

## M.Sc. (Statistics) Degree Course

### PG - SCHEME OF EXAMINATIONS: CBCS PATTERN

(For the students admitted during the academic year 2018-2019 and onwards)

Sub Code	Title of the Paper	Hrs (wk)	Internal (CA) Marks	External Marks	Total Marks	Ext- Min.	Total Pass Mark	Credits
<b>Semester – I</b>								
<b>18MST11C</b>	Core I : Real Analysis & Linear Algebra	6	25	75	100	38	50	5
<b>18MST12C</b>	Core II : Probability Theory	6	25	75	100	38	50	5
<b>18MST13C</b>	Core III : Statistical Inference - I	6	25	75	100	38	50	5
<b>18MST14E</b>	Elective I: Statistics using R & SPSS	6	25	75	100	38	50	3
	Core Practical I : Statistics Practical - I	3						-
	Core Practical II : Statistics Practical - II (Using R-Software)	3						-
<b>Semester – II</b>								
<b>18MST21C</b>	Core IV: Sampling Theory	6	25	75	100	38	50	5
<b>18MST22C</b>	Core V : Distribution Theory	6	25	75	100	38	50	5
<b>18MST23C</b>	Core VI : Statistical Quality Control & Reliability	6	25	75	100	38	50	5
<b>18MST24E</b>	Elective - I : Stochastic Processes	6	25	75	100	38	50	3
<b>18MST25P</b>	Core Practical I : Statistics Practical - I	3	40	60	100	30	50	4
<b>18MST26P</b>	Core Practical II : Statistics Practical - II (Using R-Software)	3	40	60	100	30	50	4

Sub Code	Title of thePaper	Hrs (wk)	Internal (CA) Marks	External Marks	Total Marks	Ext- Min.	Total Pass Mark	Credits
<b>Semester – III</b>								
18MST31C	Core VII : Statistical Inference - II	6	25	75	100	38	50	5
18MST32C	Core VIII : Design of Experiments	6	25	75	100	38	50	5
18MST33C	Core IX : Multivariate Analysis	6	25	75	100	38	50	5
18MST34E	Elective III : Numerical Analysis	6	25	75	100	38	50	4
	Core Practical III : Statistics Practical - III	2						-
	Core Practical IV : Statistics Practical – IV (Using SPSS)	2						-
	Project / Dissertation	2						-
<b>Semester – IV</b>								
18MST41C	Core X : Advanced Operations Research	6	25	75	100	38	50	5
18MST42C	Core XI : Applied Regression Analysis	6	25	75	100	38	50	5
18MST43E	Elective IV : Econometrics	6	25	75	100	38	50	4
18MST44P	Core Practical III : Statistics Practical - III	4	40	60	100	30	50	4
18MST45P	Core Practical IV : Statistics Practical – IV (Using SPSS)	4	40	60	100	30	50	4
18MST46V	Project / Dissertation	4	20	80	100	40	50	5
	<b>Total Credits</b>				<b>2000</b>			<b>90</b>

Core -Includes core theory, practical and electives

Includes 25/40 continuous Internal Assessment Marks for Theory and Practical papers respectively

Project evaluation done by both Internal and External examiner for 80 Marks

Year	Subject Title	Sem	Sub Code
2018–19 Onwards	Core I : REAL ANALYSIS AND LINEAR ALGEBRA	I	18MST11C

**Objective :** This paper enables the student to get a good and advance knowledge in mathematical analysis.

#### UNIT - I

Limit Continuity and derivability of a real valued function – Uniform Continuity – Point-wise convergence of sequence and series of functions.

#### UNIT - II

Limit, Continuity and Derivability of functions of two variables - Maxima and Minima of functions of two variables only

#### UNIT - III

Riemann Integral: Partitions and Sums –Upper and Lower R – Integrals – Riemann Integrability – Riemann’s necessary and sufficient conditions for R – Integrability – Algebra of Integrable functions - Fundamental theorem of Integral Calculus – First and Second Mean value theorems. Riemann – Stieltjes integral – Partitions – Lower and Upper R-S sums and integrals.

#### UNIT - IV

Vector Spaces: Introduction - Definition - Sub spaces – Basis – Orthogonalisation – Gram Smith orthogonalisation process - Linear Combinations - Examples of vector spaces - Inner Product - Linear transformations - Linear product applications.

#### UNIT - V

Matrices – Rank of a matrix – inverse of a matrix – symmetric and orthogonal matrices – Characteristic roots of a vector - Quadratic form – Canonical representation of Quadratic forms.

#### Text Books:

1. R. Goldberg, Method of Real Analysis, Oxford & IBH publishers, New Delhi, 2014.
2. J.N. Sharma and A.R.Vashista., Real Analysis, Krishna Series, 2014.
3. Seymour, Lipschutz, More Lars Lipsons, Linear Algebra, third Edition, Mcgraw Hill Education (India) Private Limited, 2015.

#### Reference Books:

1. Tom.M, Apostol, Calculus, Second Edition. John Wiley and Sons, New York, 2016.
2. Shanti Narayan, Dr,M.D. Narasinghania, Elements Real Analysis S.Chand, New Delhi, 2008.

