expected to answer 3 questions. At least one question from each of the above papers must be asked. Use of packages R and MS-Excel is allowed for answering the questions in this paper. Examination of 3 hour duration for this paper must be conducted in the computer lab under the supervision of an external examiner appointed by the University.

SYLLABI OF COURSES OFFERED IN SEMESTER III

ST3 C11: SAMPLING THEORY

UNIT I

Census and sampling methods, probability sampling and non-probability sampling, principal steps in sample surveys, sampling errors and non-sampling errors, bias, variance and mean square error of an estimator, simple random sampling with and without replacement, estimation of the population mean, total and proportions, properties of the estimators, variance and standard error of the estimators, confidence intervals, determination of the sample size.

UNIT II

Stratified random sampling, estimation of the population mean, total and proportion, properties of estimators, various methods of allocation of a sample, comparison of the precisions of estimators under proportional allocation, optimum allocation and srs. Systematic sampling – Linear and Circular, estimation of the mean and its variance. comparison of systematic sampling, srs and stratified random sampling for a population with a linear trend.

UNIT III

Ratio method of estimation, estimation of the population ratio, mean and total, first order approximate expression for bias, mse of ratio estimates, comparison with srs estimation. Unbiased ratio type estimators- Hartly- Ross estimator, regression method of estimation, first order approximate expression for bias and mse of linear regression estimators, large sample comparison with mean per unit estimator and ratio estimators, Cluster sampling, single stage cluster sampling with equal and unequal cluster sizes, estimation of the population mean and its standard error. Two- stage cluster sampling with equal and unequal cluster sizes, estimation of the population mean and its standard error.

UNIT IV

Unequal probability sampling, PPS sampling with and without replacement, cumulative total method, Lahiris method, Midzuno-Zen method, estimation of the population total and its estimated variance under PPS wr sampling, ordered and unordered estimators of the population total under PPS wor, Horwitz – Thomson estimator and its estimated S. E, Des-Raj's ordered estimator, Murthy's unordered estimator (properties of these estimators for n=2 only)

Text Books:

1. Cochran W. G. (1999) Sampling Techniques, 3rd edition, John Wiley and Sons.
2. Mukhopadyay P. (2009) Theory and Methods of Survey Sampling, 2nd edition, PHL, New Delhi.

Reference Books:

1. Singh D. and Choudhary F. S. (1986) Theory and Analysis of Sample Survey Designs, Wiley Eastern Ltd.
2. Des Raj (1967) Sampling Theory, Tata McGraw Hill, New Delhi.
3. Sampath S. C. (2001) Sampling Theory and Methods, Alpha Science International Ltd., India.

ST3 C12: STATISTICAL TESTING OF HYPOTHESES

UNIT I

Basic concepts in testing of hypothesis, randomized tests, Neymann- Pearson lemma and most powerful tests, monotone likelihood ratio (MLR) property, uniformily most powerful (UMP) tests, construction of uniformly most accurate (UMA) confidence intervals using UMP tests, uniformly most powerful unbiased (UMPU) tests, construction of uniformly most accurate unbiased (UMAU) confidence intervals using UMPU tests, Locally most powerful (LMP) and locally most powerful unbiased (LMPU) tests.

UNIT II

Similar regions tests, Neymann structure tests, likelihood ratio (LR) tests and their properties, LR tests for testing equality of mean and variance of two normal populations.

UNIT III

Sequential probability ratio tests (SPRT), Properties of SPRT, Construction of sequential probability ratio tests, Wald's fundamental identity, Operating characteristic (OC) function and Average sample number (ASN) functions.

UNIT IV

Non-parametric tests-- sign test, signed rank test, Chi-square tests, Kolmogorov-Smirnov one sample and two samples tests, median test, Mann- Whiteny U-test, Wilcoxon test, test for randomness, Wald–Wolfowitz run test for equality of distributions, Kruskall–Wallis one-way analysis of variance, Friedman's two-way analysis of variance.

