

BHARATHIAR UNIVERSITY: COIMBATORE– 641 046

M.Sc., Statistics / M.Sc. Statistics with Computer Applications (CBCS PATTERN)
(For the students admitted during the academic year 2018–2019 batch and onwards)

Duration of the course: 2 Years

Eligibility Conditions for admission to M.Sc. Statistics

B.Sc. Statistics
B.Sc. Mathematics
B.Sc. Mathematics with Computer Applications along with Statistics as one of the
Papers

Eligibility Conditions for admission to M.Sc. Statistics with Computer Applications

B.Sc. Statistics
B.Sc. Mathematics
B.Sc. Mathematics with Computer Applications along with Statistics as one of the
Papers
B.Sc. Computer Science along with Statistics as one of the Papers
B.C.A along with Statistics as one of the Papers

BHARATHIAR UNIVERSITY:: COIMBATORE - 641 046
BRANCH II - STATISTICS

Course Title: M.Sc. (Statistics)

List of Core/Elective/Supportive Subjects to be offered

CORE Subjects

1. Probability Theory
2. Distribution Theory
3. Sampling Theory and Methods
4. Object Oriented Programming with C++
5. Statistical Inference – I
6. Multivariate Analysis
7. Statistical Quality Control
8. Statistics Practical - I
9. Statistical Software Practical-I (Using SPSS, MINITAB & STATISTICA)
10. Statistical Inference - II
11. Linear Models and Design of Experiments
12. Data Mining
13. Operations Research
14. Stochastic Processes
15. Biostatistics and Survival Analysis
16. Statistics Practical - II
17. Statistical Software Practical - II (Using R)
18. Project & VIVA-VOCE

ELECTIVE Subjects (for students of M.Sc., Statistics)

1. Official Statistics
2. Demography and Vital Statistics
3. Econometrics
4. Applied Regression Analysis
5. Statistical Data Analysis Using R
6. Actuarial Statistics

ELECTIVE Subjects (for students of other departments)

1. Bio-Statistics
2. Probability and Statistics
3. Statistics for Management
4. Operations Research Methods
5. Actuarial Statistics

SUPPORTIVE Subjects (for students of other departments)

1. Descriptive Statistics
2. Data Analysis
3. Statistical Methods for Industries
4. Statistical Methods for Researchers
5. Statistical Methods for Biologists
6. Elements of Operations Research

M.Sc., Statistics– Semester wise Syllabus and Scheme

Sem	Core/ Elective / Supportive	Subject Code	Title of the Papers	Cred its	Int. Mark s	Ext. Mar ks	Total Marks
I	Core-I	17S13A	Probability Theory	4	25	75	100
	Core-II	17S13B	Distribution Theory	4	25	75	100
	Core-III	17S13C	Sampling Theory and Methods	4	25	75	100
	Core-IV	17S13D	Object Oriented Programming with C++	4	25	75	100
	Elective-I	17S13EA/B	Elective I	4	25	75	100
	Supportive-I	Supportive	Offered by other Departments	2	12	38	50
II	Core-V	17S23A	Statistical Inference – I	4	25	75	100
	Core-VI	17S23B	Multivariate Analysis	4	25	75	100
	Core-VII	17S23C	Statistical Quality Control	4	25	75	100
	Core Prac -I	17S2P1	Statistics Practical – I	4	40	60	100
	Core Prac-II	17S2P2	Statistical Software Practical – I (Using SPSS, MINITAB & STATISTICA)	4	40	60	100
	Supportive-I	Supportive	Offered by other Departments	2	12	38	50
III	Core-VIII	17S33A	Statistical Inference – II	4	25	75	100
	Core-IX	17S33B	Linear Models and Design of Experiments	4	25	75	100
	Core-X	17S33C	Data Mining	4	25	75	100
	Core-XI	17S33D	Operations Research	4	25	75	100
	Elective-II	17S33EA/B	Elective II	4	25	75	100
	Supportive-III	Supportive	Offered by other Departments	2	12	38	50
IV	Core-XII	17S43A	Stochastic Processes	4	25	75	100
	Core-XIII	17S43B	Biostatistics and Survival Analysis	4	25	75	100
	Elective-III	17S43EA/B	Elective III	4	25	75	100
	Core Prac-III	17S4P3	Statistics Practical – II	4	40	60	100
	Core Prac-IV	17S4P4	Statistical Software Practical -II (Using R)	4	40	60	100
	Project	17S4PV	Project and Viva-voce	4	25	75	100
	Online	SWAYAM – MOOC – online course *	2			50	
TOTAL				92			2300

*SWAYAM –MOOCs –online - atleast2 credits 4 week course is mandatory and it should be completed within third semester.

1 Credit = 1 Hr

TOTAL MARKS: 2300
Core & Elective : 1800
Elective : 300
Supportive : 150

TOTAL CREDITS: 92
Core: 72
Elective: 12
Supportive: 6
Online SWAYAM Course: 2

THEORY

Core and Elective Papers: Maximum Marks– 100

Internal Marks: 25

Test –15 Marks
Assignment – 5 Marks
Seminar – 5Marks

External Marks: 75

Question Pattern

SECTION– A: 5x3=15 Marks (Question No. 1 to 5)

Answer all questions. All question carry equal marks.

SECTION– B: 5x12=60 Marks (Either or type– Question No. 6 to 10)

Answer all questions. All Question carry equal marks.

PRACTICAL: Maximum Marks– 100

Internal Marks : 40

Test : 25
Assignment : 05
Record : 10

External Marks : 60

PROJECT: Maximum Marks – 100

Internal Assessment: 25

External Assessment: 75

Project Evaluation : 50
Project Viva-voce : 25

SUPPORTIVE: Maximum Marks– 50

Internal Marks: 12

Test – 6 Marks
Assignment – 3 Marks
Seminar – 3Marks

External Marks: 38

Question Pattern

SECTION– A: 4x2=8 Marks (Question No. 1 to 7)

Answer any 4 questions out of 7 questions. All questions carry equal marks.

SECTION– B: 5x6=30 Marks (Either or type– Question No. 8 to 12)

Answer all questions. All Question carry equal marks.

SEMESTER I

AIMS

1. To provide a broad based high quality education with a combination of the subjects like Probability Theory, Distribution Theory, Sampling Theory and Methods and Object Oriented Programming with C++ to Post-Graduate Degree level for students who have to demonstrate their ability and potential towards Statistical Theory and Applications.
2. To develop knowledge, understanding and experience of the theory, practice and application of selected areas of statistical computing and to produce graduates needed by public and private sector to help and solve practical problems using the skills and techniques of these areas and to develop analytical skills for Insurance Sector.
3. To develop enterprise competences emphasizing the key skills of learning and communication for Statistical theory.

OBJECTIVES

1. An understanding of the Statistical principles, techniques and applications of selected areas of Statistics and computing.
2. The ability to evaluate, select, write and use of computer software packages for Statistical theory, which takes into account the needs of the user and constraints towards computing environment.
3. The ability and confidence to analyze and solve problems both of a routine and of obvious nature towards applications of Statistical theory.
4. To gain deeper understanding, problem solving skills and greater knowledge of selected topics in statistical computation.

17S13A	Probability Theory	Core - 1
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Unit I

Functions and Inverse Functions- Random Variables – Limits of Random Variables – Definition of Probability – Simple Properties – Discrete Probability Space – General Probability Space – Induced Probability Space.

Unit II

Distribution Function of a Random Variable – Decomposition of Distribution functions – Jordan Decomposition Theorem – Distribution Functions of Vector Random Variables. Expectation – Properties of Expectation – Moments – MGF – Holder’s Inequality – Minkowski Inequality- Basic Inequality-Markov Inequality.

Unit III

Convergence of Random Variables : Convergence in Probability, Convergence Almost Surely, Convergence in Distribution, Convergence in rth Mean, Monotone Convergence Theorem - Fubini Theorem (Statement only)

Unit IV

Definition and Properties of Characteristic Functions – Inversion Formula – Problems - Kolmogorov 0-1 Law- Borel 0-1 Law- Bochner’s Theorem (Statement only)

Unit V

Law of Large Numbers- Weak and Strong Law of Large Numbers – Bernoulli’s Weak Law of Large Numbers- Khintchine’s WLLN – Kolmogorov’s SLLN – Central Limit Theorem – Lindeberg – Levy’s CLT - Liapounov’s form of Central Limit Theorem- Lindberg – Feller Central Limit Theorem (Statement only)

Books for Study

1. Rohatgi V.K. (2002) : Introduction to Mathematical Statistics, Wiley.
2. Bhat, B. R. (2005) : Modern Probability Theory – An Introductory Text Book, Third Edition, New Age International

Books for Reference

1. Feller, W. (1972) : Introduction to Probability Theory and its Applications, Vol. II, Second Edition, Wiley Eastern.
2. Rao, C.R. (1973): Linear Statistical Inference, Second Edition, Wiley Eastern.
3. Johnson and Kotz (1972): Distributions in Statistics, Princeton University Press.