Year	Subject Title	Sem	Sub Code
2018-19 Onwards	Core II : PROBABILITY THEORY	I	18MST12C

**Objective:** To impart the knowledge and applications of Probability Theory in the field of Statistics.

#### UNIT – I

Probability space – Discrete and General probability space- Conditional probability space- Functions and Inverse Functions - Random Variables – Induced probability space by the Random variables.

#### UNIT – II

Distribution Function – properties - Decomposition theorem - Distribution function of vector random variables - Conditional distribution function - Concept of Independence- Kolmogorov 0-1 law - Borel – Cantelli lemma - Borel 0-1 law.

#### UNIT – III

Mathematical Expectation – properties - Conditional Expectation – properties - Inequalities based on Expectation - Basic Inequality - Holder’s Inequality - Markov Inequality - Jensen’s Inequality.

#### UNIT – IV

Convergence of sequence of random variables - mode of convergence and their relationships - Characteristic Function – Definition and Properties – Inversion Theorem — Uniqueness Theorem – Simple problems only.

#### UNIT – V

Law of Large Numbers — Bernoulli’s Weak Law of Large Numbers – Kolmogorov’s Strong Law of Large Numbers – Central Limit Theorem –Liapounov’s, Lindeberg Levy theorem – Lindeberg – Feller Central Limit Theorem for i.i.d. random variables - simple problems.

#### Text Books:

1. B.R. Bhat : Modern Probability Theory – An Introductory Text Book, Fourth Edition, New Age international (P) Ltd., 2015.
2. K.N. Kapoor : A Text Book on Probability Theory, International Book House Pvt. Ltd., First Edition, 2011.

#### Reference Books :

- 1.V.K. Rohatgi and A.K. Md. Ehranes Saleh: An Introduction to Probability and Statistics, Wiley Student Edition, India, Second Edition, 2009.
2. William Feller: An Introduction to Probability Theory and its Applications, Volume II, Second Edition, 2013.

Year	Subject Title	Sem	Sub Code
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<b>2018–19 Onwards</b>	<b>Core III : STATISTICAL INFERENCE – I</b>	<b>I</b>	<b>18MST13C</b>
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**Objective:** To understand the theoretical knowledge in estimation and acquire practical experience in the estimation of parameters.

#### **UNIT – I**

Parametric Point Estimation – Properties of Estimators – Unbiasedness - Consistency – Sufficient condition for consistency – Sufficient statistic – Factorization theorem– Fisher’s information – Minimal sufficient statistics.

#### **UNIT – II**

Concept of Completeness – Cramer-Rao inequality – Minimum variance bound estimator – Bhattacharya bounds – Concept of Efficiency – UMVUE – Rao-Blackwell theorem – Lehmann – Scheffe theorem.

#### **UNIT – III**

Methods of Point Estimation – Method of MLE - Properties of MLE estimators – Method of Moments - Method of Minimum Chi-square – Method of Modified minimum Chi-square.

#### **UNIT – IV**

Exponential family – Measure of location and scale – Location invariant estimator – Scale invariant Estimator – Pitman’s estimation - Concept of Bayesian Inference - Baye’s Estimator (Concept Only)

#### **UNIT –V**

Interval Estimation – Confidence level and confidence co-efficient – Shortest length confidence intervals – Construction of Confidence intervals for Population Proportion – Confidence intervals for mean, variance of a normal population – Confidence intervals for Difference between means - Confidence intervals for ratio of variances.

#### **Text Books:**

1. M. Mood, A. Greybill, C. Boes, Introduction to the Theory of Statistics, Tata McGraw – Hill Education Pvt. Limited, New Delh, 2012.
2. S.C.Gupta and V.K.Kapoor “Fundamentals of Mathematical Statistics”, Eleventh Edition, Sultan Chand & Sons, New Delhi 2013.
3. M. Rajagopal and P. Dhanavandan : “Statistical Inference “, PHI Learning Private Limited, New Delhi , 2012.

#### **Reference Books:**

1. R.V. Hogg and A.T.Craig , An Introduction to mathematical Statistics, New York , London, Seventh Edition ,2012.
2. A.M. Goon, M.K.Gupta and B. Gupta, An Outline of Statistical Theory, Volume2, World press Pvt. Ltd., Calcutta, 2017.

<b>Year</b>	<b>Subject Title</b>	<b>Sem</b>	<b>Sub Code</b>
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<b>2018–19 Onwards</b>	<b>Elective I: STATISTICS USING R &amp; SPSS</b>	<b>I</b>	<b>18MST14E</b>
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**Objective:**

To impart the knowledge of data analytical skills using statistical software packages (R & SPSS)

**UNIT – I**

Introduction to R: Reading and Getting Data into R – Viewing Named objects – Types of Data Items – The structure of Data Items.

Working with Objects: Forms of data objects. Data : Descriptive Statistics and Tabulation: Summary Commands – Summarizing Samples – Summary of Tables.

