PERIYAR UNIVERSITY

PERIYAR PALKALAI NAGAR

SALEM – 11

M.Phil. Statistics

(SEMESTER PATTERN)

(Under Choice Based Credit System)

(For Periyar University Department)

REGULATIONS AND SYLLABUS

(Candidates admitted from 2018-2019 onwards)

PERIYAR UNIVERSITY, PERIYAR PALKALAI NAGAR, SALEM –11

M. Phil., (STATISTICS)

REGULATIONS AND SYLLABUS

(For those candidates who joined 2018-2019 onwards)

1. Eligibility Criteria for Admission

A candidate who has acquired M.Sc., Degree in Statistics or M.Sc., Degree in Statistics (with Computer Applications) with a minimum of 55% of marks in aggregate from this University or from any other University recognized by the Syndicate as equivalent shall be permitted to join the course, appear in the University examinations and qualify for the award of M.Phil., Degree in STATISTICS after a course of study for a duration of one year in the Department of Statistics at this University.

2. Duration of the Programme and Credits

The duration of the M.Phil., Programme in Statistics shall be for a period of one year comprising two semesters. Each candidate shall be allotted with a research supervisor from the department. During the course of study, two core courses and one optional (elective) course shall be offered in the first semester and dissertation work shall be carried out by the candidate in the second semester under the supervision of the research supervisor. The course of study shall be based on the pattern of Choice Based Credit System (CBCS) with continuous internal assessment and comprehensive external assessment. The comprehensive external assessment shall be done as the end semester University examination. Each candidate shall earn a minimum of 24 credits during the period of study. The break-up of total credits for the programme shall be as given under:

Part I	**Core Papers**	**Credits**
	Course I	4
	Course II	4
	Optional (Elective)	4
Part II	Dissertation	8
	Viva-Voce	4
	Total	**24**

3. Course Structure and Scheme of Examination

Candidates admitted to the course shall be examined in each paper under continuous internal assessment and end semester University examination. The maximum marks to each paper shall be fixed as 100. The maximum marks for continuous internal assessment and end semester University examination for theory papers shall be fixed as 25 and 75, respectively. All the admitted candidates shall have to carry out dissertation work during the second semester under the supervision of the research supervisor of the Department of Statistics in the University. Candidates shall have to prepare and submit the dissertation at the end of the second semester. Tests, seminars and attendance shall be the components for continuous internal assessment. A maximum of 25 marks shall be allotted under continuous internal assessment in each of the three theory papers. The distribution of marks is as given under:

Sl. No	Classifications	Marks
1.	Marks for Internal Tests	10
2.	Marks for Seminars	10
3.	Marks for Attendance	05
	Total	**25**

There shall be three tests and at least one seminar for each paper. The pattern of question paper for tests and the allotment of topics for seminars shall be at the discretion of the course teacher and the research supervisor. The average of best two tests for a maximum of 10 marks, the actual marks secured by the candidate in the seminar(s) for a maximum of 10 marks and the actual marks secured by the candidate for a maximum of 5 marks for attendance shall be taken for calculating the continuous internal assessment marks for a paper. The dissertation will be evaluated by the research supervisor for a maximum of 75 marks and by an External Examiner for a maximum of 75 marks. Each candidate shall appear for a Viva-Voce examination for a maximum of 50 marks, which will be conducted jointly by an External Examiner and the Research Supervisor.

Sl. No	Classifications	Marks
1.	Dissertation evaluated by the Supervisor	75
2.	Dissertation evaluated by the External Examiner	75
3.	Viva-Voce examination	50
	Total	**200**

The external examiners for evaluating the core and optional (elective) theory papers shall be appointed by the authorities from the panels comprising four examiners submitted by the department and research supervisors. Candidates shall submit the dissertation to the university duly signed by the research supervisor and the Head of the Department at the end of second semester. The dissertation shall be evaluated by the research supervisor (internal examiner) and one external examiner appointed by the University from the panel submitted by the supervisor through the Head of the Department at the time of submitting the dissertation.

The examiners who value the dissertation shall grade the research works of the candidates as **Highly Commended** (75% marks and above) or **Commended** (above 50% marks and below 75% marks) or **Not Commended** (below 50% marks). If one examiner grades the dissertation as '**Commended'** and the other examiner grades it as '**Not commended**', the dissertation shall be referred to the third examiner. The gradation given by the third examiner shall be final. Submission or resubmission of the dissertation will be allowed twice a year subject to the University rules.

Course Structure and Scheme of Examination

Code	Title of the Subject	Examination				Credits
		Duration	CIA Marks	External Marks	Total Marks	
SEMESTER I						
18URSTA1C01	Research Methodology in Statistics	3	25	75	100	4
18URSTA1C02	Advanced Statistical Inference	3	25	75	100	4
18URSTA1E01	Specialization Paper*	3	25	75	100	4
SEMESTER II						
18URSTA2D01	Dissertation+	-	-	-	150	8
	Viva Voce++	-	-	-	50	4
		Total	**75**	**225**	**500**	**24**

* Each candidate is required to choose the paper from the list of specialization papers.

+ Evaluation by the Research Supervisor and by the External Examiner for a maximum of 75 marks each.

