



# **University of Rajasthan Jaipur**

## **SYLLABUS**

### **M.A./M.Sc. STATISTICS**

**(Annual Scheme)**

**M.A./M.Sc. (Previous) Examination 2023**

**M.A./M.Sc. (Final) Examination 2024**

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# M.A. / M.Sc. STATISTICS Final

| Compulsory Papers                                                                |                                                                                                                                                                                                       |     |         |
|----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|---------|
| Paper III                                                                        | Multivariate Analysis and Statistical Inference                                                                                                                                                       | 100 | 3 Hours |
| Paper IX                                                                         | Advanced Design of experiments and Sample Theory                                                                                                                                                      | 100 | 3 Hours |
| Paper X                                                                          | S.Q.C. and O.R.                                                                                                                                                                                       | 100 | 3 Hours |
| Paper XI                                                                         | Practical based on Paper IX                                                                                                                                                                           | 100 | 4 Hours |
| Paper XII                                                                        | Paper VIII & X                                                                                                                                                                                        | 100 | 4 Hours |
| OPTIONAL PAPERS                                                                  |                                                                                                                                                                                                       |     |         |
| Any two papers of the following with the permission of the institution concerned |                                                                                                                                                                                                       |     |         |
| Paper XIII                                                                       | Economic Statistics and Demography                                                                                                                                                                    | 100 | 3 Hours |
| Paper XIV                                                                        | Stochastic Process                                                                                                                                                                                    | 100 | 3 Hours |
| Paper XV                                                                         | Reliability and Survival Analysis                                                                                                                                                                     | 100 | 3 Hours |
| Paper XVI                                                                        | Advance Multivariate Analysis and Bayesian Inference                                                                                                                                                  | 100 | 3 Hours |
| Paper XVII                                                                       | Econometrics & Investment System                                                                                                                                                                      | 100 | 3 Hours |
| Paper XVIII                                                                      | Project Work                                                                                                                                                                                          | 100 | 3 Hours |
| Notes: (1)                                                                       | The project work shall be based on either primary data involving field work or secondary data. The candidates will be required to prepare comprehensive and Critical reports on the same.             |     |         |
| (2)                                                                              | The teacher supervising the Projects work/Dissertation of a candidate shall be provided one hour per week towards his/her supervision.                                                                |     |         |
| (3)                                                                              | In all theory papers of M.A. / M.Sc. (Previous and Final) Statistics except Paper XIV the candidates will be required to answer five question in all taking at least two questions from each section. |     |         |

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Syllabus  
M.Sc. (Previous)  
PAPER I  
(MATHEMATICAL ANALYSIS)  
SECTION-A  
(Unit-I)

Real Analysis: Real Valued Function, Continuous Function, Uniform Continuity, Sequences of Functions, Uniform Convergence

Differentiation, maxima-minima of function, functions of several variables, constrained maxima-minima of functions, Multiple integrals and their evaluation by repeated integration, change of variables in multiple integration, differentiation under the sign of integral-Leibnitz rule, Beta & Gamma integrals.

(24L+12T)

(Unit-II)

Linear Algebra: Inverse and rank of a matrix, Linear equations, Orthogonal matrix, Orthogonal reduction of a real symmetric matrix to a diagonal form, Hermite canonical form, generalized inverse and its simple properties, Idempotent matrices, Solutions of matrix equations, Kronecker Product.

SECTION-B

(Unit-I)

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

(24L+12T)

(Unit-II)

Numerical Analysis: Interpolation formulae (with remainder terms) due to Lagrange's, Newton-Gregory, Newton divided Difference, Gauss and Stirling formulae, Inverse interpolation, Numerical differentiation and integration, Trapezoidal, Simpson's  $1/3^{rd}$  and  $3/8$  rules, Waddle's rules, Euler-Maclaurin's Summation Formula, Difference equations of the first order (homogeneous linear difference), homogeneous linear difference equation with constant coefficients.

