PERIYAR UNIVERSITY

Re-accredited with 'A' grade by the NAAC

PERIYAR PALKALAI NAGAR

SALEM – 11

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)

PERIYAR UNIVERSITY, SALEM –11
M.Phil. Statistics - Choice Based Credit System (CBCS)
Regulations and Syllabus
(For the candidates admitted from 2018-2019)

1. PERIYAR UNIVERSITY VISION AND MISSION

Vision

- Periyar University aims towards excellence in education, research, promoting invention, innovation and preserving cultural identity for future generation.

Mission

- Provide a vibrant learning environment, fostering innovation and creativity inspired by cutting edge research.
- Aspire to be a national leader in developing educated contributors, career ready learners and global citizens.
- Provide well equipped facilities for teaching, research, and administration and student life.
- Have well defined autonomous governance structure.
- To make a significant, consistent and sustainable contribution towards social, cultural and economic life in Tamil Nadu, India.

Values

- Motivation of students to be responsible citizens making them aware of their societal role.
- Inculcate scientific temper, honesty, integrity, transparency, empathy and ethical values amidst students.
- Impart a desire for lifelong learning to foster patriotic sensibility, accountability and holistic wellbeing.
- Provide conducive and cosmopolitan environment for innovation and free thinking.
- Imbibe value based education leading to inclusive growth.

Goals

- Become a global leader in teaching, research, invention and innovation.
- Make significant contribution to advancement of knowledge through quality teaching and innovative research.
- Produce research scholars possessing creativity and reflective thoughts, strong analytical skills and a passion for learning.
- Be a part in social and economic upliftment of society to infuse sense of social and national responsibility among students.

2. DEPARTMENT VISION AND MISSION

Vision

- To centre stage statistical knowledge in the curriculum in-still analytical and logical thinking among students and promote statistical thought as an important area of human thought.

Mission

- To encourage students to conduct student projects to develop their analytical and logical thinking.
- To establish industry links to develop statistical models and help the industry.
- To conduct outreach programmes for the socially marginalized students.

- The department creates an environment where the faculty and continue to grow as teachers and scholars, while providing public and professional service.

3. PROGRAM EDUCATIONAL OBJECTIVES, PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

3.1 Program Educational Objectives (PEOs)

Program educational objectives are broad statements that describe the career and professional accomplishments that the program is preparing research scholars to achieve.

3.2 Program Outcomes (POs)

Program outcomes describe what students are expected to know and would be able to do by the time of M.Phil. These relate to the skills, knowledge, and behaviors that students acquire as they progress through the program.

3.3 Program Specific Outcomes (PSOs)

Program Specific Outcomes are statements that describe what the M.Phil. of a specific Science Programme should be able to do.

4. STATEMENTS OF PEOs, POs AND PSOs

4.1 PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO1-Professional Development

To develop in the students the ability to acquire knowledge of Statistics, Mathematics & Statistical Software's and apply it professionally within realistic constraints such as economic, environmental, social, political, ethical, health and safety and sustainability with due ethical responsibility.

PEO2 - Core Proficiency

To provide ability to identify, formulate, comprehend, analyze and data analytics with hands on experience in various technologies using modern tools necessary for theoretical research and data processing practice to satisfy the needs of society and the industry.

PEO3 - Technical Accomplishments

To equip the students with the ability to design, simulate statistical experiments, analyze, optimize and interpret in their core applications through multi-disciplinary concepts and contemporary learning to build them into industry.

PEO4 - Professionalism

To provide training, exposure and awareness on importance of soft skills for better career and holistic personality development as well as professional attitude towards ethical issues, team work, responsibility, accountability, multidisciplinary approach and capability to relate data analysis issues to broader social context.

PEO5 - Learning Environment

To provide students with an academic environment and make them aware of excellence, develop the urge of discovery, creativity, inventiveness, leadership, written ethical codes and guidelines and the life-long learning to become a successful professional in Statistics.

The Programme curriculum is designed by incorporating inputs from members of Board of Studies and academic council who are drawn from various academic

institutions, research and development organizations and industry. Inputs are also obtained from alumni and other stake holders. Besides, a skill in demand analysis is carried out periodically to identify the core areas in the Statistics domain that are consistent with industry needs. Thus the PEOs are established, checked for consistency with the mission statement of the department.