++ To be conducted jointly by the Research Supervisor and by the External Examiner

4. List of Specialization Papers

The papers on the specialization of research supervisors are listed below from which each candidate shall choose one as the optional paper:

1. Advanced Design of Experiments
2. Advanced Sampling Techniques
3. Advanced Statistical Quality Control
4. Bayesian Inference
5. Stochastic processes and its Applications
6. Advanced Operations Research
7. Time Series Analysis and its Applications
8. Reliability Theory and survival Analysis
9. Data Mining Methods and Their Applications
10. Advanced Bio Statistics
11. Design Theory

5. Model Question Paper

Question Paper Pattern for University Examination
M.Phil. Degree Examination
STATISTICS

Time: 3 Hours Max. Marks: 75

Part – A (5 x 5 = 25 Marks)
Answer ALL questions

Five Questions (One question from each Unit) with internal choice
Each question carries 5 marks

1. (a)

(Or)

(b)

2. (a)

(Or)

(b)

3. (a)

(Or)

(b)

4. (a)

(Or)

(b)

5. (a)

(Or)

(b)

Part – B (5x10 = 50 Marks)
Answer ALL questions

Five Questions (One question from each Unit) with internal choice
Each question carries 10 marks

6. (a)

(Or)

(b)

7. (a)

(Or)

(b)

8. (a)

(Or)

(b)

9. (a)

(Or)

(b)

10. (a)

(Or)

(b)

Core Paper I	**Research Methodology in Statistics**	**Paper Code: 18URSTA1C01**

Unit I

Research Methodology - Concept of Research in Statistics – Identify Research Problem - Necessity of Defining the Problem-Technique Involved in Defining a Problem-Selection of Topic for Research.

Unit II

Meaning of research design - Features of good design - Important concepts relating to research design - Different research designs - Significance of report writing- Importance of literature survey – Reports, Thesis and assignment writing - Different steps in writing report - Layout of the research report.

Unit III

Statistical Studies – Significance – Data Measurement Scales, Nominal, Ordinal, Ratio and Interval Scales – Sources of error in measurement – Tests of Measurement – Technique of Developing Measurement Tools – Scaling Technique – Likert type Scaling – Cumulative Scaling.

Unit IV

R Language and its simple applications – Computation of probabilities and cumulative probabilities using Binomial and Poisson models - Evaluation area and ordinate under normal distribution using R Software.

Unit V

Simulation - Concept and Advantages of Simulation – Event type Simulation – Generation of Random Numbers – Monte-Carlo Simulation Technique – Generation of Random Numbers using uniform (0,1), Exponential, Gamma and Normal random variables – Simulation Algorithm.

Book for Study

1. Kothari, C. (2005). Research Methodology, New Age International Publications, New Delhi.

Books for Reference

1. Jonathan, Anderson et al. (1977). Thesis and Assignment Writing, Wiley Eastern Ltd, New York.
2. Pannerselvam, R. (2006). Research Methodology, Prentice-Hall of India Private Limited, New Delhi.
3. Sastry, S.S (2006). Introductory Methods of Numerical Analysis Practice – Hall of India Private Ltd., New Delhi.
4. Venkataraman, M. K. (1998). Numerical Methods in Sciences and Engineering, The National, Publishing Company, Chennai.

5. Kanti Swarup, Gupta, P.K., & Man Mohan.(2008). Operations Research Sultan Chand & Sons, (Publications), New Delhi.

6. Maria L.Rizzo.(2007). Statistical Computing with R, Chapman & Hall/CRC, Taylor and Francis Group.

7. Sudha.G.Purohit, Sharad.D.Gore and Shailaja R.Deshmukh .(2008). Statistics Using *R*, Narosa, Publishing House, New Delhi.

Core Paper II	**Advanced Statistical Inference**	**Paper Code: 18URSTA1C02**

Unit I

Statistical decision problems – loss function – risk function – minimax decision - Sufficiency – factorization theorem – minimal sufficiency – completeness – ancillary statistic – Basu's theorem - Uniformly minimum variance unbiased estimator - Lower bounds to variance of unbiased estimators.

Unit II

Point estimation – method of moments and method of least squares - Method of maximum likelihood and its properties – maximum likelihood estimation in censored and truncated distributions - method of scoring and EM algorithm - Consistent and consistent asymptotically normal estimators - Prior and posterior distributions – natural conjugate prior and Jeffreys non-informative prior – Bayes estimator under squared error loss function – Bayes risk.

Unit III

Testing of hypotheses – most powerful and uniformly most powerful tests - Generalization of Neyman - Pearson fundamental lemma (statement only): Unbiased tests – construction of uniformly most powerful unbiased tests for one-parameter and multi-parameter exponential family of distributions – applications to standard statistical distributions - Similar tests – Neyman structure - Locally most powerful and locally most powerful unbiased tests.

Unit IV

Likelihood ratio test – asymptotic distribution of likelihood ratio test statistic – consistency of likelihood ratio test – construction of likelihood ratio tests for standard distributions - analysis of variance (one-way method) – Bartlett's test for homogeneity of variances - Confidence sets – most accurate, uniformly most accurate and uniformly most accurate unbiased confidence sets.

Unit V

Sequential methods - Sequential unbiased estimation - Sequential probability ratio test – approximation to stopping bounds – Wald's fundamental identity (statement only) – operating characteristic and average sample number functions – Applications to standard distributions.

