KURUKSHETRA UNIVERSITY, KURUKSHETRA
(Established by the State Legislature Act XII of 1956)
('A+' Grade, NAAC Accredited)

Scheme of Examination and Syllabus of

M.Sc. Statistics CBCS w.e.f. session 2020-21 in Phased manner

DEPARTMENT OF STATISTICS & OPERATIONAL RESEARCH

CBCS CURRICULUM (2020-21)

Program Name: M.Sc. Statistics (CBCS)

KURUKSHETRA UNIVERSITY, KURUKSHETRA

Curriculum for M.Sc. Statistics (CBCS)

Scheme of Examination

(With effect from the Academic Session 2020-2021 in phased manner)

The duration of the course leading to the degree of Master of Science (M.Sc.) Statistics shall be of two academic years, comprising of four semesters. The examinations of Semester –I and Semester- III are usually held in the month of December and those of Semester-II and Semester-IV in the month of May on the dates being notified by the controller of examinations.

There will be four theory papers and one practical paper in each semester. In addition, there will also be two Open Elective Papers, one each in Semester-II & III and will be opted by the students from the list of the Open Elective Papers of the other departments of faculty of Sciences.

Every student will be required to go for Training for at least two weeks in reputed Institute/Industry and after the completion of the training; the student will submit the Training Report. The evaluation of the Report will be done jointly by the Practical Examiners (External & Internal) in Semester -IV.

The details of the Scheme of Examination
Semester-I

Paper No.	Nomenclature	Paper type	Credits	Contact hours per week	Internal marks***	External marks	Total marks	Duration of Exam (Hours)
ST-101	Measure and Probability Theory	Core	4	4	25	75	100	Three
ST-102	Statistical Methods and Distribution Theory	Core	4	4	25	75	100	Three
ST-103	Linear Algebra and Numerical Analysis	Core	4	4	25	75	100	Three
ST-104	Industrial Statistics	Core	4	4	25	75	100	Three
ST-105	Practical (Calculator and SPSS/R based)	Core	4	8	25	75	100	Four
		Total Credits-20			Total Marks -500			

KURUKSHETRA UNIVERSITY, KURUKSHETRA
Curriculum for M.Sc. Statistics (CBCS)
Scheme of Examination
(With effect from the Academic Session 2020-2021)

Semester – II

Paper No.	Nomenclature	Paper type	Credits	Contact Hours per week	Internal marks***	External marks	Total marks	Duration of Exam (Hours)
ST-201	Applied Statistics	Core	4	4	25	75	100	Three
ST-202	Operations Research	Core	4	4	25	75	100	Three
ST-203	Inference-I	Core	4	4	25	75	100	Three
ST-204	Programming with C and R	Core	4	4	25	75	100	Three
ST-205	Practical (Computer based)	Core	4	8	25	75	100	Four
OE-	One open elective paper is to be opted by the students of Department out of the Open Elective papers offered by the departments of the Faculty of Sciences (other than the Department of Statistics & O.R)	Open Elective	2	2	15	35	50	Three
		Total Credits-22			Total Marks- 550			
OE-209	**Statistics -I** (This Open Elective paper will be offered by the Department of Statistics & O.R. to the students of other Departments of the Faculty of Sciences)		2	2	15	35	50	Three

KURUKSHETRA UNIVERSITY, KURUKSHETRA
Curriculum for M.Sc. Statistics (CBCS)
Scheme of Examination
(With effect from the Academic Session 2021-2022)

Semester –III

Paper No.	Nomenclature		Paper type	Credits	Contact Hours per week	Internal marks***	External marks	Total marks	Duration of Exam. (Hours)
ST-301	Sampling Theory		Core	4	4	25	75	100	Three
ST-302	Inference-II		Core	4	4	25	75	100	Three
ST-303 & ST-304	Opt. (i) Optimization Techniques Opt.(ii) Stochastic Processes Opt.(iii) Programming with Python Opt.(iv)Econometrics Opt. (v)Bio-Statistics Opt. (vi)Statistical Methods in Epidemiology Opt. (vii) Real and Complex Analysis	Any Two	Elective **	4	4	25	75	100	Three
			Elective **	4	4	25	75	100	Three
ST-305	Practical (Computer based)		Core	4	8	25	75	100	Four
OE-	One open elective paper is to be opted by the students of Department out of the Open Elective papers offered by the departments of the Faculty of Sciences(Other than the Department of Statistics & O.R)		Open Elective	2	2	15	35	50	Three
			Total Credits-22			Total Marks-550			
OE-309	**Statistics -II** (This Open Elective paper will be offered by the Department of Statistics & O.R. to the students of other Departments of the Faculty of Sciences)			2	2	15	35	50	Three

KURUKSHETRA UNIVERSITY, KURUKSHETRA
Curriculum for M.Sc. Statistics (CBCS)
Scheme of Examination
(With effect from the Academic Session 2021-2022)
Semester –IV

Paper No.	Nomenclature		Paper type	Credits	Contact Hours per week	Internal marks**	External marks	Total marks	Duration of Exam. (Hours)
ST-401	Multivariate Analysis		Core	4	4	25	75	100	Three
ST-402	Linear Estimation and Design of Experiments		Core	4	4	25	75	100	Three
ST-403 & ST-404	Opt. (i) Theory of Queues Opt.(ii) Reliability and Renewal Theory Opt.(iii)Machine Learning Opt. (iv) Information Theory Opt.(v) Game Theory Opt. (vi) Actuarial Statistics Opt. (vii) Official Statistics	Any Two	Elective ** Elective **	4 4	4 4	25 25	75 75	100 100	Three Three
ST-405	Practical (Calculator and SPSS/SYSTAT based)		Core	4	8	25	75	100	Four
			Total Credits-20			Total Marks-500			

Note:

*Total Credits for Two Academic Years: 84 (42+42).

** The elective papers will be offered subject to availability of teaching faculty.

*** The marks of internal assessment/Internal marks will be based on the following criteria

For Theory Papers:

(i) Class Test-I : 20 Marks
Class Test-II

(ii) Attendance : 5Marks

For Practicals:

(i) Seminar/Viva-Voce/Test for each practical paper : 20 Marks

(ii) Attendance : 5Marks

For Open Elective theory papers

(i) Class Test-I : 10 Marks
Class Test-II

(ii) Attendance : 5 Marks

Marks for attendance will be given asunder:

(1) 91% on wards: 5 Marks (2) 81%to90% : 4Marks
(3) 75%to 80% : 3 Marks (4) 70%to 74% : 2 Marks#
(5) 65%to 69% : 1 Mark#

For students engaged in co-curricular activities of the Department /Institute only / authenticated medical grounds duly approved by the concerned Chairperson.

Program Outcomes (PO) for Post Graduate Programmes (CBCS) in the Faculty of Sciences, Kurukshetra University, Kurukshetra

PO1	Knowledge	Capable of demonstrating comprehensive disciplinary knowledge gained during course of study
PO2	Research Aptitude	Capability to ask relevant/appropriate questions for identifying, formulating and analyzing the research problems and to draw conclusion from the analysis
PO3	Communication	Ability to communicate effectively on general and scientific topics with the scientific community and with society at large
PO4	Problem Solving	Capability of applying knowledge to solve scientific and other problems
PO5	Individual and Team Work	Capable to learn and work effectively as an individual, and as a member or leader in diverse teams, in multidisciplinary settings.
PO6	Investigation of Problems	Ability of critical thinking, analytical reasoning and research based knowledge including design of experiments, analysis and interpretation of data to provide conclusions
PO7	Modern Tool usage	Ability to use and learn techniques, skills and modern tools for scientific practices
PO8	Science and Society	Ability to apply reasoning to assess the different issues related to society and the consequent responsibilities relevant to the professional scientific practices
PO9	Life-Long Learning	Aptitude to apply knowledge and skills that are necessary for participating in learning activities throughout life
PO10	Ethics	Capability to identify and apply ethical issues related to one's work, avoid unethical behavior such as fabrication of data, committing plagiarism and unbiased truthful actions in all aspects of work
PO11	Project Management	Ability to demonstrate knowledge and understanding of the scientific principles and apply these to manage projects

PSO for M.Sc. Statistics CBCS LOCF Programme

On successful completion of the programme a student will be able to

1. Apply analytical and practical skills learned in the course work
2. Provide hands- on training of Statistical Softwares and computer skills to handle and analyze large database by making optimum usage of time and resources in industries.
3. Engage the students in life-long learning by pursuing higher education and participation in research and development activities to meet all challenges to transform them as responsible citizens of the nation.

M.Sc. Statistics Semester – I

(ST-101) **Measure and Probability Theory**

Course Objectives:

The aim of the course is to pay a special attention to applications of Probability as a Measure. It provides the proper understanding of probability spaces for random variables, their sequences, various measures and measurable functions. The course will focus on the concept of law of large numbers and Central Limit Theorem.

Course Outcomes:

On completion of this course students will be able to:

- Understand the concepts of random variables, different measures & their properties.
- Understand the concept of measurable functions and Integration of measurable functions.
- Apply the results based on various modes of convergence and their interrelationship.
- Describe the advanced techniques of Probability theory including Laws of large numbers and Central limit theorem.

M.Sc. Statistics Semester – I

(ST-101) **Measure and Probability Theory** **(4Credits)**

Max Marks: 75+25***

*****Internal Assessment**

Time: 3 hrs.

Note: There will be nine questions in all. Question No.1 will be compulsory covering whole of the syllabus and comprising short answer type questions. Rest of the eight questions will be set from the four units uniformly i.e. two from each unit. The candidate will be required to attempt five questions in all selecting one from each unit and the compulsory one. The weightage of all the questions will be the same.

Unit –I

Fields; sigma field, sigma-field generated by a class of subsets, Borel fields. Sequence of sets, limsup and liminf of sequence of sets, random variables, distribution function. Measure, probability measure, properties of a measure, Concept of outer measures, inner measures, lebesgue measures and Lebesgue-Stieltjes measure.

Unit –II

Measurable functions: Sequence and algebra of measurable functions. convergence in measure. Integration of measurable function. Bounded convergence theorem, Fatou's Lemma, Monotone convergence theorem, General lebesgue integral, Dominated convergence theorem.

Unit –III

Borel-Contelli Lemma, Borel 0-1 law, Kolmogorov's 0-1 law, Tchebycheff's and Kolmogorov's inequalities, various modes of convergence: in probability, almost sure, in distribution and in mean square and their interrelationship.

Unit –IV

Laws of large numbers for i.i.d. Sequences. Characteristic function its uniqueness, continuity and inversion formula. Applications of characteristic functions. Central limit theorems: De Moivre's-Laplace, Liapounov, Lindeberg-Levy and their applications

References:

1. Kingman, J. F. C. & Taylor S.J., (1966) : Introduction to Measure and Probability, Cambridge University Press.
2. Bhat, B.R.(2014) : Modern Probability Theory, Wiley Eastern Limited
3. Taylor, J. C.(1997) : An Introduction to Measure and Probability, Springer.
4. Royden, H.L .(2010) : Real Analysis, Pearson Prentice Hall.
5. Billingsley, P. (1986). : Probability and Measure, Wiley.
6. Halmos, P.R.(1974) : Measure Theory, Springer
7. Basu, A.K(2017). : Measure Theory and Probability, PHI Learning (Pt.Lim.)

M.Sc. Statistics Semester – I

(ST-102) Statistical Methods and Distribution Theory

Course Objectives:

The course aims to shape the attitudes of learners regarding the field of statistics. This course will lay the foundation to probability theory and Statistical modeling of outcomes of real life random experiments through various Statistical distributions.

Course Outcomes:

On completion of this course students will be able to:

- Explain the basic concepts of probability, marginal and conditional distributions.
- Understand the Mathematical Expectation, correlation and regression analysis.
- Understand the applications of discrete and continuous distributions.
- Understand the concepts and utility of sampling distributions.

M.Sc. Statistics Semester – I

(ST-102) **Statistical Methods and Distribution Theory**

(4 Credits)
Max Marks: 75+25***
*****Internal Assessment**
Time: 3 hrs.

Note: There will be nine questions in all. Question No.1 will be compulsory covering whole of the syllabus and comprising short answer type questions. Rest of the eight questions will be set from the four units uniformly i.e. two from each unit. The candidate will be required to attempt five questions in all one from each unit and the compulsory one. The weightage of all the questions will be the same.

Unit-I

Basic concepts of probability: Random variable, sample space, events, Definition of Probability : Classical, Relative Frequency and Axiomatic Approach, notations. Additive law of probability, theorem of total probability, theorem of compound probability and Baye'stheorem. Random variables (discrete and continuous), Probability density function(pdf), Probability mass function(pmf), Distribution Function, Bivariate random variable, joint, marginal and conditional pmfs and pdfs.