4.2. PROGRAMME OUTCOMES (PO's)

The M.Phil. Programme in Statistics will enable:

- Professionally inclined Statistics educators who have sound knowledge of subject matter and specialized in constructivist and alternate pedagogy.
- Contribute as researchers in curriculum design and in evaluation reforms to raise the standard of Statistics education.
- Contribute as trained work force to provide teaching-learning support to schools as a part of extension activity using ICT in Statistics teaching in multiple ways.
- Develop need based Statistics teaching-learning resources.

PROGRAMME OUTCOMES		
PO1	**Subject Knowledge**	An ability to apply knowledge of mathematical statistics including statistics, mathematics, computer programming and data analytics to solve Statistical/Analytical problems.
PO2	**Problem Analysis and Developing Solutions**	An ability to design, simulate data, as well as to analyze and interpret data to meet desired specific solutions using appropriate data analysis/statistical tools
PO3	**Investigations Of Complex Problems and Modern Tool Usage**	An ability to identify, formulate, comprehend and analyze the synthesis of the information to solve using the techniques, skills and modern statistical packages which are necessary for real time data analysis and provide valid conclusions.
PO4	**The Statistician and The Society, Environment And Sustainability**	The broad education should provide necessary understanding on professional, health, safety, legal and cultural with an impact of statistical solutions to benefit the Society, Economy, and Environment and demonstrate the knowledge on Sustainable development.
PO5	**Team Work, Ethics and Life-Long Learning**	Apply ethical principles to work as a member and leader in a multi-disciplinary team to resolve contemporary issues and acquire lifelong learning.

4.3 PROGRAM SPECIFIC OUTCOMES (PSO's)

The M.Phil. Programme in Statistics will attain:

PSO1: The ability to analyze and implement application specific theory and analysis for complex statistical problems in Advanced Statistical Inference, Statistical Quality Control, Design of Experiments, Bio-statistics and Data analytics by applying the knowledge of basic Mathematical Statistics fundamentals.

PSO2:The ability to adapt for rapid changes in tools and technology with an understanding of societal and real time industrial issues relevant to professional statistical practice through life-long learning.

	BLOOM'S TAXONOMY		
	Domains	**Keywords**	
K1	**Knowledge** Recall or retrieve previous learned information.	Defines, Describes, Identifies, Knows, Labels, Lists, Matches, Names, Outlines, Recalls, Recognizes, Reproduces, Selects and States.	
K2	**Understanding** Comprehending The Meaning, Translation, Interpolation, and Interpretation of Instructions and Problems. State A Problem In One's Own Words.	Comprehends, converts, defends, distinguishes, estimates, explains, extends, generalizes, gives an example, infers, interprets, paraphrases, predicts, rewrites, Summarizes, translates.	
K3	**Applying** Use a concept in a new situation or unprompted use of an abstraction. Applies what was learned in the classroom into novel situations in the work place.	Applies, changes, computes, constructs, demonstrates, discovers, manipulates, modifies, operates, predicts, prepares, produces, relates, shows, solves and uses.	
K4	**Analyzing** Separates material or concepts into component parts so that its organizational structure may be understood. Distinguishes between facts and inferences.	Analyzes, breaks down, compares, contrasts, and diagrams, deconstructs, differentiates, discriminates, distinguishes, identifies, illustrates, infers, outlines, relates, selects and separates.	
K5	**Evaluating** Make judgments about the value of ideas or materials.	Appraises, Compares, Concludes, Contrasts, Criticizes, Critiques, Defends, Describes, Discriminates, Evaluates, Explains, Interprets, Justifies, Relates, Summarizes, Supports	
	Creating Builds a structure or pattern from diverse elements. Put parts together to form a whole, with emphasis on creating a new meaning or structure.	categorizes, combines, compiles, composes, creates, devises, designs,	

K6		explains, generates, modifies, organizes, plans, rearranges, reconstructs, relates, reorganizes, revises, rewrites, summarizes, tells, writes	

PSO3: Excellent adaptability to function in multi-disciplinary work environment, good interpersonal skills as a leader in a team in appreciation of professional ethics and societal responsibilities.

6. COURSE OUTCOMES

6.1 Course Outcome Statement

Statements indicating what a student can do after the successful completion of a course. Every Course leads to some Course Outcomes. The CO statements are defined by considering the course content covered in each module of a course. For every course there may be 4 or 5 COs. The keywords used to define COs are based on Bloom's Taxonomy.