**UNIT – II**

Graphical Analysis – Bar charts – Pie-charts – Scatter Plots – Box-Whisker Plots. Adding Legends to Graphs – Adding Text to Graphs. Data Distribution: Looking at the distribution of Data. Simple Hypothesis testing – using the Student's t-test – Paired t test – U tests – Correlation– Tests for Association.

**UNIT – III**

Creating Mathematical Expressions – Plotting Linear Models and Curve fitting. ANOVA – one – way and two – way and  $2^2$  factorial experiments - Regression (Linear Modeling) – Simple Linear Regression – Multiple Regression.

**UNIT – IV SPSS** – Introduction to SPSS – Variables and constants - Data declarations – Data in and Data out – uses of help menu – Creating Data sheets – Creating Graphs and Charts – One sample t-test – Paired t test – One way ANOVA – Two way ANOVA – ANOCOVA – Correlations.

**UNIT – V** Simple Linear Regression – Multiple Linear Regression – Chi Square test for Goodness of Fit – Test for Independence of attributes – Non-parametric tests: Median Test – Mann-Whitney U test – Kolmogrov - Simrov test.

**Text Books:**

1. Mark Gardener, Beginning: R – The Statistical Programming Language, Wiley India Pvt. Ltd, New Delhi, 2013.
2. James B Cunningham and James O.Aldrich – Using SPSS, SAGE Publications, New Delhi, 2014.

**Reference Books:**

1. Sudha G. Purohit, Shard D. Gore, Shailaja R. Deshmukh: Statistics using R, Narosa Publisher's, Second Edition
2. Darren George and Paul Mallery, SPSS for Windows Step by Step, Pearson Education, 2006.

<b>Year</b>	<b>Subject Title</b>	<b>Sem</b>	<b>Sub Code</b>
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<b>2018-19 Onwards</b>	<b>Core IV: SAMPLING THEORY</b>	<b>II</b>	<b>18MST21C</b>
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**Objective:** To help the students to understand the various sampling techniques and its applications

#### **UNIT – I**

Census and Sampling surveys - Principal steps in a sample survey – Pilot survey – Concept of sampling and non-sampling errors- Sources of non-sampling errors- Finite population-sampling techniques – Simple Random Sampling With Replacement - Simple Random Sampling Without Replacement - Stratified Random Sampling - Systematic Random Sampling- Estimation of mean and variance of Stratified Random Sampling and Systematic Random Sampling

#### **UNIT – II**

Varying Probability Sampling- Introduction, Procedures of selecting a sample, Estimation in Probability proportional to size (PPS) sampling with replacement: population total and its variance, Gain due to PPS sampling with replacement - PPS sampling without replacement, Procedures of selection of a PPS sampling without replacement, Estimation in PPS sampling without replacement : Population total and its sampling variance – PPS systematic sampling.

#### **UNIT – III**

Ratio estimators: Introduction, Definition and notations, Bias of ratio estimators, approximate variance of ratio estimator-Ratio estimators in stratified sampling, comparison of separate and combined ratio estimator. Regression estimators: Introduction, Difference estimator, regression estimator, Regression estimator in stratified sampling.

#### **UNIT – IV**

Cluster sampling-Introduction-Notations-Equal cluster sampling –Estimation of mean and variance – Relative efficiency of cluster sampling – optimum cluster size –Cluster sampling for proportions. Unequal Cluster sampling – Estimation of mean and variance – Relative efficiency of unequal cluster sampling.

#### **UNIT – V**

Two stage sampling with equal first stage units – Estimation of mean and variance - Two stage sampling with unequal first stage units – Estimation of mean and variance- Two stage Probability proportional to size sampling- Three stage with equal probability - Three-stage Probability proportional to size sampling.

#### **Text Book:**

1. Daroga Singh and F.S.Chowdhary, Theory and analysis of Sampling Survey Design, John Wiley & Sons, New Age International (P) Ltd., Publishers,New Delhi, 2002.
2. S.C.Gupta and V.K.Kapoor, : Fundamentals of Applied Statistics, Fourth thoroughly revised edition, Sultan Chand & Sons Publishers, New Delhi, Reprint 2009.

#### **Reference Books:**

1. Sampling Techniques: Wiiliam G. Cocharan, John Wiley & Sons, Third Edition,2011.

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<b>2018–19 Onwards</b>	<b>Core V : DISTRIBUTION THEORY</b>	<b>II</b>	<b>18MST22C</b>
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**Objective :** To gain knowledge about the advanced probability distributions that are applied in real time situation.

#### **UNIT – I**

Probability Distribution of a random variable – Distribution functions of random variables – Properties – Distributions of sum, difference, product, quotient, range, maximum and minimum of random variables – Simple Problems.

#### **UNIT – II**

Discrete Distributions: Binomial, Poisson, Geometric, Hyper-geometric, Negative Binomial, Multinomial distributions – Properties – Power Series distributions – limiting cases - Properties.

#### **UNIT – III**

Continuous Distributions: Gamma distribution – Beta distribution of first kind - Exponential, Laplace, Cauchy, Normal, Log normal, Logistic, Weibull distributions – properties.

#### **UNIT - IV**

Non-central distributions – Non-central t, Non-central F and Non-central  $\chi^2$  distributions – Relationships - Distribution of Simple correlation co-efficient for null case and regression co-efficient. Distribution of Quadratic forms.