Text Books:

1. Rohatgi V.K. (1976) An Introduction to Probability Theory and Mathematical Statistics, John Wiley & Sons, New York.
2. Manojkumar Srivastava and Namita Srivstava (2009) Statistical Inference: Testing of Hypothesis, Eastern Economy Edition, PHI Learning Pvt. Ltd., New Delhi.

References Books:

1. Gibbons J.K. (1971) Non-Parametric Statistical Inference, McGraw Hill.
2. Casella G. and Berger R.L. (2002) Statistical Inference, Second Edition Duxbury, Australia.
3. Lehman E.L. (1998) Testing of Statistical Hypothesis. John Wiley, New York.
4. Wald A. (1947) Sequential Analysis, Wiley, Doves, New York.
5. Dudewicz E.J. and Mishra S.N. (1988) Modern Mathematical Statistics, John Wiley & Sons, New York.
6. Siegel S. and Castellan Jr. N. J. (1988) Non-parametric Statistics for the Behavioral Sciences, McGraw Hill, New York.
7. Rao C.R. (1973) Linear Statistical Inference and its Applications, Wiley.

ST3 C13: DESIGN AND ANALYSIS OF EXPERIMENTS

UNIT I

Linear estimation: standard Gauss Markoff set up, estimability of parameters, method of least squares, best linear unbiased Estimators, Gauss – Mark off Theorem, tests of linear hypotheses.

UNIT II

Planning of experiments, Basic principles of experimental design, uniformity trails, analysis of variance, one-way, two-way and three-way classification models, completely randomized design (CRD), randomized block design (RBD) latin square design (LSD) and Graeco-latin square designs, Analysis of covariance (ANCOVA), ANCOVA with one concomitant variable in CRD and RBD.

UNIT III

Incomplete block design; balanced incomplete block design (BIBD); incidence Matrix, parametric relation; intrablock analysis of BIBD, basic ideas of partially balanced incomplete block design (PBIBD).

UNIT IV

Factorial experiments, 2^n and 3^n factorial experiments, analysis of 2^2, 2^3 and 3^2 factorial experiments, Yates procedure, confounding in factorial experiments, basic ideas of response surface designs.

Reference Books:

1. Aloke Dey (1986) Theory of Block Designs, Wiley Eastern, New Delhi.

2. DAS M.N. and GIRI N.C. (1994) Design and analysis of experiments, Wiley Eastern Ltd.

3. Joshi D.D. (1987) Linear estimation and Design of Experiments, Wiley Eastern.

4. Montgomery C.D. (1976) Design and Analysis of Experiments John Wiley, New York.

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

ST3 C14: MULTIVARIATE ANALYSIS

UNIT I

Likelihood ratio test, Hotelling's T^2 (one and two samples), Mahalanobi's D^2 statistic, Fisher-Behren problem, MANOVA (one way and two-way)

UNIT II

Dimension reduction methods, principal components, canonical correlation and variates, ,

profile analysis, factor analysis.

UNIT III

Classification problem, discriminant analysis, Bayes' procedures, Fishers approach, more than two groups, selection of variables. testing independence of sets of variates, tests for equality of dispersion matrices, sphericity test.

UNIT IV

Cluster analysis, proximity data, hierarchical clustering, non-hierarchical clustering methods.

Text Books:

1. Anderson T. W. (1984) An Introduction to Multivariate Statistical Analysis (2^{nd} ed.) John Wiley.

2. Johnson R.A. and Wichern D.W. (1990) Applied Multivatiate Statistical Analysis. Pearson education.

Reference Books:

1. Rencher,A. C. (1995) Methods of Multivariate Analysis. John Wiley.

2. Seber G. F. (1983) Multivariate Observations, John Wiley.

3. Rao C. R. (1973) Linear Statistical Inference and Its Applications (2^{nd} Ed.), Wiley Eastern Ltd.

ST3 C15: STATISTICAL COMPUTING-2

Applications of topics covered in the following papers

1. ST3 C11:Sampling Theory
2. ST3 C12: Statistical Testing of Hypotheses
3. ST3 C13: Design and Analysis of Experiments
4. ST3 C14: Multivariate Analysis

Here 6 numerical questions each having a weight of 10 are to be asked. The student is expected to answer 3 questions. At least one question from each of the above papers must be asked. Use of packages R and MS-Excel is allowed for answering the questions in this paper. Examination of 3 hour duration must be conducted in the computer lab under the supervision of an external examiner appointed by the University.