Perspectives in Statistics Education upon Completion of this course the students will be able to:

- Understand Statistics education as an academic and research field.
- Discuss the nature of Statistics with reference to pure and applied Mathematical Statistics.
- Analyze nature of statistics from cognitive to social perspective.
- Define specific components of statistics (axioms, postulates, paradoxes, mathematical statements, theorem and proof).
- Develop an understanding of philosophical, cultural, social, historical and psychological facets of statistics education.
- Discuss and analyses the history of Mathematical Statistics with respect Demography, Statistical Quality Control, Design of Experiments, Statistical Inference, Distribution Theory, Sampling Theory, Stochastic Processes Time Series Analysis.
- Apply the history and development of field of Mathematical Statistics in the present statistics curriculum.
- Critically analyze the present statistics curriculum.

6.2 Digital Technologies in Statistics Education

Upon completion of this course the students will be able to:

- Apply basic ICT skills in planning and teaching Statistics at school level.
- Create web-based learning environment using blogs, virtual classrooms and web based Educational applications.
- Use Statistics specific software, such as R Programming, Minitab, Stata, E-views, Python.
- Use design software such as Photoshop, documentation software such as LATEX and others to create need based e-learning resources for students.
- Teach Statistics by organizing virtual classrooms.

7. CO – PO AND CO – PSO MAPPING OF COURSES

All the courses together must cover all the POs (and PSOs). For a course we map the COs to POs through the CO-PO matrix and to PSOs through the CO-PSO matrix as shown below. The various correlation levels are:

- "1" – Slight (Low) Correlation
- "2" – Moderate (Medium) Correlation
- "3" – Substantial (High) Correlation
- "-" indicates there is No Correlation

7.1 Levels of Outcomes

There are four levels of outcome such as; (a) Course Outcome (CO), (b) Programme Outcome (PO), (c) Program Specific Outcome (PSO) and (d) Program Educational Objective (PEO). Course Outcomes are the statements that declare what students should be able to do at the end of a course. POs are defined by Accreditation Agencies of the country, which are the statements about the knowledge, skills and attitudes, graduate attributes of a formal engineering program should have Graduates Attributes (GAs) are the components indicative of the graduate's potential to acquire competence to practice at the appropriate level. GAs form a set of individually assessable outcomes of the programme. The NAAC laid down the graduate attributes relating to programme outcomes and is to be derived by programme. Figure 7.1 shows the building block of CO-PO&PSO-PEO relationship.

8. Duration of the Course 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**

8.1. 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

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
-	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

8.1.1 Scheme of Examination

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.

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.

8.2. List of Core, Elective Papers

A total of 2 Core Theory Papers,1 Specialization Course shall be offered by the Department of Statistics. The list of papers is given as below;

8.2.1: List of Core Papers – Theory

S. No.	Course Code	Title of the Course	Credits
1.	18URSTA1C01	Research Methodology in Statistics	4
2.	18URSTA1C02	Advanced Statistical Inference	4

8.2.2: List of specialization Courses

S. No.	Course Code	Title of the Course	Credits
1.	19URSTA1E01	Advanced Design of Experiments	4
2.	19URSTA1E02	Advanced Sampling Techniques	4
3.	19URSTA1E03	Advanced Statistical Quality Control	4
4	19URSTA1E04	Bayesian Inference	4
5	19URSTA1E05	Stochastic processes and its Applications	4
6	19URSTA1E06	Advanced Operations Research	4
7	19URSTA1E07	Time Series Analysis and its Application	4
8	19URSTA1E08	Reliability Theory and survival Analysis	4
9	19URSTA1E09	Advanced Demographic Methods	4
10	19URSTA1E10	Advanced Biostatistics	4

(*Note*: One paper is to be chosen from the list)

9. Quality/Relevance of Assessment Process Theory

Tests, assignments, seminars and attendance shall be the components for continuous internal assessment. There shall be three tests, three assignments and one seminar for each paper. The pattern of question paper for tests, the problems for assignments and the topics for seminars shall be at the discretion of the course teacher. The average of **best two** tests for a maximum of 10 marks, the average of all the assignments for a maximum of 5 marks, the actual marks secured by the candidate in the seminar for a maximum of 5 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.

