University of Rajasthan
Jaipur

SYLLABUS

M.A/M.SC. STATISTICS

(Semester Scheme)

I/II Semester Examination 2018-19
III/IV Semester Examination 2019-20

Scheme of Examination:

Part-I (Course and Internal Assessment)

- The student will require to earn minimum 120 credits out of total 144 credits, in four semesters, for PG degree.
- Each student has to earn minimum 30 credit per semester (i.e. 120 credits in four semester for PG degree).
- Each semester of PG courses shall have 36 credits. There will be three core papers and three elective papers (4 credits each) and one core laboratory and one elective laboratory (6 credits each).
- Core papers (Theory and Practical) are compulsory papers for the students of MA/MSc.(Statistics).
- In theory papers, 15 hrs of contact classes is equal to one credit.
- In practical, 45 hrs of laboratory work is equal to 2 credits.
- Each semester will have continuous assessment (CA). The continuous assessment (CA) consists of two parts, namely (i) Internal Assessment and (ii) Sessional Test(s) in the ratio 30:70. The Internal Assessment component comprises of assessment of student's performance on the basis of factors like Attendance, Class Room Participation, Quiz, Home Assignment etc.

Part-II (Examination Pattern)

- Each theory paper EoSE shall carry 100 marks.
- The EoSE will be of 3 (Three) hrs duration for each theory paper and 4hrs duration for each practical paper.
- Part A of theory paper shall contain 10 (ten) Short Answer Questions, covering entire syllabus and each question will carry 2 (two) marks i.e. part A will be of total 20 marks.
- Part B of the Question Paper will consist of Four (04) questions with internal choice and weightage of 20 marks each. i.e. total of 80 marks.
- Each laboratory EoSE will be of four hours duration and involve laboratory experiments/ exercises, and viva- voce examination with weightage in the ratio of 75:25 (i.e. 15% for record and 10% for viva.)

Abbreviations Used

Course Category
CCC: Compulsory Core Course
ECC: Elective Core Course
OEC: Open Elective Course
SC: Supportive Course
SSC: Self Study Core Course
SEM: Seminar
PRJ: Project Work
RP: Research Publication

Contact Hours
L: Lecture
T: Tutorial
P: Practical or Other
S: Self Study

Relative Weights
IA: Internal Assessment (Attendance/ Classroom Participation/Quiz/Home Assignment etc.)

ST: Sessional Test
EoSE: End of Semester Examination

Course Structure: The details of the courses with code, title and the credits assigned are as given below

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Semester Wise Course Plan

Semester	Paper	Paper Number	Nomenclature	Max. Marks	Duration of Exam
I	Core Theory	MST 101	Statistical Mathematics	100	3 Hours
		MST 102	Probability Theory	100	3 Hours
		MST 103	Probability Distributions	100	3 Hours
	Elective Theory	MST A01	Statistical Computing with C	100	4 Hours
		MST A02	Official Statistics	100	3 Hours
		MST A03	Statistical Quality Control	100	4 Hours
	Core Lab	MST PC1	Practical based on Core papers (MST 101 & MST 103)	100	4 Hours
	Elective Lab	MST PE1	Practical based on Elective papers	100	4 Hours
II	Core Theory	MST 201	Sampling Distributions	100	3 Hours
		MST 202	Statistical Inference-I	100	3 Hours
		MST 203	Design of Experiment-I	100	3 Hours
	Elective Theory	MST B01	Demography	100	3 Hours
		MST B02	Applied Statistics	100	3 Hours
		MST B03	Operation Research-I	100	3 Hours
	Core Lab	MST PC2	Practical based on MST 201, MST 202 and MST 203	100	4 Hours
	Elective Lab	MST PE2	Practical based on Elective papers	100	4 Hours
III	Core Theory	MST 301	Design of Experiment-II	100	3 Hours
		MST 302	Statistical Inference-II	100	3 Hours
		MST 303	Sample Surveys-I	100	3 Hours
	Elective Theory	MST C01	Econometrics	100	3 Hours
		MST C02	Numerical Analysis	100	3 Hours
		MST C03	Operation Research-II	100	3 Hours
	Core Lab	MST PC3	Practical based on MST 301, MST 302 and MST 303	100	4 Hours
	Elective Lab	MST PE3	Practical based on Elective Papers	100	4 Hours

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Semester	Paper	Paper Number	Nomenclature	Max. Marks	Duration of Exam
IV	Core Theory	MST 401	Multivariate Analysis	100	3 Hours
		MST 402	Sample Surveys-II	100	3 Hours
		MST 403	Project Work	100	3 Hours
	Elective Theory	MST D01	Measure Theory	100	3 Hours
		MST D02	Basic Statistics*	100	3 Hours
		MST D03	Stochastic Process	100	3 Hours
	Core Lab	MST PC4	Practical based on Core Papers MST 401, MST 402.	100	4 Hours
	Elective Lab	MST PE4	Statistical Computing with R and SPSS**	100	4 Hours

*: Only for Non Statistics Students

**: Non-Statistics Students may opt for this elective lab(MST PE4) if they have opted for Elective Theory paper MST D02.

Extra Elective Papers

Semester	Paper	Paper Number	Nomenclature	Max. Marks	Duration of Exam
IV	Extra Electives	MST D04	Reliability Theory	100	3 Hours
		MST D05	Survival Analysis	100	3 Hours
		MST D06	Statistics for Clinical Trials	100	3 Hours

Instructions to students:

1. Non Statistics Students may opt for Elective paper MST D04 (Statistical Computing with R and SPSS) if they have opted for elective paper MST D02.
2. Scheme for class room study, Internal Assessment and End of Session Examination (ESoS) for these Extra Elective Papers (MST D04,MST D05,MST D06) will be same as that of other elective papers, mentioned in Table of Semester IV above.

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First Semester

S. No.	Subject Code	Course Title	Course Category	Credit	Contact Hours Per week			EoSE Duration (Hrs.)	
					L	T	P	Thy.	P
01	MST 101	Statistical Mathematics	CCC	4	4	0	0	3	0
02	MST 102	Probability Theory	CCC	4	4	0	0	3	0
03	MST 103	Probability Distributions	CCC	4	4	0	0	3	0
04	MST A01	Statistical Computing with C	ECC	4	4	0	0	3	0
05	MST A02	Official Statistics	ECC	4	4	0	0	3	0
06	MST A03	Statistical Quality Control	ECC	4	4	0	0	3	0
07	MST PC1	Practical based on Core papers(MST 101 & MST 103)	CCC	6	0	0	9	0	4
08	MST PE1	Practical based on Elective papers	ECC	6	0	0	9	0	4
		Total Credit		36	24		12	-	-

Second Semester

S. No.	Subject Code	Course Title	Course Category	Credit	Contact Hours Per week			EoSE Duration (Hrs.)	
					L	T	P	Thy.	P
01	MST 201	Sampling Distributions	CCC	4	4	0	0	3	0
02	MST 202	Statistical Inference-I	CCC	4	4	0	0	3	0
03	MST 203	Design of Experiment-I	CCC	4	4	0	0	3	0
04	MST B01	Demography	ECC	4	4	0	0	3	0
05	MST B02	Applied Statistics	ECC	4	4	0	0	3	0
06	MST B03	Operation Research - I	ECC	4	4	0	0	3	0
07	MST PC2	Practical based on MST 201,MST 202 and MST 203	CCC	6	0	0	9	0	4
08	MST PE2	Practical based on Elective Papers	ECC	6	0	0	9	0	4
		Total Credit		36	24		12		