Books for Study

1. Casella, G., and R. L. Berger. (2002). Statistical Inference (Second Edition): Thompson Learning, New York.
2. Lehmann, E.L., and J. P. Romano. (2005). Testing Statistical Hypotheses (Third Edition). Springer Verlag, New York.
3. Rajagopalan, M. and Dhanavanthan, P. (2012). Statistical Inference. PHI Learning Pvt. Ltd., New Delhi.

Books for References

1. Berger, J.O. (1985). Statistical Decision Theory and Bayesian Analysis (Second Edition): Springer Verlag, New York.
2. Dudewicz,E.J., and S.N.Mishra. (1988). Modern Mathematical Statistics. John Wiley & Sons, New York.
3. Ghosh,B.K.(1970): Sequential Tests of Statistical Hypotheses. Addison-Wesley, New York.
4. Goon, A.M., M.K.Gupta and B. Dasgupta (1989). An Outline of Statistical Theory, Volume .II. World Press, Kolkata.
5. Kale,B.K.(2005). A First Course in Parametric Inference (Second Edition). Narosa Publishing House, New Delhi.
6. Keith Knight(2000). Mathematical Statistics. Chapman & Hall/CRC, New York.
7. Kundu,D., and A.Basu(2004). Statistical Computing – Existing Methods and Recent Developments. Alpha Science International, New Delhi.
8. Lehmann, E.L., and G.Casella (1998). Theory of Point Estimation. (Second Edition): Springer Verlag, New York.
9. Rao, C.R. (1973). Linear Statistical Inference and Its Applications (Second Edition): Wiley, Eastern Ltd., New Delhi.
10. Wald, A. (1947). Sequential Analysis. John Wiley & Sons, New York.

Paper III Specialization Paper	**Advanced Design of Experiments**	**Paper Code: 18URSTA1E01**

Unit I

Construction of Mutually Orthogonal Latin Square of order *s*, *s* is a prime or prime power - Construction of Orthogonal arrays.

Unit II

Construction and analysis of confounded Symmetrical and Asymmetrical Factorial Experiments - Fractional Factorials and Main Effects plans – Method of construction of plans with factors at 2 levels, a series of orthogonal arrays of strength 3 (Resolution 4 Plans) with factors at 2 levels - Orthogonal main effects plan with factors at 3 and other levels - Construction and Analysis of Fractionally replicated factorial experiments blocking in fractionally replicated designs.

Unit III

Construction and analysis of Quasi - Factorial Experiments Lattice designs – Simple Lattice – *M*-ple Lattice, *n* dimensional Lattice - Square Lattice – Rectangular Lattice - Construction and Analysis of Balanced Incomplete Block Designs - BIBD Partially Balanced Incomplete Block designs.

Unit IV

Second and third order Rotatable designs – Central composite rotatable designs - Blocking in response surface designs - Analysis of groups of Experiments – Sequential experiments analysis of long term experiments – Problems faced in the design and analysis of experiments for perennial crops - Construction and analysis of cross-over designs.

Unit V

Diallel Crosses – Complete Diallel crosses, its analysis and efficiency factor, Optimal Diallel crosses plane - Robustness of Designs. Robustness of Diallel crosses plan.

Books for Study

1. Das, M.N. and Giri, N.C. (1986). Design and analysis of experiments, Wiley Eastern Ltd. New Delhi.
2. Kempthorne, O. (1952). The design and analysis of experiments, John Wiley, New York.

3. Montgomery, D.C. (2012). Design and analysis of Experiments. John Wiley & Sons, New Delhi.

Books for References

1. Chakraborti, M.C. (1962). Mathematics of Design and Analysis of Experiments. Asia Publishing House, Bombay.
2. Cochran, W.G and Cox, G.M. (1987). Experimental Designs, John Wiley, New York.
3. Cox, D.R. (1958). Planning of Experiments, John Wiley, New York.
4. Das, M.N. and Giri, N.C. (1986). Design and analysis of experiments, Wiley Eastern Ltd. New Delhi.
5. Dey, A. (1985). Orthogonal Fractional Factorial Designs, John Wiley, New York.
6. Dey, A. (1986). Theory of Block Designs. Wiley Eastern Ltd., New Delhi.
7. Dey, A and Mukerjee, R. (1999). Fractional Factorial Plans. John Wiley, New York.
8. Federer, W.T. (1955). Experimental Design: Theory and Applications, Mac Millon.
9. Fisher, R.A. (1947). The Design of experiments, 4th edition, Oliver and Boyd, London.
10. Graybill, F.A. (1976). Theory and Application of the Linear Model, Wadsworth.
11. Joshi, D.D. (1987). Linear estimation and design of experiments. Wiley Eastern, New Delhi.
12. Raghava Rao, D. (1971). Construction and Combinational Problems in design of experiments, John Wiley, New York.
13. Rao, C.R. (1974). Linear Statistical inference and its applications, Wiley Eastern, 2nd edition.

Paper III Specialization Paper	**Advanced Sampling Techniques**	**Paper Code: 18URSTA1E01**

Unit I

Single stage cluster sampling: Clusters of equal sizes – Reasons for Cluster Sampling – A simple rule – Comparison of Precision Made from Survey Data – Variance in terms of Intra cluster correlation – Variance and Cost Functions – Cluster Sampling for Proportions. Cluster Units of unequal sizes – Selection with unequal probabilities with replacement – Optimum measure of size – The Horvitz-Thompson estimator – Brewer's Method – Murthy's Method – The Rao, Hartley, and Cochran Method.