17S13B	Distribution Theory	Core - 2
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Unit I

Probability Distributions : Cauchy distribution– Laplace distribution - Pareto distribution – Log Normal distribution –Power Series distribution – Logarithmic Series distribution – Distribution of functions of random variables

Unit II

Concept of truncated distribution- compound distribution-mixture distribution and their properties

Unit III

Non Central t, f and chi-square distributions and their properties

Unit IV

Order Statistics- distribution of order statistics – Joint distribution of order statistics – Asymptotic distribution of rth order statistics- Joint distribution of Range & Mid range.

Unit V

Distribution of Quadratic forms – Properties –Cochran’s Theorem – Empirical Distributions - Properties

Books for Study

1. Rohatgi V.K. (2002) : Introduction to Mathematical Statistics, Wiley.
2. Johnson, N, Kotz,S and Balakrishnan,N(1995): Continuous Univariate Distributions, Vol.1 & 2, Second Edition, Wiley

Books for Reference

1. Feller, W. (1972) : Introduction to Probability Theory and its Applications, Vol. II, Second Edition, Wiley Eastern.
2. Hogg, R.V, Craig, A and Mckean W.J (2005): Introduction to Mathematics Statistics, Sixth Edition, Pearson,
3. Johnson and Kotz (1972): Distributions in Statistics, Princeton University Press.

17S13C	Sampling Theory and Methods	Core - 3
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Unit I

Concept of Sampling Design, Sampling Scheme and Sampling Strategy, Estimator of Population mean in SRS with replacement. Systematic sampling - Variance of Estimated mean, Populations in Random order, population with Linear and Period Trend, Auto-Correlated Populations.

Unit II

Des Raj method of Estimation, Murthy's Unordering Principle, Sampling Strategy due to Rao-Hartley and Cochran, Hartley-Ross Estimator, Midzuno Scheme of Sampling, PPS Sampling Procedures.

Cluster Sampling-Single Cluster Sampling-Cluster of Equal and Unequal sizes, Two Stage Cluster Sampling; Mean, Variance, Variance of the Estimated Mean.

Unit III

Ratio Estimates-Methods of Estimation, Approximate Variance of Ratio Estimates, Bias of the Ratio Estimates, Conditions under which the Ratio Estimate is Optimum, Unbiased Ratio-Type Estimates.

Regression Estimates-Linear Regression Estimates, Regression estimated when computed from sample, Accuracy of the Variance of Regression Estimates.

Unit IV

Double sampling Procedures and repeated surveys, Double Sampling for Stratification and Optimum Allocation, Regression Estimates-Estimated Variance for Stratification and Regression Ratio Estimates-Repeated Samplings-Sampling on two occasions, Sampling on more than two occasions.

Unit V

Errors in Surveys-Non Response, types of Non-Response, Call -Backs, a mathematical model of the effects of Call-Backs adjustment for basis without Call-backs, Mathematical Model for Errors of Measurement, Interpenetrating sub sample.

Books for Study

1. Cochran, W.G.(1972): Sampling Techniques, Wiley Eastern Private Limited.
2. Sukhatme, P.V. and Sukhatme, B.V.(1977): Sampling Theory of Survey with Applications, Asia publishing House.

Books for Reference

1. Des Raj (1976): Sampling Theory, Tata-Mcgraw Hill.
2. Sampath.S (2000) : Sampling Theory and Methods, Narosa publishing company, New Delhi.
3. Murthy, M.N. (1967): Sampling theory and Methods, Statistical Publishing Society, Calcutta.

17S13D	Object Oriented Programming with C++	Core – 4
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Unit I

Principles of Object – Oriented Programming – Software Evolution Procedure and Object Oriented Paradigm – Basic concepts of Object – Oriented Programming – Benefits of OOP – Object Oriented Languages – Application of OOP - Beginning with C++ - What is C++?. - Application of C++ - C++ statements – Structure of C++ Program – Tokens , Expressions and Control Structures – Tokens – Identifiers – Basic and User – Defined Data Types – Operators in C++ - Operator Overloading – Operator precedence – Control Structures.

Unit II

Functions in C++:- The Main Function – Function Prototyping – Call by Reference – Return by Reference – Inline functions – Function Overloading – Friend and Virtual Functions – Classes and Objects – Introduction – Specifying a Class – Defining Member function – Nesting of Member Function – Private member Functions – Arrays within a Class – Static Data Members- Static Member Function – Array of Objects – Objects as Function Arguments, Friendly Functions – Pointers to Members.

Unit III

Constructors and Destructors:- Constructors – Copy Constructor Dynamic Constructor- Constructing Two – Dimensional Arrays – Destructors – Operators Overloading –Type Conversions.

Unit IV

Inheritance, Extending Classes:- Defining Derived classes – Single, Multilevel, Multiple, Hierarchical and Hybrid inheritance – Virtual Base Classes – Abstract Classes-Pointers, Virtual Functions and Polymorphism – Pointers to Derived Classes – Virtual Functions.

Unit V

Managing Console I/O Operations:-C++ streams – C++ stream Classes – Unformatted I/O Operations - Formatted Console I/O Operations – Managing output with Manipulators- Working with Files:- Classes for File Stream Operations- Opening and Closing a File - File Pointers and their manipulators – sequential I/O Operations. Simple Statistical Problems.

Books for Study and Reference:

1. E.Balagurusamy (1998) : Object Oriented Programming with C++. Tata McGraw Hill Publishing Company Limited.
2. K.R.Venugopal, Rajkumar, T.Ravi shankar (1998): Mastering C++, Tai.

SEMESTER II

AIMS

1. To provide a broad based high quality education with combination of the subjects like Statistical Inference, Multivariate Analysis, Data Mining, Financial Mathematics and Statistical Practical (calculator based) and Statistical Software Practical (using SPSS, MINITAB and STATISTICA) to Post-Graduate Degree level for students who have to demonstrate their ability and potential towards Statistical Theory and Applications.
2. To develop knowledge, understanding and experience of the theory, practice and application of selected areas of statistical computing and to produce graduates needed by public and private sector to help and solve practical problems using the skills and techniques of these areas and to develop analytical skills for Insurance Sector.
3. To develop enterprise competences emphasizing the key skills of learning and communication for Statistical theory.

OBJECTIVES

1. An understanding of the Statistical principles, techniques and applications of selected areas of Statistics and computing.
2. The ability to evaluate, select, write and use of computer software packages for Statistical theory which takes into account the needs of the user and constraints towards computing environment.
3. The ability and confidence to analyze and solve problems both of a routine and of obvious nature towards applications of Statistical theory.
4. To gain deeper understanding, problem solving skills and greater knowledge of selected topics in statistical computation.

17S23A	Statistical Inference - I	Core - 5
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Unit I

Estimation and point estimation - Sufficiency – Factorization Theorem – minimal sufficiency, likelihood equivalence – completeness – Uniformly minimum variance unbiased estimator – Rao-Blackwell and Lehmann-Scheffe’s theorems.

Unit II

Mean-squared error, Fisher’s information measure. Cramer-Rao inequality, Bhattacharya inequality, Chapman-Robbins inequality - Fisher’s information matrix-simultaneous of parameters in normal(univariate and bivariate) distribution.

Unit III

Methods of point estimation-maximum likelihood method(the asymptotic properties of ML estimators are not included),method of moments, method of minimum chi-square and modified minimum chi-square.

Unit IV

Consistency and CAN estimators. Asymptotic properties of maximum likelihood estimators. Example of consistent but not asymptotic normal estimators from Pitman family.Information lower bound for asymptotic variance. Asymptotic relative efficiency. Method of least squares.

Unit V

Interval estimation: Confidence level and confidence coefficient. Duality between acceptance region of a test and a confidence interval. Pivotal quantity method. Shortest length confidence intervals.

Construction of confidence intervals for population proportion (small and large samples) and between two population proportions(large samples)-confidence intervals for mean, variance of a normal population-difference between mean and ratio of two normal populations.

Books for Study

1. Goon,A.M.,Gupta,M.K.and Dasgupta,B.(1989).An Outline of Statistical Theory-Vol.II.
2. Kale,B.K.(1999). A First Course on Parametric Inference,Narosa Publishing House, NY
3. Rohatgi,V.K.(1992).An Introduction to Probability Theory and Mathematical Statistics,Wiley Eastern Ltd,New Delhi.

Books for Reference

1. Dudewicz,E.J., and S.N.Mishra(1988).Modern Mathematical statistics, JohnWiley, NY.
2. Lehman,E.L.,and G.Cassella(1998).Theory of point estimation(II Edition),Springer, NY

17S23B	Multivariate Analysis	Core - 6
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Unit I

Reviews of Multivariate Distributions, Multiple and Partial Correlation and Regression, Multivariate Normal Distribution, Marginal and Conditional Distributions - Maximum likelihood Estimators of sample Mean and dispersion Matrix.

Unit II

Distribution of mean vector and Sample Dispersion Matrix - James-Stein Estimator for the Mean Vector, Wishart Distribution and its Properties (without derivation)- Distribution of Total, Partial and Multiple correlation under null case – Maximum likelihood estimators of total, partial and multiple correlation – Test based on total, partial and multiple correlations.