#### **UNIT – V**

Order statistics – distribution of order statistics – joint distribution of order statistics – Distribution of the smallest and largest order statistics – asymptotic distribution of  $r^{\text{th}}$  order statistics - Distribution of range, mid-range and median – Simple Problems.

#### **Text Books:**

1. A.M. Mood, F.A. Greybill & D.C. Boes, Introduction to the Theory of Statistics, Tata McGraw–Hill Education Pvt Limited, New Delhi, 3<sup>rd</sup> Edition, 2001.
2. S.C. Gupta and V.K. Kapoor: Fundamentals of Mathematical Statistics, Sultan Chand & Sons Publishers, New Delhi, Eleventh Edition, 2012.

#### **Reference Books:**

1. V.K. Rohatgi and A.K. Md. Eshanes Saleh: An Introduction to Probability and Statistics, Wiley Student Edition, India, Second Edition, 2009.
2. R.V. Hogg and A.T. Craig, An Introduction to mathematical Statistics, New York, London, Seventh Edition, 2012.

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<b>2018–19 Onwards</b>	<b>Core VI: STATISTICAL QUALITY CONTROL &amp; RELIABILITY</b>	<b>II</b>	<b>18MST23C</b>
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**Objective:** To develop the skills in applying SQC tools and techniques in Industries.

### UNIT I

Basis of Control Charts - Shewhart Control Charts for  $\bar{x}$ , R, p, np, c and their uses – OC and ARL of Control Charts – Modified Control Charts – CUSUM procedures – Concept and use of V-mask – Derivation of ARL - Decision Procedure – Tabular CUSUM Procedure.

### UNIT II

Charts for individual observations - Moving Range and Moving Average Charts – Exponentially Weighted Moving Average Charts - Process Capability Index – Process Capability Ratio - Process Capability Analysis.

### UNIT III

Attribute Sampling Plans – Single Sampling Plan- Conditions of Applications – Operating Procedure – Measures of Performance - OC, ASN, AOQ, ATI functions of SSP – Double Sampling Plan – Measures of Performance - OC, ASN, AOQ, ATI functions – MIL STD 105-D (Concept only).

### UNIT IV

Variable Sampling Plan – Single Sampling Plan– Operating Procedure – Known & Unknown Sigma plans for one sided specifications - OC function - Determination of the sample size – MIL STD 414 (Concept only) – Continuous Sampling Plans – CSP-I, CSP-II and CSP-III Plans – Derivation of OC function (for CSP-I only) – Sequential Sampling Plans by attributes.

### UNIT V

Need for Reliability - Definitions of Reliability – Basic elements of Reliability – Hazard Rate – Measurement of Reliability – Exponential model Hazard rate – Mean Time between failures (MTBF) – Mean Time to Repair (MTTR) - IFR and DFR distributions – Censored Samples – MLE of reliability under Type – I Censoring and Type II censoring in exponential case – Reliability for Series and Parallel Systems - k out of m System – Maintainability (Concept only).

### Text Books:

1. Douglas C.Montgomery : Introduction to Statistical Quality Control, Wiley India(P) Ltd, Fourth Edition, Second Reprint 2008, New Delhi.
2. Edward G. Schilling : Acceptance Sampling in Quality Control, Marcel Dekker, Inc, ASQC Quality Press, 1982, USA.
3. M. Mahajan, : Statistical Quality Control, Dhanpat Rai & Co(P) Ltd, 2009, Delhi.

### Reference Books:

1. A.J.Duncan, : Quality Control and Industrial Statistics, Irwin Homewood.
2. S.C.Gupta and V.K.Kapoor, : Fundamentals of Applied Statistics, Fourth thoroughly revised edition, Sultan Chand & Sons Publishers, Reprint 2009, New Delhi.

Year	Subject Title	Sem	Sub Code
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<b>2018–19 Onwards</b>	<b>Elective II: STOCHASTIC PROCESSES</b>	<b>II</b>	<b>18MST24E</b>
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**Objective:** To impart the notions of Stochastic processes and their applications.

#### **UNIT – I**

Introduction to Stochastic Processes – Definition – Classification of Stochastic processes according to state space and time domain- – Markov process – Markov chain – Countable State Markov Chain –Transition Probability Matrix – Chapman-Kolmogrov Equations – Calculation of ‘n’ step transition probability matrix.

#### **UNIT – II**

Classification of states of a Markov Chain – Recurrent and Transient states – Criteria for classification of the states – Random walk with absorbing and reflecting barriers – Probability of absorption – Duration of Random Walk – Gambler’s ruin problem.

#### **UNIT – III**

Continuous time Markov Chain- Kolmogrov’s differential equations – Poisson Process – Pure Birth process- Birth and Death Process – Simple applications.

#### **UNIT – IV**

Branching Process (one dimension only) – Generating Functions - – Properties of Generating Functions — Concept of Weiner Process- Weiner Process as a limit of random walk.