(24L+12T)

References:

1. Apostol, T.M. (1985): Mathematical Analysis, Narosa Publishing House.
2. Burkil, J.C. (1980): A first course in Mathematical Analysis, Vikas publishing House.
3. Courant, R. and John, F. (1965): Introduction to calculus and analysis, Wiley.
4. Khuri, A.L. (1983): Advanced Calculus with Applications in Statistics, Wiley.
5. Miller, K.S. (1957): Advanced Real Calculus, Harper, New York.
6. Miller, K.S. (1957): Introductory Methods of Numerical Analysis, Prentice Hall.
7. Saxena, H.C.: Calculus of Finite Difference.
8. Searle, S.R. (1982): Matrix Algebra Useful for Statistics, Wiley.
9. Shanti Narayan, (1998): Matrix Algebra, S.Chand & co

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Paper II  
Probability and Measure theory  
SECTION-A

(Unit-I)

General probability space, various definitions of probability, axiomatic definition of probability, combinations of events, laws of total and compound probability, Conditional probability, Baye's theorem and its applications, Concept of random variables, cumulative distribution function and probability density function, joint, marginal and conditional distribution.

(24L+12T)

(Unit-II)

Mathematical Expectation, moments, conditional expectation, moment generating functions, cumulative generating functions and their applications, Characteristic function, uniqueness theorem, Levy's continuity theorem (statement only) Probability inequalities: Chebyshev, Markov and Johnson, Convergence in probability and in distribution, weak law of large numbers and central limit theorem for a sequence of independent random variable under Landenberg's condition central limit theorem for identical independent and identically distributed, random variables: Zero one laws of Borel and Kolmogorov, almost sure convergence in mean square, Kintchin's weak law of large numbers, Kolmogorov inequality, strong law of large numbers.

(24L+12T)

SECTION-B

(Unit-I)

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 Lebesgue Stieltjes measure (one dimension only), P(Probability measure, distribution function and its correspondence with lebesgue Stiltjes.

(Unit-II)

Measurable sets and space, measurable space, Simple, elementary and measurable functions. Sequence of measurable functions, Integrability of measurable function, properties of integrals Lebesgue monotone convergence theorems, Fatuous lemma, dominant convergence theorem, Absolute continuity, Random Nikodym theorem, product measure, Fubini's theorem.

(24L+12T)

Reference:

1. Kingman J.F. & Taylor, S.J. : Introduction to Measure and Probability.
2. Loeve : Probability Theory.
3. Bhatt, B.R. Probability
4. Feller, W. Introduction to Probability Theory and its Applications Vol. I and II
5. Rohatgi, V.K. An Introduction to Probability theory Mathematical Statistics, Wiley Eastern.
6. Billingsley, P. Probability and measure Wiley
7. Dudley, R.M. real Analysis and Probability

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Paper III  
Distribution Theory  
SECTION A  
(Unit-I)

and variables and their distributions using Jacobian of transformation Bernoulli, Binomial (compound and truncated also), Negative Binomial distributions. (24L+12T)

(Unit-II)

Geometric, Hyper-geometric and Multinomial distributions. Rectangular, Normal (truncated also), Exponential, Cauchy (truncated also), Lognormal and Triangular distributions. (24L+12T)

SECTION B  
(Unit-I)

Sampling distributions-Chi-square, t and F distributions (Central and non-central) & their applications. Bivariate normal (including marginal & conditional distribution), Beta and Gamma distributions. (24L+12T)

(Unit-II)

Linear regression and correlation; intra-class correlation & correlation ratio; null & non-null distributions of sample correlation coefficient, standard errors of functions of moments. Order statistics their Distributions and properties; joint & marginal distributions of order statistics; Sampling Distributions of range & median (24L+12T)

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, Calcutta.
3. Hogg, R.V. and Craig, A.T. (1971): Introduction to Mathematical Statistics. McMillan.
4. Jonson, S. and Kotz (1972) Distribution in Statistics. Vol. I, II. And III. Houghton and Muffin.
5. Kendall, M.G. and Stuart, An Advanced theory of Statistics Vol. I, II.
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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Paper-IV  
Sample Surveys & Design of Experiment  
SECTION-A

(UNIT-I)

Planning, Execution and analysis of large, small sample surveys with illustrative examples. Non sampling errors and biased responses, randomized responses for variables, errors in survey, modeling observational errors, estimation of variance components, application to longitudinal studies (repetitive surveys). Basic finite population sampling techniques: SRSWOR, Stratified sampling schemes, Allocation problem in stratified sampling.