Unit II

Multi stage sampling-Two-Stage and three Stage Sampling – Finding means and variance in two-stage sampling – variance of the estimated mean in two-stage sampling - Sample estimation of the variance – Estimation of proportions - Optimum Sampling and Subsampling Fractions.

Unit III

Double Sampling – Description – Double sampling for Stratification – Optimum allocation – Estimation of variance in Double Sampling for Stratification - Regression and Ratio Estimators.

Unit IV

Successive Sampling – Repetitive Surveys – Sampling on two occasions – Sampling on more than two occasions – Sampling for Time series.

Unit V

Sequential Sampling – Definition – Estimation of population size – Comparative study – estimation of population mean – acceptable sequential estimators – Markov Sampling.

Books for Study

1. Daroga Singh and F.S. Choudry. (1977). Theory and Analysis of Sample Survey Designs. Wiley Eastern Ltd., New Delhi.
2. Murthy,M.N.(1977). Sampling Theory and Methods. Statistical Publishing Society, Kolkatta, India.
3. Desraj. (1976). Sampling Theory. Tata McGraw Hill, New York. (Reprint 1979).

Books for References

1. Ardilly P and Yves T. (2006). Sampling Methods. Exercise and Solutions. Springer.
2. Cochran, W.G. (1977). Sampling Techniques, Third Edition, Wiley Eastern Ltd., New Delhi.

3. Daroga Singh and F.S. Choudry. (1977). Theory and Analysis of Sample Survey Designs. Wiley Eastern Ltd., New Delhi.
4. Mukhopadyay, P. (1998). Theory and Methods of Survey Sampling. Narosa Publisher, New Delhi.
5. Raj, D. (1976). Sampling Theory, Tata McGraw Hill, New York.
7. Raj, D. (1972). The Design of Sample Surveys. McGraw-Hill, New York.
8. Raj, D. and Chandhok, P. (1998). Sample Survey Theory. Narosa Publishing House, London.
9. Mukhopadyay, P. (2007). Survey Sampling. Narosa Publisher, New Delhi.
10. Mukhopadyay, P. (1998). Small area estimation in Survey Sampling. Narosa Publisher, New Delhi.
11. Sukhatme, P.V. and Sukhatme, B.V. (1958). Sampling Theory Surveys with Applications, Indian Society of Agricultural Statistics, New Delhi.

Paper III Specialization Paper	**Advanced Statistical Quality Control**	**Paper Code: 18URSTA1E01**

Unit I

Process Control: Control Charts by Variables and Attributes – Rational Subgroups - Basic Charts - Operating Characteristic and Average Run Length Functions – Designing Control Charts – Control Charts for Variable Sample Sizes and Varying Sampling Intervals – Control Charts for Short Production Runs - Cumulative Sum (CUSUM) Control Charts – V-mask Procedure – Tabular CUSUM Procedure - Moving Range, Moving Average and Exponentially Weighted Moving Average Control Charts – Design and Robustness of Charts.

Unit II

Tolerance Limits and Specification Limits – Setting Specification Limits – Estimation of Tolerance Limits. Acceptance Control Charts, Modified Control Charts. Capability Analysis: Process Capability Ratios - Process Capability Analysis using Histogram, Probability Plotting, Control Chart, Designed Experiments. Multivariate Control Chart - Hotelling's T^2 and Chi-square Control Charts, Multivariate Exponentially Weighted Moving Average Control Chart.

Unit III

Product Control: Sampling Inspection by Attributes – Single, Double, Multiple, Repetitive Group, Sequential Sampling Plans – Operating Procedure, Plan Selection, Measures of Performance. Sampling Inspection by Variables – Assumption of Normality – Single, Double and Sampling Plans – Operating Procedures, Plan Selection Procedures, OC Functions.

Unit IV

Attributes Sampling schemes – MIL-STD - 105D - Normal, Reduced and Tightened Inspections - Plan selection - Variables Sampling Schemes – MIL-STD-414 – Procedures for Operation and Selection of Plans. Rectifying Sampling Schemes – Concept of ATI and AOQL - Dodge – Romig LTPD and AOQL Single and Double Sampling Plans Schemes – Selection of Parameters.

Unit V

Sampling Plans for Continuous Production – Continuous Sampling Plans - CSP-1, CSP-2 and CSP-3 – Operation, Stopping Rules and Plan Selection – Measures of Performance. MIL –STD - 1235 (ORD). Special Purpose Plans: Skip-lot and Chain Sampling Plans - Operation and Selection - Measures of Performance - Switching Systems and TNT Sampling Schemes. Reliability Sampling Plans – Type I and Type II Censoring – Reliability Criteria – Operation and Plan Selection – Measures of Performance.

Books for Study

1. Duncan, A.J. (1986). Quality Control and Industrial Statistics (Fifth Edition): Irwin, Homewood, Illinois.
2. Grant, E.L., and Leavenworth, R.S. (2000). Statistical Quality Control, Seventh Edition, Tata McGraw Hill, New Delhi.
3. Montgomery, D.C. (2002). Statistical Quality Control – An Introduction (Sixth Edition): Wiley India, New Delhi. (Reprint, 2008).