Internal mid Tests: Internal tests serve to encourage students to keep up with course content covered in class. Three written examinations are conducted and its average marks are considered. For theory subjects, during a semester there shall be 3 mid-term examinations. Each mid- term examination consists of multiple choice questions and higher order thinking questions. The test is conducted for 50 marks in each cycle. A maximum of 25 marks shall be allotted under continuous internal assessment in each theory paper offered by the Department. The distribution of theory papers marks is as given under:

Sl. No	Classifications	Marks
5.	Marks for Internal Tests	10
6.	Marks for Assignments	05
7.	Marks for Seminars	05
8.	Marks for Attendance	05
	Total	**25**

The maximum marks for continuous internal assessment and end semester University examination for practical papers shall be fixed as 40 and 60, respectively. The distribution of continuous internal assessment marks for each core - practical paper is as given below:

Sl. No	Classifications	Marks
1.	Marks for Internal Tests	10
2.	Marks for Record	25
3.	Marks for Attendance	05
	Total	**40**

The questions in the internal examinations and assignment sheets are mapped against COs of respective course. The questions for two internal examinations and Assignments are framed in such a way to cover all Course Outcomes. First Assignment should be submitted before the conduct of the second mid-examination. The total marks secured by the student in each mid-term examination are evaluated for 50 marks, and the average of the three mid-term examinations shall be taken as the final marks secured by each candidate. The questions in the internal examinations and assignment sheets are mapped against COs of respective course. The questions for three internal examinations and Assignments are framed in such a way to cover all Course Outcomes.

9.1 University Examination

The end semester examination shall be conducted with an internal supervisor/faculty incharge. The end-semester examinations are of 3 - hour duration and cover the entire syllabus of the course. It would generally satisfy all course outcomes for a particular course. The COs is evaluated based on the set attainment levels. The distribution shall be 25 marks for internal evaluation (5 marks for attendance, 5 marks for seminar, 5 marks for assignment and 10 marks for internal tests) and 75 marks for end semester examination. There shall be three internal tests in a Semester and the average of the three shall be considered for the award of marks for internal tests.

9.2 AWARD OF DEGREE

A candidate who secures a minimum of 50% of marks in the end semester University examination and also a minimum of 50% of marks in aggregate comprising both continuous internal assessment and end semester University examination in each paper shall be declared to have passed the M.Sc. degree course in Statistics.

A candidate who secures a minimum of 75% of marks in aggregate comprising both continuous internal assessment and end semester University examination shall be declared to have passed the examination in FIRST CLASS WITH DISTINCTION, if the candidate has passed all the examination prescribed for the course in the first appearance.

A candidate who secures a minimum of 60% of marks comprising both continuous internal assessment and end semester University examination in aggregate shall be declared to have passed the examination in FIRST CLASS.

A candidate who has passed in all the papers prescribed for the course in the FIRST APPEARANCE shall be eligible for Ranking/Distinction.

9.3 DISSERTATION

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.

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

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

Chapter Number	Title	Page Number
1.	Introduction	
2.	Review of Literature	
3.	Summary	
4.	Findings	
5.	References	

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

9.4. Pattern of Question Paper for the End Semester Comprehensive Examination

The question paper shall consist of three sections. While there shall be no choice in Part A, internal choice (either or type) shall be given Part B and Open choice in Part C. In Part A, there shall be two questions from each of the five units. In Part B there shall be one question with internal choice (either/or type) from each of the five units and Part C, there shall be eight questions from each of the five units.

Part A - (10 x 2 = 20 marks)
(Two questions from each units)
Part B - (5 x 5 = 25 marks)
(One question from each unit with internal choice)
Part C – (3 x 10 = 30 marks)
(Answer any three questions out of five questions)

M.Phil Examination
Branch – Statistics

SUBJECT

Time: 3 Hours Max. Marks: 75

Part - A (10×2 =20 Marks)
Answer *ALL* questions
Each question carries *two* mark

1. from Unit I
2. from Unit I
3. from Unit II
4. from Unit II
5. from Unit III
6. from Unit III
7. from Unit IV
8. from Unit IV
9. from Unit V
10. from Unit V

Part - B (5 × 5 = 25 Marks)
Answer *ALL* questions
Each question carries *Five* marks

11.(a) from Unit I

(OR)

(b) from Unit I

12.(a) from Unit II

(OR)

(b) from Unit II

13**.** (a) from Unit III

(OR)

(b) from Unit III

14.(a) from Unit IV

(OR)

(b) from Unit IV

15.(a) from Unit V

(OR)

(b) from Unit V

Part – C (3× 10 = 30 marks)
Answer *any three* questions
Each question carries *ten* marks

16. from Unit I
17. from Unit II
18. from Unit III
19. from Unit IV
20. from Unit V

SEMESTER I

AIMS

1. To develop knowledge, understanding and experience of the theory, practice and application of selected areas of statistical computing and to produce graduates needed by public and private sector to help and solve practical problems using the skills and techniques of these areas and to develop analytical skills for respective Sector.
2. To develop enterprise competences emphasizing the key skills of learning and communication for Statistical theory.