(Unit-II)

Systematic sampling schemes and related results on estimator of mean/total. Cluster sampling, double sampling, two-stage sampling with equal and unequal number of second stage units. Ratio, Product and regression method estimation: Estimators based on SRSWOR method of sampling (24L+12T)

SECTION-B

(Unit-I)

Analysis of Experimental model by least square, Cochran's Theorem and Regression Analysis (Case of Full rank). Analysis of variance and covariance Transformations, Principles of Experimentation, Uniformity Trials, Randomized experiments, Randomized Blocks, Latin Squares, Balanced Incomplete Block Design (Intra-Block Analysis), Missing Plot Technique (24L+12T)

(Unit-II)

Factorial Experiment  $2^n$  and  $3^n$ , total and partial confounding, split-plot designs, Construction of confounded factorial experiments belonging to  $2^n$  series (24L+12T)

References:

1. Cochran W.G. (1984): Sampling-Techniques (3<sup>rd</sup> Ed.) Wiley
2. Desraj & Chandak (1998): Sampling Theory, Narosa Publishing House.
3. Murthy M.N. (1977): Sampling Theory and Methods, Statistical Publishing Society, Calcutta.
4. Sampath S. (2000) Sampling theory and Methods, Narosa Publishing House.
5. Singh, D. and Chaudhary, F.S (1986). Theory and Analysis of Sample Survey Designs. New Age International Publishers.
6. Sukhatme B.V. (1984): Sample Survey methods and its Applications Indian Society of Agricultural Statistics.
7. Fedrer, W.T. (1975): Experimental Design-Theory and Application, Oxford & IBH.
8. Das, M.N. & Giri, N.C. (1979): Design and Analysis of Experiments, Wiley Eastern.
9. Goon, Gupta & Das Gupta (1991): Fundamentals of Statistics Vol. II world Press, Kolkata
10. Sukhatme, P.V., Sukhatme, B.V., Sukhatme S. & Ashok, C: Sampling Theory and Surveys with Applications

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Paper-V  
Statistical Inference  
SECTION-A  
(Unit-I)

Point estimation, Criteria of good estimator, unbiased estimators uniformly minimum variance unbiased estimator (UMVUE), Cramer-Rao Inequality, Consistent estimator, Sufficient estimator, Fisher-Neyman factorization theorem, Non uniqueness theorem, Exponential theorem (without proof) Davi's theorems (without proof), Rao-Blackwell efficient estimator, Completeness and Lehmann-Scheffe theorem minimal sufficient statistic, maximum likelihood estimator and its properties (without proof) and the method of estimation (moments, minimum Chi-square and modified minimum Chi-square). (24L+12T)

(Unit-II)

Confidence intervals, Determination of confidence intervals based on large samples, confidence interval based on small samples, Hypothesis- simple and composite, Critical region, error of I<sup>st</sup> and II<sup>nd</sup> kind, power of test, most powerful test, Neyman-Pearson lemma, Derivations of some Common tests of a simple hypothesis against a simple alternative, uniformly most powerful test. (24L+12T)

(SECTION B)

(Unit-I)

Likelihood ratio-method of test construction, Asymptotic distribution of the logarithm of LRT statistic, Definition of S.P.R.T, Fundamental relation among  $\alpha$ ,  $\beta$ , A and B, Determination of A and B in practice, Wald's fundamental identity and the derivation of O.C. and A.S.N. functions (24L+12T)

(Unit-II)

Non-Parametric tests, Sign Tests, Singed rank test, Kolmogorov-Smirnov one sample test, General two sample Problem, Wallowitz runs test, Kolmogorov-Smirnov two sample test (for sample of equal size), Median test, Wilcoxon-Mann-Whitney test, Test of randomness based on runs test based on the total number of runs, test based on the length of longest run. (24L+12T)

Reference:

1. Cramer, H.: Mathematical methods of Statistics.
2. Goon and others, Outline of Statistical theory, Vol.I.
3. Gibbons: Non-Parametric Statistical Inference.
4. Kendall, M.G. and Stuart, A.: Advanced Theory of Statistic Vol.I and II.
5. Mood, Graybill and Boes: Introduction to the theory of Statistics 3<sup>rd</sup>ed.
6. Rohtagi, V.K. Introduction to Probability theory and mathematical statistics.
7. Hogg and Craig Introduction to Mathematical Statistics.
8. Wald, A. Sequential Analysis.