Unit-II

Mathematical Expectation : Expectation and moments, expectation of sum of variates, expectation of product of independent variates, moment generating function. Tchebycheff's, Markov and Jensen inequalities, Relation between characteristic function and moments. Covariance, correlation coefficient , regression lines partial correlation coefficient, multiple correlation coefficient . Correlation ratio, rank correlation and intraclass correlation

Unit – III

Binomial, Poisson, Geometric, Negative binomial, Hypergeometric and Multinomial, Normal and log normal distributions.

Unit –IV

Uniform, Exponential, Laplace, Cauchy, Beta, Gamma distribution, Sampling distributions: Student – t distributions, F- distribution, Fisher's z – distribution and Chi-square distribution. Inter relations, asymptotic derivations. Simple tests based on t, F, chi square and normal variate z.

References:

1. Feller, W. (1968) : Introduction to probability and its applications, Vol.I, Wiley
2. Parzen, E. (1992) : Modern Probability Theory and its Applications, Wiley Interscience
3. Meyer, P.L. (1970) : Introductory Probability and Statistical Applications, Addison wesely.
4. Cramer, H.(2004) : Random variable and Probability Distribution, Cambridge University Press.
5. Kapur, J.N. (2010) & Sexena, H.C. : Mathematical Statistics & S.Chand & Co.

M.Sc. Statistics Semester – I

(ST-103) Linear Algebra and Numerical Analysis

Course Objectives:

To introduce the theory of Linear Algebra and Numerical Analysis in the scenario of statistics. The course will focus on Vector Spaces, Numerical Integration and Numerical solutions of ODEs.

Course Outcomes:

On successful completion of this course, the students will be able to:

- Describe the fundamentals of linear algebra and Numerical Analysis.
- Understand the concepts of Vector Spaces and Linear transformations
- Apply the results based on real quadratic forms, its reduction and classification.
- Apply the results and formulas based on interpolation, divided differences and Numerical Integration.

M.Sc. Statistics Semester – I

(ST-103) **Linear Algebra and Numerical Analysis** **(4 Credits)**

Max Marks: 75+25***

*****Internal Assessment**

Time: 3 hrs.

Note: There will be nine questions in all. Question No.1 will be compulsory covering whole of the syllabus and comprising short answer type questions. Rest of the eight questions will be set from the four units uniformly i.e. two from each unit. The candidate will be required to attempt five questions in all one from each unit and the compulsory one. The weightage of all the questions will be the same.

Unit – I

Vector Spaces: Linear dependence and independence , Basis and dimension of a vector space, examples of vector spaces .Linear transformations , Algebra of matrices , row and column spaces of a matrix , elementary matrices , determinant , rank and inverse of a matrix , null space and nullity ,Hermit canonical form. Solutions of matrixequations.

Unit – II

Orthogonal Transformations and Orthogonal matrix, Gram-Schmidt orthogonalisation process, characteristic roots and characteristic vectors, diagonalisation of a matrix, triangular form of a matrix .Real quadratic forms, reduction and classification of quadratic forms .

Unit – III

Difference and shift operators, identities involving separation of symbols and differences of zero, Newton's forward and backward interpolation formulae and estimation of the missing terms . Divided differences, Newton's and Lagrange's interpolation formulae for unequal intervals. Solution of systems of linear algebraic equations using Gauss elimination and Gauss-Seidal methods.

Unit – IV

Numerical Integration : Simpson's one-third and three eighth and Weddle's formulae, The Euler-Meclaurin's summation formula . Numerical solutions of ODEs using Picard, Euler, modified Euler and Runge-Kutta methods.

References:

1. Hadley,G., (2002) : LinearAlgebra
2. Datta,K.B.,(2016) : Matrix and Linear Algebra
3. Sushma, V : Linear Algebra(Macmillan)
4. Saxena.H.C : Calculus of Finite differences and numerical analysis.
5. Jain, M.K. (2019) : Numerical Methods for Scientific andEngineering
6. Guruswamy, B.(2009) : Computer Oriented NumericalMethods.

M.Sc. Statistics Semester – II

(ST-104) Industrial Statistics

Course Objectives:

The course aims to provide the theoretical knowledge about time series and S.Q.C.'s skills..It focuses on concepts and various techniques used in sampling and design in the context of quality control. It provides the knowledge to the students with the qualitative and analytical skills necessary to assist in planning, decision making and research within various industries. The course also aims to develop the skills of programming language R.

Course Outcomes:

On completion of this course students will be able to:

- Explain the concepts of Statistical Quality Control and Construct appropriate Quality Control Charts useful in monitoring a process.
- Apply various sampling inspection plans to real world problems for both theoretical and applied research and Assess the ability of a particular process to meet customer expectations.
- Understand to estimate Trend, Seasonal and Cyclic components of time series.
- Understand past and future behavior of phenomena under study and understand how a product quality can be improved and elimination of assignable causes of variations.

M.Sc. Statistics Semester – I

(ST-104) **Industrial Statistics**

(4 Credits)
Max Marks: 75+25***
*****Internal Assessment**
Time: 3 hrs.

Note: There will be nine questions in all. Question No.1 will be compulsory covering whole of the syllabus and comprising short answer type questions. Rest of the eight questions will be set from the four units uniformly i.e. two from each unit. The candidate will be required to attempt five questions in all one from each unit and the compulsory one. The weightage of all the questions will be the same.

Unit- I

Objectives of time series analysis, Components of time series, Measurement of secular trend: Method of mathematical curves (use of polynomial, logistic, Gompertz and lognormal functions) ,Method of moving averages Approximate formula(Spencer's 15-point and 21-point formulae); Method of variate- differencing and its use for estimation of variance of the random component. Measurement of seasonal fluctuations: Ratio-to moving average method, Ratio-to-trend method, Method of link relatives.

Unit- II

Measurement of cyclical fluctuations: Periodogram analysis. Different schemes which account for oscillations in a stationary time series, Concept of serial(auto) correlation and correlogram, Autoregressive series ,Correlogram of (i) moving average,(ii) an autoregressive series and (iii) Harmonic series.

Unit- III

Introduction, Different types of quality measures, Rational sub-groups and technique of control charts, 3 sigma control limits and probability limits, control charts for variables (mean and range, mean and standard deviation), Control chart for number defective and fraction defective, Control charts for percent defective, Control chart for number of defects. Two types of control charts. Natural tolerance limits and specification limits; Modified control limits. Sampling inspection by attributes: single , double and multiple sampling plans.

Unit- IV

Sequential sampling inspection plans, comparison of three types of plans. Sampling inspection by variables: underlying principles, variables inspection with known and unknown standard deviation.

Cumulative sum control chart (Cusum chart): Advantage, Two-sided and one –sided decision procedure. The ARL curve: The ARL Curve for a Shewart chart and for a Cusum chart. Design of a Cusum chart and V-Mask.

References:

1. Kendall, M.G. (1989) : Time Series, Griffin London
2. Ekambaram, S.K.,(1963) : The Statistical Basis of Acceptance Sampling, Asia Publishing House.
3. Goon, A.M., Gupta, M.K. & Dasgupta, B. (2016) : Fundamentals of Statistics, Vol. II, ed. VI, Word Press Calcutta.
4. Montgomery, D.C.,(1996) : Introduction to Statistical Quality Control, J.Wiley.1985
5. Duncan, A.J. (1986) : Quality Control and Industrial Statistics, Richard O.Irwin, Homewood.IL

M.Sc. Statistics Semester – I

(ST-105) Practical (Calculator and SPSS/R based)

Course Objectives:

The main objective of the course is to provide an understanding of basic statistical methods and ability to use through Softwares. During the course the students will train how to use SPSS and R for analysis. To acknowledge students the use of testing hypotheses for different parameter(s). It also provides practical knowledge about the concepts of Statistical Quality Control and Time Series.

Course Outcomes:

On completion of this course students will be able to:

- Obtain experience in using SPSS & R and Interpret the results of Statistical Analysis.
- Test the hypothesis using suitable statistical test(s).
- Understand to identify whether a process in statistical control or not.
- Understand to estimate Trend, Seasonal and Cyclic components of

M.Sc. Statistics Semester – I

(ST-105) **Practical (Calculator and SPSS/R based)** **(4Credits)**

Max Marks75+25***
-Practical: 60
-Class Record: 05
-Viva-Vice: 10
**** * Internal Assessment**
Time: 4 hrs.

Note: There will be 4 questions, the candidate will be required to attempt any 3 questions.

List of Practicals:

1. Testes of significance based on t-distribution.
   (i) Testing the significance of the mean of a random sample from a normal population.
   (ii) Testing the significance of difference between two sample means,
   (iii) Testing the significance of an observed correlation coefficient.
   (iv) Testing the significance of an observed partial correlation coefficient.
   (v) Testing the significance of an observed regression coefficient.

2. Tests based on F-distribution.
   (i) Testing the significance of the ratio of two independent population variances.
   (ii) Testing the homogeneity of means (Analysis of variance).

3. Testing the significance of the difference between two independent correlation coefficients.

4. Testing the significance for
   (i) A single proportion
   (ii) Difference of proportions for large samples.

5. Testing the significance of the difference between means of two large samples.

6. Testing the significance of difference between standard deviations of two large samples.

7. Fitting of the

   (i) Binomial distribution
   (ii) Poisson
   (iii) Normal distribution
   and their test of goodness of fit using $\chi 2$ test.

8. Correlation and regression
   (i) Pearson's coefficient of correlation
   (ii) Spearman's rank correlation coefficient (with ties and without ties).
   (iii) Fitting of the lines of regression.

9. Multiple and partial correlations

   (i) Multiple correlation coefficients
   (ii) Partial correlation coefficients
   (iii) Fitting of regression plane for three variates

10. Time series and SQC

   a. To obtain trends by using
      (i) Method of Semi-Averages
      (ii) Method of curve fitting
      (iii) Method of moving average.
      (iv) Spencer's 15 - point and 21 point -formulas.

   b. To obtain seasonal variation indices by using
      (i) Ratio to trend method.
      (ii) Ratio to moving average method.
      (iii) Link relative method.

   c. To construct

      (i) $\overline{X}$ and R–chart
      (ii) p–chart
      (iii) c–chart and u-chart
      and comment on the State of Control of the process.

M.Sc. Statistics Semester - II

(ST-201) Applied Statistics

Course Objectives:

The aim of this course is to provide adequate knowledge of Demography, Demand analysis and Index numbers. This course describes current population trends, in terms of fertility, mortality and population growth. It describes the structure and composition of populations and develop different measures used to keep track of the phenomena that affect populations.

Course Outcomes:

On completion of this course students will be able to:

- Understand the basic concept of various measures of mortality and Life table.
- Describe the Abridged life tables and methods of population projection.
- Apply the results based on Demand Analysis
- Understand the concept of Index Numbers and Official Statistics.

M.Sc. Statistics Semester - II

(ST-201) **Applied Statistics** **(4 Credits)**

Max Marks: 75+25***

*****Internal Assessment**

Time: 3 hrs.

Note: There will be nine questions in all. Question No.1 will be compulsory covering whole of the syllabus and comprising short answer type questions. Rest of the eight questions will be set from the four units uniformly i.e. two from each unit. The candidate will be required to attempt five questions in all one from each unit and the compulsory one. The weightage of all the questions will be the same.

Unit –I

Methods of obtaining demographic data, Rates and ratios, measurement of population at a given time , measurement of mortality : crude death rate , specific rates ,infant mortality rate , perinatal mortality rate , standard death rates . Graduation of mortality rates: Makehams and Gompertz graduation formula, Life table : Construction of a complete life table and its uses.

Unit –II

Abridged life tables: Kings method, Reed and Merrell's method, Greville's method, Keyfitz and Frauenhal's method and Chiang's method . Measurement of fertility: Crude birth rate , general fertility rate , age specific fertility rate , total fertility rate , gross reproduction rate and net reproduction rate . Stable and quasi-stable population, Methods of population projection, survival rates : UN model lifetable.

Unit –III

Demand Analysis– Laws of Demand and Supply, Price and Supply Elasticity of Demand. Partial and Cross Elasticity of Demand. Income Elasticity of Demand. Utility Function Methods of Determining Demand and Supply Curves from Family Budget and Time Series Data, Leontief's Method, Pigou's Method Engel Curve and its Different Forms,. Pareto's Law of Income Distribution. Curves of Concentration.