OBJECTIVES

1. An understanding of the Statistical principles, techniques and applications of selected areas of Statistics and computing.
2. The ability and confidence to analyse and solve problems both of a routine and of obvious nature towards applications of Statistical theory.
3. To gain deeper understanding, problem solving skills and greater knowledge of selected topics in Statistical computation.

SEMESTER 1.1 RESEARCH METHODOLOGY IN STATISTICS

Paper code	18URSTA1C01
Paper title	Research Methodology in Statistics
Number of teaching hrs per week	4
Total number of teaching hrs per semester	60
Number of credits	4
Cognitive level	K1, K2, K3, K4, K5, K6
Course Objective	➢ To understand the importance of Research problem in Statistics, and significance of report writing. ➢ Learning some statistical methodology for random variables ➢ Acquiring knowledge of R software for statistical Computation.

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.

Course outcome:

On completion of the course, the students should be able to.,

Course Outcome No.	Course outcome statement	Cognitive level
CO1	Describe the necessity of defining the problems and techniques and can explain the importance of literature survey, Layout of the research report and significance of report writing-	K1, K2
CO2	Generalise the statistical studies using the data measurement scales, (nominal, ordinal, ratio and interval scales)	K2,K3
CO3	Apply the sources of error in measurement compare the scaling technique (likert type scaling ,cumulative scaling).	K3,K4

CO4	Summarize the knowledge of simulation Concept and its Advantages with respect to Simulation Algorithm and anlayse the simulation techniques with random number generation.	K4,K5
C05	Describe the R language and interpret the statistical computation. Manipulate the R coding to categorize the cumulative probabilities using Binomial and Poisson models.	K1,K2,K3, K6

MODEL BLUEPRINT		
Subject Code		18URSTA1C01
Title of the Paper		Research Methodology in Statistics
Unit Number	**Number of Hours**	**Total Marks**
1	12	15
2	12	15
3	12	15
4	12	15
5	12	15
	60	75
Maximum marks for the paper		75

SEMESTER 1.2 ADVANCED STATISTICAL INFERENCE

Paper code	18URSTA1C02
Paper title	ADVANCED STATISTICAL INFERENCE
Number of teaching hrs per week	4
Total number of teaching hrs per semester	60
Number of credits	4
Cognitive level	K1, K2, K3, K4, K5, K6
Course Objective	➢ Explain the principles of data reduction ➢ Judge the quality of estimators ➢ Choose appropriate methods of inference to tackle real problems.

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.

Course outcome:

On completion of the course, the students should be able to.,

Course Outcome No.	Course outcome statement	Cognitive level
CO1	Understand and generalize the statistical decision problem	K1, K2
CO2	Intrepret the Estimation theory	K2,K3
CO3	Summarize the concept of testing of hypotheses	K3,K4
CO4	Categorize likelihood ratio test	K4,K5
C05	Generalize the sequential methods for standard distributions.	K2, K4,K6

MODEL BLUEPRINT		
Subject Code		**18URSTA1C02**
Title of the paper		**ADVANCED STATISTICAL INFERENCE**
Unit Number	**Number of hours**	**Total Marks**
1	12	15
2	12	15
3	12	15
4	12	15
5	12	15
Total	60	75
Maximum marks for the paper		75

SEMESTER 1.3.1 ADVANCED DESIGN OF EXPERIMENTS

Paper code	19URSTA1E01
Paper title	ADVANCED DESIGN OF EXPERIMENTS
Number of teaching hrs per week	4
Total number of teaching hrs per semester	60
Number of credits	4
Cognitive level	K1, K2, K3, K4, K5, K6
Course Objective	➢ Understand the process of developing strategic plans for experimentation in scientific and industrial research projects. ➢ Apply the principles of DoE to generate experimental designs. ➢ Analyze alternative designs for experimentation and carry out output analysis for quality improvement projects.

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.

Course outcome:

On completion of the course, the students should be able to.,

Course Outcome No.	Course outcome statement	Cognitive level
CO1	Understand the principles of experimental designs and constructing the designs.	K1, K3
CO2	Construct and anlyses factorial and fractional designs	K2,K4
CO3	Summarize the concept of Balanced Incomplete block designs	K3,K4
CO4	Categorize the Rotational designs	K4,K5
C05	Categorize the diallel cross (Complete and partial diallel crossing).	K4, K6

MODEL BLUEPRINT		
Subject Code		19URSTA1E01
Title of the paper		**Advanced Design of Experiments**
Unit Number	Number of hours	Total Marks
1	12	15
2	12	15
3	12	15
4	12	15
5	12	15
Total	60	75
Maximum marks for the paper		75

SEMESTER 1.3.2 ADVANCED SAMPLING TECHNIQUES

Paper code	19URSTA1E02
Paper title	ADVANCED SAMPLING TECHNIQUES
Number of teaching hrs per week	4
Total number of teaching hrs per semester	60
Number of credits	4
Cognitive level	K1, K2, K3, K4, K5, K6
Course Objective	➢ Sampling theory helps in determining whether observed differences are actually due to chance or whether they are really significant. ➢ To estimate population parameters from the sample. ➢ To find out the degree of reliability of the estimate.