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Paper VI (a)  
Computer Programming (Theory)  
SECTION-A

Programming Fundamentals: Computer based Problem solving techniques. Flow charts and Algorithm. Structured Programming Techniques. Statistical Computations using MS-Excel.  
Programming through C-Language: Introduction, Structure & Execution of a C Program. Character Set. Keywords. Constants & Variables. Data Types. Types of Operators & Precedence. Input & Output Statements. Assignment Expression. Decision making structure. Looping Structures and Branching Structures and related C-Programs.  
(24L+12T)

SECTION-B

Arrays, Character Strings, Standard Library Functions, Header Files Modular programming-User defined Functions, Returning values, Parameter passing Mechanism, Structures, Pointers Defining a Pointer, Array Vs Pointers, Dynamic Memory allocation C-Preprocessors, Related Programs.  
(24L+12T)

- Reference:
1. Ram B., Computer Fundamentals- Architecture and Organization New Age International (P) Ltd 3<sup>rd</sup> Edition.
  2. Pelosi M.K. et. al., Doing Statistics for Business with Excel Data, Inference and Decision Making, John Wiley & Sons.
  3. Venugopal et. al Mastering C. Tata Mc Graw Hill.
  4. Gottfried B.S., Theory and Problems of programming with TMH

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M.Sc. (Final)  
Paper- VIII  
Multivariate Analysis and Statistical Inference

SECTION-A  
(Unit-I)

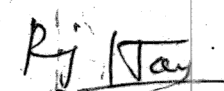
Multivariate Normal distribution, marginal and conditional distributions joint distribution of linear function of correlated normal variates. Characteristic function of multivariate normal distribution. Maximum likelihood estimator of the mean vector and dispersion matrix and their independence.  
(Unit-I)  
(24L+12T)

Classification and discrimination procedure for discrimination between two multivariate normal population. sample discriminate function test associated with discriminate functions probabilities of misclassification and their estimation Null distribution of Hotelling  $T^2$  and its applications Wishart matrix-its distribution (without proof) and its properties. Null distribution (without proof) of partial Correlation. multiple correlations and sample regression coefficient and its applications.  
Section-B  
(Unit-I)  
(24L+12T)

Proof of the properties of M.L.E. Pitman Family of distributions and their M.L.E properties. Huzur Bazaar theorem. Consistent Asymptotic Normal (CAN) estimator, Invariance of CAN estimator. Likelihood ratio tests. Asymptotic Distribution of Likelihood Ratio Statistic, Similar Regions  
(Unit-II)  
(24L+12T)

Generalized Neyman Pearson lemma Elements of statistical decision function: Formulation of the problem. Loss function. Risk functions. Convex sets, convex function, hyper plane, convex null convex polyhedral and its relevant theorem. Concepts of admissibility of Baye's rules and minimax sequential decision rule. Bartlett's Test for homogeneity of variances.

- References:
1. Anderson T.W. An Introduction to Multivariate Statistical Analysis. 2<sup>nd</sup> ed. Wiley
  2. Cramer H: Mathematical Methods of Statistics.
  3. Ferguson, F.S. Mathematical Statistics, Academic Press
  4. Gibbons. Non-Parametric Statistical Inference.
  5. Hogg and Craig: Introduction to Mathematical Statistics.
  6. Kendall, M.G. and Stuart, A. Advanced Theory of Statistic Vol. I and II.
  7. Mood, Graybill and Bose: Introduction to the Theory of Statistics 3<sup>rd</sup> ed.
  8. Rao, C.R. Linear Statistical Inference and its Applications 2<sup>nd</sup> ed. Wiley.
  9. Rohatgi, V.K.: An Introduction to Probability theory and Mathematical Statistics. Wiley Eastern.
  10. Srivastava, M.S. and Khatri, C.G.: An Introduction to Multivariate Statistics. North Holland
  11. Wald, A. Sequential Analysis.
  12. Zacks, S. Theory of Statistical Inference. John Wiley.

  
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**Paper-IX**  
**Advanced Sample Survey & Design of Experiments**  
**Section-A**

**(Unit-I)**

Unequal probability sampling: Probability Proportional to size with and without replacement method (PPSWR/PPSWOR) (including Lahiri's scheme), related estimators of finite population mean. (Hansen-Horvitz and 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  $V(HTE)$  and its unbiased estimator. Sure on non-negative variance estimation. I.P.P.S Schemes of sampling due to Midzuno-Sen, Brewer, Durbin and JNK Rao (Sample size of 2 only) Rao-Hartley Cochran sampling scheme and their estimation procedure. Theory of multi-stage sampling with varying probabilities with or without replacement. Introduction to super population models.

(24L+12T)

**(Unit-II)**

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).

