PERIYAR UNIVERSITY

SALEM – 636 011, TAMIL NADU, INDIA

NAAC A Grade – State University – NIRF Rank 68

M.Phil. Statistics

(SEMESTER PATTERN)

(Under Choice Based Credit System)

(For Periyar University Department and Affiliated Colleges)

REGULATIONS AND SYLLABUS

(Candidates admitted from 2018-2019 onwards/ Revised for 2019-2020)

PERIYAR UNIVERSITY, PERIYAR PALKALAI NAGAR, SALEM –11

M. Phil. (STATISTICS)

REGULATIONS AND SYLLABUS

(For those candidates who joined 2018-2019 onwards / Revised for 2019-2020)

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 thereto, provided that those who have qualified for the Master's degree prior to 1st January 1991 must have secured a minimum of 50 percent of marks and those who have qualified for the Master's degree on or after 1st January 1991 must have secured a minimum of 55 percent of marks. For SC / ST candidates who have qualified on or after 1st January 1991 a concession of 5 percent of marks shall be given in the minimum eligibility marks shall be permitted to join the course.

2. Duration of the Programme and Credits

The duration of the M.Phil, Programme in Statistics shall be for a period of one year with 24 credits. The break-up of total credits for the programme shall be as given under:

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

3. Course Structure and Scheme of Examination

The courses of study for the M.Phil, Degree shall be in Statistics (under Choice Based Credit System) with internal assessment according to syllabi prescribed from time to time. The Internal Assessment is distributed to Internal Tests, Seminar, Assignment and Attendance as 10, 05, 05 and 05 marks, respectively.

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

There are three courses under Part-I for Semester I and Dissertation and Viva Voce under Part-II for Semester II. The optional (Elective) course in the first semester shall be specialization related to the dissertation. The student in consultation with the research supervisor must select anyone optional (Elective) course from the given list of specialization.

Sl. No.	Classifications	Internal Marks	External Marks	Total Marks
1.	For Each Core Paper	25	75	100*
2.	Dissertation	75 (Valuation)	75 (Valuation)	200
	Joint Viva Voce	25	25	
			Total	**500**

* Course Core (2x100) 200 Marks + Elective 100 Marks

4. Course Structure and Scheme of Examination

Course Code	Title of the Course	Core/Elective	Hours			Credits
			L	T	P	
I SEMESTER (Part-I)						
18URSTA1C01	Research Methodology in Statistics	Core	4	1	0	4
18URSTA1C02	Advanced Statistical Inference	Core	4	1	0	4
18URSTAIE01	Specialization Course	Elective	4	1	0	4
II SEMESTER (Part-II)						
18URSTA2D01	Dissertation	Core	-	-	-	8
	Viva Voce	Core	-	-	-	4

- **L – Lecture, T – Tutorial, P – Practical.**

5. Scheme of Examination

5.1 Part-I Written Examination: For the purpose of uniformity, particularly for inter departmental transfer of credits, there shall be a uniform pattern of examination to be adopted by all the teachers offering courses. There shall be three tests, one seminar and one assignment for internal evaluation and End semester examination during first semester. The distribution of marks for internal evaluation and End Semester Examination shall be 25 marks and 75 marks respectively. Further, distribution of internal marks shall be 10 marks for test, 5 marks for seminar, 5 marks for assignment and 5 marks for attendance respectively. The average of the highest two test marks out of the three internal tests should be taken for Internal Assessment.

5.2 Part-II – Dissertation: The exact title of the dissertation shall be intimated within one month after the registration of the programme. Candidates shall submit the dissertation to the University through the supervisor and Head of the Department at the end of the year from the commencement of the programme which shall be valued by internal examiner (supervisor) and one external examiner appointed by the university from a panel of four names sent by the supervisor through the Head of the Department at the time of submitting the dissertation.

The examiners who value the dissertation shall report the merit of candidates as "**Highly Commended**" (75% and above) or "**Commended**" (50% and above and below 75%) or "**Not Commended**" (below 50%).

If one examiner commends the dissertation and the other examiner, does not commend, the dissertation will be referred to the third examiner and the third valuation shall be final. Submission or resubmission of the dissertation will be allowed twice a year subject to the University rules.

