KURUKSHETRA UNIVERSITY, KURUKSHETRA

Curriculum for M.Sc. Statistics (CBCS)

Scheme of Examination

(Effective from the Academic Session 2018-2019)

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 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 the IVth semester.

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 and R Programming	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			

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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	Computer Fundamentals and Problem Solving Using C	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

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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) Econometrics Opt.(iv) Bio-Statistics Opt. (v) Statistical Methods in Epidemiology Opt. (vi) 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

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(Effective from the Academic Session 2019-2020)
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) Information Theory Opt. (iv) Game Theory Opt.(v) Actuarial Statistics Opt. (vi) Official Statistics	Any Two	Elective **	4	4	25	75	100	Three
			Elective **	4	4	25	75	100	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 : 5 Marks

For Practicals:

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

(ii) Attendance : 5 Marks

For Open Elective theory papers

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

(ii) Attendance : 5 Marks

Marks for attendance will be given as under:

(1) 91% on wards : 5 Marks (2) 81% to 90% : 4 Marks
(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.

M.Sc. Statistics Semester – I

Paper – I (ST-101) **Measure and Probability 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 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. : Modern Probability Theory, Wiley Eastern Limited
3. Taylor, J. C. : An Introduction to Measure and Probability, Springer.
4. Royden, H.L. : Real Analysis, Pearson Prentice Hall.
5. Billingsley, P. (1986). : Probability and Measure, Wiley.
6. Halmos, P.R. : Measure Theory, Springer
7. Basu, A.K. : Measure Theory and Probability,PHI Learning(Pt.Lim.)

M.Sc. Statistics Semester – I

Paper-II (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, different definitions of probability, notations, distribution functions. Additive law of probability, theorem of total probability, theorem of compound probability and Baye's theorem. Concept of bivariate, marginal and conditional distributions.

Unit-II

Mathematical Expectation : Expectation and moments, expectation of sum of variates, expectation of product of independent variates, moment generating function. Tchebycheff's, Markov , Jensen and Holder and Minkowski 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. : Introduction to probability and its applications, Vol.I, Wiley
2. Parzen, E. : Modern Probability Theory and its Applications, Wiley Interscience
3. Meyer, P.L. : Introductory Probability and Statistical Applications, Addison wesely.
4. Cramer, H. : Random variable and Probability Distribution, Cambridge University Press.
5. Kapur, J.N. & Sexena, H.C. : Mathematical Statistics & S.Chand & Co.

M.Sc. Statistics Semester – I

Paper – III (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 matrix equations.

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 : Linear Algebra
2. Datta, K.B. : 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., : Numerical Methods for Scientific and Engineering
6. Guruswamy, B. : Computer Oriented Numerical Methods.

M.Sc. Statistics Semester – I

Paper IV (ST-104) **Industrial Statistics and R Programming** **(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

Analysis of time Series, Trend measurement ; use of polynomial, logistic, Gompertz and lognormal functions . Moving average method, Spencer's formulae; variate difference method, its use for estimation of variance of the random component. Measurement of seasonal fluctuations, measurement of cyclical movement.

Unit- II

Periodogram analysis. Concept of stationary time series, correlogram analysis, correlogram of an autoregressive scheme, a moving average scheme and a Harmonic series. Statistical quality control and its purposes; 3 sigma control limits, control charts for variables (mean and range, mean and standard deviation). Control chart for attributes- np, p, c and u charts.

Unit- III

Natural tolerance limits and specification limits; Modified control limits. Sampling Inspection Plan : Concepts of Acceptance quality level (A.Q.L) ,Lot tolerance proportion defective (LTPD) and indifference quality. The single, double and sequential sampling plans, and their four curves viz, AOQ, Operating characteristic (OC), Average Sample Numper (ASN) and Average Total Inspection (ATI) curves. Acceptance Sampling plan by variables.

Unit- IV

Introduction to R language. Creation of data object, vector, factor and data frame. Extraction operators in R, data import/export. Summary of data and statistical graphics with R. The function curve. Common distributions in R. Common statistical tests. Correlation and regression analysis.