(24L+12T)

**Section-B**

**(Unit-I)**

Linear estimation, Gauss Markoff's theorem. Testing of hypothesis involving several linear functions. test of sub-hypothesis and test involving equality of the parameters. Introduction to one way random model and estimation of variance components. General theory of analysis of experimental designs. Designs for two-way elimination heterogeneity. Desirable properties of a good design: Orthogonality, Connectedness and Balance. Various Optimality criteria and their interpretations. Relation between blocks of incomplete block designs. duality, resolvability and affine resolvability. Theorems on bounds.

(24L+12T)

**(Unit-II)**

Group divisible, lattice and linked block designs- intrablock analysis, Latin square and Youden square designs. Combination of result in groups of experiments. Construction of orthogonal Latin square- (i) for prime power numbers and (ii) by Mann-Mecneish theorem, simple methods of construction of BIB designs. Constructions of symmetrical fractional factorial designs.

(24L+12T)

**References:**

1. Atkinson, A.C. and Donev, A.N: Optimal Experimental Design.
2. Raghava Rao: Construction and Combinatorial Problems in Design of Experiments.
3. Searle, S.R. Casella, G. And McCulloch, C.E: Variance Components, John Wiley, New York.
4. Rao, C.R. and Kleffe, J: Estimation of Variance Components and Applications.
5. Chaudhary, A. and J.W.E. Vos (1988). Unified Theory and Strategies of Survey Sampling, North Holland Amsterdam
6. Hedayat, A.S. and Sinha, B.K. Design and Inference, infinite Population sampling, Wiley.
7. Chaudhary, A and R. Mukherjee: randomized Response. Theory and Techniques, New York, Marcel Dekker

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**Paper X**  
**Statistical Quality Control & Operation Research**  
**Section-A**  
**(Unit-I)**

Meaning of specification limits. Item quality. Process and product control. Objective of SQC. Control charts for measurable quality characteristic. Chance variation and assignable variation of process. Distribution of chance variable. Need for detection of assignable causes of variation. Determination of control limits and central line in various situations. Mean ( $\bar{x}$ ) and R control charts. Control charts for defectives p, np, c charts. Meaning of Statistical Control and its relation with specification limits. Modified control limits warning limits and tolerance limits. Methods of estimation of rational subgrouping and successive estimate. Advantages of SQC. Comparison of Mean ( $\bar{x}$ ) and R charts with p-chart for common use.

**(Unit-II)**

Acceptance Sampling by Attribute: Need for sampling inspection, methods for acceptance. Lot Quality and lot by lot acceptance. AQL, AOQL, Producer's risk and Consumer Risk. Rectification, O.C. function, ASN and average total inspection. of an acceptance procedure. Single and double sampling plans and their mathematical analysis. Idea of Standard sampling tables: Dodge and Roming Table and MIL Std. 105A. Sampling inspection plans for production process where lots cannot be formed. Sampling Inspection Plans for Variables-One sided specification standard (Known and Unknown Cases) Two Sided specifications (for known standards). Use of Design of Experiments in Statistical Process Control, Fractional Experiments, Fractional factorial Experiments. Multivariate Quality Control. Control of means and control of process variability.

**Section-B**  
**(Unit-I)**

Definition and scope of Operation Research: Phases, Principles of Operation Research. Models and their Solutions. Monte carlo Simulation Technique & its Applications. Review of Linear Programming Problems. Revised Simplex Method. Dual Simplex Method. Transport Problems and Assignment Problem: Sequencing & Scheduling Problem: 2 machine n-jobs and 3-machines n-jobs problems with identical machine sequence for all jobs, 2 jobs n-machine problem with different routings. Theory of Games: Pure & Mixed strategies. Minimax (Maximin) criterion. Solution of Games with Saddle Point. Rectangular Games Theorem. m x n games and linear programming 2x2 games without saddle point. Graphical Solution of 2x2 and m x 2 games.

**(Unit-II)**

Inventory Control System. Inventory Models. Costs. Advantages, EOQ. Models without shortages. Reorder level and Optimum Buffer Stock, EOQ Models with shortages. Multi-item Inventory Models with quantity Discount. Probabilistic Models, Queueing System: Characteristics of Queueing System, Steady State Solution of (M/M/1) and (M/M/C) models. (M/G/1) model Pollaczek-Khinchine Formula, Steady State solution of (M/F, 1) models. Mixed Queueing Model (M/D/1), (M/D/1) (FCFS).