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Third Semester

S. No.	Subject Code	Course Title	Course Category	Credit	Contact Hours Per week			EoSE Duration (Hrs.)	
					L	T	P	Thy.	P
01	MST 301	Design of Experiment-II	CCC	4	4	0	0	3	0
02	MST 302	Statistical Inference-II	CCC	4	4	0	0	3	0
03	MST 303	Sample Surveys-I	CCC	4	4	0	0	3	0
04	MST C01	Econometrics	ECC	4	4	0	0	3	0
05	MST C02	Numerical Analysis	ECC	4	4	0	0	3	0
06	MST C03	Operation Research-II	ECC	4	4	0	0	3	0
07	MST PC3	Practical based on MST 301 MST 302and MST 303	CCC	6	0	0	9	0	4
08	MST PE3	Practical based on Elective papers	ECC	6	0	0	9	0	4
			Total Credit	36	24		12		

Fourth Semester

S. No.	Subject Code	Course Title	Course Category	Credit	Contact Hours Per week			EoSE Duration (Hrs.)	
					L	T	P	Thy.	P
01	MST 401	Multivariate Analysis	CCC	4	4	0	0	3	0
02	MST 402	Sample Surveys-II	CCC	4	4	0	0	3	0
03	MST 403	Project Work	CCC	4	4	0	0	3	0
04	MST D01	Measure Theory	ECC	4	4	0	0	3	0
05	MST D02	Basic Statistics*	ECC	4	4	0	0	3	0
06	MST D03	Stochastic Process	ECC	4	4	0	0	3	0
07	MST PC4	Practical based on MST 401 & MST 402	CCC	6	0	0	9	0	4
08	MST PE4	Statistical Computing with R and SPSS**	ECC	6	0	0	9	0	4
			Total Credit	36	24		12		

*: Only for Non Statistics Students.

**: Non-Statistics Students may opt for this elective lab(MST PE4) if they have opted for Elective Theory paper MST D02.

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Additional Electives for Fourth Semester*

Semester	Paper	Paper Number	Nomenclature	Max. Marks	Duration of Exam
IV	Extra Electives	MST D04	Reliability Theory	100	3 Hours
		MST D05	Survival Analysis	100	3 Hours
		MST D06	Statistics for Clinical Trials	100	3 Hours

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Semester I

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MST 101: Statistical Mathematics

Linear Algebra: Inverse and rank of a matrix, solution of linear equations, orthogonal matrix, orthogonal reduction of a real symmetric matrix to a diagonal form, generalized inverse and its simple properties, idempotent and nilpotent matrices, solutions of matrix equations.

Bilinear and quadratic forms, reduction to canonical forms, definite, semi-definite and indefinite forms, index and signature, triangular reduction of a positive definite matrix, Hermitian canonical form, characteristic equation, its roots and vectors, Cayley-Hamilton theorem.

Real Analysis: Real valued functions, limit, continuous function, differentiability of a function ; Rolle' s theorem, Lagrange's mean value theorem, Canchy's ean value theorem , maxima-minima of functions, maxima-minima of a function of two independent variables, Lagrange's method of undetermined multipliers.

Differentiation under the sign of Integration, Multiple integrals, Transformation of Multiple Integrals, Dirichlets theorem, Liouville's Extension of Dirichlet's theorem. , Beta and Gamma integrals.

References:

1. Apostol, T.M. (1985): Mathematical Analysis, Narosa Publishing House.
2. Burkill,J.C.(1980):A first Course in Mathematical Analysis, Vikas Publishing House.
3. Courrat, R.and John, F. (1965): Introduction to Calculus and Analysis, John Wiley.
4. Khuri,A.I(1983): Advanced Calculus with Applications in Statistics, John Wiley.
5. Miller,K.S.(1957): Advanced Real Calculus, Harper, New York.
6. Searle, S.R.(1982): Matrix Algebra Useful for Statistics, John Wiley.
7. Shanti Narayan,(1998):A Textbook of Matrices , S. Chand & Co

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MST 102: Probability Theory

Probability space, various definitions of probability. Combinations of events: additive and multiplicative laws of probability. Conditional probability. Bayes theorem and its applications.

Concept of random variables, cumulative distribution function and probability functions, joint, marginal and conditional distributions. Functions of random variables and their distributions using Jacobian of transformation for one and two variables.

Mathematical expectation, conditional expectation, moments, moment generating functions, cumulative generating functions and their applications, Characteristic function, Inversion uniqueness and continuity theorems. Chebyshev, Markov and Johnson. Probability inqualities and their applications.

Convergence in probability, Convergence in distribution. Weak law of large numbers. Central limit theorem for a sequence of independent random variables under Lindeberg's condition, central limit theorem for independent and identically distributed random variables with finite variance.

Sequence of events and random variables: Borel 0-1 law, Kolmogorov's 0-1 law,. Law of large numbers and central limit theorems for independent variables. Kintchin's weak law of large numbers, Tchebycheff's and Kolmogorov's inequalities and strong law of large numbers. Martingales.

Reference:

1. Kingman J.F. & Taylor.S.J. (1996): Introduction to Measure and Probability, Cambridge Univ.Press.
2. Loeve (1996): Probability Theory Affiliated East –West Press Pvt. Ltd. New Delhi.
3. Bhatt, B.R.(2000): Probability, New Age International India.
4. Feller,W.(1971): Introduction to Probability Theory and its Applications, Vol. I and II. Wiley, Eastern-Ltd.
5. Rohatgi, V.K (1984): An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.
6. Billingsley, P. (1986): Probability and Measure, John Wiley Publications.
7. Dudley, R.M. (1989): Real Analysis and Probability, Worlds Worth & Books.
8. Tucket H.G. (1967): A Graduate Course in Probability; Academic Press.
9. Basu, A.K. (1999): Measure Theory and Probability, PHI.

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MST-103 : Probability Distributions

Measures of location, dispersion, Skewness and Kurtosis, Moments, Sheppard's correction, moment and cumulant generating functions, probability generating function.

Bernoulli, Binomial (compound and truncated also), Poisson (compound and truncated also), negative binomial, geometric, Hyper-geometric and multinomial distributions.

Rectangular, Normal (truncated also), Exponential, Lognormal and Triangular distributions.

Gamma, Beta, Cauchy (truncated also), Laplace distributions, Pearson's distributions (Type I, IV and VI).

References:

1. Goon, Gupta & Das Gupta, (1991): Outline of Statistical Theory. Vol. I & Vol. II World Press.
2. Hogg, R.V. and Craig, A.T.(1971): Introduction to Mathematical Statistics, McMillan.
3. Johnson, S. and Kotz. (1972): Distribution in Statistics, Vol.I, II. And III, Houghton and Muffin.
4. Kendall, M.G.and Stuart. (1996): An Advanced Theory of Statistics, Vol. I,II. Charls Griffin.
5. Mood,A.M., Graybill, F.A. and Boes. D.C.(1974): Introduction to the Theory of Statistics, McGraw Hill.
6. Mukhopadhyay, P. (1996): Mathematical Statistics, New Central Book Agency (P) Ltd.
7. Rohatgi, V.K. (1984): An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.
8. Johnson, S. and Kotz. (1972): Distribution in Statistics, Vol.I, II and III, Houghton and Muffin.

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MST A01: Statistical Computing with C

Basics of C: Components of C language, structure of a C program, Data type, basic Data types, Enumerated data types, Derived data types, Variables. Variable declaration, Operators. Type modifiers and expressions. Basic input/output. Control statements: conditional statements, loops, goto and label declarations, break, continue, exit(). Arrays.

Storage classes: Automatic variables, External variables, Static variables, Scope and lifetime of declarations. Functions: classification of functions, functions definition and declaration, assessing a function, return statement, parameter passing in functions.

Pointers (concept only). Structure: Definition and declaration; structure (initialization) comparison of structure variable; Array of structures: array within structures, structures within structures, passing structures to functions; Unions accessing a union member, union of structure, initialization of a union variable, uses of union. Introduction to linked list, linear linked list, insertion of a node in list, removal of a node from list.