Unit III

Tests based on Mean Vectors for one and two Multivariate Normal Distributions - Hotelling's T^2 and Mahalanobis D^2 test statistics with their null and non-null distributions - Related Confidence Regions - Testing and Illustration using likelihood Ratio Criterion.

Unit IV

Principal Component Analysis, Factor Analysis Underlying Models and Illustrations- Identification Problem, Estimation - Maximum likelihood Method, Centroid Method, Canonical Correlation – Extraction - Properties.

Unit V

Classification Analysis using Discriminant functions - Clustering techniques- Hierarchical Clustering - Agglomerative techniques, Single Linkage Method, Complete average linkage method – Non-hierarchical method – K-Mean concept of multidimensional scaling and correspondence analysis.

Books for Study

1. Anderson, T.W. (1980): An Introduction to Multivariate Statistical Analysis, Second Edition, Wiley Eastern.
2. Applied Multivariate Statistical, 5th Edition, Richard A.Johnson Dean.W.Wichern.
3. M.Jambu and Lebeaux, M.O.(1983): Cluster Analysis and Data Analysis, North-Holland Publishing Company.

Books for Reference

1. Kshirsagar, A.M. (1972): Multivariate Analysis, Marcel Decker.
2. Morrison, D.F.(1976): Multivariate Statistical Methods, Second Edition, McGraw Hill.
3. Afifi,A.A.and Azen, S.P. (1979): Statistical Analysis - A Computer Oriented Approach, Academic Press.
4. N.Giri, Multivariate Statistical Inference, Academic Press.
5. Reucher, Multivariate Analysis, Academic Press.

17S23C	Statistical Quality Control	Core -7
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Unit I

Shewhart Control Charts for \bar{X} , \bar{R} , np, p, c etc., and their uses, OC and ARL of Control Charts, Control Charts based on C.V., Modified Control Charts, CUSUM procedures, use of V-mask, Derivation of ARL.

Unit II

Decision Interval Schemes for CUSUM charts. Economic Designs of Control Charts, Pre-control, Relative Precision and Process Capability analysis and Gauge capability analysis, Multivariate Control charts and Hotelling T^2 .

Unit III

Basic Concepts of Acceptance Sampling, Single, Double, Multiple and Sequential Sampling Plans for Attributes, Curtailed and Semi Curtailed Sampling. Dodge-Romig Tables-LTPD and AOQL protection (Single Sampling Plan only). MIL-STD-105D.

Unit IV

Variable Sampling: Assumptions, Single and Double Variable Sampling Plans. Application of Normal and Non-central t-Distributions in Variable Sampling. Continuous Sampling Plans: CSP-1, CSP-2 and CSP-3. Special Purpose Plans: Chain Sampling Plans, Skip-lot Plans.

Unit V

Concept : Hazard Function and Reliability Function. Exponential, Gamma and Weibull Failure Models. Models for wearout failures. System Reliability-Serial, parallel and mixed systems.

Books for Study

1. Montgomery, D.C., (1985): Introduction to Quality Control John Wiley.
2. Schilling, E.G. (1982): Acceptance Sampling in Quality Control, Marcel Dekker.
3. Burr, I.W., (1976): Statistical Quality Control Methods, Marcel Dekker.
4. H.J. Mittag and H. Rinne (1993): Statistical Methods of Quality Assurance, Germany Chapman & Hall India (UK) – Chapter 3 and 4.

Books for Reference

1. Whetherill, G.B., (1977): Sampling Inspection and Quality Control, Halsted Press, New York.
2. Freeman, H.A., Friedman, M. and Others (1948). Sampling Inspection Principles- Procedures and Tables for Single, Double and sequential Plans in Acceptance Quality Control, McGraw Hill.
3. Hald, A. (1981): Statistical theory of Sampling by Attributes, Academic Press.
4. Ott, E.R., (1975): Process Quality Control, McGraw Hill.
5. Halpern, S (1979): An Introduction to Quality Control and Reliability, Prentice Hall of India.
6. Lawless J.R. (1982) : Statistical Methods for Lifetime Data, John Wiley & Sons.

17S2P1	Statistics Practical - I	Core – 8
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The maximum marks for continuous internal assessment and end semester University examination for Statistics Practical I shall be fixed as 40 and 60, respectively. The continuous internal assessment shall involve test and record work. The question paper at the end semester examination shall consist of four questions with internal choice. A candidate shall attend all the four questions, each of which shall carry 15 marks. The examination shall be conducted at the end of Semester II. Problems relating to the following topics which are covered in Semester I and Semester II shall form the basis for setting the question paper:

1. Sampling Theory and Methods

Simple Random Sampling – Stratified Random Sampling – Systematic Sampling – Single-stage and Two-stage Cluster Sampling – Ratio and Regression estimates – Double Sampling methods.

2. Multivariate Analysis

Test based on Discriminant function – Hotelling T^2 Statistic – Mahalanobis D^2 Statistic - Principal component analysis – Factor analysis - Single Linkage Method – Complete Linkage Method – Classification Analysis – Discriminant Function.

3. Statistical Inference

Point Estimation – Methods of Maximum Likelihood, Moments, Minimum Chi-Square - Interval Estimation.

4. Statistical Quality Control

Control charts for mean, range, fraction defective, number of defective, number of defects – Single, double and sequential sampling plans, Reliability based on type I and II censoring and complete censoring.

17S2P2	Statistical Software Practical - I (Using SPSS, MINITAB & STATISTICA)	Core –9
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The maximum marks for continuous internal assessment and end semester University examination for Statistical Software Practical I shall be fixed as 40 and 60, respectively. The continuous internal assessment shall involve test and record work. The question paper at the end semester examination shall consist of four questions with internal choice. A candidate shall attend all the four questions, each of which shall carry 15 marks. The examination shall be conducted at the end of Semester II. Problems relating to the following topics which are taught using statistical software such SPSS, STATISTICA and MINITAB shall form the basis for setting the question paper:

1. Functions of Statistics (Classification, Diagrams and Graphical representation of Data)
2. Descriptive Statistics
3. Calculation of Probabilities under various distributions
4. Correlation & Regression-Partial and Multiple Correlations, Multiple Regression
5. Curve Fitting, Time series and Forecasting models
6. Confidence Intervals for mean, variance, proportions
7. Inferential Statistics for Single through multiple samples. (Chi-square, t, F, and z test)
8. Non-parametric tests
9. Experimental Design: One way ANOVA-two way ANOVA-factorial designs– Multiple comparison tests
10. Multivariate Analysis: Principal component and factor Analyses, and discriminant analysis
11. Statistical Quality Control charts – Determination of parameters for constructing basic control charts, such as \bar{X} , R, S, p and c charts.
12. Generating random samples.

SEMESTER III

AIMS

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2. To develop knowledge, understanding and experience of the theory, practice and application of selected areas of statistical computing and to produce graduates needed by public and private sector to help and solve practical problems using the skills and techniques of these areas and to develop analytical skills for Insurance Sector.
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OBJECTIVES

1. An understanding of the Statistical principles, techniques and applications of selected areas of Statistics and computing.
2. The ability to evaluate, select, write and use of computer software packages for Statistical theory which takes into account the needs of the user and constraints towards computing environment.
3. The ability and confidence to analyze and solve problems both of a routine and of obvious nature towards applications of Statistical theory.
4. To gain deeper understanding, problem solving skills and greater knowledge of selected topics in statistical computation.

17S33A	Statistical Inference - II	Core – 10
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Unit I

Testing of hypotheses: simple and composite hypothesis, two types of errors, level of significance, randomized and non-randomised tests, power and size of a test. Most powerful test-Neyman-Pearson lemma. Monotone likelihood ratio property-uniformly most powerful tests. Applications to standard statistical distributions.

Unit II

Generalization of Neyman-Pearson fundamental lemma (statement only). Unbiased tests- Construction of uniformly most powerful unbiased tests for one-parameter and multi-parameter exponential families-applications to standard statistical distribution-similar regions. Locally most powerful(LMP)test-LMP unbiased test.

Unit III

Invariance-maximal invariant statistic-invariant test. Likelihood ratio(LR)test-asymptotic distribution of LR test statistic-consistency of LR test-Construction of LR tests for standard statistical distributions. Analysis of variance(one-way). Bartlett's test for homogeneity of variances.

Unit IV

U statistic and its property as an estimator of its expected value. Tests for goodness of fit-Chi-square and Kolmogorov-Smirnov tests. Test for randomness. Wilcoxon's signed-rank test. Kolmogorov-Smirnov two sample test. Mann-Whitney U test. Kruskal-Wallis test.

Unit V

Introduction to sequential procedures - Stopping times - Wald's equation. SPRT: termination property, approximation to stopping bounds and applications to standard distributions. Statement of Wald's fundamental identity. OC and ASN functions and their plotting

Books for Study

1. Rohatgi, V.K. (1988). An Introduction to probability Theory and Mathematical Statistics, Wiley Eastern Ltd., New Delhi.
2. Lehmann, E.L. (1986). Testing Statistical hypotheses (Second Edition), John Wiley, New York.
3. Gupta and Kapoor (2002). Fundamentals of Mathematical Statistics, Sultan Chand & Sons
4. Goon, A.M., Gupta, M.K., Das Gupta, B. (1973). An outline of Statistical Theory, Vol. II, World Press, Calcutta.