**(24L+12T)**

**References:**

1. Taha H.A. Operation Research, McMillan Publishing Co. Inc 6<sup>th</sup> Edition, 1999
2. Kantiswaroop et al. Operation research, 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. Bronson R. and Shamum's outlines Operation Research, Tata McGraw Hill Edition

**Additional References:**

1. Cohen J. Queueing System, Vol. I Theory, John Wiley
2. Von Neuman J. Introduction to the theory of games, McGraw Hill

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Paper-XI  
Practicals based on Paper IX

Paper XII  
Practicals based on Paper VIII & Paper X

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## Optional Papers

### Paper-XIII

#### Economic Statistics & Demography

Time series: Concept, its components and methods of their determination. Variate difference method. Yule-Slasky effect. Autoregressive model for first & second order. Periodogram and Correlogram analysis. Index number of prices and quantities and their relative merits. Construction of index numbers of wholesale and consumer prices. (24L+12T)

#### Unit-II

Meaning and basis of demand. Demand equation, demand curve. Relation between demand curve and demand function. Estimation of demand function by Leontief's method. Static law of demand and supply. Price elasticity, income elasticity and cross elasticity of demand. Concept of indifference curve, Budget line. Parato's law of income distributions. Engles curve, curves of concentration. Concept of national income and methods of estimating national income intersectoral flows, inter industry table.

#### Section-B

##### (Unit-I)

Demography: Census and Vital statistical data. Vital rates and ratio, standardization of rates trends and differentials in mortality and fertility. Stationary and stable populations. Population estimation and projection. The life table: its construction and properties. Makeham's and Gompertz curves. National life tables. UN model life tables, Abridged life tables, (Greville's formula for construction, Reed and Merrell's formula, King's method) T.F.R., G.R.R., N.R.R. (24L+12T)

##### (Unit-II)

Demographic trends in India. Labour force analysis, Birth & Death stochastic process. Stochastic population models, logistics model, bivariate growth models, migration models, fertility analysis model, mortality analysis models. Decennial population census in India. (24L+12T)

#### REFERENCES:

1. Anderson, W. (1971): The Statistical Analysis of Time series, Wiley, New York.
2. Barchay, Techniques of Population Analysis
3. Brocks well, P.J. and Davis, R.A.: Time series-An Introduction, (2 Edn) Springer-Verlag
4. Chatfield, C. (1980): The Analysis of Time Series-An Introduction, (2 Edn) Chapman and Hall
5. Chenery, H.B. Inner Industrial Economics
6. Cox, P.R. (1970): Demography, Cambridge University Press
7. Croxton, Cowden and Klein (1971) Applied General Statistics, PHI
8. Ganguly and others: Studies in Consumer's Behaviour.
9. Goon, A.M., Gupta, M.K and Dasgupta, B. (1986): Fundamentals of Statistics, Vol.2 World
10. Kamitakar & Bhende: Principles of Population Studies, Press Calcutta.
11. Kendall, M.G. and Stuart, A. (1996): The Advanced Theory of Statistics, Vol.3 Charles Griffin, London
12. Srivastava, O.S. (1983): A text book of Demography, Vikas Publishing House, N. Delhi.

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Paper XIV  
STOCHASTIC PROCESSES

Section-A

(Unit-I)

Introduction of Stochastic Processes: Definition, Classification of Stochastic Processes according to state space and time domain, Markov Process and Markov chain, Stationary Processes and its types, Laplace Transformations of Probability Distribution, Difference Equations in Probability Theory, Differential Difference Equations

(Unit-II)

Markov Chains: Discrete Time Markov Chain, Order of Markov Chain, Chapman-Kolmogorov Equations, Determination of Higher order Transition Probability and its limit, Classification of States and Chains, Limit Theorems for Markov Chain, Stationary Distribution, Random Walk-Gambler's Ruin's Problem, Applications of Discrete Time Markov Chains, Time-Reversal Markov Chains, Markov Chains with Continuous State Space. (24L+12T)

Section-B

(Unit-I)

Markov Process: Poisson Process and its generalization, Yule-Furry process, Birth-Death Process Definition, Markov Process with Discrete State Space-Kolmogorov Differential Equation, Erlangian Process, Markov Process with Continuous State Space-Wiener Process, Kolmogorov Diffusion Equations, Renewal Theory-Renewal Processes, Renewal Function and its properties, Elementary renewal theorem and applications, Delayed Renewal Process, Renewal Reward Process, Regenerative Stochastic Process and its Limits. (24L+12T)

(Unit-II)

Stationary Process and Time Series- Weakly Stationary and Strongly Stationary Processes, Moving average and Auto-Regressive Processes, Stationary Processes of different Time series models, Branching Processes, Galton-Watson's Branching Process, Properties of Generation Function of BP's, Probability of ultimate extinction, Distribution of population size, Idea of Martingales. (24L+12T)

References:

1. Adke, S.R. & Manjunath S.M.(1984): An introduction of Finite Markov Processer: 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. Mdhi, J.(1982): Statistical Inference for Markov Chains. Chicago University Press, Chicago.
5. Ross, S.M (1983): Stochastic Processes Wiley.