Unit –IV

Index Numbers and their Construction, Uses of Index Numbers. Price, Quantity and Value Relatives, Link and Chain Relatives, Laspeyer's, Paashce's, Marshall –Edge Worth and Fisher's Index Numbers, Chain Base Index Numbers, Tests for Index Numbers. Base Shifting, Splicing and Deflating of Index Numbers. Cost of Living Index Numbers.

Official Statistics: National Sample Survey Office (NSSO) and Central Statistics Office (CSO) and their role in national development.

References:

1. Ramakumar, R. : Technical Demography, Wiley, Eastern Limited.
2. Gupta, S.C. &Kapoor, V.K. : Fundamental of applied Statistics, 1990. Sultan Chand andSons,
3. Cox, P.R. (1970). : Demography, Cambridge University Press.
4. Keyfitz, N (1977). : Applied Mathematical Demography; Springer Verlag.
5. Spiegelman, M. (1969). : Introduction to Demographic Analysis; Harvard University
6 Goon, A.M., Gupta, M.K:(2016): Fundamental of Statistics Volume-II, &Dasgupta,B.
7. Guide to official Statistics (CSO) 1999.

M.Sc. Statistics Semester – II

(ST-202) Operations Research

Course Objectives:

Operations Research aims to introduce students to use quantitative methods and techniques for effective decisions–making; model formulation and applications that are used in solving business decision problems.

Course Outcomes:

On completion of this course students will be able to:

- Formulate Linear Programming problems and apply appropriate solving techniques to obtain optimum solution
- Build and solve Transportation Models and Assignment Models.
- Understand the concept of Game Theory, CPM and PERT.
- Solve the Inventory and Queueing models

M.Sc. Statistics Semester – II

(ST-202) **Operations Research** **(4 Credits)**

Max Marks: 75+25***

** *Internal Assessment**

Time: 3 hrs.

Note: There will be nine questions in all. Question No.1 will be compulsory covering whole of the syllabus and comprising short answer type questions. Rest of the eight questions will be set from the four units uniformly i.e. two from each unit. The candidate will be required to attempt five questions in all one from each unit and the compulsory one. The weightage of all the questions will be the same.

Unit –I

Convex sets, Linear Programming problems (LPP): Formulation, examples and forms, Hyperplane, Open and Closed half spaces. Feasible, basic feasible and optimal solutions.Solution of LPP by Graphical and Simplex method. Duality in linear programming.

Unit –II

Transportation Problems- Initial Basic Feasible Solution by North-West Corner Rule, Row minima method, Column minima method, Lowest Cost Entry Method, Vogel's Approximation Method, Optimum Solution of Transportation Problems. Assignment problem and its solution. Decision Theory : Algorithm for decision based problems, Types of decision making, Decision making under uncertainty : Criterion of optimism , Criterion of pessimism and Hurwicz criterion . Decision making under risks: EMV and EOL.

Unit-III

Game Theory : Terminology , two person zero sum game; game of pure strategy , reducing game by dominance, solution of game of mixed strategy without saddle point using linear programming method. Replacement models: replacement of items whose efficiency deteriorates with time and **(i)** The value of the money remains same during the period **(ii)** The value of the money also changes with time. Criterion of present value for comparing replacement alternatives.CPM (Critical path method) to solve the network problems and PERT.

Unit – IV

Inventory models: Deterministic inventory models (D.I.M) without shortages: EOQ model with constant rate of Demand, EOQ model with different rate of Demand, EOQ with finite rate of replenishment. D.I.M. with shortages : E O Q model with constant rate of Demand and scheduling time constant, E O Q model with constant rate of Demand and scheduling time variable. Simple Multi-item deterministic inventory model with constraint: model with limitation on space, model with limitation on investment. Queueing models : Introduction of queueing models, steady state solution of M/M/1 , M/M/1/N , M/M/C and M/M/C/N and their measures of effectiveness.

References:

1. Hadley, G.(1997): Linear Programming, Narosa Publications House.
2. Churchman, C.W.(1965) : Introduction to Operations Research John Wiley& Sons NewYork.
3. Goel, B.S. & Mittal, S.K.(2014): Operations Research, Pragater Prekshlen, John& Sons.
4. Gross, D. &Harris, C.M. (2008): Fundamentals of Queuing Theory
5. Sharma, S.D.(2012):Operation Research, KNRN

M.Sc. Statistics Semester – II

(ST-203) Inference –I

Course Objectives:

The main objective of the course is to draw statistically valid conclusions about a population on the basis of a sample in a scientific manner. This course deals with fundamental concepts and techniques of statistical inference including point and interval estimation. Alternative philosophical approaches to inference such as likelihood methods, and fiducial methods will be described.

Course Outcomes:

On completion of the course, students will be able to:

- Apply various discrete and continuous probability distributions in modeling statistical processes. Familiar with the fundamental concepts of random variables as they apply to statistical inferences.
- Understand how sampling distributions are used in making statistical inferences and familiar with the fundamental concepts of statistical inference as they apply to problems found in other disciplines.
- Estimate unknown parameters of a given probability distribution using various estimation techniques.
- Understand (i) how probability is used to make statistical inferences, (ii) what inferential statistics are used for and (iii) know how to perform point and interval estimation.

M.Sc. Statistics Semester – II

(ST-203) **Inference–I** **(4 Credits)**

Max Marks: 75+25***

*****Internal Assessment**

Time: 3 hrs.

Note: There will be nine questions in all. Question No.1 will be compulsory covering whole of the syllabus and comprising short answer type questions. Rest of the eight questions will be set from the four units uniformly i.e. two from each unit. The candidate will be required to attempt five questions in all one from each unit and the compulsory one. The weightage of all the questions will be the same.

Unit – I

Elements of Statistical Inference. Concept of likelihood function. Point estimation. Concept of consistency, unbiased estimators, correction for bias, minimum variance estimator, Cramer – Rao inequality, Minimum Variance-Bound (M.V.B.) estimator, Bhattacharya Bounds, Uniqueness of minimum variance estimators, efficiency, Minimum mean- square estimation.

Unit – II

Sufficient statistic, Neymann factorization theorm sufficiency and minimum variance. Rao- Blackwell theorem. Lehman Schefe's theorem. Distributions possessing sufficient statistics. Sufficiency when range depends on the parameter. The method of Least squares, The Least Squares estimator in the linear model, Optimum properties, Estimation of variance, the normality assumption.

Unit – III

Methods of estimation : Method of moments, Method of minimum chi-square and modified minimum chi-square , Method of maximum likelihood estimators and their properties, sufficiency, consistency of ML estimators. Hazurbazar's theorem, unique consistent ML estimators, efficiency and asymptotic normality of ML estimators.

Unit – IV

Interval estimation : Confidence intervals, confidence statements , central and non-central intervals , confidence intervals, Most selective intervals , Fiducial intervals : Fiducial inference in student's distribution , Problem of two means and its fiducial solution . Exact confidence intervals based on student's distribution, Approximate confidence- intervals solutions. Elementary Bayesian inference: Ideas of subjective probability, prior and posterior distribution, Bayesian intervals, Discussion of the methods of interval estimation.

References:

1. Kendall and Stuart (1979) : Advanced Theory of Statistics Vol.-II, Fourth edition Charles Griffin Co .Ltd London.
2. Rohtagi,V.K.. (2015) Saleh , A.K.Md. Ehsanes : Introduction to probability and Statistics (for & Numerical and Theoretical Applications), John Wiley and Sons.
3. Wald, A (2013) : Sequential Analysis, Dover publications, INC, New York.
4. Rao, C.R. (1970) : Advanced Statistical Methods in Biometric John Wiley&Sons, INC, NewYork.

M.Sc. Statistics Semester – II

(ST-204) Programming with C and R

Course Objectives:

The objective of this course is to make the students familiar with the programming basics using C language. This course also focuses on the statistical programming using R programming language**.**

Course Outcomes:

On completion of the course, students will be able to:

- Understand the basics of C programming language such as data types, operators, control structures and functions.
- Understand and apply the concepts of pointers, arrays, structures and unions.
- Understand the basics of R programming language such as data types, operators, control structures and functions.
- Handle data manipulations and various statistical models.

M.Sc. Statistics Semester – II

(ST-204) **Programming with C and R** **(4 Credits)**

Max. Marks: 75+25***

*****Internal Assessment**

Time: 3 hrs.

Note: Total number of questions shall be nine. Question number one will be compulsory and will be consisting of short/objective type questions from complete syllabus. In addition to compulsory first question there shall be four units in the question paper each consisting of two questions. Student will attempt one question from each unit in addition to compulsory question. All questions will carry equal marks.

Unit – I

Overview of C: History of C, Importance of C, Structure of a C Program. Elements of C: Character set, identifiers and keywords, Data types, Constants and Variables. Operators and their hierarchy & associativity. Input/output in C.

Control statements: Sequencing, Selection: if and switch statement; alternation, Repetition: for, while, and do-while loop; break, continue, go to statement. Functions: Definition, prototype, passing parameters, recursion.

Unit – II

Storage classes in C: auto, extern, register and static storage class, their scope, storage and lifetime. Arrays: Definition, types, initialization, processing an array, passing arrays to functions. Pointers: Declaration, operations on pointers, use of pointers. String handling functions Structure & Union: Definition, processing, Structure and pointers, passing structures to functions. Data files: Opening and closing a file, I/O operations on files.

Unit – III

Introduction to R: Overview of R programming, Evolution of R, Applications of R programming, Basic syntax; Basic Concepts of R: Reserved Words, Variables & Constants, Operators, Operator Precedence, Data Types, Input and Output; Data structures in R: Vectors, Matrix, List in R programming, Data Frame, Factor.

Control flow: If...else, If else() Function, For loop, While Loop, Break & next, Repeat Loop; Functions: R Functions, Function Return Value, Environment & Scope, R Recursive Function, R Infix Operator, R Switch function; Strings: String construction rules, String Manipulation functions

Unit – IV

R packages: Study of different packages in R; R Data Reshaping: Joining Columns and Rows in a Data Frame, Merging Data Frames, Melting and Casting; Working with files: Read and writing into different types of files.

R object and Class Object and Class: R S3 Class, R S4 Class, R Reference Class, R Inheritance; Data visualization in R and Data Management: Bar Chart, Dot Plot, Scatter Plot (3D), Spinning Scatter Plots, Pie Chart, Histogram, Box plot, Plotting with Base and Lattice Graphics, Sorting Datasets, Merging Datasets; Statistical modelling and Databases in R: Mean, mode, median, Linear regression, Decision tree, K-means Clustering

References

1. Gottfried, B. S. : Programming with C, Tata McGraw Hill
2. Balagurusamy, E. : Programming in ANSI C, McGraw-Hill
3. Yashwant, K : Let us C, BPB
4. Norman Matloff :The Art of R Programming-a tour of statistical software design by
5. Paul Teetor :R Cookbook Proven Recipes for Data Analysis, Statistics, and Graphics (O'Reilly Cookbooks)
6. Jeri R. H & Elliot P. K : Problem Solving and Program Design in C, Addison Wesley.
7. Kabacoff, Rob : R in Action Book
8. Zumel Nina, Mount John, Porzak Jim :Practical Data Science with R
9. Cotton Richard: Learning R : A Step-by-Step Function Guide to Data Analysis

M.Sc. Statistics Semester – II

(ST-205) Practical (Computer based)

Course Objectives:

The objective of this course is to provide an understanding for the student on statistical concepts to include measurements of location, dispersion, probability distributions, regression, correlation analysis and testing the significance of small sample size with the help of C Programming. The main objective of the course is to provide an understanding of C programming for calculation of statistical data.

Course Outcomes:

On completion of this course students will be able to:

- Calculate measures of location, dispersion, regression, correlation analysis and testing the significance of small sample with the help of C Programming.
- Compare different sets of data using C Programming.
- Able to fit probability distributions using C Programming.
- Understand data structures, use of pointers, memory allocation and data handling through files in 'C'.

M.Sc. Statistics Semester – II

(ST-205) **Practical (Computer based)** **(4 Credits)**

Max Marks: 75+25***
-Practical: 60
-Class Record: 05
-Viva-Vice: 10
-Time: 4 Hours

Note: There will be 4 questions; the candidate will be required to attempt any 03 questions.