Books for References

1. Conover, W.J. (1980). Practical Non-parametric Statistics, (Second Edition), John Wiley and sons, New York.
2. Gibbons, J.D. and Chakrabarti. S. (1992) Non-parametric Statistical Inference (Third Edition)
3. Kale, B.K. (1999). A First course on parametric Inference, Narosa Publishing House, New Delhi.
4. Wald, A. (1982) Sequential Analysis .John Wiley, New York.

17S33B	Linear Models and Design of Experiments	Core – 11
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UNIT-1

Linear Models - Assumptions on Error Components - Fixed/Mixed and Random effect Models – Generalised linear model - Gauss-Markov set up - Estimation – Least square method – MLE Method – Gauss - Markov theorem - BLUE - Tests for Linear Hypothesis - Principles of Experimentation - Review of Basic Designs - CRD – RBD - LSD.

UNIT-II

Multiple Comparison and Multiple Range Tests: Need – Tukey’s Test, Fisher’s Least Significance Difference (LSD) Method, Duncan’s Multiple Range Test, Newman-Keuls Test - Analysis of Covariance – One way and two way - Analysis of Graeco Latin Squares, Cross Over Designs, Split Plot and Strip Plot Designs.

UNIT-III

Factorial Experiments – Advantages and limitations – main effects and interaction effects - Analysis of 2^n , 3^n , s^n and $n \times p$ Asymmetrical Factorial Experiments – Concept and Principle of total, partial and balanced Confounding in Symmetrical Factorial experiments – Advantages and disadvantages of confounding - Analysis of confounded 2^n and 3^n factorial experiments.

UNIT-IV

Concept of Fractional Replication in Symmetrical Factorial experiments - $\frac{1}{2}$ and $\frac{1}{4}$ replicate of 2^n , $\frac{1}{3}$ replicate of 3^n experiments - Construction and analysis – Concept of Response Surface experiments – First order Response surface Designs - steepest ascent method - Second order Response surface Designs.

UNIT-V

Incomplete Block Designs, Incidence matrix and its properties, C- matrix and its significance - Concept of Connectedness and Orthogonality – Balanced Incomplete Block Designs – parametric relationships – inter and intra block analyses - Partially Balanced Incomplete Block Design and its analysis - Youden Square Design - Simple and Balanced Lattice Designs.

Books for Study

1. Montgomery, D.C. (2009): Design and Analysis of Experiments, 8th Edition, John Wiley and Sons,
2. Das M.N. and Giri N.C., (2017): Design and Analysis of Experiments, 3rd Edition, New Age International (P) Ltd.
3. Graybill, F.A. (1961): An Introduction to Linear Statistical Models, McGraw Hill.
4. Graybill, F.A. (2000): Theory and Application of the Linear Model, Duxbury Classic Series.

Books for References

1. Fisher, R.A. (1947): The Design of Experiment, Fourth Edition, Oliver and Boyd.
2. Federer, W.T. (1963): Experimental Design Theory and application, Macmillan and Co., New York Oxford IBM.

3. Kempthorne, O (1965): The Design and Analysis of Experiments, Wiley Eastern, New Delhi
4. Cochran, W.G. and Cox, G.M.(1957): Experimental Designs, 2nd Edirion, John Wiley and Sons, New York.
5. Nigam, A.K., Puri, P.D and Gupta, V.K. (1988): Characterizations and Analysis of Block Designs, Wiley Eastern, New Delhi.
6. Kshirsagar, A.M(1983): A Course in Linear Models, Marcel Dekkar, New York.
7. Paneerselvam, R. (2012): Design and Analysis of Experiments, PHI learning private Ltd.
8. Dey,A. (2010): Incomplete Block Designs. World Scientific Publishing Company, New Delhi .
9. Aloke Dey. (1986): Theory of Block Designs, Wiley Eastern, New Delhi.
10. John, P.W.M. (1998): Statistical Design of Experiments. Oliver and Boyd, London.
11. Joshi, D.D (1987): Linear Estimation and Design of Experiments, 1st Edition, New Age International (P) Ltd, New Delhi.
12. Searle, S.R. (2012): Linear Models. John Wiley & Sons, Inc., New York.

17S33C	Data Mining	Core – 12
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Unit I

Introduction – An expanding universe of data – production factor – data mining – data mining verses query tools – data mining in marketing – practical applications. Learning: Introduction – self learning – machine learning and methodology of science – concept learning.

Unit II

Data mining and the data warehouses: Introduction – need – decision support system – integration with data mining – client / server data warehousing – multi processing machine – cost justification.

Unit III

Knowledge discovery process: Introduction – data selection – cleaning – enrichment – coding – data mining and its techniques – reporting.

Unit IV

KDD environment: Introduction – different forms of knowledge – getting started – data selection – cleaning – enrichment – coding – reporting - ten golden rules.

Unit V

Customer profiling – predicting bid behavior of pilots – learning of compression of data sets – noise and redundancy – fuzzy database – the traditional theory – relation to tables – statistical dependencies – data mining primitives.

Books for Study and References

1. Pieter Adriaans and Dolf Zantinge – Data Mining, Addison Wesley publications.
2. K.P. Soman, Shyam Diwakar, V. Ajay - Data Mining theory and Practice PHI.
3. Rhonda Delmater and Monte hancock – Data Mining explained, Digital press.
4. David Hand, Heikki Mannila and Padhraic Smyth - Principles of Data Mining, PHP

17S33D	Operations Research	Core – 13
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Unit I

Review of LP problems -Methods using Artificial Variables- Two Phase Method - Principle of Duality-Dual Simplex Method- Transportation and Assignment Problems- Travelling Salesman Problem- Degeneracy and cycling.

Unit II

Games in Normal and Extended Forms, Fundamental Theorem of Matrix Games(without proof), Solution of 2×2 , $2 \times m$ and $m \times n$, Zero Sum Games by Dominance Principle, LP Representation and Graphical Methods. Sequencing and Scheduling Models, 2 Machine n-job problem (no passing), 3 Machine n-job problems.

Unit III

Introduction to Networks, Determination of Flows and of Critical Path, PERT, Multi-stage Decision Processes and Dynamic Programming, Delman's Principle.

Unit IV

Analytic Structure of Inventory Problems, EOQ formula, its Sensitivity Analysis and Extensions allowing Quantity Discounts and Shortages. Multi-Item Inventory subject to Constraints, Models with Random Demand, The Static Risk Model P and Q Systems with constant and Random Lead Times.

Unit V

Queueing Models-Specifications and Effectiveness Measures. The M/M/1, M/M/C and M/C/1 Queues and their steady state Solutions, Machine Interference Problems, Waiting Time Distributions for M/M/1 and M/M/C Models.

Books for Study

1. Hadley, G. (1969): Linear Programming, Addison-Wesley.
2. Hillier, F. S. and Lieberman, G. J. (1962): Introduction to Operations Research, Holden Day.
3. Kanti Swarup, Gupta P.K., and Man Mohan. (1977): Operations Research, Sultan Chand and Sons.

Books for Reference

1. Taha, H. A. (1982): Operations Research, Third Edition, Collier- McMillan.
2. Saaty, T. L. (1961): Elements of Queueing Theory with Applications, McGraw Hill.
3. Wagner, H. M. (1973): Principles of Operations Research with Application to Managerial Decisions, Prentice Hall of India.

SEMESTER IV

AIMS

1. To provide a broad based high quality education with combination of the subjects like Stochastic Processes, Econometrics, Statistical Practical (calculator based) Statistical Software Practical (using R) and Project Viva-voce to Post-Graduate Degree level for students who have to demonstrate their ability and potential towards Statistical Theory and Applications.
2. To develop knowledge, understanding and experience of the theory, practice and application of selected areas of statistical computing and to produce graduates needed by public and private sector to help and solve practical problems using the skills and techniques of these areas and to develop analytical skills for Insurance Sector.
3. To develop enterprise competences emphasizing the key skills of learning and communication for Statistical theory.

OBJECTIVES

1. An understanding of the Statistical principles, techniques and applications of selected areas of Statistics and computing.
2. The ability to evaluate, select, write and use of computer software packages for Statistical theory which takes into account the needs of the user and constraints towards computing environment.
3. The ability and confidence to analyze and solve problems both of a routine and of obvious nature towards applications of Statistical theory.
4. To gain deeper understanding, problem solving skills and greater knowledge of selected topics in statistical computation.

17S43A	Stochastic Processes	Core – 14
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Unit I

Introduction to Stochastic Processes - Classification of Stochastic Processes, Markov Processes – Markov Chain - Countable State Markov Chain. Transition Probabilities, Transition Probability Matrix. Chapman - Kolmogorov's Equations, Calculation of n - step Transition Probability and its limit.

Unit II

Classification of States, Recurrent and Transient States - Transient Markov Chain, Random Walk and Gambler's Ruin Problem. Continuous Time Markov Process:, Poisson Processes, Birth and Death Processes, Kolmogorov's Differential Equations, Applications.