#### **UNIT –V**

Renewal process – Renewal function and its properties- Elementary renewal theorem – Strict and wide sense stationary processes with Examples – Basic ideas of Time series - Auto-regressive and moving average processes.

#### **Text Books:**

1. J. Medhi : Stochastic Processes, Wiley eastern limited, New Delhi, Second Edition, 1994.
2. Karlin & Taylor: A first course in Stochastic processes, Vol.No.1, second edition, Academic press, New York, 1975.

#### **Reference Book:**

1. Sheldon M. Ross : Stochastic Processes, Wiley series in Probability and Statistics, Second Edition, 1995.
2. B.R.Bhat: Stochastic Models- Analysis and Applications: New Age international (P) Limited, New Delhi, 2004.

Year	Subject Title	Sem	Sub Code
2018-19 Onwards	Core Practical – I : STATISTICS PRACTICAL – I	I & II	18MST25P

**Objective:** To apply the theoretical knowledge in solving practical problems

### **STATISTICAL INFERENCE –I (Estimation)**

1. Minimum Chi-Square method of estimation.
2. MLE for Binomial Distribution.
3. MLE for Poisson Distribution.
4. MLE for Normal.

### **DISTRIBUTION THEORY**

5. Fitting Poisson distribution.
6. Fitting Binomial distribution.
7. Fitting Normal distribution.
8. Fitting lognormal distribution.
9. Fitting logistic distribution

### **SAMPLING THEORY**

10. Probability proportionate to size sampling with replacement.
11. Probability proportionate to size sampling without replacement
12. Cluster sampling.
13. Ratio Estimation.
14. Regression Estimation.

### **STATISTICAL QUALITY CONTROL & RELIABILITY**

15. Single sampling plans.
16. Double sampling plans.
17. Sequential Sampling plans.
18.  $\bar{X}$  and R Charts
19. CUSUM control chart.
20. Estimation of Reliability under Type – I and Type – II censoring under the assumptions of exponential life times.

Year	Subject Title	Sem	Sub Code
2018–19 Onwards	Core Practical – II : STATISTICS PRACTICAL – II (Using R)	I & II	18MST26P

**Objective:** To apply the R-software knowledge to analyze the data collected through various studies.

1. Diagrammatic representation of data (Multiple Bar, Pie-chart).
2. Descriptive Measures: Mean, Median, Mode, SD and Correlation Coefficient.
3. Construction of Regression Equations.
4. Fitting Binomial Distribution.
5. Fitting Poison Distribution.
6. Calculation of Probabilities under Normal Distribution.
7. Calculation of Probability of Acceptance & drawing OC Curve using Poisson distribution.
8. Partial and Multiple Correlation Coefficients.
9. Multiple Regression Coefficients.
10. Fitting Linear Trend by Least Square method.
11. Confidence Interval for mean.
12. t-test for two means.
13. F-test for two variances.
14. Chi-square test for independence of attributes.
15. One-way ANOVA .
16. Two-way ANOVA.
17. 2<sup>2</sup>-Factorial Design.
18. Finding mean vector and covariance matrix.
19. Factor Analysis.
20. Construction of control charts for Mean and Range.

Year	Subject Title	Sem	Sub Code
2018–19 Onwards	Core VII : STATISTICAL INFERENCE - II	III	18MST31C

**Objective:** To understand the strong theoretical knowledge of parametric and non-parametric test and acquire practical knowledge in analyzing the data.

#### UNIT – I

Test of hypothesis: Simple and Composite hypothesis – Two types of Errors – Critical Regions – Randomized and Non-Randomized tests – Power function – Most powerful test – Neyman – Pearson lemma – examples - Neyman – Pearson Generalized lemma (Statement only).

#### UNIT – II

Uniformly Most Powerful (UMP) Test – One parameter Exponential Family – MLR property – Unbiased Test - UMP Unbiased Test – Similar test – Relation between UMP unbiased test and UMP similar test – Unbiased test for one parameter exponential family – Test with Neyman Structure – Invariant tests.

#### UNIT –III

Likelihood Ratio test – Construction- LR test for Standard Distributions (Binomial, Poisson, Normal and Exponential distributions) – Large sample properties – Asymptotic distribution of LRT –Consistency of LRT- Bortlett test for homogeneity of variances.

#### UNIT – IV

Non-parametric tests: One sample tests – Kolmogorov – Smirnov test – test for randomness – Sign test- Wilcoxon’s signed rank test – Two samples tests – Run test, Median test, K-S test and Mann-Whitney U tests- Kruskal-Wallis H test.

#### UNIT –V

Basic structure of SPRT – Derivation of boundary constants A and B – Derivation of OC function – Power function – ASN function – Simple problems based on Binomial, Poisson, Normal and Exponential distributions.

#### Text Books:

1. M. Rajagobal & R. Dhanavandan , Statistical Inference, PHI, Prentice Hall, 2012.
2. Goon A.M, Gupta M.K and Das Gupta B., An Outline of Statistical Theory, Volume 2, World Press Pvt Ltd., Calcutta , 2017.