Files in C: Defining and opening a file, input– output operation on a file, creating a file, reading a file. Statistics Methods and Techniques in R. Introduction to SPSS, Data Entry, Data Analysis and Statistical Tests.

References:

1. Balaguruswamy, E.(2009): Programming in ANSI C ,Tata McGraw Hill Education Pvt. Ltd., Delhi
2. Kamthane, Ashok(2014): Programming with ANSI and Turbo C, Pearson Education, N.Delhi.
3. Somashekera, N.T: Programming in C,PHI Learning Pvt.Ltd. New Delhi.
4. Somashekera, N.T: Problem Solving with C, PHI Learning Pvt.Ltd. New Delhi.

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MST A02: Official Statistics

National and International official statistical system: Official Statistics (a) Need, Uses, Users, Reliability, Relevance, Limitations, Transparency, its visibility (b) Compilation, Collection, Processing, Analysis and Dissemination of records. Agencies Involved, Methods.

National Statistical Organization: Vision and Mission, NSSO and CSO; roles and responsibilities; Important activities, Publications. National Statistical Commission: Need, Constitution, its role, functions. Legal Acts/ Provisions/ Support for Official Statistics; Important Acts.

Sector Wise Statistics: Agriculture, Health, Education, Women and Child etc. Important Surveys & Census, Indicators, Agencies and Usages etc. National Accounts: Definition, Basic Concepts; issues; the Strategy. Collection of Data and its Release.

Population Census: Need, Data Collected, Periodicity, Methods of data collection, dissemination, Agencies involved. Socio-Economic Indicators, Gender Awareness/ Statistics, Important Surveys and Censuses.

1. Kaul,R. & Chawdhury.: Applied Statistics, Indian Official Statistics (free downloadable).
2. Saluja,M.R.(1972) : Indian official statistical systems, Statistical Pub. Society,India
3. Asthana,B.N. & Shrivastav,S.S.(1960); Applied Statistics of India, Chaitanya Publishing House, India
4. Reports od MOSPI,CSO etc.

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MST A03: Statistical Quality Controls

Basic Concepts of Statistical Process and Product Control. Need for Quality Control. Objectives of SQC. Concepts of Process monitoring, control, process capability and process optimization and Product Control.

General Theory of Control Charts, Causes of Variation in Quality, Control Limits, Sub-Grouping. Control-Charts: Concept and construction of control charts for variables and attributes and their OC Curve. Modified control limits. A.R.L. of control charts; control by gauging; moving average and exponentially weighted moving average charts; Cu-Sum charts using V-masks and decision intervals; Economic design of X-bar chart

Acceptance Sampling Plans by Attribute: AQL, AOQL, Producer's Risk and Consumer Risk. Rectification and their O.C. function, ASN and ATI . Single and double sequence sampling plans and their mathematical analysis.

Idea of Standard sampling tables: Dodge and Romig tables. Sampling Inspection Plans for Variables (single, double, multiple and sequential) One sided specification standard (Known and Unknown Cases), two sided specifications (for known standards).

REFERENCES

1. Montgomery, D.C.: Introduction of Statistical Quality Control, John Wiley & Sons, Inc., 6th edition (2009).
2. Chandra, M.Jeya: Statistical Quality Control,CRC Press(2001).
3. Mahajan,M.: Statistical Quality Control, Dhanpat Rai and Co.Delhi (2009)
4. Burr, John T.: Elementary Statistical Quality Control, 2nd Edition, Statistics: A Series of Textbooks and Monographs by Marcel Dekker, CRC Press.(2004)

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MST-PC1 (Practical Paper Based on MST 101, MST 103))

List of Practical

(MST 101)

1. Determinants - by row and column operations, by partitioning.
2. Inverses of a matrix - by row and column operations, by partitioning
3. Rank of a matrix
4. Solutions of matrix equations
5. Characteristic roots and vectors of a matrix.

(MST 103)

1. Coefficient of variation.
2. Calculation of central moments, coefficient of variation, β_1, β_2 and γ_1, γ_2 coefficients, Sheppard's correction to moments.
3. Plot binomial curve for different values of n and p
4. Fitting of binomial distributions , Poisson distribution, Negative Binomial distribution and Normal distribution

MST-PE1 (Practical Paper Based on Elective Papers)

MST A01: Statistical Computing with C

1. Practical based on Conditional Statements
2. Practical based on Loops Statements
3. Practical based on Structures and Unions.
4. Solving Statistical Problems with C Programming.

MST A03: Statistical Quality Control

1. Control charts for variables

(i) $\bar{x}$ & R charts with known parameters.
(ii) $\bar{x}$ & R charts with unknown parameters.
(iii)$\bar{x}$ & s charts with known parameters.
(iv)$\bar{x}$ & s charts with unknown parameters.

2 Control Charts for Attributes

i. C - charts with known & unknown parameters.
ii. p - charts with known & unknown parameters.
iii. np - charts with known & unknown parameters.
iv. 100 np - charts with known & unknown parameters.

3. Control charts for varying sample size.

4. Draw O.C. ASN and AOC curves of :

(i) Single sampling Plan
(ii)Double sampling Plan

5. Find producer's risk and consumer's risk

6. Construction of single sample plan.

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Semester II

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MST 201: Sampling Distributions

Sampling Distributions: Basic concepts, standard error, Chi-Square, t and F distributions (central and non-central) and their applications. Fisher's Z-distribution and its applications.

Standard errors of functions of moments. Order statistics: their distributions and properties; joint and marginal distributions of order statistics, sampling distributions of range and median of univariate population.

Bivariate Normal Distribution: Joint, marginal and conditional distributions and their properties.

Correlation, linear regression, intra-class correlation and correlation ratio. Null and non-null distribution of sample correlation coefficient. Power series distribution.

References:

1. Arnold, B.C. Balakrishnan, N. and Nagaraja,H.N.(1992): A First Course in Order statistics, Wiley.
2. Goon, Gupta & Das Gupta (1991): Outline of Statistical Theory, Vol.I ,World Press.
3. Hogg,R.V. and Craig,A.T.(1971): Introduction to Mathematical Statistics, McMillan.
4. Jonson, S. and Kotz,S. (1972): Distribution in Statistics, Vol.I,II and III, Houghton and Muffin.
5. Kendall, M.G.and Stuart,A. (1996): An Advanced Theory of Statistics, Vol.I,II. Charles Griffin.
6. Mood,A.M., Graybill,F.A. and Boes, D.C.(1974): Introduction to the Theory of Statistics, McGraw Hill.
7. Mukhopadhyay P.(1996):Mathematical Statistics , New central Book Agency(P)Ltd. Calcutta.
8. Rao, C.R. (1973): Linear Statistical Inference and its Applications,2/e, Wiley Eastern,
9. Rohatgi, V.K. (1984): An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.

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MST 202: Statistical Inference-I

Point estimation, criteria of a good estimator: unbiascdness, consistency, efficiency and sufficiency. Fisher Neyman factorization theorem, Cramer-Rao inequality, Bhattacharyra Bounds, Rao-Blackwell theorem, uniformly minimum variance unbiased estimator (UMVUE).

Methods of Estimation: Maximum likelihood method, moments, minimum Chi-square and modified minimum Chi-square methods. Properties of maximum likelihood estimator (with proof). Confidence intervals: Determination of confidence intervals based on large samples & small samples. Statistical Hypothesis: Simple and composite, critical region, types of errors, level of significance ,power of a test, most powerful test and Neyman-Pearson lemma.

Sequential Analysis: Definition and construction of S.P.R.T. Fundamental relation among α, β,A and B. Wald's inequality. Determination of A and B in practice. Average sample number and operating characteristic curve.

Non-Parametric Tests: Sign tests, signed rank test, Kolmogorov-Smirnov one sample test. General two sample problems: Wolfowitz runs test, Kolmogorov Smirnov two sample test (for sample of equal size), Median test, Wilcoxon-Mann-Whitney test. Test of randomness using run test based on the total number of runs and the length of a run. Kruskal-Wallis k-samplet Test. Concept of asymptotic relative efficiency(ARE).