References:

1. Kendall, M.G. : Time Series,Griffin London
2. Gupta, S.C. & Kapoor, V.K. : Fundamentals of Applied Statistics, Sultan Chand & Sons.
3. Ekambaram, S.K. : The Statistical Basis of Acceptance Sampling, Asia Publishing House.
4. Goon, A.M., Gupta, M.K. & Dasgupta,B. : Fundamentals of Statistics, Vol. II, ed. VI, Word Press Calcutta
5. Montgomery, D.C. : Introduction to Statistical Quality Control, J.Wiley. 1985
6. Duncan, A.C : Quality Control and Industrial Statistics, Richard O.Irwin, Homewood.IL
7. Dalgaad, P. (2008): *Introductory Statistics with R*. 2nd Edition. Springer

M.Sc. Statistics Semester – I

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

Max Marks : 75+25***

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-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 estimates of the population variance.
   (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

Paper –I (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 life table.

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 and Sons,
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: Fundamental of Statistics Volume-II,
& Dasgupta,B.
7. Guide to official Statistics (CSO) 1999.

M.Sc. Statistics Semester-II

Paper-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 Problem-Methods of obtaining basic feasible solution-optimality-MODI and Stepping Stone Methods, 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: EVM, EOL and decision tree techniques.

Unit-III

Game Theory : Terminology , two person zero sum game; game of pure strategy , game of mixed strategy , reducing game by dominance, 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) with no shortages: Basic EOQ model , EOQ with several runs of unequal lengths , EOQ with finite replenishment D.I.M. with shortages : E O Q with instantaneous production and variable (fixed) order cycle time., EOQ with finite production EOQ with price breaks : E.O.Q with one price break. Simple Multi-item deterministic inventory model, 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. : Linear Programming, Narosa Publications House.
2. Churchman, C.W. : Introduction to Operations Research John Wiley& Sons New York.
3. Goel, B.S. & Mittal, S.K.: Operations Research, Pragater Prekshlen, John & Sons.
4. Gross, D. & Harris, C.M. : Fundamentals of Queuing Theory Wiley
5. Allen, A.O : Probability Statistics & Queuing Theory With Computer Science Applications (Academic Press) INC. Elsevier Direct.

M.Sc. Statistics Semester – II

Paper – III (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 , sufficiency and minimum variance. Rao- Blackwell theorem. Lehman Schefe's theorem. Distributions possessing sufficient statistics. Sufficiency when range depends on the parameter. Least squares method of estimation and its properties.

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 : Advanced Theory of Statistics Vol.-II, Charles Griffin Co .Ltd London.
2. Rohtagi,V.K. : Introduction to probability Theory and Mathematical Statistics (for Numerical and Theoretical Applications), John Wiley and Sons.
3. Wald, A: : Sequential Analysis, Dover publications, INC, New York.
4. Rao, C.R. : Advanced Statistical Methods in Biometric Research. John Wiley &Sons, INC, New York.

M.Sc. Statistics Semester – II

Paper –IV(ST-204) Computer Fundamentals and Problem Solving Using C

(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

Computer Fundamentals: Definition, Block Diagram along with Computer components, characteristics & classification of computers, hardware & software, Software concepts: Overview of operating systems, Types and functions of operating systems. Techniques of Problem Solving: Flowcharting, decision table, algorithms, Structured programming concepts.

UNIT – II

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: Arithmetic, relational, logical, bitwise, unary, assignment and conditional operators and their hierarchy & associativity. Input/output: Unformatted & formatted I/O function in C.

UNIT – III

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

UNIT – IV

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, Error handling during I/O operation.