Unit III

Branching Processes – Galton – Watson Branching Process - Properties of Generating Functions – Extinction Probabilities – Distribution of Total Number of Progeny. Concept of Weiner Process.

Unit IV

Renewal Processes – Renewal Process in Discrete and Continuous Time – Renewal Interval – Renewal Function and Renewal Density – Renewal Equation – Renewal theorems: Elementary Renewal Theorem. Probability Generating Function of Renewal Processes.

Unit V

Stationary Processes: Discrete Parameter Stochastic Process – Application to Time Series. Auto-covariance and Auto-correlation functions and their properties. Moving Average, Autoregressive, Autoregressive Moving Average, Autoregressive Integrated Moving Average Processes. Basic ideas of residual analysis, diagnostic checking, forecasting.

Books for Study

1. Karlin,S. and Taylor,H.M. (1975): A First Course in Stochastic Process, vol.I, Academic Press.
2. Medhi, J. (1982): Stochastic Process, Wiley Eastern.
3. Box, G.E.P., and Jenkins, G.M., (1976): Time Series Analysis- Forecasting and Control. Holden-Day San Francisco.

Books for Reference

1. Granger, C.W.J. and Newbold, (1984): Forecasting Econometric Time Series, Third Edition, Academic.
2. Anderson, T.W., (1971): The Statistical Analysis of Time Series, Wiley, NY.
3. Kendall, M.G., and Stuart, A.(1966): The advanced Theory of Statistics, Vol.3, Charles Griffin, London.
4. Adke, S.R. and Manjunath, S.A. (1984): An Introduction to Finite Markov Processes, Wiley Eastern.
5. Parzen, E. (1962): Stochastic Processes, Holland-Day.

17S43B	Biostatistics and Survival Analysis	Core – 15
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UNIT I

Introduction - Clinical Trials- Goals of Clinical Trials - Phases of Clinical Trials - Classification of Clinical Trials - Randomization: Fixed Allocation, Simple, Blocked, Stratified, Baseline Adaptive and Response Adaptive - Blinding: Single, Double and Triple - Designs for Clinical Trials : Parallel Groups Design, Cluster Randomization Designs, Crossover Designs.

UNIT II

Multiple Regression – Assumptions – uses – Estimation and interpretation of coefficients – Testing the regression coefficients – Coefficient of determination – Testing model adequacy. Logistic regression : Introduction – Logistic regression model –relative risk – logit - odds ratio – properties of odds ratio – relationship between odds ratio and relative risk– Maximum Likelihood estimates and interpretation –Test for coefficients - Test of overall regression and goodness of fit using Maximum Likelihood technique – Inference for Logistic regression – Deviance statistics, Wald test, LR test and score test.

UNIT III

Introduction to Survival analysis - terminology and functions of survival analysis- goals - Basic data layout – Censoring - different types of censoring - Parametric survival models based on basic life time distributions - Exponential, Weibull, Gamma and Log- logistic.

UNIT IV

Kaplan-Meier's method- general features - the log rank test for two groups, several groups alternatives to the log rank test - Cox PH model and its features - ML estimation of the Cox PH model-Hazard Ratio-adjusted survival curves-Cox likelihood.

UNIT V

Evaluating the proportional Hazards Assumptions - overview - graphical approach - log-log plots - Observed versus expected plots - time - dependent covariates - The Stratified Cox Procedure- hazard function- Extension of the Cox PH Model- hazard ratio formula- extended Cox likelihood.

Books for Study and Reference

1. Shein-Chung Chow, Jen-Pei Liu (2014), “Design and Analysis of Clinical Trials: Concepts and Methodologies”, Third edition, Wiley Series
2. Lawrence M. Friedman, Curt D. Furberg (2010), “Fundamentals of Clinical Research”, 4th edition, Springer Science
3. David G. Kleinbaum and Mitchel Klein (2011), “Logistic Regression- A Self-Learning Text”, Second edition, Springer.
4. Elisa T. Lee & John Wenyu (2003): "Statistical methods for Survival Data Analysis", 3rd Edition, John Wiley
5. Gerald van Belle, Lloyd D. Fisher, Patrick J. Heagerty, Thomas lumley(2004): "Bio Statistics- A Methodology for the Health Science", Second edition, John Wiley
6. Wayne W. Dainel and Chad L. Cross (2014): “Bio Statistics - Basic Concepts and Methodology for the Health Science”, 9th edition, John Wiley
7. David G. Kleinbaum, Mitchel Klein (2012): “Survival analysis- A Self-Learning Text”, Third edition, Springer
8. John P. Kelin, Melvin L. Moeschberger(2005): “Survival analysis - Techniques for Censored and Truncated data”, Second edition, Springer.

17S4P3	Statistics Practical - II	Core – 16
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The maximum marks for continuous internal assessment and end semester University examination for Statistics Practical II shall be fixed as 40 and 60, respectively. The continuous internal assessment shall involve test and record work. The question paper at the end semester examination shall consist of four questions with internal choice. A candidate shall attend all the four questions, each of which shall carry 15 marks. The examination shall be conducted at the end of Semester IV. Problems relating to the following topics which are covered in Semester III shall form the basis for setting the question paper:

1. Statistical inference

Most powerful test – Uniformly Most Powerful test – Likelihood Ratio test – Chi-Square goodness of fit test – Non-parametric Tests

2. Linear Models and Design of Experiments:

Linear Models and Estimation of BLUE – Analysis of Covariance – Greco Latin Square Design – Split plot and Strip plot techniques – 2^n and 3^n factorial experiments with and without total and partial confounding - BIBD – PBIBD - Youden Square Design – Lattice Design.

3. Operations Research

Artificial Variable – Dual Simplex methods – Game with and without saddle point – Dominance principle and job sequencing problems – PERT and CPM techniques – Inventory problems – Queueing problems.

4. Demography and Vital Statistics

Measurements of mortality and fertility: CDR, SDR, IMR, SDR, CBR, GFR, SFR, TFR.
Construction of life tables. Gross production rate (GPR) and net production rate (NPR).

17S4P4	Statistical Software Practical II (Using R Programming)	Core –17
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The maximum marks for continuous internal assessment and end semester University examination for Statistical Software Practical II shall be fixed as 40 and 60, respectively. The continuous internal assessment shall involve test and record work. The question paper at the end semester examination shall consist of four questions with internal choice. A candidate shall attend all the four questions, each of which shall carry 15 marks. The examination shall be conducted at the end of Semester IV. The aim of this paper is to utilize theoretical knowledge gained and to develop computational and technical skills for real life applications emphasizing the importance of R programming. Problems relating to the following topics shall form the basis for setting the question paper:

1. Using R command-Operations on vectors, logical vector, index vector and matrices.
2. Graphical procedures - Bar chart, Box plots, Histograms using single & multiple groups.
3. Creating and Manipulation of data frames, using various user defined functions.
4. Calculations of probability functions and generation of random samples for various discrete and continuous distributions.
5. Writing R functions for descriptive statistics, correlations and regression co-efficients.
6. Statistical Inference: Parametric and Non-Parametric test.
7. Experimental design for One way and Two way ANOVA
8. Execution of control charts and Acceptance sampling plans
9. Using R functions writing program for Linear models and least square techniques.
10. Multivariate techniques.

17S4PV	Project and Viva-Voce	Core –18
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All the admitted candidates shall have to carry out a project/dissertation work during the fourth semester under the supervision of the faculty of the Department of Statistics in the University. Candidates shall have to submit three copies of the report of the project/dissertation work at the end of the fourth semester at least two weeks before the last working day and shall have to appear for a viva-voce examination. The report shall be evaluated and viva-voce examination shall be conducted jointly by an External Examiner and the Project Guide. The maximum marks for the project/dissertation report and viva – voce examination shall be fixed as 100, which is split with the following components:

Internal Assessment Marks by the Project/Dissertation Guide	:	25 marks
Evaluation of Project/Dissertation Report jointly by the External Examiner and the Guide	:	50 marks
Conduct of Viva-Voce Examination jointly by the External Examiner and the Guide	:	25 marks

Syllabus for Elective Papers
(For Candidates of M.Sc. (Statistics with Computer Applications))

17S13EA	Official Statistics	Elective I
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Unit I

Statistical System in India: Central and State Government Organizations, Functions of Central Statistical Organization (CSO), National Sample Survey Organization (NSSO). Organization of large scale sample surveys. General and special data dissemination systems.

Unit II

Official statistics: Meaning, methods of collection, limitations and reliability. Principal publications containing data on the topics such as population, agriculture, industry, trade, prices, labour and employment, transport and communications - Banking and finance.

Unit III

System of Collection of Agricultural Statistics - Crop forecasting and estimation - Productivity, fragmentation of holdings - Support prices - Buffer stocks - Impact of irrigation projects. Statistics related to industries, foreign trade - Balance of payment - Inflation - Social statistics.

Unit IV

Index Numbers: Price, Quantity and Value indices. Price Index Numbers: Construction, Uses, Limitations, Tests for index numbers, Chain Index Number. Consumer Price Index, Wholesale Price Index and Index of Industrial Production – Construction of index numbers and uses.