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.
6. Raj, D. (1972). The Design of Sample Surveys. McGraw-Hill, New York.
7. Raj, D. and Chandhok, P. (1998). Sample Survey Theory. Narosa
   Publishing House, London.
8. Mukhopadyay, P. (2007). Survey Sampling. Narosa Publisher, New Delhi.
9. Mukhopadyay, P. (1998). Small area estimation in Survey Sampling.
   Narosa Publisher, New Delhi.
10. Sukhatme, P.V. and Sukhatme, B.V. (1958). Sampling Theory

    Surveys with Applications, Indian Society of Agricultural Statistics,

    New Delhi.

Course outcome:

On completion of the course, the students should be able to.,

Course Outcome No.	Course outcome statement	Cognitive level
CO1	Understand the principles of double sampling plan and their construction.	K1, K3
CO2	Construct and analysis the multi-stage sampling and estimation of proportions	K2,K4
CO3	Summarize the concept of cluster sampling	K3,K4
CO4	Categorize the successive sampling and interpreting the sampling for time series analysis.	K4,K5
C05	Analyzing sequential sampling and acceptable sequential estimators.	K4, K6

MODEL BLUEPRINT		
Subject Code		19URSTA1E02
Title of the paper		**Advanced Sampling Techniques**
Unit Number	**Number of hours**	**Total Marks**
1	12	15
2	12	15
3	12	15
4	12	15
5	12	15
Total	60	75
Maximum marks for the paper		75

SEMESTER 1.3.3 ADVANCED STATISTICAL QUALITY CONTROL

Paper code	19URSTA1E03
Paper title	ADVANCED STATISTICAL QUALITY CONTROL
Number of teaching hrs per week	4
Total number of teaching hrs per semester	60
Number of credits	4
Cognitive level	K1, K2, K3, K4, K5, K6
Course Objective	➢ Understand the philosophy and basic concepts of quality improvement. ➢ Demonstrate the ability to use the methods of statistical quality control interpret control charts for variables and attributes. ➢ Perform analysis of process capability and measurement system capability.

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.

Course outcome:

On completion of the course, the students should be able to.,

Course Outcome No.	Course outcome statement	Cognitive level
CO1	Estimating the control chart by variables and attributes by process control	K1, K3
CO2	Construct the analysis of multivariate control charts	K2,K4
CO3	Applying the innovative sampling plans for product control charts.	K3,K4
CO4	Categorize the attribute sampling scheme and their constructions.	K4,K5
C05	Analyzing the continuous sampling plans and reliability criteria.	K4, K6

MODEL BLUEPRINT		
Subject Code		19URSTA1E03
Title of the paper		**Advanced Statistical Quality Control**
Unit Number	**Number of hours**	**Total Marks**
1	12	15
2	12	15
3	12	15
4	12	15
5	12	15
Total	60	75
Maximum marks for the paper		75

SEMESTER 1.3.4 ADVANCED BAYESIAN INFERENCE

Paper code	19URSTA1E04
Paper title	ADVANCED BAYESIAN INFERENCE
Number of teaching hrs per week	4
Total number of teaching hrs per semester	60
Number of credits	4
Cognitive level	K1, K2, K3, K4, K5, K6
Course Objective	➢ Understand Bayesian thinking ➢ Use prior information and Bayes' rule in probability and statistical inference problems ➢ Apply Bayesian inference methods to common parameters (binomial, Normal) and relationships between variables.

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.