List of Practicals based on C

1. Finding the mean and standard deviation for discrete and continuous data.
2. Computation of Moments, Skewness and Kurtosis of given data.
3. Computation of Karl Pearson's, Partial & Multiple correlation coefficient and Spearman's rank correlation coefficient.
4. Curve fitting, fitting of lines of regression.
5. Fitting of distribution: Binomial, Poisson and Normal.
6. Testing the significance of the mean of a random sample from a normal population.
7. Testing the significance of difference between two sample means,
8. Testing the significance of an observed correlation coefficient.
9. Testing the significance of an observed partial correlation coefficient.
10. Testing the significance of an observed multiple correlation coefficient.
11. Testing the significance of an observed regression coefficient.
12. Testing the significance of the ratio of two independent population variances.
13. To test the goodness of fit.
14. To test if the hypothetical value of the population variance is $\sigma^2 = \sigma_0^2$ (say).

Semester – II

Open Elective
(OE-209)

Statistics-I

Course Objectives

This course is designed to provide the fundamental concepts. This course is to provide an understanding for the student on statistical concepts to include measurements of location and dispersion, probability, probability distributions, regression, and correlation analysis. It provides knowledge about basic probability theory and its significance in the real world.

Course Outcomes:

On completion of this course students will be able to:

- Understand the importance and scope of Statistics.
- Calculate measures of location and dispersion with their applications.
- Understand the significance of statistics and probability in the real world
- Assess the nature of random variables and probability distributions.

Semester – II

Open Elective

(OE-209) **Statistics-I** **(2 Credits)**

Max Marks: 35+15***

*****Internal Assessment**

Time: 3 hrs.

Note: There will be ten questions in all i.e. five from each unit. The candidate will be required to attempt five questions selecting atleast two from each unit. The weightage of all the questions will be the same.

Unit -I

Meaning, importance and scope of statistics, Types of statistical data: primary and secondary data, qualitative and quantitative data, time series data, discrete and continuous data, ordinal, nominal, ratio and interval scales, Frequency distributions, cumulative frequency distributions, Diagrammatic representation of data: Bar diagrams, histogram, pie chart, measures of central tendency, Measures of dispersion, moments, skewness, kurtosis, Correlation coefficient , rank correlation, regression lines, partial correlation coefficient, multiple correlation coefficient.

Unit-II

Basic concepts of probability: Random experiment, sample space, events, different definitions of probability, Additive law of probability, conditional probability, Random variables: discrete and continuous random variables, Probability density function, distribution functions, mathematical expectation, moment generating function and characteristic function, Bivariate probability distributions: marginal and conditional distributions, Probability distributions: Binomial, Poisson, Normal, exponential, uniform, Central limit theorem.

References:

1. Gupta, S.C. & (2010): Fundamentals of Mathematical Statistics, Sultan Chand and Sons. Kapoor,V.K.
2. Gupta, S.C. &Kapoor, V.K. (2014): Fundamentals of Applied Statistics, Sultan Chand andSons.
3. Goon, A.M., Gupta, M.K (2016) : Fundamentals of Statistics, Vol. II, ed.VI,Word Press & Dasgupta,B.

M.Sc. Statistics Semester – III

(ST-301) Sampling Theory

Course Objectives: The main objectives of the sampling theory are to understand the advanced techniques of sample surveys and related issues which would be beneficial for the students to their further research. This course also focuses on how to obtain the best possible estimates of the population parameters.

Course Outcomes:

On completion of this course students will be able to:

- Understand the distinctive features of sampling schemes and its related estimation problems.
- Learn about the applications of sampling techniques: systematic, stratified and cluster sampling.
- Learn how to use the supplementary information for the purpose of estimation.
- Learn about probability proportionate to sampling (PPS) with replacement and without replacement methods and how to compare the results obtained under different sampling designs.

M.Sc. Statistics Semester – III

(ST-301) **Sampling Theory** **(4Credits)**

MaxMarks:75+25***

*****Internal Assessment**

Time: 3 hrs.

Note: There will be nine questions in all. Question No.1 will be compulsory covering whole of the syllabus and comprising short answer type questions. Rest of the eight questions will be set from the four units uniformly i.e. two from each unit. The candidate will be required to attempt five questions in all one from each unit and the compulsory one. The weightage of all the questions will be the same.

Unit -I

Basic finite population sampling techniques: Simple random sampling with replacement, Simple random sampling without replacement, stratified sampling and related results on estimation of population mean/total, Relative precision of Stratified and Simple random sampling techniques, Allocation problems in stratified sampling.

Unit –II

Use of supplementary information: Ratio estimation, bias and mean square error, estimation of variance, comparison with SRS, ratio estimator in stratified sampling, unbiased ratio-type estimators, regression and difference estimators, comparison of regression estimator with SRS and ratioestimator.

Unit –III

Systematic sampling (excluding circular systematic sampling) comparison with stratified and simple random sampling, double sampling for stratification and ratio estimate.Cluster sampling (equal clusters) and its efficiency relation between the variance of the mean of a single cluster and its size, Jesson's cost function and determination of optimum sampling unit. Sampling with unequal clusters, estimates of the means and their variances .

Unit –IV

Two stage sampling with equal first stage units, estimate of the population mean and its variance Repetitive surveys: Sampling over two occasions, probability proportionate to sampling (PPS) with replacement and without replacement methods [Cumulative total and Lahiri's method] and related estimators of a finite population mean[Horvitz Thompson and Desraj estimators for a general sample size and Murthy's estimator for a sample of size two].

References:

1. Chaudhuri A and Mukerjee R. (2017): Randomized Response, Theory and Techniques, New York: Marcel; DekkerInc.
2. Cochran W.G. (2007) : Sampling Techniques (3rd Edition, Wiley.
3. Des Raj and Chandak (2013) : Sampling Theory, Narosa Publications House.
4. Murthy.M.N (1977) : Sampling Theory & Statistical Method Publishing Society, Calcutta.
5. Sukhatme et al (1984). : Sample Theory of Surveys with Applications. Lowa State University Press &IARS.

M.Sc. Statistics Semester – III

(ST-302) **Inference -II**

Course Objectives: This course deals with concepts and techniques to arrive at decisions in certain situations where there is lack of certainty on the basis of a sample whose size is fixed or regarded as a random variable. Interpret statistical analysis and draw conclusions in context and in the presence of uncertainty. This course also focuses on Nonparametric tests deal with concepts of Empirical distribution function and order statistics.

Course Outcomes:

On completion of this course students will be able to:

- Understand the elements of Statistical decision theory.
- Know the concepts of Likelihood ratio test and its applications.
- Identify multiple applications where nonparametric approaches are appropriate.
- Perform and interpret various nonparametric tests.

M.Sc. Statistics Semester – III

Inference -II

(ST-302)

(4 Credits)
Max Marks: 75+25***
*****Internal Assessment**
Time: 3 hrs.

Note: There will be nine questions in all. Question No.1 will be compulsory covering whole of the syllabus and comprising short answer type questions. Rest of the eight questions will be set from the four units uniformly i.e. two from each unit. The candidate will be required to attempt five questions in all one from each unit and the compulsory one. The weightage of all the questions will be the same.

Unit – I

Elements of Statistical decision theory. Neyman - Pearson lemma (with emphasis on the motivation of theory of testing of hypothesis) BCR and sufficient statistics.Testing a simple hypothesis against a class of alternatives. Most powerful test, Uniformly most powerful test and sufficient statistics, power function. One and two sided tests.

Unit –II

Composite hypotheses, An optimum property of sufficient statistics. Similar regions, Elementary ideas of complete statistics, Completeness of sufficient statistics.Likelihood ratio test and its applications, asymptotic distribution of LR statistic and asymptotic power of LR tests.Sequential Analysis. Concept of ASN and OC functions. Wald's sequential probability ratio test and its OC and ASN functions.Distribution of order statistics and range.

Unit –III

Non - parametric tests and their applications: Empirical distribution function and its properties(without Proof), Test of randomness (Test based on the total number of runs). One-sample and paired-sample techniques: The Ordinary Sign test and Wilcoxon Signed-rank test. Tests of Goodness of Fit: Chi-square Goodness of Fit, The Empirical distribution function, Kolmogrov- Smirnov tests, Independence in Bivariate sample: Kendall's Tau coefficient and Spearman's rankcorrelation.

Unit –IV

Generalized two-sample problem: The Wald-Wolfowitz Runs test, Kolmogrov-Smirnov two sample Test, Median Test, Mann-Whitney U Test, Linear Ranked tests for the Location and Scale problem: Wilcoxon Test, Mood Test, Siegel-Tukey Test, Klotz Normal-scores Test, Sukhatme Test.Kruskalwallis ANOVA test, Concept of Jackknife, Bootstrap methods.

References:

1. Kendall and Stuart (1967) : Advanced Theory of Statistics Vol.-II, Charles Griffin & Co. Ltd,London
2. Rohtagi,V.K.(2015) Saleh Md. Ehsanes,A.K. : Introduction to probability and Statistics (for Numerical and Theoretical Applications).
3. Wald, A(2013) : Sequential Analysis Dover Publications, INC. New York.
4. Gibbons, Jean Dickinson (2010) Subhabrata Chakraborti : Nonparametric Statistical Inference (For Unit –III &IV only). McGraw – Hill Book Co. NewYork.
5. Rao, C.R.(1970) : Advanced Statistical Methods in Biometric Research, John Wiley&Sons, INC, NewYork.

M.Sc. Statistics Semester – III

(ST-303 & ST-304)Opt.(i) **Optimization Techniques** **(4 Credits)**

Course Objectives:

The course aims to introduce and understand the concept of non linear optimization problems

It focuses on the concept of integer programming and some other advanced optimization techniques which are necessary to assist in planning, decision making and research within various institutions.

Course Outcomes:

On successful completion of this course, the students will be able to

- Deal with complex nature of non linear programming.
- Formulate real life problems with integer programming problem and apply appropriate solving techniques to obtain optimum solution.
- Solve the Quadratic Programming.
- Explain the concept of Dynamic Programming, Comparison of Linear & Dynamic Programming.

M.Sc. Statistics Semester – III

(ST-303 & ST-304)Opt.(i) **Optimization Techniques** **(4 Credits)**

Max Marks: 75+25***

*****Internal Assessment**

Time: 3 hrs.

Note: There will be nine questions in all. Question No.1 will be compulsory covering whole of the syllabus and comprising short answer type questions. Rest of the eight questions will be set from the four units uniformly i.e. two from each unit. The candidate will be required to attempt five questions in all one from each unit and the compulsory one. The weightage of all the questions will be the same.

Unit-I

Artificial and unrestricted Variables, Two phase method, Big M-method, degeneracy and breaking the ties, Charne's perturbation method, revised Simplex method, Duality theory : Formulation and solution of dual problems, dual simplex algorithm and primal dual algorithm.

Unit-II

Non-Liner Programming Problems (NLPP): formulation of NLPP. Kuhn-Tucker Necessary and Sufficient Conditions of Optimality and Saddle Points. Integer Programming Problems(IPP), formulation of IPP, Solution of IPP: Gomory's algorithm for all integer programming problems, Branch and Bound Algorithm.

Unit-III

Quadratic Programming : Wolfe's and Beale's Method of Solutions. Separable Programming and its Reduction to LPP.Separable Programming Algorithm. Geometric Programming: Constrained and Unconstrained. Complementary Geometric Programming Problems.Fractional programming Algorithm and its computational procedure.

Unit – IV

Dynamic Programming: Principle of optimality , Cargo Loading problem, Inventory Problem, Computational Technique , Dimensionality Problem , Approximation by piecewise linear functions, Optimal path Problem, Sequencing Problem, Control Problem, Optimal page allocation Problem , Serial Multi Stage system , Comparison of Linear & Dynamic Programming.

References:

1. Hadley, G.(1997) :Linear programming, Narosa PublicationsHouse.
2. Vejda, S.(2009) :Mathematical Programming, DoverPublications.
3. Saul E.Gauss. :Linear programming Methods and Applications, DoverPublications.
4. Kambo, N. S. (2008) : Mathematical Programming Techniques, East –WestPressPvt. Ltd.
5. Mittal, K.V.(2016) :Optimization Methods, New Age International (P)Ltd.
6. Hadley, G.(1970): Non linear and Dynamic programming.

M.Sc. Statistics Semester – III

Stochastic Processes

(ST-303 & ST-304) Opt. (ii)

Course Objectives:

The course aims at:

Developing an awareness of the use of stochastic processes to build adequate mathematical models for random phenomena evolving in time.Acquainting students with notions of long-time behavior including transience, recurrence, and equilibrium to answer basic questions in several applied situations including branching processes and random walk models.

Course Outcomes:

On completion of this course students will be able to:

- Understand the concept of stochastic processes and its classifications.
- Deal with Random walk models.
- Classify states and Markov chains according to their long term behavior.
- Derive the probabilities for the birth death process and Polya processes

M.Sc. Statistics Semester – III

Stochastic Processes

(4 Credits)

(ST-303 & ST-304) Opt. (ii) **Max Marks: 75+25*****

***Internal Assessment**

Time: 3 hrs.