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Paper XV  
Reliability & Survival Analysis  
Section-A

(Unit-I)

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 test in these models (24L+12T)

(Unit-II)

Notions of ageing: IFR, IFRA, NBU, DMRL and 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, Reliability estimation based on failure times in variously censored life tests and in tests with replacement of failed items. Maintenance and replacement policies, availability of repairable systems, modeling of a repairable system by a nonhomogeneous Poisson process, Basic ideas of accelerated life testing (24L+12T)

Section-B

(Unit-I)

Concepts of time, Order and random censoring, likelihood in these case, Life distribution Exponential, Gamma, Weibull Lognormal, Pareto, Linear Failure rate, Parametric inference (Point estimation, confidence intervals Scores, LR, MLE tests (Rao-Wilks-Wald) for these distribution) Life tables failure rate, mean residual life and their elementary properties. Ageing classes and their properties, Bathtub failure rate.

(Unit-II)

Estimation of survival function-Actuarial Estimator, Kaplan Meier estimator, estimation under the assumption of IFR/DFR. Tests of Exponentiality against non-Parametric classes. Total time on test Deshpande test. Two sample problem-Gehan test, log rank test Mantel-Haenszel test Tarone-Ware tests. Rank test for the regression coefficients. Competing risks model, parametric and Non-Parametric inference for this model. Multiple decrement life table. (24L+12T)

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. L. and Engelhardt (1991) Statistical Analysis of reliability and Life Testing Models. Marcel Dekker
4. Nelson W. (1982): Applied Life data analysis. John Wiley
5. Cox D.R. and Oakes, D. (1984). Analysis of Survival Data. Chapman and Hall, New York
6. Miller, R.G. (1981). Survival Analysis. John Wiley
7. Kalbfleisch, J.D. & Prentice, R.L. (1980) the Statistical Analysis of Failure Time Data. John Wiley.

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Paper XVI  
Advance Multivariate Analysis and Bayesian Inference

Section-A

(Unit-I)

Principal components, dimension reduction, canonical variables and canonical correlation definition, use, estimation and computation, multivariate linear regression model-estimation of parameters, tests of linear hypotheses about regression co-efficient, Likelihood Ratio test criterion, Multivariate analysis of variance (MANOVA) one and two way classified data

(24L+12T)

(Unit-II)

Wishart matrix & its distribution, Distribution of sample generalized variance Non-Null distribution of partial and multiple correlation coefficient distribution of sample regression coefficient, Distribution of sample intra-class correlation coefficient in a random sample from a symmetric multivariate normal distribution Application in testing and interval estimation.

(24L+12T)

Section - B

(Unit-I)

Subjective interpretation of probability in terms of fair odds. Evaluation of (i) subjective probability of an event using a subjectively unbiased com(ii) subjective prior distribution of a parameter. Bayes theorem and computation of the posterior distribution. Bayesian point estimation as prediction problem from posterior distribution. Bayes estimators for (i) absolute error less (ii) squared error less (iii) 0-1 loss. Generalization of a common loss functions. Evaluation of the estimate in terms of posterior risk. Bayesian interval estimation Credible interval. Highest posterior density regions interpretation of the confidence co-efficient for a classical confidence interval.

(24L+12T)

(Unit-II)

Bayesian testing of hypothesis Specification of the appropriate form of the prior distribution for a Bayesian test of hypothesis problem. Prior odds, posterior odds, Bayes factor for various types of testing hypothesis problems depending upon whether the null hypothesis and the alternative hypothesis are simple or composite. Specification of the Bayes tests in the above cases. Discussion of Lindley's paradox for testing a point hypothesis for normal mean against the two sided alternative hypothesis Bayesian predication problem.