#### Reference Books:

1. Hogg R.V. and Craig A.T., An introduction to Mathematical Statistics, Seventh Edition, Amerind, New York, London, 2012.
2. Rohatgi V.K., Introduction to Probability theory and Mathematical Statistics, Wiley Eastern Limited, New Delhi
3. Lehmann E.L., Testing Statistical Hypothesis, 2nd Edition, Springer.

Year	Subject Title	Sem	Sub Code
2018–19 Onwards	Core VIII: DESIGN OF EXPERIMENTS	III	18MST32C

**Objective:** To impart the knowledge and applications of various advanced Design of Experiments in the field of Agriculture and Industries.

### UNIT –I

Basic Principles of Experimentation – Experimental Error – Review of CRD & RBD - LSD – Applications – Layout of LSD – Advantages and Disadvantages of LSD – Statistical Analysis of LSD – Least Square Estimates of parameters – Multiple comparison methods – Least Significant Difference method – DMRT and Tukey’s Test.

### UNIT –II

Factorial experiments – Introduction –  $2^2$  factorial Design – Statistical Analysis of  $2^2$  factorial Design – Yates method of computing  $2^2$  factorial totals.  $2^3$  Factorial Experiment – Model Description - Statistical Analysis of  $2^3$  factorial Design- Yates method of computing  $2^3$  factorial totals –  $3^2$  Factorial Experiment - Confounding – Partial confounding and complete Confounding.

### UNIT – III

Split Plot Design – Introduction – model description – Statistical Analysis – Advantages and Disadvantages. - Analysis of Covariance with one Concomitant variable – model – Least Square Estimates for parameters – Estimation of variance – Statistical analysis in CRD & RBD.

### UNIT –IV

Incomplete Block Designs – Introduction – Balanced Incomplete Block Designs – Parametric Relationships – Symmetric BIBD – Statistical Analysis of Balanced Incomplete Block Designs (Intra Block only) - Partial BIBD.

### UNIT –V

Response surface methodology – Introduction – First Order Design – Model – Statistical Analysis of Response surface first order design – Design for Bio-assays – Direct, Indirect and Parallel line assays.

### Text Books:

1. S.C. Gupta and V.K. Kapoor : Fundamental of Applied Statistics – Sultan Chand & Sons, Fourth Edition, 2015.
2. R. Panneer Selvam : Design And Analysis of Experiments, Prentice Hall.
3. M.N. Das and N.P. Giri : Design and Analysis of Experiments, New Age International, 2<sup>nd</sup> Edition, 2008.

### Reference Books:

1. W.G. Cochran and G.M. Cox : Experimental Designs – John Wiley.
2. Montgomery : Design and Analysis of Experiments, John Wiley & Sons (p) Ltd.. 5<sup>th</sup> Edition 2009.
3. Angela Dean and Daniel Voss : Design and Analysis of Experiments, Springer.

Year	Subject Title	Sem	Sub Code
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<b>2018–19 Onwards</b>	<b>Core IX: MULTIVARIATE ANALYSIS</b>	<b>III</b>	<b>18MST33C</b>
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**Objective:** To impart the knowledge and the applications of Multivariate Analysis in the field of data analysis to the Statistics students.

#### **UNIT I**

Multivariate Analysis: Introduction – Bi-variate and multivariate Normal Distributions- Application of Multivariate Techniques. Estimation of the mean vector and covariance matrix - The maximum likelihood estimators of the mean vector and covariance matrix.

#### **UNIT II**

Generalized T-square statistic: Introduction – Derivation of the Generalized  $T^2$ -statistic - distribution - uses - applications. Mahalanobis  $D^2$  and applications. Wishart distribution - properties – Characteristic function of Wishart distribution.

#### **UNIT III**

Discriminant function analysis – Assumptions in Discriminant function analysis – Discriminant and Logistic analysis comparison – Discriminant and Regression analysis comparison – Sample size – Purpose of analysis.

#### **UNIT IV**

MANOVA comparing two groups – Multivariate Hotelling's  $T^2$  special issues concerning Hotelling's  $T^2$  MANOVA – Principal Component analysis: Definitions – Maximum likelihood estimators – Computation and interpretation of principal components.

#### **UNIT V**

Factor Analysis – Introduction –Model Description – Factor Loadings and Factor Rotations – Designing – Assumptions – Deriving Factors through Centroid method and MLE method – Interpreting the Factors.

#### **Text Books:**

1. Richard A. Johnson & Dean W. Wichern, Applied Multivariate Statistical Analysis, PHI Learning Private Limited, New Delhi (Sixth Edition) , 2012.
2. Lawrence S. Meyers & Glenn Gamst & AJ Guarino - Applied Multivariate Research Design and interpretation.

#### **Reference Books:**

1. Anderson T.W, An Introduction to Multivariate Statistical Analysis, Wiley India Pvt.Ltd, New Delhi (Third Edition), 2011
2. Hair, Black, Babin & Anderson & Tatham - Multivariate Data Analysis (Pearson Education) 5<sup>th</sup> Edition, 2005.

<b>Year</b>	<b>Subject Title</b>	<b>Sem</b>	<b>Sub Code</b>
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2018–19 Onwards	Elective III : NUMERICAL ANALYSIS	III	18MST34E
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**Objective :** To improve the mathematical skills among the PG students

**UNIT – I**

Errors in Numerical Calculations – Introduction – Error and their Computations – Relative Error – A general error formula – Error in series approximation.