Reference:

1. Cramer, H.(1946) : Mathematical methods of Statistics, Princeton University Press.
2. Goon and others.(1991): Outline of Statistical theory Vol-I, World Press.
3. Gibbons,J.D. (1985): Non- Parametric Statistical Inference, McGraw-Hill.
4. Kendall, M.G. and Stuart, A. (1971): Advanced Theory of Statistic Vol. I and II,Charles Griffin.
5. Mood, Graybill and Boes. (1974): Introduction to the theory of Statistics 3rd ed, McGraw- Hill.
6. Hogg,R.V.and Craig,A.T.(1971): Introduction to Mathematical Statistics, Princeton Universit· Press.

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MST 203: Design of Experiment-I

Analysis of experimental model by least square. Regression Analysis (case of full rank). Analysis of Variance and Covariance.

One way and two-way classifications, fixed, random and mixed effects models. Analysis of variance (two-way classification only).

Principles of design of experiments, uniformity trails, randomized experiments, completely randomized design, randomized block design, Latin square design .Factorial Experiment 2^n and 3^2, total and partial confounding. Construction of confounded factorial experiments belonging to 2^n series.

Analysis of non orthogonal data, analysis of missing plot and mixed plot data. Split plot and strip plot designs. Balanced incomplete block design (intra - block analysis).

References:

1. Fedrer, W.T. (1975): Experimental Design - Theory and Application , Oxford & IBH.
2. Das, M.N. and Giri, N.C. (1979) : Design and Analysis of Experiments , Wiley Eastern.
3. Goon, Gupta, and DasGupta. (1991): Fundamentals of Statistics. Vol.II , World Press, Kolkotta.
4. Kempthorne, O.(1979): The Design and Analysis of Experiments, John Wiley Publications.
5. Cocharan ,W.G. and Cox,G.M.(1950): Experimental Design, Wiley;Chapman & Hall.

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MST B01: Demography

Sources of demographic data, census, registration, ad-hoc surveys, Hospital records,Vital Rates and Ratios. Demographic profiles of the Indian Census.

Measurement of Mortality: Crude death rate, Standardized death rates, Age-specific death rates, Infant Mortality rate, Death rate by cause.Measurement of Fertility: Crude birth rate, General fertility rate, Age specific birth rate, Total fertility rate, Gross reproduction rate, Net reproduction rate.

Complete life table and its main features, Uses of life table. Makehams and Gompertz curves. National life tables. UN model life tables. Abridged life tables (Greville's Formula, Reed-Merrels's Formula and King's Method). Stable and stationary populations.

Internal migration and its measurement, migration models, concept of international migration. Net migration. International and post censal estimates. Projection method Including logistic curve fitting. Decennial population census in India.

5. Kaul,R. & Chawdhury,: Applied Statistics,Indian Official Statistics (free downloadable).
6. Saluja,M.R. : Indian official statistical systems, Statistical Pub. Society,India
7. Asthan,B.N. & Shrivastav,S.S.; Applied Statistics of India, Chaitanya Publishing House,India
8. Reports od MOSPI,CSO etc.
9. Cox,,P.R.(1970): Demography, Cambridge University Press

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MST B02: Applied Statistics

Index Numbers: Price relatives and quantity or volume relatives, Link and chain relatives composition of index numbers ; Laspeyre's, Paasches', Marshal Edgeworth and Fisher index numbers; chain base index number, tests for index number. Construction of index numbers of wholesale and consumer prices,

Income distribution-Pareto and Engel curves, Concentration curve, Methods of estimating national income, Inter-Sectoral flows, Inter-industry table. Demand Analysis- Price Elasticity of Demand and Supply. Partial Elasticity of Demand. Elasticity Estimation- Leontief's, Pigou Methods.

Time Series Analysis: Economic time series, different components, illustration, additive and multiplicative models, determination of trend, seasonal and cyclical fluctuations. Time-series as discrete parameter stochastic process, auto covariance and Auto-correlation functions and their properties. Exploratory time Series analysis, tests for trend and seasonality, exponential and moving average smoothing. Holt and Winters smoothing, forecasting based on smoothing.

Detailed study of the stationary processes:(1) Moving Average (MA),(2)auto regressive(AR), (3)ARMA and(4)AR integrated MA (ARIMA) models. Box-Jenkins models, choice of AR and MA periods. Discussion (without proof) of estimation of mean, auto covariance and Auto-correlation functions under large sample theory, estimation of ARIMA model parameters. Spectral analysis of weakly stationary process, periodogram and correlogram analyses, computations based on Fourier transform.

1. Anderson, T.W.(1971): The Statistical Analysis of Time series, Wiley, New York.
2. Brock well, P.J. and Davis,R.A.(1991): Time Series-Theory and Methods(2nd Ed.) Springer- Verlag.
3. Chatfield, C.(1980): The Analysis of Time Series- An Introduction,(2 Edn.) Chapman and Hall.
4. Croxton, Cowden and Klein (1971):Applied General Statistics, PHI
5. Goon,A.M.,Gupta.M.K.and Dasgupta,B.(1986):Fundamentals of Statistics.Vol.2,World Press.
6. Montgomery, D.C. and Johnson, L.A.(1977): Forcasting in Time series Analysis, McGraw- Hill.
7. Kendall Sir Mourice and Ord,J.K.(1990): Time Series, Edwards Arnold

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MST B03:Operation Research-I

Operation Research: Definition, scope, phases, principles, models. Allocation Problems-LPP with Duality Problems, Transportation and Assignment Problems. Monte-Carlo Simulation Technique and its Applications.

Sequencing Problem: Assumptions, Solution of n jobs 2 machines system, Johnson Algorithm, Processing of n jobs and 3 Machines.

Inventory Control System: Inventory models, costs, advantages, EOQ models without shortages, reorder level and optimum buffer stock, EOQ models with shortages and quantity discounts. ABC analysis. Multi-item inventory subject to constraints. Models with random demand, the static risk model. P and Q-systems with constant and random lead times.

Queuing System: Characteristics of queuing system, Poisson proccss , pure birth and pure death process. Steady state solution of (M/M/1) and (M/M/C) models. (M/G/1) model–Pollaczek Khintchine formula.

References:

1. Taha, H.A.(1999): Operation Research, McMillan Publishing Co. Inc 6th Edition,
2. Kanti Swaroop et. al Operation Reseach ,Sultan chand & Sons.
3. Gross, D. & Harris C.M. , Fundamentals of Queueing Theory, John Wiley & Sons.
4. Sharma, S.D. , Operation Research, Kedar Nath Pub. Meerut.
5. Bronso,.R. et.al.(1983) , Schaum's outlines Operation Research, Tata McGraw Hill Edition
6. Klienrock, L.(1975): Queueing System , Vol. 1 Theory , John Wiley.
7. Mckinsey,J.C.C.(1952): Introduction to the theory of games, McGraw Hill

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MST-PC2 (Practical Paper Based on MST 201, MST 202, & MST 202)

MST 201(Sampling Distributions)

1. Correlation and regression coefficients for Bivariate frequency distributions.
2. Large sample tests.(i)For population mean(ii) equality of two population means.(iii)For population variance(iv) equality of two population variances.
3. Small sample tests viz. t, F, x^2 and Z tests.
4. Bartlett's test for homogeneity of variances.

MST 202(Statistical Inference-I)

1. Test of significance of sample correlation coefficient.
2. Sign, median and run tests for small and large samples.
3. Sequential probability ratio test and calculation of constants and graphical representation for testing simple null against simple alternative for (i) Binomial (ii) Poisson (iii) Normal (iv) Exponential distributions.