Unit V

National Income – Measures of national income - Income, expenditure and production approaches - Applications in various sectors in India. Measurement of income inequality: Gini's coefficient, Lorenz curves, Application of Pareto and Lognormal as income distribution.

Books for Study and Reference

1. Allen R. G. D. (1975). Index Numbers in Theory and Practice, Macmillan.
2. Bhaduri, A. (1990). Macroeconomics: The Dynamics of Commodity Production, Macmillan India Limited, New Delhi.
3. Branson, W. H. (1992). Macroeconomic Theory and Policy, Third Edition, Harper Collins Publishers India (P) Ltd., New Delhi.
4. C. S. O. (1990). Basic Statistics Relating to the Indian Economy.
5. C.S.O. (1995). Statistical System in India.
6. C. S. O. (1999). Guide to Official Statistics.
7. Goon A. M., Gupta M. K., and Dasgupta. B. (2001), Fundamentals of Statistics, Vol. 2, World Press, India.
8. Mukhopadhyay P. (2011). Applied Statistics, Second Edition, Books & Allied Ltd, India.
9. Panse, V. G. (1964). Estimation of Crop Yields (FAO), Food and Agriculture Organization of the United Nations.

17SE13B	Applied Regression Analysis	Elective IV
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Unit I

Simple regression models with one independent variable, assumptions, estimation of parameters, standard error of estimator, testing the significance of regression coefficients, standard error of prediction. Testing of hypotheses about parallelism, equality of intercepts, congruence. Extrapolation, optimal choice of independent variable.

Unit II

Diagnostic checks and correction: graphical techniques, tests for normality, uncorrelatedness, homoscedasticity, lack of fit, modifications like polynomial regression, transformations on Y or X. Inverse regression.

Unit III

Multiple regression: Standard Gauss Markov Setup. Least square (LS) estimation, Error and estimation spaces. Variance - Covariance of LS estimators. Estimation of error variance, case with correlated observations. LS estimation with restriction on parameters. Simultaneous estimation of linear parametric functions.

Unit IV

Non-linear regression: Linearization transforms, their use & limitations, examination of non-linearity initial estimates, iterative procedures for NLS grid search, Newton-Raphson, steepest descent, Marquardt's methods. Logistic Regression: Logic transform, ML estimation, Tests of hypotheses, Wald test, LR test, score test, test for overall regression.

Unit V

Multiple logistic regressions, forward, backward method. Interpretation of parameters relation with categorical data analysis. Generalized Linear model: link functions such as Poisson, binomial, inverse binomial, inverse Gaussian and gamma.

Books for Study and Reference

1. Draper, N. R. and Smith, H. (1998). Applied Regression Analysis, Third Edition, John Wiley and Sons.
2. Montgomery, D. C., Peck, E. A., and Vining, G. G. (2012). Introduction to Linear Regression Analysis, Fifth Edition, John Wiley and Sons.
3. Hosmer, D.W., Lemeshow, S., and Sturdivant, R. X. (2013). Applied Logistic Regression, Third Edition, John Wiley and Sons.
4. Seber, G.E.F. and Wild, C.J. (2003). Nonlinear Regression, John Wiley and Sons.
5. Neter, J., Wasserman, W., and Kutner, M.H. (1989). Applied Linear Statistical Models, Second Edition, Irwin.

17S33EA	Demography and Vital Statistics	Elective II
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Unit I

Population Theories: Coverage and content errors in demographic data, use of balancing equations and Chandrasekharan - Deming formula to check completeness of registration data. Adjustment of age data, use of Myer and UN indices, Population composition, dependency ratio.

Unit II

Introduction and sources of collecting data on vital statistics, errors in census and registration data. Measurement of population, rate and ratio of vital events. Measurements of Mortality: Crude Death Rate (CDR), Specific Death Rate (SDR), Infant Mortality, Rate (IMR) and Standardized Death Rates.

Unit III

Stationary and Stable population, Central Mortality Rates and Force of Mortality. Life (Mortality) Tables: Assumption, description, construction of Life Tables and Uses of Life Tables.

Unit IV

Measurements of Fertility: Crude Birth Rate (CBR), General Fertility Rate (GFR), Specific Fertility Rate (SFR) and Total Fertility Rate (TFR). Measurement of Population Growth: Crude rates of natural increase, Pearl's Vital Index, Gross Reproduction Rate (GRR) and Net Reproduction Rate (NRR).

Unit V

Special Distribution of Population – Basic concepts – Measurements and Models of Migrations. Components of Population Growth and Change – Methods of Projection – Logistic Equation – Component Method of Projection.

Books for Study

1. Barclay, G. W. (1958). Techniques of Population Analysis, John Wiley and Sons, New York.
2. Biswas, S. (1988). Stochastic Processes in Demography & Application, Wiley Eastern Ltd., India
3. Bogue, D. J. (1969). Principles of Demography, Wiley, New York.
4. Croxton, F. E., Cowden, D. J., and Klein, S. (1973). Applied General Statistics, Third Edition, Prentice Hall of India Pvt. Ltd.
5. Goon, A. M., Gupta, M. K., and Dasgupta, B. (2008). Fundamentals of Statistics, Vol. II, Ninth Edition, World Press, India.
6. Keyfitz, N., and Caswell, H. (2005). Applied Mathematical Demography, Springer - Verlag, New York.
7. Mishra, B. D. (1980). An Introduction to the Study of Population, South Asian Publishers Pvt. Ltd., New Delhi.
8. Mukhopadhyay, P. (2011). Applied Statistics, Second Edition, Books and Allied (P) Ltd., India.

17S33EB	Statistical Data Analysis Using R	Elective V
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Unit I

Data types in r numeric/character/logical; real/integer/complex strings and the paste command matrices, data frames, lists, setwd, read.table, read.csv, write.matrix, write.csv, creation of new variables, categorization, cut, factor; round, apply, creation of patterned variables - saving output to a file; source; print -saving workspace / history.

Unit II

Graphics in r - the plot command, histogram, bar plot, box plot - points, lines, segments, arrows, paste - inserting mathematical symbols in a plot, pie diagram, customization of plot-setting graphical parameters - text and mtext, the pairs command, colours and palettes, saving to a file; graphical parameters such as mar/mai/mfrow, xlab/ylab/las/xaxp/yaxp/xlim/ylim/cex/axis/tck/srt,main/title/legend/locator, identify.

Unit III

Basic statistics -r help-command help, help.search(), r mailing list - contributed documentation on cran - one and two sample t tests, Bartlett's test for variance, f test for equality of variances, multi sample means, non parametric tests, chi-squared tests - randomness, homogeneity, independence, exact tests and confidence intervals, checking the assumptions, distribution fitting.

Unit IV

Vector matrix operations - matrix operations - addition, subtraction, multiplication, linear equations and eigenvalues, matrix decomposition - lu, qr and svd and inverse, the linear model and qr decomposition, determinant, g inverse, finding a basis, orthonormalization, finding rank, the lm function; fitting a linear model; anova / ancova / regression

Unit V

Linear models - models, the summary function, goodness of fit measures, predicted values and residuals; residual plots, the anova table, creating factors - r functions - random number generation & simulations - r libraries.

Books for Study and Reference

1. Purohit, S. G., Gore, S. D., and Deshmukh, S. R. (2009). Statistics Using R, Narosa Publishing House, New Delhi.
2. Quick, J. M. (2010). Statistical Analysis with R, Packt Publishing Ltd., UK.
3. Everitt, B. S., and Hothorn, T. (2010). A Handbook of Statistical Analyses Using R, Second Edition, Chapman and Hall, CRC Press.

17S43EA	Econometrics	Elective III
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Unit I

Introduction to Econometrics- Meaning and Scope – Methodology of Econometrics – Nature and Sources of Data for Econometric analysis – Types of Econometrics

Unit II

Aitken's Generalised Least Squares(GLS) Estimator, Heteroscedasticity, Auto-correlation, Multicollinearity, Auto-Correlation, Test of Auto-correlation, Multicollinearity, Tools for Handling Multicollinearity

Unit III

Linear Regression with Stochastic Regressors, Errors in Variable Models and Instrumental Variable Estimation, Independent Stochastic linear Regression, Auto regression, Linear regression, Lag Models

Unit IV

Simultaneous Linear Equations Model : Structure of Linear Equations Model, Identification Problem, Rank and Order Conditions, Single Equation and Simultaneous Equations, Methods of Estimation- Indirect Least squares, Least Variance Ratio and Two-Stage Least Square

Unit V

Statistical Inference in Simultaneous Equations Models : Conditions for Identification, Asymptotic properties of Two-Stage Least Squares Estimator, Limited Information Maximum Likelihood and K-Class Estimators, Methods of Three- Stage Least Squares.

Books for Study

1. Johnston,J (1997) : Econometric Methods, 4th Edition, McGraw Hill
2. Gujarathi, D and Dawn Porter (2008) : Basic Econometrics, 5th Edition, McGraw-Hill

Books for References

1. Intriligator, M.D (1980): Econometric Models-Techniques and Applications, Prentice Hall.
2. Theil,H(1971): Principles of Econometrics, John Wiley.
3. Walters, A.(1970) : An Introduction to Econometrics, McMillan and Co.