Books for References

1. Bowker,A.N., and N.P.Goode .(1952): Sampling Inspection by Variables. McGraw Hill, New York.
2. Costa,A.F.B.(1995): $\bar{X}$ Charts with Variable Sample Size and Sampling Intervals. Report No.133, Centre for Quality and Productivity Improvement, University of Wisconsin, Wisconsin.
3. Costa,A.F.B.(1996): Joint $\bar{X}$ and R Charts with Variable Sample Size and Sampling Intervals. Report No.142, Centre for Quality and Productivity Improvement, University of Wisconsin, Wisconsin.
4. Costa,A.F.B.(1997): X-bar Chart with Variable Sample Size and Sampling Intervals. Journal of Quality Technology, 29(2), 197-204.
5. Epstein, B.(1954): Truncated Life Tests in the Exponential Case. The Annals of Mathematical Statistics, 25(3), 555-564.
6. Epstein, B., and Sobel, M.(1953): Life Testing. Journal of American Statistical Association, 48(263), 486-502.
7. Jun, C.H., Lee, H., Lee, S.H., and S.Balamurali.(2006): Variable Sampling Plans for Weibull Distributed Lifetimes under Sudden Death Testing. IEEE Transactions on Reliability, 55(1), 53-58.
8. Juran,J.M., and J.A.De Feo.(2010): Juran's Quality Handbook – The Complete Guide to Performance Excellence. Tata McGraw Hill, New Delhi.
9. Kim, M., and B.J.Yum.(2009): Reliability Acceptance Sampling Plans for the Weibull Distribution under Accelerated Type-I Censoring, Journal of Applied Statistics, 36(1), 11-20.
10. Qiguang, W., and L.Jianhua.(2006): Sampling Inspection of Reliability in Log(Normal) Case with Type-I Censoring. Acta Mathematica Scientia, 26(2), 331-343.
11. Schilling, E.G., and D.V.Neubauer.(2009): Acceptance Sampling in Quality Control (Second Edition): CRC Press, New York.
12. Schneider, H.(1989): Failure Censored Variables Sampling Plans for Lognormal and Weibull Distributions. Technimetrics, 31(2), 199-206.
13. Squeglia, N.L. (2009): Zero Acceptance Number Sampling Plans (Fifth Edition): ASQ Quality Press, Wisconsin.
14. Stephens, K.S.(2001): The Handbook of Applied Acceptance Sampling – Plans, Principles and Procedures. ASQ Quality Press, Wisconsin.

Paper III Specialization Paper	**Bayesian Inference**	**Paper Code: 18URSTA1E01**

Unit I

Subjective probability – its interpretation and evaluation - Subjective determination of prior distributions - Improper prior, noninformative prior, invariant prior, Jeffreys noninformative prior and natural conjugate prior – family of distributions admitting natural conjugate prior - Models with hyperparameters and hierarchical priors.

Unit II

Point estimation – Bayes estimators under various loss functions – generalization to convex loss functions - Evaluation of the estimate in terms of posterior risk – comparison with frequentist methods.

Unit III

Interval estimation – credible interval, highest posterior density region - Comparison of interpretation of the confidence co-efficient of an interval by Bayesian and frequentist methods – simple problems.

Unit IV

Bayesian testing of statistical hypotheses and model selection – specification of the appropriate form of the prior distribution for Bayesian hypothesis testing problem – prior odds, posterior odds, Bayes factor and their computations to various hypotheses testing problems – specification of Bayes tests.

Unit V

Bayesian computation – Monte Carlo sampling and integration – Markov Chain Monte Carlo methods – Markov chains in these methods, Metropolis-Hastings algorithm, Gibbs sampling – theory and applications of these methods to high dimensional problems. Large sample methods – limit of posterior distribution, asymptotic expansion of posterior distribution, Laplace approximation.

Books for Study

1. Bansal, A.K. (2007). Bayesian Parametric Inference. Narosa Publishing House, New Delhi.
2. Berger, J.O. (1985). Statistical Decision Theory and Bayesian Analysis (Second Edition): Springer Verlag, New York.

Books for References

1. Bernardo,J.M., and A.F.M.Smith.(2000): Bayesian Theory. John Wiley & Sons, New York.
2. Ferguson, T.S. (1967): Mathematical Statistics – A Decision Theoretic Approach. Academic Press, New York.

3. Gelman,A., J.B.Carlin, H.B.Stern and D.B.Rubin. (2004): Bayesian Data Analysis (Second Edition): Chapman & Hall, London.
4. Ghosh,J.K., Mohan Delampady and T.Samanta. (2006): An Introduction to Bayesian Analysis – Theory and Methods. Springer Verlag, New York. (Reprint, 2011).
5. Kundu,D., and A.Basu. (2004): Statistical Computing – Existing Methods and Recent Developments. Alpha Science International, New Delhi.
6. Lee,P.M. (2012): Bayesian Statistics – An Introduction (Fourth Edition): John Wiley & Sons, London.
7. Leonard,T., and J.S.J.Hsu. (1999): Bayesian Methods: An Analysis for Statisticians and Interdisciplinary Researchers. Cambridge University Press, London.
8. Robert,C.P. (1994): The Bayesian Choice: A Decision-Theoretic Motivation (Second Edition): Springer Verlag, New York.
9. Robert,C.P., and G.Casella. (2004): Monte Carlo Statistical Methods (Second Edition): Springer Verlag, New York.