MST-203 (Design of Experiment I)

1. One-way classified data
2. Two way classification with single and equal observations
3. Two way classification with unequal observations
4. Analysis of CRD, RBD, LSD with and without missing observations.
5. Analysis of BIBD.
6. Yates method for analysis
7. 2^n factorial experiments - n=3
8. 2^n factorial experiments for n = 4
9. Total confounding in 2^n, n = 3, 4
10. Partial confounding in 2^n, n = 3, 4
11. 3^2 factorial experiments
12. Analysis of a confounded factorial experiment.
13. Analysis of covariance in one way classified data
14. Analysis of covariance in two way classified data

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MST PE2: Practical Based on Elective Papers

List of Practical:

1. **MST B01 (Demography)**
   1. Computation of various Death rates.
   2. Computation of various Birth rates, NRR,GRR.
   3. Construction of Life tables- Abridged, Lotka Life Tables
   4. Construction of Makehams and Gompertz curves.
   5. Logistic curve fitting for projection.

2. **MST B02 (Applied Statistics)**
   1. Practical based on Index Number
   2. Practical based on Income Distribution & Demand Analysis
   3. Practical based on Time Series Analysis

3. **MST B03 (Operation Research)**
   1. Problems based on Monte Carlo Simulation
   2. Duality problems
   3. Transportation Problems
   4. Assignment Problems
   5. Replacement Problems and Sequencing Problems
   6. Simulation Problems based on Inventory Control and Queuing Problems

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Semester III

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MST 301: Design of Experiment-II

Linear Models: Theory of linear estimation, Gauss-Markov Theorem, estimable functions, error and estimation space, normal equations and least square estimators, estimation of Error variance, estimation with correlated observations , properties of least square estimators, generalized inverse of a matrix and solution of normal equations, variances and covariances of least square estimators. Testing of hypothesis: involving several linear functions, test of sub-hypothesis and test involving equality of the parameters.

General theory of analysis of experimental designs. Desirable properties of a good design: orthogonality, connectedness and balancing. Various optimality criteria and their interpretations. Relation between blocks of incomplete block designs, duality, resolvability and affine resolvability. Theorems on bounds.

Group divisible, lattice and linked block designs-intra-block analysis. Designs for two-way elimination of heterogeneity and Youden square designs. Elementary ideas of response-surface and rotatable designs.

Constructions of orthogonal Latin squares - (i) for prime power numbers and (ii) by Mann-Mcchneish theorem. Simple methods of construction of BIB, PBID designs. Constructions of symmetrical fractional experiments.

References:

Atkinson ,A.C. and Donev.A.N.(1992): Optimal Experimental Design, Oxford University Press.

Raghava Rao.(1971): Construction and Combinatorial Problems in Design of Experiments, John Wiley.

Chakravarti, M.C.(1962): Mathematics of Design of Experiments, Asia Publishing House.

John, P.W.N.(1971): Statistical Design and Analysis of Experiments, Mc Millan.

Khuri,A.N. and Cornell, M.(1991): Response Surface Methodology,Marchell & Decker.

Shah, K.R. and Sinha, B.K.(1989): Theory of Optimal Design, Springer-Verlog.

Dey, Alok,(1987):Theory of Block Designs, John Wiley & Sons

Montgomery,D.C.: Design and Analysis of Experiments, John Wiley & Sons Inc., Eighth Edition

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MST 302: Statistical Inference-II

Location Invariance, scale invariance. Pitmann's estimators for location and scale parameters. Proof of the properties of M.L.E, Huzur Bazaar theorem, consistent asymptotic normal (CAN) estimator, invariance property. Resampling, Bookstrap and Jacknife.

Completeness and Lehmann-Scheffe theorem, minimal sufficient statistic, Wilks likelihood ratio tests estimator, invariance of consistent asymptotic normal estimator. Asymptotic distribution of likelihood ratio statistic. Bartlett's test for homogeneity of variances.

Generalized Neyman- Pearson lemma. Randomized tests. Uniformly most powerful tests for two-sided hypothesis. Unbiased tests. Uniformly most powerful unbiased tests. Tests with Neyman's Structures and its relation with complete family of distributions.

Basic Elements of Statistical Decision Problem and Game theory. Various inference problems viewed as decision problem. Randomization optimal decision rules. Bayes and minimax decision rule. Generalized Bayes rule.

Reference :

1. Cramer, H. (1946): Mathematical methods of Statistics, Princeton University Press.
2. Goon and others. (1991): Outline of Statistical theory, Vol.I, World Press.
3. Kendall, M.G. and Stuart, A.(1971): Advanced Theory of Statistic Vol. I and II, Charles Griffin.
4. Mood, Graybill and Boes. (1974): Introduction to the theory of Statistics 3rd ed, McGraw- Hill.
5. Hogg, R.V. and Craig, A.T.(1971): Introduction to Mathematical Statistics, Princeton University Press.

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MST 303: Sample Surveys-1

Planning, exécution and analyses of sample surveys with illustrative examples. Errors in survey, sources of non-sampling errors. Determination of sample size.

Basic finite population sampling techniques : Simple random sampling with and without replacement. Stratified sampling. Sample allocation problems in stratified sampling and related results on estimator of mean/total.

Systematic sampling, cluster sampling, two-stage sampling with equal and unequal number of second stage units, Multistage sampling. Estimation of their Population Mean, Total and Standard Errors.

Use of Auxiliary Information: Ratio, product and regression methods of estimation, their comparisons among them, and with sample mean under SRSWOR. Concept of double sampling and its uses in ratio, product and regression methods of estimation.

References:

1. Chaudhuri, A. and Mukerjee, R.(1988):Randomized Responses .Theory and Techniques, New York : Marcel Dekker Inc.
2. Cochran ,W.G.(1984):Sampling -Techniques (3rd ed.),Wiley
3. Des Raj & Chandak (1998): Sampling Theory, Narosa Publishing House.
4. Murthy, M.N. (1977): Sampling Theory and Methods, Statistical Publishing Society, Calcutta
5. Sampath, S. (2000): Sampling theory and Methods, Narosa Publishing House
6. Singh,D.and Chaudhary ,F.S.(1986):Theory and Analysis of Sample Survey Designs, New Age International Publishers.
7. Sukhatme, B.V. (1984): Sample Survey methods and its Applications, Indian Society of Agricultural Statistics.

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MST C01: Econometrics

Nature of econometrics ,the general linear model(GLM) and its extensions, ordinary least squares(OLS) estimation and prediction, generalized least squares (GLS) estimation and prediction, heteroscedastic disturbances, pure and mixed estimation.

Autocorrelation ,its consequences and tests. Theil BLUS procedure, estimation and prediction, multi-collinearity problem, its implications and tools for handling the problem, ridge regression.

Linear regression and stochastic regression, instrumental variable estimation, Errors invariables, auto regressive linear regression, lagged variables, Distributed Lag models, estimation of lags by OLS method, Koyck's geometric lag model. Simultaneous linear equations model and its generalization. identification problem, restrictions on structural parameters, rank and order conditions.

Estimation in simultaneous equations model, recursive systems, 2SLS estimators, limited information estimators, k-class estimators, 3SLS estimator, full information. Maximum likelihood method, prediction and simultaneous confidence intervals.