**UNIT – II**

Solution of Algebraic and Transcendental equations – Bisection Method – Method of False position – Iteration method – Newton-Raphson method – Horner’s method.

**UNIT – III**

Solution of Linear system of equations – Gauss - elimination method – Gauss-Jordon method – Iterative methods – Gauss - Jacobi and Gauss – Seidal methods – Inverse of a matrix by Gauss – Elimination method

**UNIT – IV**

Initial value problems for Ordinary Differential Equations – Introduction – Taylor series method – Euler’s method – Modified Euler’s method – Runge-Kutta methods – Predictor – Corrector methods – Adam’s and Milne’s method.

**UNIT – V**

Numerical solution for Partial Differential Equations – Introduction – Finite Difference approximations to derivatives – Laplace’s equation – Parabolic equations .

**Text Books:**

1. Dr. B.S. Grewal : “ Numerical Methods in Engineering & Science”, Khanna Publishers, New Delhi, Fifth Edition, 2000.
2. S.S. Sastry : “Introductory methods of Numerical Analysis”, , PHI Learning Pvt Ltd, New Delhi, Fifth Edition, 2013.

**Reference Books:**

1. Dr.M.K. Venkataraman : “Numerical Methods in Science and Engineering”, the National Publishing Company, Chennai, Fifth Edition 2001.
2. P.Kandasamy, V.Thilagavathy, K.Gunavathi : “Numerical Methods”, S.Chand & Company Ltd, New Delhi, 2016.

Year	Subject Title	Sem	Sub Code
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<b>2018–19 Onwards</b>	<b>Core X: ADVANCED OPERATIONS RESEARCH</b>	<b>IV</b>	<b>18MST41C</b>
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**Objective :** To impart the knowledge and applications of Operations Research techniques

### UNIT I

Linear Programming Problem: Artificial variable technique – Two phase method – Concept of Duality – Duality and Dual solution – Dual Simplex algorithm – Concept and Simple problems

### UNIT II

Non-linear programming: Introduction – General NLPP – Constrained optimization with equality and inequality constraints - Kuhn-Tucker conditions for General NLPP with  $m (< n)$  constraints – Graphical solution

### UNIT III

Queuing Theory: Introduction – Problems from Single Server: Infinite Population Model (M/M/1): (FCFS/ $\infty/\infty$ ) and Finite Population Model (M/M/1): (FCFS/N/ $\infty$ ) - Problems from Multi Server: Infinite Population Model (M/M/C): (FCFS/ $\infty/\infty$ ) and Finite Population Model (M/M/C): (FCFS/N/ $\infty$ )

### UNIT IV

Simulation: Introduction - Advantages and Disadvantages – Monte-Carlo method – Algorithm – Application of Simulation in Inventory and Queuing problems.  
Network analysis: Basic concepts – CPM and PERT calculations – Cost and Time Analysis (Crashing).

### UNIT V

Decision Analysis: Decision making environment – Decisions under uncertainty – Decisions under Risk - EMV and EOL approach – Decision tree analysis.

### Text Book

1. Kanti Swarup, P.K. Gupta and Manmohan - Operations Research Sultan Chand & Sons, New Delhi, 2009.
2. J.K. Sharma - Operations Research - Theory & Applications – Macmillan India Ltd, Third Edition, 2007.

### Books for Reference:

1. V. Sundaresan, K.S. Ganapathy Subramanian, K. Ganesan - Resource Management Techniques, A.R. Publications, Tamil Nadu, New Revised Edition, June 2000.

Year	Subject Title	Sem	Sub Code
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2018–19 Onwards	Core XI: APPLIED REGRESSION ANALYSIS	IV	18MST42C
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**Objective :** To impart the knowledge and applications of the various regression models.

#### 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.

#### UNIT II

Residual analysis definition and properties of residuals- methods of scaling residuals- residual plots-Diagnostic tests - PRESS statistic-formal test for lack of fit- variance-stabilizing transformation-transformation to linearize models- generalized and weighted least squares.

#### UNIT III

Multiple regression: Standard Gauss Markov Setup - Least square (LS) estimation, properties of least square estimators. confidence interval on regression coefficients confidence interval estimation of mean responses- prediction- standard regression coefficients- unit normal scaling unit length scaling.

#### UNIT IV

Polynomial regression- Polynomial model in one variable. Piecewise polynomial fitting (splines)  
Non-linear regression-non-linear least square transformation to linear model

#### UNIT V

Generalised linear models (GLM) Logistic regression-Estimation of parameters in logistic regression models- Interpretation of parameters in logistic regression models. Poisson regression – GLM link functions and linear prediction.

#### Text Books:

1. Montgomery, D. C., Peck, E. A., and Vining, G. G., Introduction to Linear Regression Analysis, John Wiley and Sons, 3rd Edition, 2003.
2. Draper, N. R. and Smith, H., Applied Regression Analysis, John Wiley India (P) Ltd, 3<sup>rd</sup> Edition, 2011.