References

1. Sinha, P.K. & Sinha, Priti : Computer Fundamentals, BPB
2. Dromey, R.G. : How to Solve it by Computer, PHI
3. Gottfried, B. S. : Programming with C, Tata McGraw Hill
4. Balagurusamy, E. : Programming in ANSI C, McGraw-Hill
5. Jeri R. H & Elliot P. K : Problem Solving and Program Design in C, Addison Wesley.
6. Yashwant, K : Let us C, BPB
7. Norton. P : Introduction to Computers McGraw-Hill

M.Sc. Statistics Semester – II

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

Max Marks : 75+25***

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-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. 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 regression coefficient.
11. Testing the significance of the ratio of two independent estimates of the population variance.
12. Estimation of parameters of distribution by method of Maximum Likelihood Estimators

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 -1

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

M.Sc. Statistics Semester – III

Paper –I (ST-301) **Sampling 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 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 ratio estimator.

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.(1988) : Randomized Response, Theory and Techniques, New York : Marcel; Dekker Inc.
2. Cochran W.G. : Sampling Techniques (3rd Edition, 1977), Wiley.
3. Des Raj and Chandak (1998) : 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

Paper – II (ST-302) **Inference -II**

(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 rank correlation.

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.

Kruskal wallis ANOVA test, Concept of Jackknife, Bootstrap methods.

References:

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

M.Sc. Statistics Semester – III

Paper –III & IV **Optimization Techniques** **(4 Credits)**
(ST-303 & ST-304) **Max Marks: 75+25***
(Opt.-i) ***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. : Linear programming, Narosa Publications House.
2. Vejda, S. : Mathematical Programming, Dover Publications.
3. Saul E.Gauss. : Linear programming Methods and Applications, Dover Publications.
4. Kambo, N. S. : Mathematical Programming Techniques, East –West Press Pvt. Ltd.
5. Mittal, K.V. : Optimization Methods, New Age International (P) Ltd.
6. Hadley, G. : Non linear and Dynamic programming.
7. Vejda,S. : Mathematical Programming, Dover Publications.
8. Kambo, N. S. : Mathematical Programming Techniques, East-West Press Ltd.
9. Mittal, K.V. : Optimization Methods, New Age International Pvt. Ltd.Publisher.

M.Sc. Statistics Semester – III

Paper –III & IV **Stochastic Processes** **(4 Credits)**
(ST-303 & ST-304) **Max Marks: 75+25***
(Opt.-ii) ***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 : The Elements of Stochastic Processes.(1964 Ed.)
2. Medhi , J. : Stochastic Processes, New Age International (P) Limited
3. Karlin , S. : Introduction to Stochastic Processing, Vol. I, Academic Press.
4. Karlin, S. : Introduction to Stochastic Modeling, Academic Press.
5. Basu, A.K. : Introduction to Stochastic Process, Narosa Publishing House.

M.Sc. Statistics Semester – III

Paper –III & IV **(ST-303 & ST-304)** **(Opt.-iii)**

Econometrics

(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.

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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. Generalized Least Squares Estimation.

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 Goldfeld Quand t- Tests Multicollinearity - Exact and Near Multicollinearity, Consequences and Detection of Multicollinearity , Farrar Glauber Test, Remedies for Multicollinearity, Ridge Regression Autocorrelation , Sources and Consequences, AR(1) Process Tests for Autocorrelation, Durbin Watson Test, Errors in Variables Model, Instrumental Variable Method of Estimation.

Unit-IV

Simultaneous Equations Models: Structural and Reduced forms, Identification Problem. Rank and Order Conditions of Identification, Restrictions on Structural Parameters. Estimation in Simultaneous Equations Models: Recursive Systems, Indirect Least Squares 2SLS Estimators, Limited Information maximum likelihood (LIML).

References:

1. Johnston, J. : Econometric Models, McGraw Hills
2. Jan Kmenta : Elements of Econometrics, University of Michigan Press
3. Intriligatore,M.D. : Economic models -techniques and applications, Prentice Hall
4. Maddala, G.S. : Econometrics, North Holland
5. Klein, L.R. : Applied Economics, Taylor and Francis
6. Koutsoyiannis,A. : Theory of Econometrics, Palgrave.