Note: There will be nine questions in all. Question No.1 will be compulsory covering whole of the syllabus and comprising short answer type questions. Rest of the eight questions will be set from the four units uniformly i.e. two from each unit. The candidate will be required to attempt five questions in all one from each unit and the compulsory one. The weightage of all the questions will be the same.

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Unit-I

Introduction to Stochastic processes, Classification of Stochastic processes according to state, space and time domain. Generating function, Convolutions, Compound distribution, Partial fraction expansion of generating functions.

Unit-II

Recurrent events, recurrence time distribution: necessary and sufficient condition for persistent and transient recurrent events & its illustrations and Notion of delayed recurrent event. Random walk models : absorbing, reflecting and elastic barriers, Gambler's ruin problem, probability distribution of ruin at n^{th} trial.

Unit-III

Markov chains: transition probabilities, classification of states and chains, evaluation of the n_{th} power of its transition probability matrix. Discrete branching processes, chance of extinction, means and variance of the n^{th} generation.

Unit-IV

Notions of Markov processes in continuous time and Chapman-Kolmogorov equations. The Poisson process: The simple birth process, the simple death processes. The simple birth and death process: The effect of immigration on birth and death process. The Polya Processes: Simple non-homogeneous birth and death processes.

References:

1. Bailey, N.T (1966) : The Elements of Stochastic Processes.
2. Medhi , J (2010). : Stochastic Processes, New Age International (P)Limited
3. Karlin , S.(1997) : Introduction to Stochastic Processing, Vol. I, Academic Press.
4. Basu, A.K.(2017) : Introduction to Stochastic Process, Narosa Publishing Hous

M.Sc. Statistics Semester- III

(ST-303 & ST-304) Opt. (iii) Programming with Python

Course Objectives:

The objective of this course is to provide basic knowledge of python with special emphasis on data science and machine learning packages.

Course Outcomes

On completion of this course students will be able to:

- Solve simple to advanced problems using Python language.
- Implement different data structures using Python.
- Implement Object-oriented approach and numerical computations using Python andNumPy.
- Use python for data science and machine learning.

M.Sc. Statistics Semester- III

Programming with Python

(4 Credits)

Max. Marks: 75+25***

(ST-303 &ST-304) Opt. (iii)

*****Internal Assessment**

Time: 3 hrs.

Note: Total number of questions shall be nine. Question number one will be compulsory and will be consisting of short/objective type questions from complete syllabus. In addition to compulsory first question there shall be four units in the question paper each consisting of two questions. Student will attempt one question from each unit in addition to compulsory question. All questions will carry equal marks.

Unit – I

Introduction to Python Programming: Using Python, Input, Processing, and Output, Displaying Output with the Print Function, Comments, Variables, Reading Input from the Keyboard, Performing Calculations (Operators. Type conversions, Expressions), More about Data Output. Decision Structures and Boolean Logic: if, if-else, if-elif-else Statements, Nested Decision Structures, Logical Operators, Boolean Variables. Repetition Structures: Introduction, while loop, for loop, Calculating a Running Total, Input Validation Loops, Nested Loops.

Functions: Introduction, Defining and Calling a Void Function, Designing a Program to Use Functions, Local Variables, Passing Arguments to Functions, Global Variables and Global Constants, Value-Returning Functions Generating Random Numbers, Writing Our Own Value-Returning Functions,

The math Module, Storing Functions in Modules.

Unit – II

File and Exceptions: Introduction to File Input and Output, Using Loops to Process Files, Processing Records, Exceptions.

Lists and Tuples: Sequences, Introduction to Lists, List slicing, Finding Items in Lists with the in Operator, List Methods and Useful Built-in Functions, Copying Lists, Processing Lists, Two-Dimensional Lists, Tuples. Strings: Basic String Operations, String Slicing, Testing, Searching, and Manipulating Strings. Dictionaries and Sets: Dictionaries, Sets, Serializing Objects. Recursion: Introduction, Problem Solving with Recursion, Examples of Recursive Algorithms.

Unit – III

Object-Oriented Programming: Procedural and Object-Oriented Programming, Classes, Working with Instances, Techniques for Designing Classes, Inheritance, Polymorphism.

NumPy - Introduction, Ndarray Object ,Data types, Array Attributes, Array Creation Routines, Indexing & Slicing, Advanced Indexing, Broadcasting, Iterating Over Array, Array Manipulation, Binary Operators, String Functions, Mathematical Functions, Mathematical Functions, Arithmetic Operations, Statistical Functions, Linear Algebra.

Unit – IV

Basic functions of matplotlib: Simple Line Plot, Scatter Plot, Density and Contour Plots, Histograms, Customizing Plot Legends, Colour Bars-Three-Dimensional Plotting in Matplotlib.

Introduction to Pandas Objects: Data indexing and Selection, Operating on Data in Pandas, Handling Missing Data, Hierarchical Indexing, Combining Data Sets.

Using Scikit-Learn for Linear Regression, Logistic Regression, Decision Tree, Naive Bayes, KNN, SVN, k Mean Clustering, Random Forest.

References:

1. Zhang.Y., (2016): An Introduction to Python and Computer Programming, Springer Publications,
2. Gaddis Tony, Starting Out With Python
3. Vander Plas Jake (2016): ,Python Data Science Handbook - Essential Tools for Working with Data, O'Reily Media,Inc,
4. Guttag John V, (2013): Introduction to Computation and Programming Using Python, Revised and expanded Edition, MIT Press ,
5. Sedgewick Robert, Wayne Kevin, (2016): Introduction to Programming in Python: An Inter-disciplinary Approach, Pearson India Education Services Pvt. Ltd.,
   Dondero Robert,
6. Kenneth A. Lambert, Fundamentals of Python.
7. Joel Grus , (2016): Data Science from Scratch First Principles with Python, O'Reilly Media,
8. Padmanabhan T. R., (2016): Programming with Python, Springer Publications,
9. Halterman Richard L. : Fundamentals of Python Programming,
10. Thareja Reema : Python Programming – Using Problem Solving Approach,

M.Sc. Statistics Semester- III
Econometrics

(ST-303 & ST-304) Opt. (iv)

Course Objectives:

The objective of this course is to study more advanced topics in econometrics. Students are expected to have knowledge in statistics and multiple regression models. This course also focuses on theories developed to real-world data and interprets the estimation results in many different respects.

Course Outcomes:

On successful completion of this course students will be able to:

- Acquire knowledge of Two Variable Linear Regression Models.
- Learn how to apply the Tests based on Linear Restrictions on Regression Coefficients.
- Understand the concept of Heteroscedasticity and Tests for Heteroscedasticity.
- Deal with Simultaneous Equations Models

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M.Sc. Statistics Semester- III
Econometrics

(4 Credits)

(ST-303 & ST-304) Opt.(iv) **Max Marks: 75+25*****

*****Internal Assessment**

Time: 3 hrs.

Note: There will be nine questions in all. Question No.1 will be compulsory covering whole of the syllabus and comprising short answer type questions. Rest of the eight questions will be set from the four units uniformly i.e. two from each unit. The candidate will be required to attempt five questions in all one from each unit and the compulsory one. The weightage of all the questions will be the same.

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Unit-I

Two Variable Linear Regression Model- Least Squares Estimators of Coefficients and Their Properties, Inference in Least Squares Model, The General Linear Regression Model, Ordinary Least Squares Estimator and its Properties, Inference in General Linear Regression Model. Maximum likelihood Estimates.

Unit-II

Tests of Linear Restrictions on Regression Coefficients, Use of Extraneous Information on Regression Coefficients – Restricted Regression, Restricted Least Squares and its Properties, Mixed Regression and Properties of Mixed Regression Estimator, Specification Errors Analysis- Inclusion and Deletion of Explanatory Variables, Effect on Estimation of Parameters and Disturbance Variance.

Unit-III

Heteroscedasticity, Tests for Heteroscedasticity –Bartletts's, Breusch-Pagan and GoldfeldQuand t- Tests Multicollinearity - Exact and Near Multicollinearity, Consequences and Detection of Multicollinearity, Farrar Glauber Test, Remedies for Multicollinearity, Ridge Regression Autocorrelation , Tests for Autocorrelation, Durbin Watson Test, Generalized Least Squares Estimation

Unit-IV

Simultaneous Equations Models: Structural and Reduced forms, Identification Problem. Rank and Order Conditions of Identification, Estimation in Simultaneous Equations Models: Indirect Least Squares2SLS Estimators,Instrumental Variable Method of Estimation. Limited Information maximum likelihood(LIML).Dummy Variable Technique forTesting Structural Stability of Regression Models and Comparing two regressions

Reading List

1. Johnston, J. (1996): Econometric Models, McGrawHills
2. Jan Kmenta(1986): Elements of Econometrics, University of MichiganPress
3. Intriligatore,M.D. : Economic models -techniques and applications, PrenticeHall
4. Maddala, G.S.(2009) : Econometrics, NorthHolland
5. Klein, L.R. : Applied Economics, Taylor andFrancis
6. Koutsoyiannis,A.(2001): Theory of Econometrics,Palgrave.

M.Sc. Statistics Semester- III
Bio-Statistics

(ST-303 & ST-304) Opt. (v)

Course Objectives:

The course aims at developing an awareness of the use of Biostatistics that is one of the areas of Applied Statistics.

This course is designed to teach the students about the basic principles of biostatistics.

Course Outcomes:

On completion of this course students will be able to:

- Explain biostatistics and its uses in the field of public health.
- Understand the different types of mating.
- Apply the results based ongenetic correlation and repeatability methods of estimation.
- Apply descriptive techniques commonly used to summarize public health data.

M.Sc. Statistics Semester- III
Bio-Statistics

(4 Credits)

(ST-303 & ST-304) Opt. (v) **Max Marks: 75+25*****

***Internal Assessment**

Time: 3 hrs.

Note: There will be nine questions in all. Question No.1 will be compulsory covering whole of the syllabus and comprising short answer type questions. Rest of the eight questions will be set from the four units uniformly i.e. two from each unit. The candidate will be required to attempt five questions in all one from each unit and the compulsory one. The weightage of all the questions will be the same.

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Unit-I

Bioassays : Quantitative and quantal response, dose response relation. estimation of median effective dose, estimation of unknown concentration or potency, probit and logit transformations, Parallel line and slope ratio assays , potency, ratio, Feller's theorem. Tests for non-validity, symmetric and asymmetric : assays, Toxic action of mixtures.

Unit-II

Types of mating: Random mating, Hardy-Weinberg equilibrium, Random mating in finite population. Inbreeding (Generation Matrix Approach) Segregation and linkage.Estimation of segregation and linkage parameters.

Unit-III

Concept of gen frequencies.Estimation of gene frequencies Quantitative inheritance, Genetic parameters heritability, genetic correlation and repeatability methods of estimation. Selection and its effect, Selection Index, dialled and partially dialled Crosses.

Unit-IV

Genotype environment interactions. Components of variance and Genotypic variance, Components of Covariance, Correlations between relatives, Genetic parameters; Heritability, Repeatability

References:

1. Kempthorne, O : An Introduction to Genetical Statistics, Wiley Eastern
2 Jain, l.R. (2017) : Statistical techniques in quantitativegenetics. Tata-McGraw Hill
3. Poti, S.J. (1984) : Quantitative study in life sciences, Vikas Publishing Ltd.
4. PremNarain. (1990): Bhatia : Handbook of Statistical Genetics, V.K. and Malhotra, I.A.S.R.I.P.K.
5. Daniell, W.W., Chad L. Cross(2014) : Bio Statistics – A foundation for analysis In health sciences , 3rd ed. Johnwiley
6. Falconer, D.S.(2009) : Introduction to quantitative Genetics (Longman Group Ltd.

M.Sc. Statistics Semester- III

Statistical Methods in Epidemiology

(ST-303 & ST-304) Opt. (vi)

Course Objectives:

This course aims at bio statistical methods and analysis of epidemiological studies.Course focuses on determinants of human disease and health outcomes with the application of methods to improve human health. The course develops basic statistical inference for risk measures according to the nature of the outcome variables (binary and ordinal, continuous, rate, time-to-event).

Course Outcomes:

On completion of this course students will be able to:

- Understand concepts of epidemiologic hypotheses and measuresmortality/Morbidity
- Describe epidemiologic concepts of diseases and models of transmission of infection.
- Understand the strengths and limitations of various epidemiologic study designs.
- Identify sources of bias, confounding and effect modification in epidemiological studies.