Paper III Specialization Paper	**Stochastic Processes and Its Applications**	**Paper Code: 18URSTA1E01**

Unit I

Introduction of stochastic processes - Specifications of a stochastic processes - Markov chains -Classification of states and chains - Higher transition probabilities and its limiting behavior -Chapman Kolmogorov's equations - Stationary distribution - Ergodic theorem - Continuous time Markov processes - Poisson processes.

Unit II

Birth and death processes - Kolmogorov Feller differential equations of birth and death processes - Renewal theory - Renewal equation - Stopping time - Wald's equation - Elementary renewal theorem and its applications - Renewal reward processes - Residual and Excess life times - Markov renewal and Semi Markov processes.

Unit III

Introduction to Queueing Theory - Basic characteristics of a Queueing system and Problems in Queueing system-Probability Distributions as Models - Basic Concepts in Stochastic Queueing models - Kendall's notation for Queueing models- Little's Formulas - Stochastic process representation of Queueing theory-Steady state solutions for the queueing models.

Unit IV

Birth and Death Queueing models-State dependent service pattern-transient behavior of queues-Inventory models as a queueing models - Detailed study of single and multiple server queueing models - Advanced Markovian Queueing Models - Erlangian Bulk Queues - Retrial Queues - Queue with Priority Disciplines - Preemptive priority and Non - Preemptive priority queue - Queueing Networks- Vacation Queueing Models- Bernoulli Vacation Queueing Models.

Unit V

Higher transition probabilities – higher order Markov chains - Multivariate Markov chain models - Applications to queues and storage problems - Decision Problems in Queueing Theory - Simulation techniques in Queueing Models - Case Studies and Applications in Queueing theory.

Books for Study

1. Medhi,J. (2009): Stochastic Processes, 3rd Edition, New Age International Publishing Limited, New Delhi.
2. Karlin, S. and Taylor, H.M (1968): A First Course in Stochastic Processes – Vol. I. Academic Press, New York.
3. Bhat, B. R. (2000). Stochastic Models: Analysis and Applications, New Age International (P) Ltd.

Books for References

1. Ching, W.K and Michael, K. (2006): Markov Chains: Models, Algorithms and Applications, Springer Science Business Media, Inc.
2. Cox, D.R. and A.D. Miller. (1977): The Theory of Stochastic Processes, Chapman & Hall.
3. Feller, W. (1968): An Introduction to Probability Theory and its applications, Vol I and II. John Wiley.
4. Gross, D. and Harris, C. M. (2008): Fundamentals of Queueing Theory, Fourth Edition, John Wiley & Sons.
5. Hiller, F.S and Lieberman, G.J. (2004): Introduction to Operations Research, Chapters 10 and 11- Holden-Day.
6. Jijong Li and Naishuo Tian .(2007): The M/M/1 Queue with Working Vacations and Vacation Interruptions, J. Syst. Sci. Syst. Engg. pp: 1861-9576.
7. Lindiey, D.V.: Applications of Queueing theory, Monographs on Applied Probability and Statistics, Chapman and Hall.
8. Medhi, J. (2003): Stochastic Processes in Queueing Theory, second edition, Academic Press.
9. Narayan Bhat, U. (2008): An Introduction to Queueing Theory-Modeling and Analysis in Applications, Birkhauser.

Paper III Specialization Paper	**Advanced Operations Research**	**Paper Code: 18URSTA1E01**

Unit I

Non - Linear integer programming - Beale's algorithm – Zero - one programming problem – Integer polynomial programming – Geometric programming and its applications - Stochastic programming.

Unit II

Continuous State Dynamic Programming - Bellman's principle of dynamic programming - Forward and backward process of solving a dynamic programming problem - Stage coach problem - Advanced multi-period stochastic models - Use of dynamic programming in inventory problems.

Unit III

Stochastic inventory models – multi period models - solution through dynamic programming (s, S) inventory policies - Replacement problems – replacement of item failing according to probability law - block and age replacement policies.

Unit IV

Queuing models: Transient and busy period analysis in $M/M/1$ system – $M/G/1$ and $G1/M/1$ Queues – imbedded Markov chain approach to queueing problems.

Unit V

Job sequencing problem – Principle assumptions of sequencing problem – Solution of sequencing problem – Processing n jobs through two machines problem and Processing n jobs through three machines problem. Priority queueing models - Preemptive and Non-preemptive priority queueing models.

Books for Study

1. Gross.D and Harris.C.M. (1976): Fundamental of queueing theory, Jhon Wiley.
2. Hadley,G. (1974): Non-linear and Dynamic programming, Addition-Wesley.
3. Hadley,G and Whitin, (1963): Analysis of Inventory system, Prentice Hall.
4. Hiller.F.S and Lieberman,G.J. (1974): Operations Research, Holden - Day.
5. Philips, D. T. Ravindran, A. and Solberg, J.T. Operations Research Principles and Practice.
6. Prabhu, N.U. (1978): Queues and Inventories, John Wiley.
7. Rao,S.S. (1978): Operations Theory and application, Wiley Eastern.

8. Shamblin and Stevens,Jr. (1974): Operations Research, Macraw Hill.

Paper III Specialization Paper	**Time Series Analysis and Its Applications**	**Paper Code: 18URSTA1E01**

Unit I

Stationary time Series, Auto correlation and Partial auto correlation function, Correlogram analysis, Spectral properties of stationary models, periodogram analysis, and spectral density function.

Unit II

Detail study of stationary process: moving average, autoregressive, autoregressive moving average and autoregressive integrated moving average process, Box – Jenkins models.