Course outcome:

On completion of the course, the students should be able to.,

Course Outcome No.	Course outcome statement	Cognitive level
CO1	Understanding the concept of subjective probability and its interpretation and evaluation.	K1, K3
CO2	Estimating the parameters of Point estimation	K2,K4

CO3	Applying interval estimation to various related areas .	K3,K4
CO4	Categorize Bayesian testing of Statistical Hypothesis.	K4,K5
C05	Analyzing the Bayesian computation for various models.	K4, K6

MODEL BLUEPRINT		
Subject Code		19URSTA1E04
Title of the paper		**Bayesian inference**
Unit Number	Number of hours	Total Marks
1	12	15
2	12	15
3	12	15
4	12	15
5	12	15
Total	60	75
Maximum marks for the paper		75

SEMESTER 1.3.5 STOCHASTIC PROCESSES AND ITS APPLICATIONS

Paper code	19URSTA1E05
Paper title	STOCHASTIC PROCESSES AND ITS APPLICATIONS
Number of teaching hrs per week	4
Total number of teaching hrs per semester	60
Number of credits	4
Cognitive level	K1, K2, K3, K4, K5, K6
Course Objective	➢ The student has basic knowledge about stochastic processes in the time domain. ➢ The student has acquired more detailed knowledge about Markov processes with a discrete state space, including Markov chains, Poisson processes and birth and death processes. ➢ The student also knows about queing system and Brownian motion, in addition to mastering the fundamental principles of simulation of stochastic processes and the construction of Markov chain Monte Carlo (MCMC) algorithms

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.

Course outcome:

On completion of the course, the students should be able to.,

Course Outcome No.	Course outcome statement	Cognitive level
CO1	Applying the concept of Stochastic Processes in real life	K1, K3
CO2	Estimating continous time Markov processes	K2, K4
CO3	Applying the concept of Queuing theory in related areas .	K3, K4
CO4	Categorize Birth and Death queuing models.	K4, K5
C05	Analyzing the parameters for higher order transition probability matrix	K4, K6

MODEL BLUEPRINT		
Subject Code		19URSTA1E05
Title of the paper		**Stochastic Processes and Its Applications**
Unit Number	Number of hours	Total Marks
1	12	15
2	12	15
3	12	15
4	12	15
5	12	15
Total	60	75
Maximum marks for the paper		75

SEMESTER 1.3.6 ADVANCED OPERATIONS RESEARCH

Paper code	19URSTA1E06
Paper title	**ADVANCED OPERATIONS RESEARCH**
Number of teaching hrs per week	4
Total number of teaching hrs per semester	60
Number of credits	4
Cognitive level	K1, K2, K3, K4, K5, K6
Course Objective	➢ Identify and develop operational research models from the verbal description of the real system. ➢ Understand the mathematical tools that are needed to solve optimization problems. ➢ Use mathematical software to solve the proposed models. ➢ Develop a report that describes the model and the solving technique, analyse the results and propose recommendations in language understandable to the decision-making processes in Management Engineering.

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.

Course outcome:

On completion of the course, the students should be able to.,

Course Outcome No.	Course outcome statement	Cognitive level
CO1	To Understand Non-Linear programming Algorithms	K1, K3
CO2	Estimating continuous state Dynamic programming to solve Dynamic problem.	K2, K4
CO3	Applying the concept of Stochastic inventory models in related areas of research.	K3, K4
CO4	Applying the various queuing models in real life situation.	K4, K5
C05	Analyzing and summarizing the job sequencing problem	K4, K6

MODEL BLUEPRINT		
Subject Code		19URSTA1E06
Title of the paper		**Advanced Operations Research**
Unit Number	**Number of hours**	**Total Marks**
1	12	15
2	12	15
3	12	15
4	12	15
5	12	15

Total	60	75
Maximum marks for the paper		75

SEMESTER 1.3.7 TIME SERIES ANALYSIS AND ITS APPLICATIONS

Paper code	19URSTA1E07
Paper title	**TIME SERIES ANALYSIS AND ITS APPLICATIONS**
Number of teaching hrs per week	4
Total number of teaching hrs per semester	60
Number of credits	4
Cognitive level	K1, K2, K3, K4, K5, K6
Course Objective	➢ Understand and be able to apply the concepts and methods underlying the analysis of univariate time series, and the context for interpretation of results ➢ Decompose a time series into trend, seasonal and irregular components ➢ Understand the theoretical bases of different methods of time series analysis including decomposition ➢ Determine how and when to apply different methods of time series analysis and how to test for goodness of fit using the software package X12.

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.