M.Sc. Statistics Semester- III

Statistical Methods in Epidemiology

(4 Credits)

(ST-303& ST-304) Opt. (vi) **Max Marks:75+25*****

** *Internal Assessment**

Time: 3 hrs.

Note: There will be nine questions in all. Question No.1 will be compulsory covering whole of the syllabus and comprising short answer type questions. Rest of the eight questions will be set from the four units uniformly i.e. two from each unit. The candidate will be required to attempt five questions in all one from each unit and the compulsory one. The weightage of all the questions will be the same.

Unit-I

Measures of disease frequency: Mortality/Morbidity rates, incidence, rates, prevalence rates. Sources of mortality/Morbidity statistics-hospital records, vital statistics records. Measures of accuracy or validity, sensitivity index, specificity index.

Unit-II

Epidemiologic concepts of diseases, Factors which determine the occurrence of diseases, models of transmission of infection, incubation period, disease spectrum and herd immunity. Observational studies in Epidemiology: Retrospective and prospective studies. Measures of association :Relative risk, odds ratio, attributable risk.

Unit-III

Statistic techniques used in analysis: Cornfield and Garts' method, Mantel.Haenszel method. Analysis of data from matched samples, logistic regression approach. Experimental Epidemiology: clinical and community trials. Statistical Techniques: Methods for comparison of the two treatments. Crossover design with Garts and McNamara test.Randomization in a clinical trial, sequential methods in clinical trials.Clinical lifetables.

Unit-IV

Assessment of survivability in clinical trials. Mathematical Modelling in Epidemiology: simple epidemic model, Generalized epidemic models, Reed First and Green wood models, models for carrier borne and host vector diseases.

References:

1. Lilienfeld and LiJenfeld (2015) : Foundations of Epidemiology, Oxford University Press.
2. Lanchaster, H.O.(1974) : An Introduction to Medical Statistics, John Wiley & Sons Inc.
3. FIeiss, J.L.(2003) : Statistical Methods for Rates and Proportions, Wiley InterScience.
4. Armitage(1975): Sequential Medical Trials, Second Edition,Wiley Blackwell.
5. Bailey, N.T.J. (1975): The mathematical theory of infectious disease and Applications, Griffin.

M.Sc. Statistics Semester- III

Real and Complex Analysis

(ST-303&ST-304) Opt. (vii)

Course Objectives:

To explain the basic and advanced elements of real and complex analysis.The course will focus on Topology of Real Numbers and Functions of a Complex Variable and Their Analytic Properties.The course also focuses on Singularities, their Classification and Application of Cauchy's Residue Theorem.

Course Outcomes:

On successful completion of this course, the students will be able to:

- Demonstrate an understanding of the concepts of real and complex number systems.
- Explain the concepts of Topology of Real Numbers
- Apply the results based on Functions of a Complex
  (i) Variable and Their Analytic Properties
  (ii) Singularities and Their Classification
- Apply the techniques of real and complex analysis in statistical applications.

M.Sc. Statistics Semester- III

Real and Complex Analysis

(ST-303&ST-304) Opt. (vii) **(4 Credits)**

Max Marks: 75+25***

*****Internal Assessment**

Time: 3 hrs.

Note: There will be nine questions in all. Question No.1 will be compulsory covering whole of the syllabus and comprising short answer type questions. Rest of the eight questions will be set from the four units uniformly i.e. two from each unit. The candidate will be required to attempt five questions in all one from each unit and the compulsory one. The weightage of all the questions will be the same.

Unit-I

Topology of Real Numbers: Open Set, Closed Set, Limit Point of a Set, Bounds of a Set. Convergence and Divergence of Sequences.Cauchy's Theorem on Limits, Sequence and Series of Functions and Their Convergence Properties.

Unit-II

Functions of a Complex Variable and Their Analytic Properties.Cauchy's Riemann equations.Power Series and its Radius of Convergence.Elementary idea of Mobius Transformation, Cross Ratio, Invariant Point and Criticalpoint.

Unit-III

Regular and Rectifiable Arcs. Contour. Domains: Connected, Simply Connected and Multiply Connected. Complex Line integrals.Cauchy's Theorem, Cauchy's Integral Formulae and Inequality.Morera's Theorem.Liouvelle's Theorem. Taylor and Laurent Series

Unit-IV

Singularities and Their Classification.Poles and Zeros of a Meromorphic Function, Argument Principle.Rouches Theorem. Fundamental Theorem of Algebra.Residues. Cauchy's Residue Theorem. Application of Cauchy's Residue Theorem for Evaluation of Integrals of Real Valued Functions.

References:

1 Narayan, Shanti, Mittal P.K. (2005) : A Course of Mathematical Analysis ,S.Chand.

2. Malik,S.C. &Arora,Savita(2017): Mathematical Analysis, New AgeInternational.

3. Copson, E.T. (1970): Introduction to the Theory of Functions of a Complex Variable,Clarendon PressOxford.

4. Convey, John B. (1996): Functions of one Complex Variable,Springer.

5. Sharma, J.N. (2014): Function of a Complex Variable, Krishna Parkashan, Media Ltd.,Meerut.

6. Goyal and Gupta.(2016): Function of a complex Variable,,PargatiParkashan Meerut.

7. Malik, S.C. (2016): Real and Complex Analysis, Jeevan Sons Publication, NewDelhi.

M.Sc. Statistics Semester- III
Practical (Computer based)

(ST-305)

Course Objectives: The objective of this course is to provide Knowledge to student about sampling theory with the help of C++ Programming. The main objective of the course is to provide an understanding of C++ programming for calculation and comparison of statistical data.

Course Outcomes:

On completion of this course students will be able to:

- Understand different methods of sample selection and analyzing data using C++.
- Estimate the population total, population mean and variance of estimator for different sampling designs with the help of C++ Programming
- Compare the ratio estimator with mean per unit estimator under simple randomsampling using C++.
- Compare the regression, ratio and mean per unit estimates from a simple randomsample using C++.

M.Sc. Statistics Semester- III

(ST-305) **Practical (Computer based)** **(4 Credits)**

Max Marks: 75+25***
-Practical: 60
-Class Record: 05
-Viva-Vice: 10
***** Internal Assessment**
Time: 4 hrs.

Note: There will be 4 questions, the candidate will be required to attempt any 03 questions.

List of Practicals based on C :

1. Estimation of population mean, total, confidence limits and variance of estimator under simple random sampling.
2. Estimation of population total, population mean and variance of estimator under stratified random sampling.
3. Calculation of optimum and proportional allocation.
4. Comparison of stratified sampling with different types of allocation withunstratified simple random sampling.
5. Comparison of systematic sampling with simple random and stratified random sampling.
6. Estimator of the mean squared error of the productestimator.
7. Estimation of variance in double sampling forstratification.
8. Estimation of gain in precision due to stratification from the results of stratified sample.
9. Ratio estimator for mean and total of population, variance of theestimators.
10. Comparison of ratio estimator with mean per unit estimator under simple randomsampling.
11. Comparison of separate and combined ratio estimators under stratified randomsampling with mean per unit estimate or under randomsampling.
12. Comparison of different types of allocation for ratio estimator under stratifiedrandom sampling.
13. Comparison of tworatios.
14. Comparison of regression, ratio and mean per unit estimates from a simple randomsample.

Semester – III

Open Elective
(OE-309)

Statistics-II

Course Objectives:

This is an introductory course in statistics. Students are introduced to the fundamental concepts involved in using sample data to make inferences about populations. This course is to provide an understanding for the student on statistical concepts to include:tests of hypothesis,sampling distributions, one-way and two-way *ANOVA*. It provides knowledge to perform hypothesis tests on means and proportions for one or two populations for small as well as large sample.

Course Outcomes: On successful completion of the course, Students will be able to:

- Understand concepts of sample vs. population.
- Perform basic statistical inference tasks involving various forms of hypothesis test for one and two samples.
- Apply inferential statistical methods via hypothesis testing.
- Analyze the data and use the tests based on t, F, chi square and ANOVA.

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Semester – III
Statistics-II

Open Elective **(2 Credits)**
(OE-309) **Max Marks: 35+15*****
*****Internal Assessment**
Time: 3 hrs.

Note: There will be ten questions in all i.e. five from each unit. The candidate will be required to attempt five questions selecting atleast two from each unit. The weightage of all the questions will be thesame.

Unit-I1

Concept of population and sample, parameter and statistic, need of sampling, types of sampling (definition only),sampling distribution of a statistic, standard error, Statistical hypothesis, null and alternative hypotheses, simple and composite hypotheses, procedure in hypothesis testing, types of errors, power of test and critical region, levels of significance, one and two tailed test, degrees of freedom, Tests of hypothesis-large sample tests: test of hypothesis for single mean, difference of means, proportions, difference of proportions, standard deviation and difference of standarddeviations.

Unit-II

Sampling distributions and their applications: Student - t distributions, F- distribution, Fisher's z – distribution and Chi-square distribution. Simple tests based on t, F, chi square and normal variate z. Analysis of variance: for one-way classification, two-way classification (for fixed effect modelonly).

References:

1. Gupta, S.C. & Kapoor, V.K.(2010) : Fundamentals of Mathematical Statistics, Sultan Chand andSons.
2. Gupta, S.C. &Kapoor, V.K.(2014) : Fundamentals of Applied Statistics, Sultan Chand andSons.
3. Goon, A.M., Gupta, M.K(2016) : Fundamentals of Statistics, Vol. II, ed. VI, Word Press & Dasgupta, B.

M.Sc. Statistics Semester – IV
Multivariate Analysis

(ST-401)

Course Objectives:

The objective of the course is to introduce several useful multivariate techniques and making strong use of illustrative examples. The course focuses on extensions of univariate techniques to multivariate framework, such as multivariate normal distribution, hypothesis testing and simultaneous confidence intervals. The course will also cover the advance techniques of multivariate such as principal component analysis, Canonical correlation analysis and classification.

Course Outcomes:

On completion of this course students will be able to:

- Describe the multivariate analysis tools in relation to univariate tools
- Understand sampling distribution and maximum likelihood estimators of total, partial and multiple correlation coefficients
- Conduct statistical inference by using Hotteling's T^2 and Mahalanobis D^2-Statistic
- Undertake statistical analyses using appropriate multivariate techniques, which include discriminant, Principal component and Canonical correlation analysis.

M.Sc. Statistics Semester – IV

(ST-401) **Multivariate Analysis** **(4 Credits)**

Max Marks: 75+25***

*****InternalAssessment**

Time: 3 hrs.

Note: There will be nine questions in all. Question No.1 will be compulsory covering whole of the syllabus and comprising short answer type questions. Rest of the eight questions will be set from the four units uniformly i.e. two from each unit. The candidate will be required to attempt five questions in all one from each unit and the compulsory one. The weightage of all the questions will be the same.

Unit-I

Notion of multivariate distribution, multivariate normal distribution of linear combination of normal variates, Marginal and Conditional distributions, Multiple and partial correlation coefficients. Characteristic function of a random vector, characteristic function when the random vector is normally distributed. Moments and semi-invariants of multivariate normal distribution.Estimation of the mean vector and covariance matrix, maximum likelihood estimator of the parameters of multivariate normal distribution.

Unit-II

The distribution of the sample mean vector and sample dispersion matrix. Sample correlation coefficient, maximum likelihood estimators of total, partial and multiple correlation coefficients; sampling distribution of simple, partial and multiple correlation coefficients when the corresponding population correlation coefficients are zero.Testing hypotheses of significance of these distributions.

Unit-III

Hotteling's T^2 and Mahalanobis D^2-Statistic; Justification , distribution and uses . The multivariate Behren's Fisher Problem and its solution. Classification Problem : Standards of good classification, Baye's and minimax regions for classification into one of two known multivariate normal populations when the parameters are known and unknown. Fisher's linear discriminator, Anderson'sdiscriminator.

Unit-IV

WishartDistribution : Definition, Characteristic function and properties. Sample generalized variance, asymptotic distribution of sample generalized variances. Principal components in the population, Canonical correlation in the population.

References:

1. Anderson, T.W.(1984), : An Introduction to Multivariate Statistical analysis, Second Edition John Wiley.
2. Narayan, C. Giri (2003) : Multivariate Statistical analysis, Marcel Dekker.
3. Srivastava, M.S.& C.G.(1979),Holland. : An introduction to Multivariate Statistics, North Khatri
4. Kshirsagar, A.M.(1972) : Multivariate Analysis, Marcell-Dekher
5. Johnson, R.A (2007): Applied Multivariate Statistical Analysis, PHI Learning &Wichern, D.W
6. Bhuyan, K.C (2005) : Multivariate Analysis and its applications, New Central Book Agency(P) Ltd.