References:

1. Gujarati, Porter & Gunaseker: Basic Econometrics, (Special Indian Edition), Vth Edition, McGrawHill Edition.
2. Anderson, T.W. : The Statistical Analysis of Time series, Wiley, New York.
3. Barclay, : Techniques of Population Analysis, Wiley.
4. Brock well, P.J. and Davis,R.A.: Time Series-Theory and Methods(2nd Ed.) Springer- Verlag.
5. Chatfield, C.: The Analysis of Time Series- An Introduction,(2 Edn.) Chapman and Hall.
6. Croxton,Cowden and Klein :Applied General Statistics, PHI
7. Goon,A.M., Gupta.M.K. and Dasgupta, B.: Fundamentals of Statistics.Vol.2,World Press, Calcutta
8. Montgomery,D.C. and Johnson, L.A.: Forecasting in Time series Analysis, McGraw- Hill.
9. Kendall Sir Mourice and Ord,J.K.: Time Series, Edwards Arnolds.
10. Johnston ,J. : Econometric Methods, 2nd Edition ,International Student Edition McGraw Hill Kogakusha, Ltd Tokyo

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MST C02 Numerical Analysis

Interpolation formulae (with remainder term) due to Lagrange's, Newton-Gregory, Newton's divided difference formulae. Central difference formulae: Gauss, Sterling & Bessel. Concept of Error terms in interpolation formulae.

Numerical differentiation and Integration: Trapezoidal, Simpson's 1/3rd and 3/8 rules, Weddle's Rules. Numerical solution of ordinary differential equations. Euler, Milne, Picard and Runge-Kutta Methods.

Eular-Maclaurin's summation formula. Summation of series with first difference of function and Geometric Progression. Inverse interpolation. Difference equations: Linear difference equations with constant coefficients.

Iterative solution of Non-Linear Equations- Bisection Method , Regula-Falsi method , Secant method , Newton -Raphson method , Method of Successive Approximation. Solution of Simultaneous Linear equation: Gauss elimination method, Factorisation method , Jacobi's method , Cramer's rule, Gauss- Seidel Iterative math.

References:

1. Kress,R(1998): Numerical Analysis Paperback, Springer
2. Iyenger,SRK & Jain,RK(: Numerical Methods,Paper Back,New Age Intl. Publishers, N.Delhi.
3. Sastry,S.S.(2015): Introductory Methods Of Numerical Analysis, PHI Learning, Paper back.
4. Anthony J. P.(2006): Introductory Numerical Analysis, Dover Publications.
5. Richard L. Burden: Numerical Analysis(2010) (9th edn.), Cenegage Learning.

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MST C03: Operation Research-II

Dynamic Programming: Definition, Algorithm,, Formulation of Dynamic Programming, Bellman's principle of optimality, Computational methods and application of dynamic programming to LPP.

PERT & CPM: Definitions, Basic Steps of PERT/CPM, Terminologies, Rules, Uses, Disadvantages, Time Estimate and Network Analysis, Resources Allocation.

Game Theory: Basics, Decision-making in the face of competition, Characteristics of Games, Two person Zero Sum Games, Saddle Point, Mixed Strategy, dominance criteria, Minimax-Maxmin Criterian, Solution of m x n games, Solution by LPP.

Decision Analysis: Types, Components, Laplace Criteria, Hurwitz Criteria, Decision under Risk. **Replacement Models** for items that fail or deteriorate.

References:

1. Taha, H.A.(1999): Operation Research, McMillan Publishing Co. Inc 6th Edition,
2. Kanti Swaroop et. al Operation Reseach ,Sultan chand & Sons.
3. Gross, D. & Harris C.M. , Fundamentals of Queueing Theory, John Wiley & Sons.
4. Sharma, S.D. , Operation Research, Kedar Nath Pub. Meerut.
5. Bronso,.R. et.al.(1983) , Schaum's outlines Operation Research, Tata McGraw Hill Edition
6. Klienrock, L.(1975): Queueing System , Vol. 1 Theory , John Wiley.

Mckinsey,J.C.C.(1952): Introduction to the theory of games, McGraw Hill

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MST-PC3 (Practical Based on Paper MST 301, MST 302, MST 303)

List of Practical:

1. MST 301: Design of Experiment -II

1. Testing of Hypotheses regarding equality of some treatment effects in one and two way classifications.
2. Analysis of Incomplete block designs without specific form of C matrix.
3. Group divisible designs.
4. Linked Block designs.
5. Simple lattice designs with 2 or more replications.
6. Youden square Designs.

2. MST 302: Statistical Inference -II

1. Power curve for testing one sided Null Hypothesis hypothesis against one sided and two sided alternative for Binomial distribution, Poisson distribution, Normal distribution & Exponential distribution
2. Construction of Randomized test of a desired size for testing simple null against simple alternative hypothesis for (i)Bernoulli's trial (ii) Poisson distribution.
3. Test of hypothesis using generalized likelihood ratio test for testing equality of (i) two means (ii) two variances in normal distribution(s).

3. MST-303 (Sample Surveys –I)

1. Drawing of random samples from finite populations.
2. Drawing of random samples from Binomial and Normal populations.
3. Estimation of population mean & estimation of variance in SRS with and without replacement.
4. Estimation of mean & variance in stratified sampling under proportional and optimum allocations.
5. Gain in precision due to stratification.
6. Estimation of mean& variance in systematic sampling and comparison with S.R.S.
7. Estimation of mean & variance in cluster sampling and comparison with S.R.S.
8. Estimation of mean & variance by (i) ratio and (ii) regression methods of estimation.

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MST-PE3 (Practical Based on Elective Papers MST C01, MST C02, MST C03)

List of Practical:

MST C01: Econometrics

1. OLS estimation and prediction in GLM.
2. Use of dummy variables (dummy variable trap) and seasonal adjustment.
3. GLS estimation and prediction.
4. Tests for Heteroscedasticity : pure and mixed estimation.
5. Tests for autocorrelation. BLUS procedure.
6. Ridge regression.
7. Instrumental variable estimation.
8. Estimation with lagged dependent variables.
9. Identification problems - checking rank and order conditions.
10. Estimation in recursive systems.
11. 2SLS and 3SLS estimation.

MST C02: Numerical Analysis (with software)

1. Interpolation formulae: Lagrange's, Newton-Gregory, Newton's divided difference formulae.
2. Central difference formulae: Gauss, Sterling & Bessel with error terms.
3. Trapezoidal, Simpson's 1/3rd and 3/8 rules, Weddle's Rules.
4. Iterative methods for Non-Linear Equation.
5. Differential equations. Euler, Milne, Picard and Runge-Kutta Methods.
6. Solution of Simultaneous Linear equation
7. Summation formula: Eular-Maclaurin. Summation of series with first difference of function and Geometric Progression.
8. Inverse interpolation.
9. Difference equations.

MST C03: Operation Research – II

1. Practical based on Dynamic Programming
2. PERT CPM
3. Game Theory
4. Decision Analysis
5. Replacement Problems.

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Semester IV

MST 401: Multivariate Analysis

Multivariate normal distribution, marginal and conditional distributions, joint distribution of linear function of correlated normal variates. Characteristic function of multivariate normal distribution. Distribution of quadratic forms. Canonical variates.

Maximum likelihood estimator of the mean vector and covariance, their independence and related distributions. Partial and multiple correlation coefficients.

Classification and discrimination procedure for discrimination between two multivariate normal populations, sample discriminate function, test associated with discriminate functions probabilities of misclassification and their estimation.

Hotelling-T^2 and its properties and applications, Mahanalobis D^2. Wishart distributions and its properties. Principal Components. Wilk's criterion, canonical variates and correlation.

References:

1. Anderson, T .W. (1984): An Introduction to Multivariate Statistical Analysis, 2nd ed, John Wiley.
2. Rao, C.R. (1973): Linear Statistical Inference and its Applications ,2nd ed, Wiley.
3. Srivastava, M.S. and Khatri, C.G. (1970): An Introduction to Multivariate Statistics, North Holland.
4. Morrison, D.F. (1976): Multivariate Statistical Methods, McGraw- Hill.
5. Nuirhead,R.J.(1982): Aspects of Multivariate Statistical Theory, John Wiley.
6. Kshirsagar, A.M. (1972). Multivariate Analysis, Marshell & Decker.
7. Roy, S.N. (1957): Some Aspects of Multivariate Analysis, John Wiley.

