# PERIYAR UNIVERSITY

**NAAC A++ Grade State University - NIRF Rank 59 – ARRIA Rank 10**

# SALEM – 636 011

## M.Sc. Statistics

**(Semester Pattern)**

**(Under Choice Based Credit System)**

**(For Periyar University Department)**

**Regulations and Syllabus**

**(Candidates admitted from 2023-24 onwards)**

**Tamilnadu State Council for Higher Education**
**Chennai – 600 005**

## Preamble

### 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, 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 well being
- 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 graduates 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.

### 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.

**The Process for Defining Vision and Mission of the Department**

The following steps are followed to establish Vision and Mission for the Department of Statistics;

**Step 1:** The Vision and Mission of the Periyar University is taken as the basis.

**Step 2:** The Department conducts brain-storming sessions with the faculty members on the skill-set required by the local and global employers, Industry Advances in Technology and R and D, and the draft copy of the Vision and Mission of the Department is drafted.

**Step 3:** The views from Stake Holders, Industrial Experts and Board of Studies (BOS) on the draft are also collected and incorporated to revise the draft version based on their inputs.

**Step 4:** The accepted views are analyzed and reviewed to check the consistency with the vision and mission of the institute.

# Content

## M.Sc. - STATISTICS

### 1. Course Objectives

- The course aims to inculcate knowledge on theoretical and applied aspects of Statistics in a wider spectrum. It intends to impart awareness on the importance of Statistical concepts across diversified fields and to provide practical training on the applications of Statistical tools in carrying out data analysis using Statistical software like SAS, SYSTAT and SPSS and using the programming knowledge in R.
- The course curriculum is designed in such a way that the candidate on successful completion of the course will have ample opportunities to take up national level competitive examinations like CSIR NET in Mathematical Sciences, SET, Indian Statistical Service (ISS) of UPSC, etc.
- Demonstrate the ability to use Statistics skills for formulating and tackling real world problems.
- Recognize the importance of Statistical modelling and computing in the field of Statistics.
- Plan and execute Statistical experiments or investigations, analyze and interpret data/information collected using appropriate methods, including the use of appropriate statistical software including programming languages, and report accurately the findings of the experiment/investigations with the medical data set.
- Develop Problem-solving skills that are required to solve different types of Statistics related problems with well-defined solutions. Investigative skills, including skills of independent thinking of Statistics-related issues and problems
- Develop analytical skills involving paying attention to detail and ability to construct logical arguments using correct technical language related to Statistics and ability to translate them with popular language when needed; Develop ICT skills.
- To transform graduates with sufficient strength in statistics so as to be employed in the industry, Research and development and academic sides. The course is designed to impact professional knowledge and practical skills to the students.

### 2. Conditions for Admission

- Candidates who have passed Bachelor's Degree and has studied at least 3 courses each of one-year duration or 6 courses each of one semester duration in Statistics under 10+2+3 scheme of examination with the minimum 50% marks in aggregate or equivalent CGPA from a recognized Institute/ University are eligible.
- Candidates who have passed Bachelor's degree in Mathematics with at least one paper in Statistics under 10+2+3 scheme of examination with the minimum 50% marks in aggregate or equivalent CGPA from a recognized Institute/ University are eligible.

## 3. Duration of the Course

- It consists of two academic years divided into four semesters. Each semester consists of 90 working days.

## 4. Scheme of Examinations

- As per the CBCS pattern with SE (Secured External Examinations score) and IA (Internal Assessment score)

## 5. Career Prospects

Statistician jobs can be found in government and semi-government institutes in the public and private sectors and in factories. Statistics jobs can include teaching in research institutions and establishments dedicated to higher education. Statistics career has excellent potential. Some of the job options are mentioned below:

### 5.1 Government Sector

| Central Government Jobs | State Government Jobs |
|---|---|
| Indian Statistical Service (ISS) | Assistant Statistical Invigilator |
| Senior Scientist, (CSRT) | Statistical Inspector |
| Scientist, (Indian Council of Medical Research) | Assistant Director (Eco. and Stat. Dept.) |
| Statistical Invigilator | Director/ Joint Director |
| Research Officer | Block Health Statistician |
| NSSO | Research and Scientific Officer |
| CSO | College/ University Professor |

### 5.2 Private Sectors

Statistician, Data Analyst, Data Scientist, Risk Analyst, Biostatistician, Research Analyst, Scientist, etc.

### 5.3 Future Scope

After pursuing a Master of Statistics, candidates can go for further education in M.Phil. / Ph.D. Statistics.