Unit III

Estimation of mean, auto covariance and auto correlation function under large sample theory -choice of AR and MA periods - Estimation of ARIMA model parameters, forecasting with Box – Jenkins model, Residual analysis and diagnostic checking.

Unit IV

Conditional Heteroscedasticity Model-Characteristic of Volatility- Auto regressive conditional Heteroscedasticity (ARCH)- Testing of ARCH effect-Generalized Auto regressive conditional Heteroscedasticity (GARCH) and GARCH-M model.

Unit V

Multivariate time series – cross correlation function and their properties-Vector Auto regressive model- Vector moving average model - VARIMA model – co integrated VAR model and Vector error control model (VECM).

Books for Study

1. Box, G.E.P., Jenkins, G.M. and Reinsel, G.C (2004). Time Series Analysis- Forecasting and Control, Pearson Education, Singapore.
2. Brockwel, P.J and Davis. R.A (1987). Time Series: Theory and Methods, Springer – Verlag, New York.
3. Granger, C.W.J. and Newbold (1984). Forecasting Econometric Time Series, Academic Press, New York.
4. Montgomery, D.C. and Johnson, L.A. (1977) Forecasting and Time Series Analysis, McGraw Hill, New York.
5. Shum way, R. H. and Stoffer, David S. (2006) Time Series Analysis and Its Applications: With R Examples. Springer-Verlag.
6. Tsay, R (2009). Analysis of Financial Time series, Willey Interscience Publisher.

Paper III Specialization Paper	**Reliability Theory and Its Applications**	**Paper Code: 18URSTA1E01**

Unit I

Reliability concepts and measures – components and systems – coherent systems and their reliability – cuts and paths – modular decomposition – bounds on system reliability – structural reliability importance of components

Unit II

Life time distributions – reliability function – hazard rate - common life time distributions – exponential, gamma, normal, Weibull, Rayleigh etc. – estimation of parameters and testing of hypotheses in these distributions.

Unit III

Notions of ageing – IFR, IFRA, NBU, DMRL and NBUE classes and their duals – implications – closures of these classes under formation of coherent systems.

Unit IV

Reliability estimation based on failure times under various censored life tests and tests with replacement of failed items – stress-strength reliability and its estimation.

Unit V

Reliability growth models – probability plotting techniques – Hollander - Proschan and Deshpande tests for exponentially – tests for HPP vs NHPP with repairable systems - Basic ideas of accelerated life testing

Books for Study

1. Bain L.J. and Engelhardt. (1991): Statistical Analysis of Reliability and Life Testing Models. Marcel Dekker, New York.
2. Barlow, R.E., and Proschan, F. (1981): Statistical Theory of Reliability and Life Testing (Second Edition). Holt, Rinehart and Winston, New York.
3. Blischke, W.R., and Murthy,D.N.P. (2000): Reliability – Modeling, Prediction and Optimization. John Wiley & Sons, New York.
4. Lawless, J.F. (2003): Statistical Models and Methods for Lifetime Data (Second Edition). Wiley Interscience, Singapore.
5. Mann, N.R., Schafer,R.E. and Singpurwalla,N.D. (1974): Methods of Statistical Analysis of Reliability and Life Data. John Wiley & Sons, New York.
6. Nelson,W.B. (2004): Applied Life Data Analysis. John Wiley & Sons, New York.

7. Singpurwalla, N.D. (2006): Reliability and Risk – A Bayesian Perspective. John Wiley & Sons, New York.
8. Zacks,S. (1991): Introduction to Reliability Analysis. Springer Verlag, New York.

Paper III Specialization Paper	**Data Mining Methods and Their Applications**	**Paper Code: 18URSTA1E01**

Unit I

Data mining- History-Definitions-Data Mining Functionalities- Classification of Data mining System- Major Issues in Data mining-Data warehouse and OLAP Technology-Multidimensional Data Model - Data warehouse Architecture - Data Warehouse Implementation.

Unit II

Data Preprocessing-Data Cleaning- Data Integration and Transformation-Data Reduction-Discretization and concept of Hierarchy Generation-Concept Description- characterization and comparison. Association Rule Mining- Mining Single Dimensional – Multilevel Association Rules-mining to correlation analysis-classification and prediction

Unit III

Overview on outliers – nature of Outliers - Outliers in Univariate Data - Outliers in Multivariate Data - Cluster Analysis, Cluster against Classification - impact of Outliers on clustering - clustering problems - Clustering Approaches.

Unit IV

Data-outliers in regression analysis and Time series - Regression and collinearity: Tools for handling multi- collinearity, methods based on singular value decomposition – Robust Regression- ridge regression - Properties of ridge estimator - Additive outlier – Multiplicative outlier and innovational outlier.

Unit V

Stationary time Series, Auto correlation and Partial auto correlation function, Correlogram analysis, Estimation of ARIMA model parameters, forecasting with Box – Jenkins model, Residual analysis and diagnostic checking.

Books for Study

1. Box, G.E.P., Jenkins, G.M. and Reinsel, G.C. (2004). Time Series Analysis- Forecasting and Control, Pearson Education, Singapore.
2. Daniel T. Larose. (2006). Data Mining: Methods and Models, Wiley-Interscience, New Jersey.
3. Draper, N.R, and H. Smith, Applied regression analysis, (2nd Ed) John Wiley and sons, New York.
4. Hawkins, D.M, (1980). Identification of Outliers, Chapman and Hall, London.