6. Question Paper Pattern

Time: 3 Hours Maximum Marks: 75

Part – A (10 X 2 = 20 Marks)
Answer **ALL** Questions
(Two questions from each unit)

Part – B (5 X 5 = 25 Marks)
Answer **ALL** Questions
(Two questions from each unit with internal choice)

Part – C (3 X 10 = 30 Marks)
Answer any **THREE** questions out of **FIVE** questions
(One question from each unit)

7. Dissertation

7.1 Topic: The topic of the dissertation shall be assigned to the candidate within one month (based on paper III) after registration and a copy of the same should be submitted to the University for approval.

7.2 Number of copies of dissertation: The students should prepare two copies of dissertation and submit the same to the University for the Evaluation.

7.3 Format to be followed: The format of the dissertation to be submitted by the students is given below:

Format for the preparation of project work:

(i) Title page
(ii) Bonafide Certificate
(iii) Acknowledgement
(iv) Table of Contents

CONTENTS

Format of the Title Page

TITLE

A dissertation submitted in partial fulfillment of the requirement for the Degree of

MASTER OF PHILOSOPHY IN STATISTICS

(Under Choice Based Credit System)

Submitted

By

Name
Register Number

Under the Guidance of

Guide Name
Designation

Institution Emblem

Institution Details

Month - Year

Format of the Certificate

CERTIFICATE

This is to certify that the dissertation entitled ...(Title)....submitted by ……(Candidate Name)……. to the Periyar University, Periyar Palkalai Nagar, Salem in partial fulfilment of the requirement for the award of Degree of Master of Philosophy in Statistics is a bonafide record of work carried out by the candidate during ...(Academic Year)…….. in the Department and that no part of the dissertation has been submitted for the award of any Degree / Diploma /Associateship / Fellowship or other similar titles that the dissertation represents independent work on part of the candidate under my guidance.

Date:

Place: Signature of the Guide

Signature of the Head of the Department

8. Passing Minimum

A candidate shall be declared to have passed Part-I of the examination if he/she secures not less than 50% of the marks in each course. A candidate shall be declared to have passed Part-II of the examination if his/her dissertation is at least commended. A candidate who has passed all the examinations under both parts and earned a minimum of 24 credits shall be considered to have passed the M.Phil. programme.

9. Restriction in Number of Chances

No candidate shall be permitted to reappear for the written examination in any paper for more than two occasions or to resubmit a Dissertation more than once. Candidates shall have to qualify for the degree passing all the written papers and dissertation within a period of two years from the date of joining the course.

10. Commencement of this Regulation

These regulation and syllabi shall take effect from the academic year 2019 – 2020 that is, for those admitted to the Programme during the academic year 2019 – 2020 and thereafter.

11. List of Specialization

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. Advanced Demographic Methods
10. Advanced Biostatistics

SEMESTER I (PART I)

18URSTA1C01	Research Methodology in Statistics	Hours			Credits
		L	T	P	
		4	1	0	4

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

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.

Unit V

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

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. Kanti Swarup, Gupta, P.K., & Man Mohan. (2008). Operations Research Sultan Chand & Sons, (Publications), New Delhi.
4. Maria L.Rizzo.(2007). Statistical Computing with R, Chapman & Hall/CRC, Taylor and Francis Group.
5. Sudha.G.Purohit, Sharad.D.Gore and Shailaja R.Deshmukh.(2008). Statistics Using *R*, Narosa, Publishing House, New Delhi.

18URSTA1C02	Advanced Statistical Inference	Hours			Credits
		L	T	P	
		4	1	0	4

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 (Poisson, Negative Binomial) - method of scoring and EM algorithm - Consistent and consistent asymptotically normal estimators.

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 Binomial, Poisson and Normal 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.

18URSTA1E01	**Advanced Design of Experiments**	**Hours**			**Credits**
		L	**T**	**P**	
		4	**1**	**0**	**4**

Unit I

Design of Experiments: Introduction – Principles – Basic Designs Completely Randomized Design – Randomized Block Designs – Latin Square Designs - 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.

18URSTA1E01	Advanced Sampling Techniques	Hours			Credits
		L	T	P	
		4	1	0	4

Unit I

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

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

Single stage cluster sampling: Clusters of equal sizes – Reasons for Cluster Sampling – A simple rule – 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.

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.