17S43EB	Actuarial Statistics	Elective VI
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Unit I

Mortality: Level, trend and differentials in mortality - forces of mortality - Gombertz and Makeham laws of mortality- Complete and abridged life tables-construction, interpretation - applications -stationary funds.

Unit II

Annuities: Pure endowments - Annuities – Accumulations – Assurances - Varying annuities and assurances - Continuous annuities - family income benefits.

Unit III

Policy Values: 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 last survivorship.

Unit IV

Contingent Functions: Contingent probabilities - Contingent assurances - reversionary annuities - multiple-decrement table - forces of decrement - construction of multiple decrement tables.

Unit V

Pension Funds: Capital sums on retirement and death - widow's pensions - Sickness benefits - Benefits dependent on marriage.

Books for Reference

1. Barclay G.W. (1970). Techniques of Population Analysis. John Wiley, New York.
2. Borowiak, D.S., and A. F. Shapiro. (2013). Financial and Actuarial Statistics: An Introduction, Second Edition. CRC Press.
3. Donald, D.W.A. (1970). Compound interest and annuities, Second Edition, The Institute of Actuaries and the Faculty of Actuaries at the University Press.
4. Elandt-Johnson, R.C., and Johnson, N. L. (1999). Survival Models and Data Analysis, John Wiley and Sons, New York.
5. King, G. Institute of Actuaries Textbook, Part II, Second Edition, Institute of Actuaries (Great Britain).
6. Spurgeon, E.T. (2011), Life Contingencies, Third Edition, Cambridge University Press.

**List of Elective & Supportive Papers Offered to the
Students of Other Departments**

Scheme of Examinations

Elective Papers					
Subject Code	Title of the Papers	Credits	Int. Marks	Ext. Marks	Total Marks
17STAGE13	Bio-Statistics	4	40	60	100
17STAGE14	Probability and Statistics	4	40	60	100
17STAGE15	Statistics for Management	4	40	60	100
17STAGE16	Operations Research	4	40	60	100
17STAGE24	Actuarial Statistics	4	40	60	100

Supportive Papers					
Subject Code	Title of the Papers	Credits	Int. Marks	Ext. Marks	Total Marks
17GS31	Descriptive Statistics	2	20	30	50
17STAGS18	Data Analysis	2	20	30	50
17STAGS19	Statistical Methods for Industries	2	20	30	50
17GS64	Statistical Methods for Researchers	2	20	30	50
17GS32	Statistical Methods for Biologists	2	20	30	50
17GS63	Elements of Operations Research	2	20	30	50

17STAGE13

Elective–I

Biostatistics

Unit I

Nature of biological and Clinical experiments and data - Classification of data -Need and nature of tabulation - Charts and Diagrams for data - Bar diagrams, pie diagrams, pictograms, histograms-frequency curves and their use.

Unit II

Measures of Central tendency - Mean, Median, Mode, Geometric mean, Use of these averages in biological Studies.

Measures of deviation and Standard deviation – Co-efficient of variation -Measure of Skewness and Kurtosis.

Unit III

Correlation and regression theory - Correlation coefficient - rank correlation -Regression equations (only problems) - Multiple and Partial correlation and regression.

Basic concepts of sampling - Simple random sample - Stratified sample -Systematic samples.

Unit IV

Test of significance based on large sample test: for mean - Variance and proportions-test for means, Variance and attributes using t, F and Chi-Square distribution. Test for correlation regression coefficients, Chi-Square test for goodness of fit.

Unit V

Analysis of variance: One way and two way Classifications - Completely Randomized blocks - Randomized Block Design and Latin Square Design (Simple problems based on biological and biochemical data).

Books for Study and Reference

1. Sundar Rao, Jesudian, Richard - An Introduction to Biostatistics, Wiley.
2. Alvi E-Lewis-Biostatistics-Eastwest Press.
3. Daniel. Wayne : Bio-Statistics, Wiley.
4. Campell-Statistical for Biologist, Wiley.
5. Zar.S Bio-Statistics, Prentice Hall India.

17STAGE14

Elective-II

Probability and Statistics

Unit I

Sample spaces – events – Probability axioms – Conditional Probability – Independent events – Baye’s formula- Random Variables - Distribution functions – Marginal distributions, Conditional distribution – Stochastic Independence. Expectation – Conditional expectation and Conditional Variance. Moment generating functions – Cumulant generating functions.

Unit II

Probabilty distributions – Binomial,Poisson,geometric, Uniform, exponential, normal, gamma, beta (generating function, Mean, variance & Simple problems).

Correlation – Regression – Multiple & Partial Correlation & regression(Only Problems).

Probability density function & Properties to t,f, Chi-square distributions.

Unit III

Test for means, Variances & attributes using the above distributions large sample tests – tests for means, Variances & Proportions.

Analysis of Variance: One way and two way classifications – Complete Randomized blocks – Randomized Block Design and Latin Square Design (Only Problems).

Unit IV

Estimation: Point estimation – Characteristics of estimation – Interval estimation – Interval estimates of Mean, Standard deviation, proportion, difference in Means & ratios of Standard deviations.

Time series analysis: Trend & Seasonal variations – Box – Components of time Series – Measurement of trend – linear & Second degree Parabola.

Unit V

Statistical quality control – Statistical basis for control charts – Control limits – Control Charts for variables – X,R Charts, Charts for defective – P, nP Charts – charts for defects – C Charts..

Books for Study

1. K.S.Trivedi, (1982): Probability & Statistics with reliability, queueing & Computer applications, Prentice Hall.
2. S.C.Gupta & V.Kapoor, (1977) : Fundamentals of Mathematical Statistics, Sultan Chand & Sons.

Books for Reference

1. Montgomery.DC, and Johnson.A, (1976): Forecasting & time Series analysis, McGraw Hill.
2. Dajeh Bester field, (1986): Quality Control, Prentice Hall.

17STAGE15

Elective-III

Statistics for Management

Unit I

Nature of quantitative analysis in Management, purpose of Statistics, Measurements, attributes, Units, Variables, discrete and Continuous.

Need and nature of tabulation-Charts and diagrams for data-Bar diagrams, pie diagrams, pictograms-frequency curves.

Unit II

Measure of Central tendency-Mean, Median, Mode-Measure of dispersion - Quartile deviation, Mean deviation and Standard deviation-Coefficient of variation-Measure of Skewness and Kurtosis.

Unit III

Concepts of events-probability of events-joint, conditional, Marginal probabilities-Probability distribution of a Random variable-Expected value and variance.

Unit IV

Theoretical probability distribution-Binomial, Normal and students t distributions.

Unit V

Estimation-population and sample-population parameters-Central Limit and theorem-point estimate and interval estimates of population mean and population proportion.

Concept and Construction of Index numbers. Understanding Index numbers applicable in the context of economics, business and Management.

Books for Study and Reference

1. Richard Levin, Statistics for Management. Prentice Hall.
2. Paul Marton, Applied Business Statistics, Holt and Reinlast.
3. Good and Hatt, Research Methods on Social Science.

17STAGE16

Elective-IV

Operations Research

Unit I

Linear Programming-Graphical Method for two-dimensional problems-General Problem of Linear programming-Variou definitions-Statements of basic theorems & properties. Phase I and Phase II of the Simplex Method-Sensitivity analysis-transportation Problem and its Solution. Assignment Problem and its Solution Duality and Shadow Price.

Unit II

Queueing theory: Characteristics of queueing Systems-Steady State M/M/1, M/M/C and M/M/K queueing Models.

Replacement theory: Replacement of items that deteriorate–Replacement of items that fail – Group replacement.

Unit III

Inventory theory: Costs involved in inventory Problems-Single item deterministic Model-Economic lot size Models without shortages & with shortages having production rate infinite & finite.

Unit IV

Decision Making:Decision under certainty, uncertainty & under risk. Decision trees-expected value of Project information & imperfect information.

Unit V

PERT & CPM: Arrow networks-time estimates-earliest expected time, latest allowable occurrence- critical path- probability of meeting scheduled time of completeness of projects-calculations on CPM networks, various floats for structures- external path-updating project-operation time cost trade of curve.

Books for Study and Reference

1. Kanti Swarup, Gupta P.K.,and Man Mohan.(1977): Operations Research, Sultan Chand and Sons.
2. Taha, H.A (1982): Operations Research, Third Edition, Collier- McMillan.
3. Ackoff,R.L. and Sasieni,M.W (1968):Fundamentals of Operations Research,John Wiley.

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Elective-V

Actuarial Statistics

Unit I

Elements of Compound Interest (nominal and effective rates of interests). Annuities certain, Present values, accumulated amounts, deferred annuities – Simple problems.

Unit II

Redemption of loans, Sinking funds, The Average yield on the life fund of an insurance office. Simple Problems.

Unit III

The mortality table – construction, characteristics and uses of mortality table . The features of Indian assured lives, Orientals 1925-1935 mortality tables. The LIC (1961-64) table and the LIC(1970-7 table – Simple Problems

Unit IV

Premiums, general principles, natural premiums, level premiums, office premiums, loading for expenses. With profit and without profit premiums, adequacy of premiums relative consistency.