Course outcome:

On completion of the course, the students should be able to.,

Course Outcome No.	Course outcome statement	Cognitive level
CO1	Understanding the concept of Auto correlation and Partial Auto correlation in Stationary models.	K1, K3
CO2	Summarizing the detailed study on Stationary Process	K2, K4
CO3	Estimating the parameters for ARIMA models..	K3, K4
CO4	Applying the characrestics of Volatility in ARCH and GARCH models.	K4, K5
C05	Analyzing and summarizing Multi variate time series models.	K4, K6

MODEL BLUEPRINT		
Subject Code		19URSTA1E07
Title of the paper		**Time Series Analysis and Its Applications**
Unit Number	**Number of hours**	**Total Marks**
1	12	15
2	12	15
3	12	15
4	12	15
5	12	15
Total	60	75
Maximum marks for the paper		75

SEMESTER 1.3.8: RELIABILITY THEORY AND ITS APPLICATIONS

Paper code	19URSTA1E08
Paper title	**RELIABILITY THEORY AND ITS APPLICATIONS**
Number of teaching hrs per week	4
Total number of teaching hrs per semester	60
Number of credits	4
Cognitive level	K1, K2, K3, K4, K5, K6
Course Objective	➢ Understand a reliability concepts and measures ➢ Getting vast knowledge on life time distributions and its applications ➢ Determine the impact of growth models in different fields.

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.

Course outcome:

On completion of the course, the students should be able to.,

Course Outcome No.	Course outcome statement	Cognitive level
CO1	Understanding the reliability concepts and measures.	K1, K3
CO2	Summarizing the life time distributions and its applications.	K2, K4
CO3	Estimating the notion of ageing with different areas	K3, K4

CO4	Applying the reliability estimation based on failure time models.	K4, K5
C05	Analyzing and summarizing reliability growth models.	K4, K6

MODEL BLUEPRINT		
Subject Code		19URSTA1E08
Title of the paper		**Reliability Theory and Its Applications**
Unit Number	**Number of hours**	**Total Marks**
1	12	15
2	12	15
3	12	15
4	12	15
5	12	15
Total	60	75
Maximum marks for the paper		75

SEMESTER 1.3.9: ADVANCED DEMOGRAPHIC METHODS

Paper code	19URSTA1E09
Paper title	**ADVANCED DEMOGRAPHIC METHODS**
Number of teaching hrs per week	4
Total number of teaching hrs per semester	60
Number of credits	4
Cognitive level	K1, K2, K3, K4, K5, K6
Course Objective	➢ Measurement of mortality by age and cause. ➢ Current trends and differentials by age, sex, race, occupation and marital status. ➢ Consequences of mortality declines for fertility change and development. ➢ Fertility trends and it affects the population growth. ➢ Migration issues and importance on Government planning and execution of policies.

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.

Course outcome:

On completion of the course, the students should be able to.,

Course Outcome No.	Course outcome statement	Cognitive level
CO1	Understanding the meaning and scope of demographic measures and their sources	K1, K3
CO2	Evaluating the basic measurements of mortality and Fertility.	K2, K4
CO3	Constructing and interpreting life table	K3, K4
CO4	Estimating and Evaluating the net migration.	K4, K5
C05	Analyzing and summarizing population growth models.	K4, K6

MODEL BLUEPRINT		
Subject Code		19URSTA1E09
Title of the paper		**Advanced Demographic Methods**
Unit Number	**Number of hours**	**Total Marks**
1	12	15
2	12	15
3	12	15
4	12	15
5	12	15
Total	60	75
Maximum marks for the paper		75

SEMESTER 1.3.10: ADVANCED BIOSTATISTICS

Paper code	19URSTA1E10
Paper title	**ADVANCED BIOSTATISTICS**
Number of teaching hrs per week	4
Total number of teaching hrs per semester	60
Number of credits	4
Cognitive level	K1, K2, K3, K4, K5, K6
Course Objective	➢ Demonstrate an understanding of the central concepts of modern statistical theory and their probabilistic foundation. ➢ Select from, use, and interpret results of, the principal methods of statistical inference and design. ➢ Communicate the results of statistical analyses accurately and effectively. ➢ Make appropriate use of statistical software. ➢ Read and learn new statistical procedures independently.

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.

Course outcome:

On completion of the course, the students should be able to

Course Outcome No.	Course outcome statement	Cognitive level
CO1	Understanding the concept of Bio statistics, clinical trials and the study designs	K1, K3
CO2	Evaluating the disease exposure association and confounding.	K2, K4
CO3	Estimating the mean and proportion of bio statistics data	K3, K4

CO4	Evaluating the knowledge on linear regression and correlation.	K4, K5
C05	Summarizing the concept of Survival analysis using parametric and Nonparametric distributions.	K4, K6

MODEL BLUEPRINT		
Subject Code		19URSTA1E10
Title of the paper		**Advanced Biostatistics**
Unit Number	**Number of hours**	**Total Marks**
1	12	15
2	12	15
3	12	15
4	12	15
5	12	15
Total	60	75
Maximum marks for the paper		75