M.Sc. Statistics Semester – III

Paper –III & IV **Bio-Statistics** **(4 Credits)**
(ST-303 & ST-304) **Max Marks: 75+25***
Opt. (iv) ***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. (1982) : Statistical techniques in quantitative genetics. Tata-McGraw Hill
3. Poti, S.J. (1983) : Quantitative study in life sciences, Vikas Publishing Ltd.
4. Prem Narain; Bhatia : Handbook of Statistical Genetics, V.K. and Malhotra, I.A.S.R.I.P.K. (1979)
5. Daniell, W.W : Bio Statistics – A foundation for analysis in health sciences , 3rd ed. John wiley
6. Falconer, D.S. : Introduction to quantitative Genetics (Longman Group Ltd.

M.Sc. Statistics Semester – III

Paper –III & IV **Statistical Methods in Epidemiology** **(4 Credits)**
(ST-303 & ST-304) **Max Marks: 75+25***
Opt. (v) ***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 Mcnemars test. Randomization in a clinical trial, sequential methods in clinical trials. Clinical life tables.

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

M.Sc. Statistics Semester – III

Paper –III & IV **Real and Complex Analysis**

(ST-303 & ST-304) **(4 Credits)**

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

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 Critical point.

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 : A Course of Mathematical Analysis ,S.Chand.

2. Malik,S.C. & Arora,Savita : Mathematical Analysis, New Age International.

3. Copson, E.T. : Introduction to the Theory of Functions of a Complex Variable ,Clarendon Press Oxford.

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

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

6. Goyal and Gupta : Function of a complex Variable,, Pargati Parkashan Meerut.

7. Malik, S.C. : Real and Complex Analysis, Jeevan Sons Publication, New Delhi.

M.Sc. Statistics Semester – III

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

Max Marks : 75+25***

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-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 with unstratified simple random sampling.
5. Comparison of systematic sampling with simple random and stratified random sampling.
6. Estimator of the mean squared error of the product estimator.
7. Estimation of variance in double sampling for stratification.
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 the estimators.
10. Comparison of ratio estimator with mean per unit estimator under simple random sampling.
11. Comparison of separate and combined ratio estimators under stratified random sampling with mean per unit estimate or under random sampling.
12. Comparison of different types of allocation for ratio estimator under stratified random sampling.
13. Comparison of two ratios.
14. Comparison of regression, ratio and mean per unit estimates from a simple random sample.

Semester – III

Open Elective (OE-309) : Statistics-II

(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-1

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 standard deviations.

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 model only).

References:

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

M.Sc. Statistics Semester – IV

Paper –I (ST-401) **Multivariate 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

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 multipal 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's discriminator.

Unit-IV

Wishart Distribution : Definition, Character 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.(1983), : An Introduction to Multivariate Statistical analysis, Second Edition John Wiley.
2. Narayan, C. Giri : Multivariate Statistical analysis, Marcel Dekker.
3. Srivastava, M.S.& Khatri C.G.(1979) : An introduction to Multivariate Statistics, North Holland.
4. Kshirsagar, A.M.(1972) : Multivariate Analysis, Marcell-Dekher
5. Johnson, R.A & Wichern,D.W : Applied Multivariate Statistical Analysis,PHI Learning
6. Bhuyan, K.C : Multivariate Analysis and its applications, New Central Book Agency(P) Ltd.

M.Sc. Statistics Semester – IV

Paper – II **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 randomised, randomised blocks 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. : Linear Models , John Wiley & sons New York.
2. Aloke Dey, : Theory of Block Designs , Wiley Eastern Ltd.
3. Chakrabarti, M.C : Mathematics of Design and Analysis of Experiments, Asia Publishing House
4. Joshi, D.D : Linear Estimation and Design of Experiments , Wiley Eastern Ltd.
5. Das, M.N.and Giri, N : Design and Analysis of Experiments,Wiley Eastern.
6. Giri, N. : Analysis of Variance, South Asian Publishers.
7. Montogomery, C.D. : Design and Analysis of Expertiments, Wiley, New York.
8. Goon, A.M., Gupta, M.K.: and Dasgupta. B. An Outline of Statstical Theory, Vol. II, World Press.