M.Sc. Statistics Semester – IV

Linear Estimation & Design of Experiments

(ST-402)

Course objective:

This course provides an overview about linear models and design of experiments. To provide orientation of statistics while designing statistical experiments. Exposure to various statisticaldesigns leading to the analysis of variance, eliminating heterogeneity of the data and construction of designs will be provided.

Course Outcomes:

On successful completion of this course, students will be able to

Understand the concepts based on Markov models, BLUE and Tests of General Linear hypothesis

Layout and analysis of completely randomized, randomized blocks and Latin-square designs

- Understand the concepts based on Markov models, BLUE and Tests of General Linear hypothesis
- Apply experimental design techniques in real problems.
- Argue the necessity of Factorial experiments and Confounding in Factorial Experiments
- Experimental design to the task of collecting valid and relevant data in order to draw the correct statistical evidence to support a hypothesis.
- Understand the effects of independence or dependence of different factor under study.

M.Sc. Statistics Semester – IV
Linear Estimation and Design of Experiments (4 Credits)

(ST-402) **Max Marks: 75+25*****

*****Internal Assessment**

Time: 3 hrs.

Note: There will be nine questions in all. Question No.1 will be compulsory covering whole of the syllabus and comprising short answer type questions. Rest of the eight questions will be set from the four unit uniformly i.e. two from each unit. The candidate will be required to attempt five questions in all one from each unit and the compulsory one. The weightage of all the questions will be the same.

Unit –I

Linear estimation : Least Square estimates of regression coefficients, Standard Gauss-Markov models, estimability of parameters, best linear unbiased estimators (BLUE), Method of least squares and Gauss Markov theorem; Variance-Covariance matrix of BLUES, Distributional Properties. Tests of General Linear hypothesis.

Unit –II

One-way and two way classifications: ANOVA for Fixed, random and mixed effects Models (One observation per cell). Terminology in experimental designs. Basic principles of design of experiments, General block design and its information matrix, balance and orthogonality, Layout and analysis of completely randomized, randomizedblocks and Latin-square designs.

Unit – III

Factorial experiments: 2^2-experiment, 2^3-experiment and 2^n-experiment in 2^k blocks per replicate. Confounding in Factorial Experiments: Complete confounding for 2^2-experiment and 2^3-experiment, Partial confounding for 2^2-experiment and 2^3-experiment., Advantages and Disadvantages of Confounding. Split-plot design.

Unit – IV

Incomplete Block Design , Balanced incomplete block design, parameters relationship of Balanced incomplete block design, Symmetric Balanced incomplete block design, construction of Balanced incomplete block design by developing initial blocks, analysis of Balanced incomplete block design. Orthogonal Latin squares: construction of orthogonal Latin squares of order 4.

References:

1. Searle,S.R.(1997) : Linear Models , John Wiley & sons NewYork.
2. AlokeDey,(1987) : Theory of Block Designs , Wiley EasternLtd.
3. Chakrabarti,M.C(1970) : Mathematics of Design and Analysis of Experiments, Asia Publishing House
4. Joshi, D.D., (1987) : Linear Estimation and Design of Experiments ,Wiley EasternLtd.
5. Das, M.N.andGiri, N(1979) : Design and Analysis of Experiments,WileyEastern.
   Giri,N. : Analysis of Variance, South AsianPublishers.
6. Montogomery, C.D.(2012) : Design and Analysis of Expertiments, Wiley, NewYork.
7. Goon, A.M.,Gupta, M.K.(2013): An Outline of Statstical Theory, Vol. II, World Press. andDasgupta. B.

M.Sc. Statistics Semester – IV

Theory of Queues

(ST-403 & ST-404) Opt.(i)

Course Objectives:

The objective of this course is to introduce the concept of probabilistic tools and concepts which are useful in modeling, such as Markov models and queueing theory. The students also study the various advanced queueing models with their practical utility in communication systems, computer networks, traffic control and other related fields.The queuing models are used to find out the optimum service rate and the number of servers so that the average cost of being in queuing system and the cost of service are minimized.

Course Outcomes:

On completion of this course students will be able to:

- Deep understanding of the theoretical background of queueing systems.
- Acquire skills in handling situations involving more than one random variables and functions of random variables.
- Understand to analyze the performance of computer systems and queues by applying basic concept of probability techniques and models.
- Understand and compute measures of effectiveness for different queueing systems also apply & extend queueing models to analyze real world systems.

M.Sc. Statistics Semester – IV
Theory of Queues

(ST-403& ST-404) Opt.(i)

(4 Credits)
Max Marks: 75+25***
*****Internal Assessment**
Time: 3 hrs.

Note: There will be nine questions in all. Question No.1 will be compulsory covering whole of the syllabus and comprising short answer type questions. Rest of the eight questions will be set from the four units uniformly i.e. two from each unit. The candidate will be required to attempt five questions in all one from each unit and the compulsory one. The weightage of all the questions will be the same.

Unit-I

Queueing system. Components of a queueing system, measures of effectiveness, notations, exponential distribution and its various properties, stochastic processes, definition and examples, Poisson process and its some important properties related to queues. Markov chains and its properties (without proof).Concepts of steady state and transient state, K-Erlang distribution.Birth and death process.

Unit-II

M/M/1 queueing system steady state and time dependent solutions.measures of effectiveness, busy period distribution, 'waiting time distribution, Little's formula. State probability generating function for M/M/1/N queueing system and its steady state probabilities measures of effectiveness, Time dependent solutions of M/M/∞ queuing system and M/M/∞ queueing system with time dependent input parameter, measures of effectiveness.

Unit-III

M/M/1 queueing system with phase type service, busy period time distribution, waiting time distribution, Mu1tiple channel queueing system with Poisson input and constant service time (M/D/C), Measures of effectiveness.Erlang service model M/Ek/1, Erlang arrival model Ek/M/1.

Unit-IV

Departure point steady state system size probabilities for M/G/1 queueing system, special cases M/Ek/1 and M/D/1 Pollaczek-Khintchine formula, waiting time, busy period analysis.Arrival point steady state system size probabilities for GI/ M/1 queueing system. Machine interference Model

References:

1. Gross, D. & Carl M. Harris (1998) : Fundamental. of queuing theory, John Wiley and Son..
2. Saaty, T.L.(2000): Elements of queuing theory with applications. McGraw Hill Book Company Inc.
3. Allen, A.O.(2010): Probability, Statistics and Queuing Theory with Computer Science Applications, Academic Press
4. Kashyap, B.R.K & Chaudhary, M.L (1988): An Introduction to Queueing Theory, AARKAY Publications, CalcuttsChaudhary, M.L.

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M.Sc. Statistics Semester – IV
Reliability and Renewal Theory

(ST-403 & ST-404) Opt.(ii)

Course Objectives:

To introduce the elementary and advanced concepts of reliability and Renewal Theory.This course providesthe students the ability to use statistical tools to characterize the reliability and the working knowledge to determine the reliability of various systems. Also, suggest various approaches to enhancing system reliability. This course also provide the students the ability to select appropriate reliability validation methods and renewal processes.

Course Outcomes:

On completion of this course students will be able to:

- Describe the basic concepts of reliability and Renewal Theory in real life scenario.
- Understand the appropriate methodologies and tools for enhancing the inherent and actual reliability of components /systems, taking into consideration cost aspects.
- Apply various Reliability and Availability evaluation Techniques for systems having different numbers of components
- Define various Renewal processes and to derive the distribution of the number of renewals.

M.Sc. Statistics Semester – IV

Reliability and Renewal Theory

(4 Credits)

(ST-403 & ST-404) Opt.(ii)

Max Marks: 75+25***

*****Internal Assessment**

Time: 3 hrs.

Note: There will be nine questions in all. Question No.1 will be compulsory covering whole of the syllabus and comprising short answer type questions. Rest of the eight questions will be set from the four units uniformly i.e. two from each unit. The candidate will be required to attempt five questions in all one from each unit and the compulsory one. The weightage of all the questions will be the same

Unit-I

Concept of reliability , early age failures, wear out failures and chance failures. Derivation of general reliability function failure rate, failure density function and mean time between failures (MTBF). System reliability evaluation: series system, parallel system, partially redundant system, standby system with perfect switching / imperfect switching. Effect of spare components (identical / non- identical) on the system reliability.

Unit-II

Wear out and Component reliability, Combined effect of wear out and chance failures. Reliability of a two component system with single repair facility. Reliability evaluation Techniques : Conditional probability approach , cut set method, approximation evaluation, Deducing the minimal cut sets. Tie set method , connection matrix technique.

Unit-III

Availability and Reliability evaluation in Repairable system, evaluation of time dependent probabilities with single repairable component, two repairable components.Evaluating limiting state probabilities with single repairable component, two identical repairable components Matrix multiplication method: reliability evaluation in repairable system, mean time to failure.Stochastic transitional probability matrix method to evaluate MTTF of two components parallel system, two component series system.

Unit-IV

General Introduction. The distribution of the number of renewals: The asymptotic distribution of N. The asymptotic normality of $N_t$with mean t/μ and variance $t/\ \mu 3$ The number of renewals in a random time, the renewal function , the asymptotic form of the renewal function. The renewal density, variance of the number of renewals.Backward and forward recurrence times.Limiting distribution of recurrence times.

References:

1. Cox D.R. & Miller H.D. (1994) : Theory of Stochastic Processes, Chapman and Hall Ltd.
2. Billinton, R.(1997) : Reliability Evaluation of Engineering systems: Concepts and Techniques Plemum Press New York London.
3. Cox, D.R.(1967) : Renewal Theory, Methuen & Co. Ltd.
4. Medhi,J. (2010): Stochastic Processes New Age International (P)Limited.
5. Igor Bazovsky (1961) : Reliability Theory and Practice, 2nd ed. Prentice Hall.

M.Sc. Statistics Semester - IV
Machine Learning
(ST-403 & ST-404) Opt.(iii)

Course Objectives:

The objective of this course is to introduce the concept of learning patterns from data and develop a strong theoretical foundation for understanding state of the art Machine Learning algorithms. This course is broad in scope and gives the student a holistic understanding of the subject.

Course Outcomes

On completion of this course students will be able to:

- Understand basics of machine learning.
- Have in-depth knowledge of supervised learning.
- Understand non-parametric methods along with decision trees.
- Understand about the basics and importance of unsupervised learning and artificial neural networks.

M.Sc. Statistics Semester - IV
Machine Learning

(4 Credits)

(ST-403 & 404) Opt. (iii) **Max. Marks:** 75+25***

***Internal Assessment**

Time: - 3 hrs.

Note: Total number of questions shall be nine. Question number one will be compulsory and will be consisting of short/objective type questions from complete syllabus. In addition to compulsory first question there shall be four units in the question paper each consisting of two questions. Student will attempt one question from each unit in addition to compulsory question. All questions will carry equal marks.

Unit – I

What is Machine Learning, Why Machine Learning is Required, Relation to Artificial Intelligence, Current Applications & Future of Machine Learning in Various Industries, Basic Process of any Machine Leaning System, Terminologies used in Machine Learning, Evaluation Metrics in Machine Learning, Machine Learning Categories , Supervised Learning, Unsupervised learning, Reinforcement Learning.

Unit – II

Understanding of Supervised Learning with example, Vapnik-Chervonenkis (VC) Dimension, PAC Learning, Regression, Model Selection and Generalization, Dimensions of a Supervised Machine Learning Algorithm, Bayesian Decision Theory, Parametric Methods : Maximum Likelihood Estimation, Regression, Model Selection Procedure, Multivariate Methods: Multivariate Data, Multivariate Classification, Tuning Complexity, Multivariate Regression; Support Vector Machines, Random Forest.

Unit – III

Non Parametric Methods: Histogram Estimator, Kernal Estimator, k Nearest Neighbor Estimator, Non Parametric Classification, Condensed Nearest Neighbor, Non Parametric Regression – Smoothing Models, How to Choose Smoothing Parameter.

Decision Trees :Univariate Trees, Classification Trees, Regression Trees, Pruning, Rule Extraction from Trees, Learning Rules from Data, Multivariate Trees.

Unit – IV

Unsupervised Machine Learning: k-Means Clustering, Expectation Maximization Algorithm, Supervised Learning after Clustering, Hierarchical Clustering, Choosing the number of Clusters.

Neural Network(NN) : Introduction, Important Concepts in NN, The Perceptron, Training a Perceptron, Learning Boolean Functions, Multilayer Perceptron, MLP as a Universal Approximator, Backpropogation Algorithm, Training Procedures, Tuning the Network Size, Bayesian View of Learning, Dimensionality Reduction, Learning Time.