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MST 402: **Sample Survey-II**

Rational behind the use of unequal probability sampling: Probability proportional to size with and without replacement method (including cumulative total method and Lahri's method) ,related estimators of finite population mean (Hansen-Hourwitz, Desraj's estimators for general sample size & Murthy's estimator for a sample of size of 2).Horvitz Thompson estimator (HTE) of a finite population total/mean and expression for variance of HTE and its unbiased estimator due to Horvitz-Thompson and Yates & Grundy.

P.P.S. Schemes of sampling due to Midzuno-Sen, Brewer, Durbin and JNKRao (sample size of 2 only), Rao-Hartley and Cochran sampling scheme and their estimation procedure. Theory of multi-stage sampling with varying probabilities (with or without replacement) due to Durbin. Narain and Sukhatme sampling schemes.

Quenouille's technique of bias reduction and its application to ratio type estimator, Hartley and Ross unbiased ratio type estimator. Ratio method of estimator under Midzuno scheme of sampling when X is known. Multivariate extension of ratio and regression method of estimator (when population mean of auxiliary variable is known). Inter penitrating sub sampling.

Non Sampling Errors: Hansen-Hurwitz approach of estimations from incomplete sample. Politz and Simmon's techniques of estimation, randomized response model due to Warner. Simmons unrelated question randomized response model.

References:

1. Cocharan,W.G.(1997): Sampling Techniques III ed, John Wiley Pub. New Yark.
2. Des Raj and Chandok (1998): Sampling Theory , Norsa Pub. New Delhi.
3. Murthy , M.N. (1962) : Sampling Theory and Methods, Statistical Pub. Society, Kolkata .
4. Chaudhary, A and. Mukherjee R (1988): Randomised Response: Theory & Techniques, Marcel Dekker Inc New Yark.
5. Shukhatme, P.V.et al(1984): Sampling Theory of Surveys in the Applications, Iawa State press & Ind.Soc. of Agri. Stat.
6. Mukhopadhy, P.(1996): Inferencial Problems in Survey Sampling, New Age International
7. Singh, D. & Choudhary, F.S.(1986): Theory and Analysis of Sample Surveys and its Applications, New Age international Publication

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MST 403: Project Work

Guidelines for Project Report

Project Duration: 1st December to 15th May. (Students may start preliminary work related to their project after third semester.)

Project Guide: Teachers from the Department of Statistics . Each project group will be guided by concerned teacher (guide) for one hour per week throughout the semester

Fieldwork: Students will be given 4 to 6 weeks during last semester for their industrial work/data collection/survey or any other fieldwork involved in the project.

Project Topic: Students in consultation with the guide will decide Project Topic/Area. Topic may be decided after completion of third semester. Project work may be carried out in a group of students depending upon the depth of fieldwork/ problem involved.

Project report: Project report should be submitted as per university norms.

Project Evaluation: Project valuation will be done according to university norms.

(i) Project Report (70marks)
(ii) Presentation by student or group of students. (30 marks)

Project report will be evaluated from the panel of examiners submitted by B.O.S. convener.

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MST D01: Measure Theory

Classes of sets: semi ring, ring, field, sigma field, monotone classes. Sequence of sets, limit supremum and limit infimum of a sequence of sets. Additive set functions, measure, outer measure and their properties.

Cartheodry extension theorem (statement only) definition of complete measure. Lebesgue and Lebsegue Stieltjes measure (one dimension only) Probability measure, distribution function and its correspondence with Lebesgue Stieltjes.

Measurable sets and measurable space. Simple, elementary and measurable functions. Sequence of measurable functions. Integrability of measurable function, properties of integrals.

Lebesgue monotone convergence theorems, Fatous lemma, dominance convergence theorem, Absolute continuity, Random Nikodym theorem (statement only) and applications, product measure (idea only), Fubinies theorem.

Reference:

1. Kingman J.F. & Taylor. S.J.(1996): Introduction to Measure and Probability, Cambridge Univ. Press.
2. Billingsley, P. (1986): Probability and measure, Wiley Publications.
3. Dudley, R.M. (1989): Real Analysis and Probability, Worlds Worth & Books.
4. Tucket, H.G. (1967): A graduate course in Probability, Academic Press.
5. Basu, A.K. (1999): Measure Theory and Probability, PHI.

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MST D02: **Basic Statistics**

Concept of statistical Population and Data. Types of Data. Data Collection, Classification, Organizations, Representation: Diagrammatic & Graphical; Graphical presentation of data- Histogram, frequency polygon, frequency curve and ogives. Measures of central tendency, dispersion, skewness and kurtosis and its computation from data. Correlation analysis- Assumption, Types-Scatter diagram, Karl-Pearson and Spearman's correlation. Regression analysis-Fitting of regression lines, regression coefficients and their properties and its computation from data.

Probability Theory: Random Experiment, Trial, Events and their types. Definitions- Classical and Axiomatic Probability. Law of Probability- Addition and Multiplication. Conditional Probability. Computation of Probability. Random Variable: Definition with illustrations, Types of Random Variables. Basic Idea of Mathematical Expectation and its Laws. Probability Mass Function, Probability Density Function. Probability Distributions- Bernoulli, Binomial, Poisson and Normal with their properties, applications and computations.

Sampling &Sampling Distributions: Concepts of population and sample, need for sampling, census & Sample surveys. Advantages of sample survey. Simple, Random Sampling, Stratified and Systematic Sampling and their illustrations, advantages and disadvantages. Basic Concepts of Sampling Distributions. Idea of t, z, chi-square and F-distributions with their properties.

Hypothesis and its Types. Test of Significance- t-test, z-test, Chi-Square Test and their applications. Analysis of Variance-Need, Assumptions, Applications. One way and Two ways ANOVA. Large Sample Tests-Single Mean and Two means. Basic Concept of Design of Experiments and types with layouts.

References:

1. Agrawal,B.L.: Basic Statistics, New Age International Pub.
2. Gupta,S.P.: Statistical Methods, Sultan Chand and Sons.
3. Elhance, D.N. : Fundamentals of Statistics
4. Croxton F.E., Cowden D.J. and Kelin S (1973) : Applied General Statistics ,PHI
5. Goon A.M.,Gupta M.K.,Das Gupta B. (1991) : Fundamentals of Statistics, Vol-I, World Press, Kolkata.

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MST D03: Stochastic Processes

Introduction of Stochastic Processes: Specifications of stochastic process, Markov process and Markov Chain. Classification of states. Determination of higher order transition probability and its limits. Limit theorems for Markov Chain, stationary distribution.

Stationary processes and its types. Discrete time Markov Chain, order of Markov Chain, Chapman-Kolmogorov Equations. Markov-Process with discrete state space: Poisson process and its generalization. Pure Birth Process, Birth & death process, Erlangian Process. Markov Process with continuous state space, Wiener Process. Renewal Process. Renewal Theorem and its examples.
Branching Process: Galeton-Watson's branching process, properties of generating function of branching process. Probability of extinction, distribution of total number of Progeny.

Random walk, gambler's ruin's problem.

References:

[1] Adke, S.R. & Manjunath S.M. (1984) : An Introduction of Finite Markov Processes, Wiley Eastern.
[2] Bhatt ,B.R. (2000): Stochastic Models: Analysis and applications, New Age International, India
[3] Harris, T.E. (1963): The Theory of Branching processes, Springer-Verlag.
[4] Medhi, J (1982): Stochastic Processes, Wiley Eastern.
[5] Ballingsley, P (1962) : Statistical Inference for Markov Chains, Chicago University Press, Chicago.
[6] Ross, S.M (1983); Stochastic Processes, Wiley.

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MST-411 (Practical Paper Based on MST 401 & MST 402)

MST 401 Multivariate Analysis

1. Linear combination of correlated normal variates and evaluation of
2. Probabilities.
3. Estimation of mean vector and covariance matrix.
4. Estimation and testing of partial and multiple correlation coefficients.
5. Discriminate function.