SYLLABI OF COURSES OFFERED IN SEMESTER IV

ST4 C16: STATISTICAL QUALITY CONTROL

UNIT I

Statistical process control, theory of control charts, Shewhart control charts for variables- $\bar{x}$, R, s charts, attribute control charts - p, np, c, u charts, modified control charts.

UNIT II

O.C and ARL curves of control charts, moving average control charts, EWMA charts, CUSUM charts, process capability analysis, process capability indices – C_p and C_{pk}.

UNIT III

Acceptance sampling for attributes, single sampling, double sampling, multiple sampling and sequential sampling plans, rectifying inspection plans, measuring performance of the sampling plans- OC, AOQ, ASN, ATI curves.

UNIT IV

Acceptance sampling plans by variables, designing a variable sampling plan with a specified OC curve, sampling plan for a single specification limit with known and unknown variance.

Text Books:

1. Montgomery D. C. (2005) Introduction to Statistical Quality control, 5^{th} edition, Wiley.
2. Grant E. L. and Leavenworth R. S. (1980) Statistical Quality control, McGraw Hill.

Reference books:

1. Duncan A. J. (1980) Quality control and Industrial Statistics, Irwin Homewood.
2. Schilling E. G. (1982) Acceptance Sampling in Quality Control, Marcel Decker.
3. Ott E.R. (1975) Process Quality Control, McGraw Hill.
4. Mittag H. J. and Rinne, H. (1993) Statistical Methods for Quality Assurance, Chapman and Hall.
5. Chin-knei Cho (1987) Quality Programming, John Wiley.

ST4 E01: ECONOMETRIC METHODS

UNIT I

Demand and supply functions, elasticity of demand, equilibrium of market, production functions- homogeneous functions, elasticity of production, input- output analysis, simple linear regression models.

UNIT II

Multiple linear regression models, estimation of the model parameters, tests concerning the parameters, confidence intervals, prediction, heteroscedasticity, tests, consequences, Multicollinearity- consequences, Farrar-Glauber test, remedial measures.

UNIT III

Aitken's generalized least square method, tests for auto correlation, consequences, and estimation procedures, stochastic regressors, errors in variables, use of Dummy variables in regression, polynomial regression models, logistic regression, step-wise regression.

UNIT IV

Simultaneous equation models, instrumental variables, recursive models, distributed- lag models identification problems, rank and order condition, methods of estimation- indirect least squares, least variance ratio and two-stage least squares, FIML- methods.

References Books:

1. Johnston J. (1984) Econometric Methods (Third edition), McGraw Hill, New York.

2. Montgomery D.C., Peck E.A. and Vining G.G. (2007) Introduction to Linear Regression Analysis, John Wiley, India.

3. Gujarati D (1979) Basic Econometrics, McGraw Hill.

4. Koutsoyiannis A (1979) Theory of Econometrics, Macmillian Press.

5. Apte P.G. (1990) Text book of Econometrics, Tata Me Graw Hill.

6. Theil H. (1982) Introduction to the Theory and Practice of Econometrics, John Wiley.

ST4 E02: OPERATIONS RESEARCH

UNIT I

Transportation problems, assignment problems, Sequencing problem, traveling salesmen problems, network analysis, GANTT, CPM, PERT.

UNIT II

Inventory models, deterministic inventory models, EOQ models with and without shortages, multi-item deterministic models with one linear constraint, EOQ problem with price breaks, probabilistic inventory models single period stochastic models without set up cost, general single period models.

UNIT III

Characteristics of dynamic programming and developing optimal decision policy using Bellman's principle of optimality, dynamic programming under certainty, single additive constraint-additives separable returns, single multiplicative constraint-additives separable return, single additive constraint multiplicatively separable return, dynamic programming approach for solving LPP, NLPP, quadratic programming, Kuhn -Tucker conditions, Wolfe's modified simplex method and Beale's method.