#### Reference Books:

1. Neter, J., Wasserman, W., and Kutner, M.H., Applied Linear Statistical Models, Second Edition, Irwin, 1989.
2. Seber, G.E.F. and Wild, C.J., Nonlinear Regression, John Wiley and Sons, 2003.

Year	Subject Title	Sem	Sub Code
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<b>2018–19 Onwards</b>	<b>Elective IV: ECONOMETRICS</b>	<b>IV</b>	<b>18MST43E</b>
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**Objective:** To develop the skills in applying Statistical tools in Econometrics.

### **Unit – I**

Definition and Scope of Econometrics – Goals and Division of Econometrics – Specification and Estimation of the model – Evaluation of the parameter estimates – Forecasting power of the model – Desirable properties of an econometric model.

### **Unit – II**

Simple Linear Regression Model: OLS method of estimating the parameters - properties of OLS estimators. Multiple Regression: Model with two explanatory variables.

### **UNIT – III**

Auto correlation: Assumptions of serial independence – Sources and Consequences of Auto correlation – Tests for Auto correlation. Multi-collinearity: Meaning - Consequences of Multi-collinearity - Solutions for Multi-collinearity - Heteroscedasticity.

### **UNIT – IV**

Identification: The problem of identification – Formal rules for identification - Identifying restrictions - Simultaneous - Equation methods: Estimation of parameters – ILS, 2SLS, LIML and FIML methods of estimation.

### **UNIT – V**

Econometric Models in Planning - Mahalanobis Four Sector Model. Harrod's growth model – Assumptions, Harrodian growth rates and growth path – Domar's model – Assumptions Mathematical or equational form - Similarities and dissimilarities between Harrod and Domar Models.

### **Text Books:**

1. A. Koutsoyiannis, Theory of Econometrics, PALGRAVE, Replica Press Pvt. Ltd, India, Second Edition, 1979.
2. S.P.Singh, Anil K. Parashar & H.P.Singh, Econometrics and Mathematical Economics, S. Chand & Company Ltd, Ramnagar, New Delhi, First Edition, 1977.

### **Reference Books:**

1. Damodar N.Gujarati and Sangeetha, Basic Econometrics, Fourth Edition, Tata McGraw Hill Private Limited, New Delhi, 2015.

<b>Year</b>	<b>Subject Title</b>	<b>Sem</b>	<b>Sub Code</b>
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<b>2018–19 Onwards</b>	<b>Core Practical – III : STATISTICS PRACTICAL – III</b>	<b>III &amp; IV</b>	<b>18MST44P</b>
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**Objective:** To apply the theoretical knowledge in solving practical problems

### **DESIGN OF EXPERIMENTS**

1. Latin Square Design
2.  $2^3$  Factorial experiments
3.  $3^2$  Confounding factorial experiments
4. Balanced Incomplete Block Design

### **NUMERICAL ANALYSIS**

5. Newton Raphson Method
6. Gauss Elimination Method
7. Gauss Jacobi Method
8. Taylor Series
9. Runge-Kutta Method

### **MULTIVARIATE ANALYSIS**

10. Hotelling's  $T^2$  statistic – Testing for mean vector
11. Hotelling's  $T^2$  statistic – Testing for equality of means
12. Fisher's discriminant function
13. Principal component analysis

### **STATISTICAL INFERENCE – II (Testing of Hypothesis)**

14. Critical regions and power curves concerning testing of hypothesis on the parameter of the Normal distribution
15. Critical regions and power curves concerning testing of hypothesis on the parameter of Exponential distribution
16. SPRT in case of Binomial distribution
17. SPRT in case of Normal distribution
18. Median test
19. Run test
20. Non-parametric test: Kolmogorov-Smirnov test – one and two samples
21. Mann-Whitney U test

### **ADVANCED OPERATIONS RESEARCH**

22. Critical Path Method
23. Program Evaluation and Review Technique
24. Queuing model: (M/M/1) : (FCFS/N/ $\infty$ )

Year	Subject Title	Sem	Sub Code
2018–19 Onwards	Core Practical – IV : STATISTICS PRACTICAL – IV	III & IV	18MST45P

**Objective:** To apply the SPSS knowledge to analyze the data collected through various studies.

1. Diagrammatic Representation (Multiple Bar, Pie-chart).
2. Descriptive Measures: Mean, Median, Mode, SD and Correlation Coefficient.
3. Construction of Regression Equations.
4. Fitting Binomial Distribution.
5. Fitting Poisson Distribution.
6. Calculation of Probabilities under Normal Distribution.
7. Partial and Multiple Correlation Coefficients.
8. Multiple Regression Coefficients.
9. Fitting Linear Trend by Least Square method.
10. t-test for means
11. F-test for two variances
12. Chi-square test for independence of attributes
13. One-way ANOVA
14. Two-way ANOVA
15.  $2^3$ -Factorial Design
16. Finding mean vector and covariance matrix.
17. Factor Analysis
18. Construction of control charts for Mean and Range.
19. Calculation of Probability of Acceptance & drawing OC Curve using Poisson distribution.