M.Sc. Statistics Semester – IV

Paper –III & IV
(ST-403 & ST-404)
(Opt.-i)

Theory of Queues

(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. & : Fundamental. of queuing theory, John Wiley and Son.. Harris C.M
2. Saaty, T.L. : Elements of queueing theory with app lications. McGraw Hill Book Company Inc.
3. Allen, A.O. : Probability, Statistics and Queuing Theory with Computer Science Applications, Academic Press
4. Kashyap, B.R.K & : An Introduction to Queueing Theory, AARKAY Publications, Calcutts Chaudhary, M.L.

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M.Sc. Statistics Semester – IV

Paper-III & IV **(ST-403 & ST-404)** **(Opt.-ii)**

Reliability and Renewal 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

Concept of reliability , early age failures, wearout 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

Wearout and Component reliability, Combined effect of wearout 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, 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. : Theory of Stochastic Processes, Chapman and Hall Ltd.
2. Billinton, R. : Reliability Evaluation of Engineering systems: Concepts and Techniques Plemum Press New York London.
3. Cox, D.R. : Renewal Theory, Methuen & Co. Ltd.
4. Medhi,J. : Stochastic Processes New Age International (P) Limited.
5. Igor Bazovsky : Reliability Theory and Practice, 2nd ed. Prentice Hall.

M.Sc. Statistics Semester - IV

Paper –III & IV **(ST-403 & ST-404)** **Opt. (iii)**

Information 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

Introduction : communication process, communication system, measure of information, unit of information. Memoryless 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. : An Introduction to Information Theory, Mc Graw Hill Book:Company Inc.
2. Feinstein, A. (I) : Foundations of Information Theory, McGraw Hill Book Company Ioc.
3. Kullback, S. (I) : Information Theory and Statistic., John Wiley and Sons.
4. Middleton, D. : An Introduction to Statistical Communication Theory, Mc Graw Hill Company.

M.Sc. Statistics Semester – IV

Paper –III & IV **Game Theory** **(4 Credits)**

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

Opt. (iv) ***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. : Introduction to the theory of games McGraw Hill Book Company. Inc.. New Delhi, Toronto and London.
2. Churchman, C.W. : Introduction to Operations Research John Wiley& Sons New York.
3. Goel, B.S. & Mittal, S.K.: Operations Research, Pragater Prekshlen, John & Sons.

M.Sc. Statistics Semester – IV

Paper –III & IV **Actuarial Statistics** **(4 Credits)**
(ST-403 & ST-404) **Max Marks: 75+25***
Opt. (v) ***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. deffered assurances, Joint life and last survivorship.

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.

References:

1. King, G. : Institute of actuaries text book of part II second ed. Charles and Edwin Layton London.
2. Jordan, C.W. Jr : Life Contingencies, second edition, Chicago Society of Actuaries.
3. Neil1, A. (1977) : Life Contingencies, Heinemann, London
4. Donald, DWA (1970) : Compound interest and annuities. Heinemann London

M.Sc. Statistics Semester – IV

Paper –III & IV **Official Statistics** **(4 Credits)**
(ST-403 & ST-404) **Max Marks: 75+25***
Opt. (vi) ***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 Such Statistics.

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 Census UNESCO.
5. Panse, V.G., Estimation of Crop Fields (FAO).

M.Sc. Statistics Semester – IV

Paper-V (ST-405) **Practical (Calculator and SPSS/SYSTAT 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 3 questions.

List of Practicals:

1. Estimating parameters of multinormal distribution.
2. Calculation of multiple and partial correlation coefficients.
3. Estimating the parameters of conditional distribution.
4. Test based on total, partial and multiple correlations.
5. Test based on Hotelling - $T^2$and Mahalanobis - D^2 Statistics.
6. Fisher's linear discriminate function.
7. Calculation of principal components.
8. Analysis of three basic designs- Basic analysis and splitting of treatment S. S. for different contrasts.
9. Analysis of 2^2 – factorial experiment.
10. Analysis of 2^3 – factorial experiment.
11. Analysis of completely confounded factorial experiment.
12. Analysis of partially confounded factorial experiment.
13. Analysis of split plot design.
14. Analysis of BIB Design.