UNIT IV

Theory of games, two person zero-sum games, fundamental theorem of matrix games, dominance property, graphical method of solution of 2xn and mx2 games, Rectangular games as LPP.

Reference Books:

1. Ravindran A, Philips D.T and Soleberg, Operations Research – Principles and Practice, John Wiley and Sons.
2. J K Sharma Operations research – Theory and Applications Macmillan.
3. Frederick S Hiller and Gerala Jlieberman, Introduction to Operations Research Tata Mcgraw Hill.
4. Kanti Swarup, Gupta, Manmohan (2004) 10^{th} edition, Operations Research – Principles and Practice.
5. Thaha H A, Operations Research – An Introduction, Prentice Hall.
6. Mittal K.V (1983) Optimization methods in OR system analysis, Wiley Eastern.

ST4 E03: STATISTICAL RELIABILITY ANALYSIS

UNIT I

Basic concepts in reliability, series and parallel systems, k out of n systems and its reliability, coherent systems, reliability of coherent systems, cuts and paths, bounds on system reliability.

UNIT II

Life distributions; reliability function, hazard rate and mean residual life function, one-one correspondence of these functions, Study of life time models viz, exponential, Weibull, Lognormal, Pareto, Gamma, Makeham, Reliegh distributions, proportional hazard models and their characteristics.

UNIT III

Notions of ageing; increasing failure rate (IFR), increasing failure rate average (IFRA), new better than used (NBU), decreasing mean residual life (DMRL) and new better than used in expectation (NBUE), classes and their duals; loss of memory property of the exponential distribution, closures of these classes under formation of coherent systems, convolutions and mixtures.

UNIT IV

Reliability estimation using MLE - Exponential, Weibull and Gamma distributions based on censored and non-censored samples, Kaplan-Meier estimates of the distribution function, stress-strength reliability and its estimation.

Text Books:

1. Barlow R.E. and Proschan F. (1965) Mathematical Theory of Reliability, Wiley, New York.
2. Sinha S. K. (1986) Reliability and Life Testing, Wiley Eastern.

Reference Books:

1. Barlow R.E. and Proschan F. (1985) Statistical Theory of Reliability and Life Testing, Holt Rinehart and Winston, New York.
2. Rao S.S. (1992) Reliability-based design, McGraw Hill, New York.
3. Lai C.D and Xie M. (2006) Stochastic ageing and dependence in reliability, Springer.

ST4 E04: POPULATION DYNAMICS

UNIT I

Sources of mortality data-mortality measures-ratios and proportions, crude mortality rates, specific rates- standardization of mortality rates, direct and indirect methods, gradation of mortality data, fitting Gompertz and Makeham curves.

UNIT II

Life tables-complete life table-relation between life table functions, abridged life table-relation between abridged life table functions, construction of life tables, Greville's formula, Reed and Merrell's formula- sampling distribution of life table functions, multivariate pgf –estimation of survival probability by method of MLE.

UNIT III

Fertility models, fertility indices-relation between CBR,GFR,TFR and NRR stochastic models on fertility and human reproductive process, dandekar's modified binomial and Poisson models, Brass, Singh models-models for waiting time distributions, Sheps and Perrin model.

UNIT IV

Population growth indices, logistic model, fitting logistic, other growth models, Lotka's stable population, analysis, quasi stable population, effect of declining mortality and fertility on age structure, population projections, component method-Leslie matrix technique, properties of time independent Leslie matrix-models under random environment

Text Books:

1. Biswas S (1988) Stochastics processes in Demography and applications, Wiley Eastern.
2. Biswas S (2007) Applied Stochastic Processes-A Biostatistical and Population Oriented Approach (2^{nd} edn), New Central Book Agency.

Reference Books:

1. Keyfitz N (1977) Applied Mathematical Demography A Wiley Interscience publication.
2. Pollard J.H (1975) Mathematical Models for the growth of Human population, Cambridge University Press.
3. Ramkumar R (1986) Technical Demography, Wiley Eastern.
4. Srinivasan K (1970) Basic Demographic Techniques and Applications.

ST4 E05: STATISTICAL DECISION THEORY

UNIT I

Basic elements of a decision problem, randomized and non-randomized decision rules, loss and risk functions, utility functions, axiomatic development and construction of utility functions.