References :

1. Alpaydin E.,(2006): Introduction to Machine Learning, Prentice Hall of India,.
2. Mitchell T. M.,: (1997)Machine Learning, McGraw-Hill,.
3. Bishop C.M., (2016):Pattern Recognition and Machine Learning, Springer,.
4. Hastie, T., Tibshirani R. & Friedman J., (2009): The Elements of Statistical Learning: Data Mining, Inference and Prediction, Springer, 2nd Edition,
5. Murphy K. P., (2012): Machine Learning A Probabilistic Perspective, MIT Press,.
6. Shwartz ShaiShalev & David Shai Ben : Machine Learning – From Theory to Algorithms Cambridge University Press.
7. Marsland, Stephen (, 2009): Machine Learning- An Algorithmic Perspective, CRC Press.

M.Sc. Statistics Semester - IV
Information theory
(ST-403 & ST-404) Opt. (iv)

Course Objectives:

The main purpose of this course is to help students to enhance knowledge of probabilities, entropy, measures of information and coding theory .This course also aims to guide the student through the implications and consequences of fundamental theories and laws of information theory and coding theory with reference to the application in modern communication.

Course Outcomes: On completion of this course students will be able to:

- Define measure of information, uncertainty and their properties.
- Relate the joint, conditional, and marginal entropies of variables in terms of their coupled probabilities.
- Define channel capacities and properties using Shannon's Theorems.
- Construct efficient codes for data on imperfect communication channels.

M.Sc. Statistics Semester - IV

Information Theory

(ST-403 & ST-404) Opt. (iv)

(4 Credits)
Max Marks: 75+25***
*****Internal Assessment**
Time: 3 hrs.

Note: There will be nine questions in all. Question No.1 will be compulsory covering whole of the syllabus and comprising short answer type questions. Rest of the eight questions will be set from the four units uniformly i.e. two from each unit. The candidate will be required to attempt five questions in all one from each unit and the compulsory one. The weightage of all the questions will be the same.

Unit-I

Introduction : communication process, communication system, measure of information, unit of information. Memory less finite scheme: Measure of uncertainty and its properties, sources and binary sources. Measure of information for two dimensional discrete finite probability scheme: conditional entropies, Noise characteristics of a channel, Relations among different entropies.

Unit-II

Measure of Mutual information, Shanan's fundamental inequalities, Redundancy, Efficiency and channel capacity, capacity of channel with symmetric noise structures, BSC and BEC, capacity of binary channels, Binary pulse width communication channel, Uniqueness of entropy function.

Unit-III

Elements of encoding : separable binary codes, Shannon-Fano encoding, Necessary and sufficient conditions for noiseless coding. Theorem of decodibility, Average length .of encoded messages; Shannon's Binary Encoding.

Unit-IV

Fundamental theorem.of discrete noiseless encoding, Huffman's minimum redundancy code, Gilbert-Moore encoding. Error detecting and Error correcting codes, Geometry of binary codes, Hammings single error correcting code.

References:

1. Reza, F.M. (2003): An Introduction to Information Theory, McGrawHill Book:Company Inc.
2. Feinstein, A. (I)(2013) : Foundations of Information Theory, McGraw Hill Book Company Ioc.
3. Kullback, S. (I) (1997): Information Theory and Statistic., John Wiley andSons.
4. Middleton, D. (1996): An Introduction to Statistical CommunicationTheory, McGraw Hill Company

M.Sc. Statistics Semester – IV
Game Theory

(ST-403 & ST-404) Opt. (v)

Course Objectives:

This course introduces students to the basics of game theory and reviews different types of games which are widely used in practice. It also considers the various solution concepts of games and how they can be applied to solve problems occurring in economics and other scientific disciplines.The course provides a strong foundation for those students wishing to study more advanced level courses in game theory.

Course Outcomes:

On completion of this course, students will be able to:

- Discuss the theory which underlies rectangu1ar games and fundamental theorem of rectangular games.
- Understand the properties of optimal strategies and method of approximating the value of a game.
- Possess a set of intermediate level game-theoretic skills which can be applied in real world contexts.
- Elucidate the games with perfect and infinitely many strategiespotential .

M.Sc. Statistics Semester – IV
Game Theory

(ST-403 & ST-404) Opt.(v)

(4 Credits)
Max Marks: 75+25***
*****Internal Assessment**
Time: 3 hrs.

Note: There will be nine questions in all. Question No.1 will be compulsory covering whole of the syllabus and comprising short answer type questions. Rest of the eight questions will be set from the four units uniformly i.e. two from each unit. The candidate will be required to attempt five questions in all one from each unit and the compulsory one. The weightage of all the questions will be the same.

Unit-I

Rectangu1ar games, rectangular games with saddle points. Fundamental theorem of rectangular games: Mixed strategies, Geometrical background, Proof of the fundamental theorem for arbitrary rectangular games.

Unit-II

Properties of optimal strategies.Relations of dominance.A graphical method of solution.Applications of linear programming. The solution of a rectangular game .A method of approximating the value of a game.

Unit-III

Game in extensive form.Normal form and extensive form. Graphical representation information sets. Chance moves. Games with more than two players.Restrictions on information sets.General theory of games in extensive form.

Unit-IV

General definition of finite games with perfect information equilibrium points.Games with perfect recall and behaviour strategies.Games with infinitely many strategies.The fundamental theorem for continuous games.

References:

1. Mackinsey, J.G.C.(2003): Introduction to the theory of games McGraw Hill Book Company. Inc..New Delhi, Toronto and London.
2. Churchman, C.W.(1957) : Introduction to Operations Research John Wiley& Sons NewYork.
3 B.S. Goel, S.K. Mittal, (2014).Operations Research, Pragater Prekshlen, John & Sons.

M.Sc. Statistics Semester – IV

Actuarial Statistics

(ST-403 & ST-404) Opt. (vi)

Course Objectives:

This course investigates modern actuarial modeling and examines the basic techniques used in actuarial analysis. The aim of this course is to provide the students a firm mathematical and statistical background so that they can apply mathematical and statistical models to assess risk factors and to apply stochastic models appropriate to the representation of the risk process.

Course Outcomes:

On completion of this course students will be able to:

- Able to recognize the basic concepts of mortality rates and other indices
- Understand the concept of differentmodels of population dynamics and Industrial assurance.
- Apply the typical long-tailed distributions representing claim size and those representing claim numbers
- Use statistical models to analyze the risk factors for categories of policy holders and apply appropriate mathematical methods to get solutions for some problems in risk theory.

M.Sc. Statistics Semester – IV

Actuarial Statistics (4 Credits)

(ST-403& ST-404) Opt. (vi) **Max Marks: 75+25*****

***Internal Assessment**

Time: 3 hrs.

Note: There will be nine questions in all. Question No.1 will be compulsory covering whole of the syllabus and comprising short answer type questions. Rest of the eight questions will be set from the four unit uniformly i.e. two from each unit. The candidate will be required to attempt five questions in all one from each unit and the compulsory one. The weightage of all the questions will be the same.

Unit-I

Concepts of mortality rates and other indices, construction of mortality table from graduated data, determination and use of the functions in mortality table, graph of force of mortality, laws of mortality, mortality funds, Sources and collection of data for the continuous mortality investigation.

Unit-II

Models of population dynamics: Lotka' theory. Relationship between the number of births and the number of women in the population.Population with unvarying age distribution. Nature of reserve, prospective and retrospective reserves, fractional premiums and fractional durations, modified reserves, (continuous reserves, surrender values and paid up policies, Industrial assurance; children's. deferred assurances, Joint life and lastsurvivorship.

Unit-III

Pure endowments, Life Annuities; Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursions, complete annuities-immediate and apportion able annuities-due. Accumulations, Assurances, family income benefits, capital sums on retirement and death.

Unit-IV

Widows pensions, Sickness benefits, disability benefits. Orphan's benefits, Benefits dependent on marriage. Contingent probabilities, contingent assurances, reversionary annuities, multiple-decrement table, forces of decrement, construction of multiple decrement table.

1. King, G. (2011) : Institute of actuaries text book of part II second ed. Charlesand Edwin LaytonLondon.
2. Jordan, C.W.(1991)Jr : Life Contingencies, second edition, Chicago Societyof Actuaries.
3. Neil1, A. (1977) : Life Contingencies, Heinemann,London
4. Donald, DWA (2016) : Compound interest and annuities. HeinemannLondon

M.Sc. Statistics Semester – IV

Official Statistics

(ST-403& ST-404) Opt.(vii)

Course Objectives:

The course aims at developing an awareness of the use of Official Statistics. The objective of this course is to make the students familiar with Present official Statistical Systems in India and its Roles & Functions.

Course Outcomes:

On completion of this course students will be able to:

- Understand the concept of Indian and International Statistical Systems.
- Deep understanding of population growth in Developed and Developing Countries.
- Deal with System of Collection of Agricultural Statistics.
- Know the responsibilities of various Agencies for data collection like CSO, NSSO and office of Registrar General.

M.Sc. Statistics Semester – IV
Official Statistics

(4 Credits)

(ST-403& ST-404) Opt. (vii) **Max Marks:75+25*****

*****Internal Assessment**

Time: 3 hrs.

Note: There will be nine questions in all. Question No.1 will be compulsory covering whole of the syllabus and comprising short answer type questions. Rest of the eight questions will be set from the four unit uniformly i.e. two from each unit. The candidate will be required to attempt five questions in all one from each unit and the compulsory one. The weightage of all the questions will be the same.

Unit-I

Introduction To Indian and International Statistical Systems. Present official Statistical Systems In India, Role, Functions and Activates of Central and State Organization. Organizations of Large Scale Sample Surveys Methods of Collection of official Statistics, Their Reliability and Imitations.

Unit-II

General and Special Data Dissemination Systems, Population Growth in Developed and Developing Countries.Evaluation of Performance of Family Welfare Programs Projection of Labor force and Manpower.Scope and Content O Population of Census of India.

Unit-III

System of Collection of Agricultural Statistics.Crop forecasting and Estimation.Productivity, Fragmentation of Holdings, Support Prices Buffer Stock.Principle Publications Containing SuchStatistics.

Unit-IV

Statistics Related To Industries, Balance of Payment, Cost of Living, Inflation, Educational and Other Social Statistics. Various Agencies Responsible for The Data Collection CSO, NSSO, office of Registrar General.

References:

1. Basic Statistics relating to the Indian Economy (CSO)1990.
2. Statistical system in India (CSO)1975.
3. Guide to official Statistics (CSO)1999.
4. Principles and accommodation of National Populations CensusUNESCO.
5. Panse, V.G., Estimation of Crop Fields(FAO).

M.Sc. Statistics Semester – IV

Practical (Calculator and SPSS/SYSTAT based)

(ST-405)

Course Objectives: The objective of the course is to provide practical knowledge about the concepts based on Multivariate Analysis and Design of Experiment. This course also focuses on hands-on training through SPSS and SYSTAT toanalyze different problems based on experimental designs.

Course Outcomes:On completion of this course students will be able to:

- Perform exploratory analysis of multivariate data using SPSS and SYSTAT.
- Conduct statistical inference about multivariate means including hypothesis testing and different types of confidence intervals estimation;
- Understand to design and conduct experiments, as well as analyze and interpret data.
- Understand to check the affects of different factors under study and analyze Split-plot design & BIBD.

M.Sc. Statistics Semester – IV

Practical (Calculator and SPSS/SYSTAT based)

(ST-405) **(4 Credits)**

Max Marks: 75+25***
-Practical : 60
-Class Record : 05
-Viva-Vice : 10
***** Internal Assessment**
Time: 4 hrs.

Note: There will be 4 questions; the candidate will be required to attempt any 3 questions.

List of Practicals:

1. Estimating parameters of multinormaldistribution.
2. Calculation of multiple and partial correlationcoefficients.
3. Estimating the parameters of conditionaldistribution.
4. Test based on total, partial and multiplecorrelations.
5. Test based on Hotelling - $T^2$and Mahalanobis - D^2Statistics.
6. Fisher's linear discriminatefunction.
7. Calculation of principalcomponents.
8. Analysis of three basic designs- Basic analysis and splitting of treatment S. S. fordifferent contrasts.
9. Analysis of 2^2 – factorialexperiment.
10. Analysis of 2^3 – factorialexperiment.
11. Analysis of completely confounded factorialexperiment.
12. Analysis of partially confounded factorialexperiment.
13. Analysis of split plotdesign.
14. Analysis of BIB Design.