References:

1. Anderson, T.W.: An Introduction to Multivariate Statistical Analysis, 2<sup>nd</sup> ed. Wiley.
2. Ferguson, T.S.: Mathematical Statistics, Academic Press
3. Kendall, M.G. and Stuart, A.: Advanced Theory of Statistics, Vol. I and II.
4. Morrison D.F. (1976). Multivariate Statistical Methods, Mc Graw Hill
5. Kshirsagar, A.M. (1972). Multivariate Analysis, Marcel Dekker.
6. Berger, J.O.: Statistical Decision Theory and Bayesian analysis, Springer Verlag.
7. Leonard, T. and Hsu, J.S.J.: Bayesian Methods, Cambridge University Press.

Additional references:

1. Rao, C.R.: Linear Statistical Inference and its Applications, 2<sup>nd</sup> ed. Wiley
2. Srivastava, M.S. and Khatri, C.G.: An Introduction to Multivariate Statistics, North Holland
3. Bernardo, J.M. & Smith A.F.M.: Bayesian Theory, John Wiley and Sons.
4. Box, G.P. and Tiao, G.C.: Bayesian Inference in Statistical Analysis, Addison Wesley

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Paper-XVII  
Econometrics & Investment System

Section-A

(Unit-I)

Nature of Econometrics. The general linear model (GLM) and its extensions. Ordinary least squares (OLS) estimation and prediction. Use of dummy variables and seasonal adjustment. Generalized least squares (GLS) estimation and prediction. Heteroscedastic disturbances. Pure and mixed estimation. Grouping of observations and of equations. Auto correlation, its consequences and tests. Theil BLUS procedure. Estimation and prediction. Multicollinearity problem. Its implications and tools for handling the problem. Ridge regression.

(Unit-II)

Linear regression with stochastic regressor. Instrumental variable estimation. Errors in variables. Autoregressive linear regression. Distributed lag models. Use of principal components. Canonical correlations and discriminant analyses in econometrics. Simultaneous. Linear equations model. Examples. Identification problem. Restrictions on structural parameters-rank and order conditions. Restrictions on variances and covariances. Estimation in simultaneous equations model. Recursive systems. 2 SLS Estimators. Limited information estimators. K-class estimators. 3 SLS estimation. Full information maximum likelihood method. Prediction and simultaneous confidence intervals. Monte Carlo studies and simulation.

Section-B

(Unit-I)

Main theme: Risk-Return Trade off. Money market. Fixed income, Equity, stocks and bonds Treasury notes. Market indexes. Rates of interest. compound interest. inflation. Risk in a portfolio context. Law of one price and arbitrage. Risk and risk aversion. Mean variance analysis. allocation between risk and risk free portfolios. Diversification and Portfolios risk Markovitz portfolio selection, optimal portfolios.

(Unit-II)

Capital asset pricing model. passive strategy. risk premium, index models and diversification. CAPM and index model. Options markets. American and European options, call and put options, open strategies. option like instruments. option valuation, Binomial option pricing. Black-Scholes option valuation, uses of Black-Scholes formula. Futures markets. Mechanics and strategies. Futures prices. expected spot prices.

REFERENCES:

1. Apte PG (1990): Test book of Economics Tata McGraw Hill
2. Cramer, J.S. (1971): Empirical Econometrics. North Holland
3. Gujarathi, D (1979): Basic Econometrics. McGraw Hill
4. Intrulligator, MD (1980): Econometric Models-Techniques and Applications, PHI
5. Johnston, J. (1984): Econometric Methods. Third ed, McGraw hill
6. Klein, L R (1962) An introduction to econometrics. Prentice Hall of India
7. Bodie, Z, Kane, A and Marcus, A.J. (1996): Investment 4<sup>th</sup> Edition, Irvin Chapters: 1,2,4-10,20-22

Additional References:

1. Theil, H (1982) Introduction to the theory and Practice of Econometrics. John Wiley
2. Walters, A (1970) An introduction to Econometrics. McMillan & co.
3. Wetherill, B.B (1986) regression Analysis with Applications, Chapman Hall

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Paper XVIII  
Project work

Important:

1. The project work shall be based on either primary data involving field work or secondary data. The candidate will be required to prepare comprehensive and critical reports on the same.
2. The teacher supervising the Project work-Dissertation of a candidate shall be provided on hour per week towards his/her supervision.
3. In all the theory papers M.A. M.Sc. (Previous & final) Statistics Except paper XVIII the candidate will be required to answer five questions in all taking at least one question from each section.

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