5. Jiawei Han, Micheline Kamber. (2006). Data Mining: Concepts and Techniques, Morgan Kaufmann Publishers, second edition, San Francisco.
6. Krzysztof J.Cios, Wiltold Pedrycz, Roman W.Swiniarski, Lukasz A.Kurgan. (2007): Data Mining: A Knowledge Discovery Approach, Springer Science +Business Media, New York.
7. Montgomery, D.C. and Johnson, L.A. (1977). Forecasting and Time Series Analysis, McGraw Hill, New York.
8. Paolo Giudici, (2005). Applied Data Mining: Statistical Methods for Business and Industry, John Wiley & Sons Ltd, England.
9. Peter J.Rousseeuw and Annick M.Lorey, (1987). Robust Regression and Outlier Detection, John Wiley & Sons, United States.
10. Vic Barnett and Toby Lewis, (1978). Outliers in Statistical Data, John Wiley & sons.

Paper III Specialization Paper	**Advanced Bio-Statistics**	**Paper Code: 18URSTA1E01**

Unit I

Introduction Definition/Phases of Clinical Trials; Study Design: Cohort, case-control and observational studies; Terminology of prospective, retrospective; treatment allocation, randomization and stratification, quality control, biases, sample size requirements, patient consent. Hypotheses / Aims: superiority, non-inferiority, equivalence primary, secondary; various types of clinical data (continuous, categorical, count, and time-to-event outcome data); Basic biological concepts in genetics, Basic concept of Bioassays and different Types of biological assays.

Unit II

Disease-Exposure Association: Risk, odds, odds ratio, relative risk, standard errors; Contingency Tables: Association (Chi-square test), Confounding (Mantel-Haenszel), Interactions (Test of homogeneity); Probability Diagnostic Testing and Screening.

Unit III

Descriptive Statistics; Estimation for Means; Estimation for Proportions; One Sample Hypothesis Test – Means ; One Sample Hypothesis Test – Proportions; Two Sample Hypothesis Test; Non-Parametric Hypothesis Testing; One Way ANOVA.

Unit IV

Introduction to Linear Regression and Correlation; Logistic Regression: estimation: Logistic regression for case-control studies, estimation and interpretation of logistic parameters.

Unit V

Introduction to Survival: Concepts of time, Censoring-different types of censoring- right and left, Survival function- Kaplan-Meier (K-M) estimator; Nonparametric Methods for Comparing Survival Distributions - log rank test, Peto's test, Gehan test, Mantel-Haenzel test. Cox Proportional Hazard regression, parametric survival models – Basic life time distributions - Exponential, Weibull, Gamma Log-Normaland Log- logistic.

Books for Reference

1. Fundamentals of Biostatistics: Bernard Rosner Recommended 6th /7th Edition.
2. Friedman, Furberg & DeMets: Fundamentals of Clinical Trials, 3rd Edition, 1996. Mosby-Year Book, Inc.
3. Rossi R.J. (2010).Applied Biostatistics for Health Sciences, Wiley.

4. Cox, P.R. (1978): Demography (Fifth Edition). Cambridge University Press.
5. David G. K., and Klein, M. (2008). Survival analysis - A Self-Learning Text, Second edition, Springer.
6. Lee, E. T., and Wenyu, J. (2003). Statistical methods for Survival Data Analysis, Third Edition, John Wiley & Sons.

Paper III Specialization Paper	**Design Theory**	**Paper Code: 18URSTA1E01**

Unit I

Introduction of Algebra - Definition – Modules - Rings and Fields – Power Cycle - Minimum Function and Power of Cycle - Irreducible Polynomials of Galois Fields.

Unit II

Field – Extension Filed - Finite Field and Galois Field - Axioms – Fermat's Theorem – Geometrical Designs - Maximum Number of Orthogonal Latin Squares of orders of prime and non-prime orders.

Unit III

The Bose construction $v \equiv 3(\mathrm{mod}\,6)$ and $v \equiv 5(\mathrm{mod}\,6)$ - A recursive construction – constructing pairwise balanced designs of *Kirkman*.

Unit IV

Introduction – The Euler and MacNeish conjecture – Disproof of the MacNeish conjecture – Disproof of Euler conjecture – orthogonal Latin square of order $v \equiv 2(\mathrm{mod}\,4)$.

Unit V

Construction of Mutually Orthogonal Latin Square Designs of Prime and Non-Prime orders - BIBD, PBIBD (*m*), Neighbour Designs, Change Over Design, Lattice, Semi Latin Squares – Trojan Square Designs and Partial Triallel Crosses using Galois Field theory.

Books for Study

1. C. A. Rodger and Charles C. Lindner, (1997), Content and Treatment as in *Design Theory,* Charles C. Lindner, CRC Press.

2. Herstein, I.N, (2006), Topics in Algebra, Second Edition, Wiley Eastern Ltd. New Delhi.

Books for References

1. Bhattacharya, P.B, Jain, S.K, and Nagpaul, S.R, (1995), Basic Abstract Algebra, Second Edition, Cambridge University Press, UK.

2. Charles Lanski, (2010), Concepts in Abstract Algebra, American Mathematical Society, US.

3. Das, M.N, and Giri, N.C, (1986), Design and Analysis of Experiments, Wiley Eastern Ltd. New Delhi.