UNIT II

Bayes approach to inference and decisions, Normal and extensive forms of analysis, loss function. Finite action problems and tests of hypothesis.

UNIT III

Ideas of subjective probability, prior and posterior distributions, determination of prior distributions, natural conjugate priors, prior-posterior analysis for Bernoulli, Poisson and normal processes, improper priors, estimation and testing using improper prior in normal samples.

UNIT IV

Mini max principle, basic elements of game theory, general techniques of solving games, mini-max estimation for normal and Poisson means, admissibility of decision rules, general theorems on admissibility.

Text Books:

1. James O Berger (1980) Statistical Decision Theory and Bayesian Analysis, Springer Verlag .
2. De Groot M.H (1970) Optimal Statistical Decisions, John Wiley.
3. Raaiffe H. and Schlaiffer R (2000) Applied Statistical Decision Theory, M.T.Press.

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. Wald A (1950) Statistical Decision Functions – Wiley.

ST4 E06: ADVANCED DISTRIBUTION THEORY

UNIT I

Pearson system of curves, properties, extensions, Fitting of curves, estimation of parameters, Johnson system, Burr systems, Edgeworth series, Gram Charlier series.

UNIT II

Characterization of probability distribution, Exponential and Geometric law, lack of memory property, Normal law – characterization based on independence of linear forms and quadratic forms and regression.

UNIT III

Power series and contagious distribution. GPSD, Hyper Poisson family of derived distribution derived from Poisson and other generalization.

UNIT IV

Non – parametric density estimation , Kernel density estimation, Bootstrap and M-estimation.

Reference Books:

1. Johnson N.L . and Kotz S Distribution in statistics (Vol. 1,2 & 3) John Wiley.
2. Kagan A.M. and Linnik Y.V.& Rao C.R. Characterization problems in mathematical statistics.
3. Kendall M.G. Advanced theory of statistics (Vol.I)

ST4 E07: TIME SERIES ANALYSIS

UNIT I

Time series, components of time series, additive and multiplicative models, determination of trend, analysis of seasonal fluctuations, test for trend and seasonality, exponential and moving average smoothing, holt-winter smoothing, forecasting based on smoothing.

UNIT II

Time series as a discrete parameter stochastic process, auto covariance and auto correlation functions and their properties, stationary processes, test for stationarity, unit root test, stationary processes in the frequency domain, spectral analysis of time series.

UNIT III

Detailed study of the stationary processes: moving average (MA), autoregressive (AR), autoregressive moving average (ARMA) and autoregressive integrated moving average (ARIMA) models.

UNIT IV

Estimation of ARMA models, maximum likelihood method (the likelihood function for a Gaussian AR(1) and a Gaussian MA(1)) and Least squares, Yule-Walker estimation for AR Processes, choice of AR and MA periods, forecasting, residual analysis and diagnostic checking.

Text Books:

1. Chatfield C. (2004) The Analysis of Time Series - An Introduction (Sixth edition), Chapman and Hall.
2. Abraham B. and Ledolter J.C. (1983) Statistical Methods for Forecasting, Wiley.

Reference Books:

1. Brockwell P.J and Davis R.A. (2002) Introduction to Time Series and Forecasting (Second edition), Springer-Verlag.
2. Box G.E.P and Jenkins G.M. (1970) Time Series Analysis, Forecasting and Control, Holden-Day.
3. Kendall M.G. (1978) Time Series, Charler Graffin.

ST4 E08: STATISTICAL COMPUTING-3

Applications of topics covered in the following papers

1. ST4 C16: Statistical Quality Control
2. ST4 E 01: Econometric Methods
3. ST4 E 02: Operations Research

Here 6 numerical questions each having a weight of 10 are to be asked. The student is expected to answer 3 questions. At least one question from each of the above papers must be asked. Use of packages R and MS-Excel is allowed for answering the questions in this paper. Examination of 3 hour duration must be conducted in the computer lab under the supervision of an external examiner appointed by the University.

ST4 CD
Dissertation/Project

ST4 CV
Viva-voce