MST 402 (Sample Surveys-II)

1. PPSWR Sampling: Cumulative total method, Lahri's method of sample selection/section, estimation of total and its variance.
2. Horvitz and Thompson's procedure of estimating mean (total) and variance of the population.
3. Yates and Grundy estimator of variance.
4. Midzuno's sampling schemes.
5. Rao-Hartley-Cocharan schemes.
6. Two-stage sampling method where f.s.u. being selected with pps with replacement and s.s.u. with equal prob. without replacement. Estimation of optimum number of s.u. and s.s.u.

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MST-PE4 (Statistical Computing with R and SPSS)

Introduction to R: The R package Starting and quitting R. Basic features of R. Calculating with R Vectors. Logical operations in R, Relational operators, Data input and output, Lists Vector arithmetics. Character vectors. Data Import.

Matrices and Arrays, Triangular matrices, Matrix arithmetic, Matrix multiplication and Inverse. Flow control- The if() statement, for() loop, while() loop. Repeated loops, break and next Statements.

Data frames, read.table function. Programming statistical graphics: Bar charts, Pie charts, Histograms, Box plots, Scatter plots, QQ plots. Measurement of Central Tendencies, Dispersion, Skewness and Kurtosis. Correlation and Regression Analysis. Statistical Tests.

Generation of pseudorandom numbers, Simulation of other random variables-1 Bernoulli, Binomial, Poisson, Exponential, Normal random variables. Monte Carlo Simulation.

SPSS 19.0: Creating Variables, Input data, Saving and opening Data. Frequency Distribution, Creating Bar Chart, Histogram. Univariate and Bivariate Data Analysis. Parametric and Non Parametric Tests. Multivariate Data Analysis.

References:

1. Crawley, M.J., The R Book, John Wiley and Sond Ltd, England.
2. Braun, W.J and Murdoch, D.J.: A First Course in Statistical Progg. with R, Cambridge Univ. Press.
3. Horton,N.J. & Kleinman,Ken: Using R and R Studio for Data Management, Statistical Analysis and Graphics, CRC Press.USA
4. Gaur S.A & Gaur,S.S.:Statistical Methods for Practice and Research, Response Books(A division of Sage Publications),N.Delhi.
5. Carver,R.H. & Nash,J.G: Data Analysis with SPSS(India Edition), Cengage Learning ,N.Delhi.
6. Asthana,B.S. & Bhushan,B.: Statistics for Social Sciences, PHI
7. Verma, J.P. : Data Analysis in Management with SPSS Software, Springer

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Extra Elective Papers for Semester-IV

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MST D04: Reliability Analysis

Reliability: Concepts and measures, components and systems, coherent systems, reliability of coherent systems; cuts and paths, modular decomposition, bounds on system reliability, structural and reliability importance of components. Life distributions, reliability function; hazard rate; common life distributions-exponential, Weibull, Gamma etc. Estimation of parameters and tests in these models.

Notions of ageing, IFR, IFRA, NBU, DMRL and NBUE classes and their duals, loss of memory property of the exponential distribution; closures or these classes under formation of coherent systems, convolutions and mixtures. Univariate shock models and life distributions arising out of them; bivariate shock models; common bivariate exponential distributions and their properties.

Reliability estimation based on failure times in variously censored life tests and in tests with replacement of failed items stress-strength reliability and its estimation. Maintenance and replacement policies, availability of repairable systems, modeling of a repairable system by a non-homogeneous Poisson process.

Reliability growth models, probability plotting techniques, Hollander-Proschan and Deshpande tests for exponentiality; tests for HPP vs. NHPP with repairable systems. Basic ideas of accelerated life testing.

REFERENCES

1. Barlow R.E. and Proschan F.(1985): Statistical Theory of Reliability and Life Testing, Holt,Rinehart and Winston.
2. Lawless J.F. (1982): Statistical Models and Methods of Life Time Data, John Wiley.
3. Bain L.J. and Engelhardt (1991): Statistical Analysis of Reliability and Life Testing Models, Marcel Dekker.
4. Nelson, W (1982): Applied Life Data Analysis, John Wiley.
5. Zacks,S.(2004): Reliability Theory, Springer.
6. Sinha,S.K.(1986): Reliability & Life Testing,Wiley7.Cox, D.R. and Oakes, D (1984): Analysis of Survival Data, Chapman and hall , New York.
7. Kalbfleisch , J.D. & Prentice, R.L. (1980): The Statistical Analysis of Failure Time Data, John Wiley.

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MST D05: Survival Analysis

Concepts of time, order and random censoring, likelihood in these cases. Life distribution-Exponential Gamma, Weibull, Lognormal, Pareto. Linear Failure rate. Accelerated Failure Time Distribution, Mean Residual Life and properties. Log-Logistic Distribution. Censoring techniques.

Parametric inference (Point estimation, Confidence intervals Scores, LR, MLE tests (Rao-Willks-Wald) for these distribution life tables failure rate, mean residual life and their elementary properties. Ageing classes-and their properties, Bathtub failure rate.

Estimation of survival function- Actuarial estimator, Kaplan-Meier estimator, estimation under the assumption of IFR/DFR. Tests of exponentially against non-parametric classes, total time on test, Deshpande test. Two sample problem-Gehan test, log rank test Mantel–Haenszel test, Tarone-Ware tests.

Cox's proportional hazards model with one and several covariates. Rank test for the regression coefficients. Competing risks model, parametric and non-parametric inference for this model. Assumptions, extended Cox model, MLE of Cox PH model, hazard ratio, survival curves.

References:

1. Gross A.J. and Clark, V.A. (1975) : Survival Distribution : Reliability applications in the Biomedical Sciences, John Wiley and Sons.
2. Elandt - Johnson, R.E. Johnson N.L.(1980) : Survival Models and Data Analysis, John Wiley and Sons.
3. Miller, R.G. (1981) : Survival Analysis, John Wiley.
4. Kalbfleisch J.D. and Prentice R.L. (1980): The Statistical Analysis of Failure Time Data, John Wiley.
5. Kleinbaum, D.G. & Klein, Mitchel (2008): Survival Analysis -A Self Learning Text, Springer International Edition, Spinger
6. Cox, D.R. and Oakes, D.(1984): Analysis of Survival Data, Chapman and Hall, New York

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MST D06 : Statistics for Clinical Trials

Introduction to clinical trials: the need and ethics of clinical trials, bias and random error in clinical studies, conduct of clinical trials, Phase I-IV trials, multi-center trials. Data management: data definitions, case report forms, database design, data collection systems for good clinical practice.

Design of clinical trials: parallel vs. cross-over designs, cross-sectional vs. longitudinal designs, review of factorial designs, objectives and endpoints of clinical trials.

Design of Phase I trials, design of single-stage and multi-stage Phase II trials, design and monitoring of Phase III trials with sequential stopping, design of bioequivalence trials.

Reporting and analysis: analysis of categorical outcomes from Phase I-III trials, analysis of survival data from clinical trials. Surrogate endpoints: selection and design of trials with surrogate endpoints, analysis of surrogate endpoint data. Meta analysis of clinical trials.

REFERENCES:

1. C. Jennison and B.W.Turnbul (1999). Group Sequential Methods with Applications to Clinical Trials, CRC Press.
2. E. Marubeni and M.G. Valsecchi (1994). Analyzing Survival Data from Clinical Trials and Observational Studies, Wiley and Sons.
3. J.L. Fleiss (1989). The Design and Analysis of Clinical Experiments. Wiley and Sons.
4. L.M.Fricdman,C.Furburg,D.L.Demets(1998). Fundamentals of Clinical Trials, Springer Verlag.
5. S. Piantadosi (1997). Clinical Trials: A Methodologic Perspective. Wiley and Sons.

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