Unit V

Life office valuation, General principles, Policy values, Retrospective and prospective methods of valuation of liabilities. (net premium, gross premium and bounds reserve) Sources of surplus principle method of surplus.

Books for Study

1.Federation of Insurance Institutes study courses : **Mathematical Basic of the Life Assurance F.I.2.1**

Books for Reference

1. Donald D.W. : Compound interest and annuities
2. Neil. A : Life Contingencies
3. Gupta S.P.CH. : Fundamentals of Applied Statistics

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Supportive Paper I

Descriptive Statistics

Unit I

Origin-Scope-Functions, limitations, uses and Misuses of statistics. Classification and Tabulation of data, Diagrammatic and graphic representation of data.

Unit II

Measure of Central tendency–Measures of Dispersion-relative measures of dispersion-Skewness and Kurtosis-Lorenz’s curve.

Unit III

Elementary Probability space-Statistical probability Axiomatic approach to probability-Finitely additive and countable additive probability functions-Addition and multiplication theorems-Conditional probability-Bayes theorem-Simple problems.

Unit IV

Random variables-Discrete and continuous random variables-Distribution function and probability density function of a random variable-Expectation of a random variable-Addition and product theorems- Evaluation of standard measures of location, dispersion, Skewness and Kurtosis.

Unit V

Simple linear correlation and regression-Regression equations-their properties spearman’s Rank correlation Co-efficient.

Books for Study

1. Goel & Sharma : Mathematical Statistics.
2. S.P.Gupta (1969): Statistical Method, Sultan Chand and Sons.
3. S.C.Gupta & V.K.Kapoor (1977): Fundamentals of Mathematical Statistics, Sultan Chand and Sons.

Books for Reference

1. A.M.Goon, Gupta & Das Gupta: Fundamentals of Statistics, Vol.1 World press Ltd, Calcutta.
2. Rohatgi, V.K.: An introduction to Probability Theory and Mathematical Statistics, Wiley Eastern Ltd., New Delhi.

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Supportive Paper II

Data Analysis

Unit I

Sampling procedure - determination of Sample size and selection of sample formation of questionnaire- Structured and unstructured questionnaire. Field work- Execution of survey- data collection, Scaling techniques -Guttman scale-Likert 5 points scale.

Unit II

Summarizing data- tabulation- averages- Dispersions- measurement of risk- relative measures of dispersion-efficiency and consistency- comparison of two or more populations-large samples test, small sample test - ANOVA - Application of Statistical packages.

Unit III

Association of attributes: Chisquare test- correlation-rank difference correlation/biserial correlation, point biserial correlation. Significance of correlation, rank correlation and biserial correlation coefficient, partial and multiple correlations. Significance of multiple regression equation-significance of b_0 , b_1 .. b_n the liner regression coefficient- application of statistical packages.

Unit IV

Non-parametric tests: Tests for randomness, Run test, Sign test, and Mann Whitney U test. Wilcoxon signed rank test. Median test- Statistical packages

Unit V

Curve fitting - Curves of type: $Y = a + bx$, $Y = a + bx + cx^2$, $Y = ab^x$ and $Y = a.e^{bx}$. Time series - estimates of trend and seasonal variation -forecasting -statistical packages.

Books for Study and Reference

1. Siegel, sand Castellan, NJ (1988): Non-Parametric Statistics for Behavioral Science McGraw Hill Book Co, New York
2. Srivastava UK, Shenoy GC and Sharma SC (1989): Quantitative Techniques Managerial Decision Wiley Eastern ,New Delhi.
3. VK Kapoor and SC Gupta, (1986): Fundamentals of Mathematical Statistics, Sultan Chand and sons, New Delhi
4. Garrett H.E, (1973): Statistics in Psychology and Education. Vakils, Feffer and Simons Pvt. Ltd.
5. Hoel P.G. (1957): Introduction to Statistics, Asia Publishing Housing Pvt Ltd, New Delhi
6. Kothari CR (1984): Quantitative Techniques, vikas Publishing House Pvt Ltd, New Delhi
7. Kothari CR (1990): Research Methodology, Wiley Eastern Ltd, New Delhi

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Supportive Paper III

Statistical Methods for Industries

Unit I

Historical development of Statistical Quality Control - Meaning of Quality - improvement - Quality cost - Total Quality Management - causes of variations - X, R, P and C charts.

Unit II

Acceptance sampling plans by Attributes - Single Sampling Plan - Double Sampling Plan - OC curves - AOQ, ATI curves, Dodge Roaming AOQL and LTPD plans, MIL - STD 105D plans.

Unit III

Variable Sampling Plan - One sided and Two sided specifications - Taguchi philosophy and contributions to Quality Improvement (Basic concepts only)

Unit IV

Test of significance and design of experiments: Tests based on t, F and chi-square distributions - Analysis of variance - One way and Two way classification Complete Randomized Design(CRD), Randomized Block Design(RBD) , Latin Square Design(LSD).

Unit V

Basic of reliability theory - Life time distribution - Hazard rate- Survival function- Exponential, Weibull, Gamma and life time distributions

Books for Study and Reference

1. Montgomery, DC (1991) Introduction of Statistical Quality Control, John Wiley and Sons.
2. Sivazlian and Stanfel (1975), Analysis of Systems in Operations Research, Prentice Hall

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Supportive Paper IV

Statistical Methods for Researchers

Unit I

Definition of Statistics and its applications in various disciplines - Collection of Data - Classification, Tabulation and graphical representation of data- Construction of univariate and Bivariate frequency distribution-measures of central tendency-measures of dispersion - coefficient of variation.

Unit II

Random experiment-sample space-events-mathematical and statistical definition of probability-conditional probability-Bayes' theorem-random variable-distribution function-moments- Binomial distribution-Poisson distribution-normal distribution and their properties

Unit III

Scatter diagram-Karl Pearson's coefficient of correlation - concurrent deviation method-coefficient of determination-Spearman's Rank correlation-Linear regression-regression lines.

Unit IV

Tests of significance-types of hypotheses-two types of errors-critical region-level of significance, small sample tests based on t, F distribution, Chi-square test of goodness of fit, contingency table-test of independence of factors-Large sample tests.

Unit V

Test of equality of several populations means, one way and two way analysis of variance. Non-parametric tests-sign, Run and Median tests-two sample rank test-sampling and its uses, sampling methods- unrestricted Random sampling (SRS)- Restricted Sampling (Stratified and Systematic).

Books for Study and Reference

1. Agarwal (1980): Basic Statistics, Wiley Eastern
2. Sokal P.R. and Rohlf F.J. (1969): Bio Statistics, W.H. Freedom & Co, San Francisco
3. Snedecor G.W. and Cochran W.G. (1967): Statistical Methods, Oxford-IBH, Pvt Co.
4. Zar,J.H.(1984): Bio Statistical Analysis, Prentice Hall,Inc, London.

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Supportive Paper V

Statistical Methods for Biologists

Unit I

Nature of Biological and Clinical experiments of data-Classification and tabulation of data-Diagrammatic representation of data- Histogram and frequency curves

Unit II

Measures of Central tendency-Mean, Median, Mode, Geometric mean, Harmonic Mean-Measures of deviation – Range, Mean deviation, Quartile and standard deviation – Measures of Skewness and Kurtosis.

Unit III

Correlation : Rank Correlation – Multiple and Partial Correlation – Regression – Regression equations for biological problems.

Unit IV

Basic concepts of sampling – Simple random sample – Stratified sample – systematic sample – cluster sample. Test of significance based on large sample – Mean, Variance and Proportions.

Unit V

Analysis of variance –One way and Two way classifications – Completely Randomized blocks – Randomized Block design and Latin Square Design (Simple problems based on biological data)

Books for Study and Reference

1. Alvi E-Lewis-Biostatistics – East west Press
- 2.Campell - Statistical for Biologist, Wiley
- 3.J.N.Kapur and H.C.Saxena – Mathematical Statistics
- 4.Marcello Pagano and Kimberlee Gauvrean – Principles of Bio- Statistics.

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Supportive Paper VI

Elements of Operations Research

Unit I

Linear Programming Problem – Graphical Method – General Problem of Linear Programming – Simplex Method – Phase I and Phase II Problems – Transportation and Assignment Problems.

Unit II

Replacement theory : Replacement of Items that deteriorate – Replacement of items that fail completely – Individual and group replacement policy.

Unit III

Sequencing Theory – Processing ‘n’ jobs through 2 machines – Processing ‘n’ jobs through 3 machines – Processing ‘n’ jobs through ‘m’ machines.

Unit IV

Network Theory – Introduction to Network – Determination and flow for Critical Path Method – Project Evaluation Review Techniques and its differences.

Unit V

Inventory Theory – Meaning of Inventory – Factors involved in Inventory – Economic Models with and without shortages.

Book for Study and Reference

- 1.Kanti Swarup, Gupta P.K. and Man Mohan (1977) – Operations Research, Sultan Chand and Sons.
2. Taha, H.A. (1982): Operations Research, McMillan.