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.

18URSTA1E01	Advanced Statistical Quality Control	Hours			Credits
		L	T	P	
		4	1	0	4

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 – Cumulative Sum (CUSUM) Control Charts – V-mask Procedure – Tabular CUSUM Procedure - Moving Range, Moving Average and Exponentially Weighted Moving Average Control 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 - Multivariate Control Chart - Hotelling's T^2 and Chi-square Control Charts.

Unit III

Product Control: Sampling Inspection by Attributes – Single, Double, Multiple, Sequential Sampling Plans – Operating Procedure, 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 Inspections - Plan selection - Variables Sampling Schemes – MIL- STD-414 – Procedures for Operation and Selection of Plans. Rectifying Sampling Schemes – Concepts of 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. Special Purpose Plans: Skip-lot and Chain Sampling Plans - Operation and Selection - Measures of Performance – 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.

18URSTA1E01	**Bayesian Inference**	**Hours**			**Credits**
		L	**T**	**P**	
		4	**1**	**0**	**4**

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.

18URSTA1E01	**Stochastic Processes and Its Applications**	**Hours**			**Credits**
		L	**T**	**P**	
		4	**1**	**0**	**4**

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.

Unit II

Continuous time Markov processes - Poisson processes - Birth and death processes - Kolmogorov Feller differential equations of birth and death processes - Renewal theory - Renewal equation - Elementary renewal theorem and its applications.

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 - 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 - Advanced Markovian Queueing Models - Erlangian Bulk Queues - Retrial Queues.

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.

18URSTA1E01	Advanced Operations Research	Hours			Credits
		L	T	P	
		4	1	0	4

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.

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.

18URSTA1E01	Time Series Analysis and Its Applications	Hours			Credits
		L	T	P	
		4	1	0	4

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 Inter science Publisher.

18URSTA1E01	Reliability Theory and Its Applications	Hours			Credits
		L	T	P	
		4	1	0	4

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.

18URSTA1E01	Advanced Demographic Methods	Hours			Credits
		L	T	P	
		4	1	0	4

Unit I

Demography - Meaning, scope and its development, demographic data and their sources - Current status - Chandrashekar - Deming index - Adjustment of age data – Whipple's Index – Myer's Blended Index – Sex Ratio Score – Age Ratio Score – United Nations Joint Score(U.N.J.S.) – Population size and growth in India - Trends and differentials in world population.

Unit II

Mortality - Basic measurements - Crude, specific, standardized death rates. Fertility - Basic measurements - Gross and Net Reproduction rate - Cohort fertility analysis - Fertility models - Population regulation programs in India - Demographic transition theory.

Unit III

Life table - construction, use and interpretation - force of mortality - abridged life tables – Methods by JIA, Reed and Merrel Grevilles and kings.

Unit IV

Migration: Causes – Estimation and Evaluation of Net Migration – Differential Migration – Migration Rates – Internal Migration and Mobility- Undocumented Migration – Indirect Method.

Unit V

Population Growth: Female Population projection by age – Growth of Female population – Population Estimation – Non-censal Estimates, censal Estimates – Inter Censal Estimates – AP method – GP method – Modification of GP method – Combined Progression Method.

Books for Study and Reference

1. Asis Kumar Chattopathyay and Anuj Kumar, (2017), Demography Techniques and Analysis, Viva Books Pvt., New Delhi.

Books for Study and Reference

1. Bogue, D. J. (2007). Principles of Demography, Wiley, New York.
2. Benjamin, B. (1975). Demographic Analysis. George Allen and Unwin Limited.
3. Cox, P.R. (1978). Demography (Fifth Edition). Cambridge University Press.
4. Gibbs, J.P. (2012). Urban Research Methods. Literary Licensing, LLC.

5. Keyfitz, N. and Caswell, H. (2006). Applied Mathematical Demography. Springer lag, New York.
6. Kumar, R. (1986). Technical Demography. John Wiley & Sons, Canada.
7. Misra, B.D. (1982). An Introduction to the Study of Population, South East Asia Publishers, New Delhi.
8. Spiegelman, M. (1969). Introduction to Demographic Analysis. Harvard University Press.

18URSTA1E01	Advanced Biostatistics	Hours			Credits
		L	T	P	
		4	1	0	4

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.

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