## 6. Curriculum Design

| Semester-I | Credit | Hours | Semester-II | Credit | Hours | Semester-III | Credit | Hours | Semester–IV | Credit | Hours |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.1 Core-I | 4 | 5 | 2.1 Core-IV | 4 | 5 | 3.1 Core-VII | 4 | 5 | 4.1 Core-XI | 4 | 5 |
| 1.2 Core-II | 4 | 5 | 2.2 Core-V | 4 | 5 | 3.2 Core-VIII | 4 | 5 | 4.2 Core-XII | 4 | 5 |
| 1.3 Core-III | 4 | 6 | 2.3 Core-VI | 4 | 5 | 3.3 Core – IX | 4 | 4 | 4.3 Statistics Practical – IV | 2 | 4 |
| 1.4 Discipline Centric Elective -I | 3 | 5 | 2.4 Discipline Centric Elective-III | 3 | 4 | 3.4 Core – X | 4 | 4 | 4.4 Project with Viva Voce | 7 | 10 |
| 1.5 Generic Elective-II | 3 | 5 | 2.5 Generic Elective-IV | 3 | 3 | 3.5 Discipline Centric Elective - V | 3 | 4 | 4.5 Elective - VI (Industry / Entrepreneurship) 20% Theory 80% Practical | 2 | 4 |
| 1.6 Statistics Practical-I | 2 | 4 | 2.6 Statistics Practical-II | 2 | 4 | 3.6 Statistics Practical – III | 2 | 4 | 4.6 Extension Activity | 1 | - |
| - | - | - | 2.7. NME I (MOOC/SWAYAM) | 2 | 2 | 3.7 NME II | 4 | 4 | 4.7 Skill Enhancement course / Professional Competency Skill | 2 | 2 |
| - | - | - | 2.8 Fundamentals of Human Rights | 1 | 2 | 3.8 Internship / Industrial Activity | 2 | - | - | - | - |
| **Total** | **20** | **30** | **-** | **23** | **30** | **-** | **27** | **30** | **-** | **22** | **30** |
| | | | | | | | | | | **Total Credit Points - 92** | |

## 7. Course Structure

| Semester | Sl. No. | Course Code | Title of the Course | Credit | Contact Hrs. per Week | Int. Marks | Ext. Marks | Tot. Marks |
|---|---|---|---|---|---|---|---|---|
| I | 1 | 23UPSTA1C01 | CC1 – Real Analysis and Linear Algebra | 4 | 5 | 25 | 75 | 100 |
| | 2 | 23UPSTA1C02 | CC2 - Sampling Methods | 4 | 5 | 25 | 75 | 100 |
| | 3 | 23UPSTA1C03 | CC3 – Distribution Theory | 4 | 6 | 25 | 75 | 100 |
| | 4 | 23UPSTA1E01/ 23UPSTA1E02/ 23UPSTA1E03 | Categorical Data Analysis / Population Studies / Data Mining | 3 | 5 | 25 | 75 | 100 |
| | 5 | 23UPSTA1E04/ 23UPSTA1E05/ 23UPSTA1E06 | Bayesian Inference / Clinical Trials Statistical Analysis using R Programming | 3 | 5 | 25 | 75 | 100 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 6 | 23UPSTA1L01 | Statistics Practical – I* | 2 | 4 | 40 | 60 | 100 |
| | | | | **20** | **30** | | | **600** |
| **II** | 7 | 23UPSTA1C04 | CC4 - Estimation Theory | 4 | 5 | 25 | 75 | 100 |
| | 8 | 23UPSTA1C05 | CC5 - Measure and Probability Theory | 4 | 5 | 25 | 75 | 100 |
| | 9 | 23UPSTA1C06 | CC6 - Time Series Analysis | 4 | 5 | 25 | 75 | 100 |
| | 10 | 23UPSTA1E07/ 23UPSTA1E08/ 23UPSTA1E09 | Actuarial Statistics / Simulation Analysis / Total Quality Management | 3 | 4 | 25 | 75 | 100 |
| | 11 | 23UPSTA1E10/ 23UPSTA1E11/ 23UPSTA1E12 | Survival Analysis / Econometrics / Statistical Computation using Python | 3 | 3 | 25 | 75 | 100 |
| | 12 | 23UPSTA1L02 | Statistics Practical – II* | 2 | 4 | 40 | 60 | 100 |
| | 13 | 23UPSTA1N01 | Non-Major Elective i (MOOC/SWAYAM) | 2 | 2 | 25 | 75 | 100 |
| | 14 | 23UPPGC1H01 | Fundamentals of Human Rights | 1 | 2 | 25 | 75 | 100 |
| | | | | **23** | **30** | | | **800** |
| **III** | 15 | 23UPSTA1C07 | CC7 – Testing of Statistical Hypothesis | 4 | 5 | 25 | 75 | 100 |
| | 16 | 23UPSTA1C08 | CC8 – Linear Models | 4 | 5 | 25 | 75 | 100 |
| | 17 | 23UPSTA1C09 | CC9–Multivariate Analysis | 4 | 4 | 25 | 75 | 100 |
| | 18 | 23UPSTA1C10 | CC10- Core Industry Module-Statistical Quality Control | 4 | 4 | 25 | 75 | 100 |
| | 19 | 23UPSTA1E13/ 23UPSTA1E14/ 23UPSTA1E15 | Operations Research/ Database Management System / Research Methodology in Statistics | 3 | 4 | 25 | 75 | 100 |
| | 20 | 23UPSTA1L03 | Statistics Practical – III* | 2 | 4 | 40 | 60 | 100 |
| | 21 | 23UPSTA1N02 23UPSTA1N03 23UPSTA1N04 23UPSTA1N05 | Non-Major Elective ii | 4 | 4 | 25 | 75 | 100 |
| | 22 | 23UPSTA1I01 | Internship / Industrial Activity (Carried out in Summer Vacation at the end of I year – 30 hours) | 2 | **-** | - | 100 | 100 |
| | | | | **27** | **30** | | | **800** |
| | 23 | 23UPSTA1C11 | CC11 – Design of Experiments | 4 | 5 | 25 | 75 | 100 |
| | 24 | 23UPSTA1C12 | CC12– Stochastic | 4 | 5 | 25 | 75 | 100 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **IV** | | | Processes | | | | | |
| | 25 | 23UPSTA1P01 | Project with viva voce | 7 | 12 | 40 | 60 | 100 |
| | 26 | 23UPSTA1E16/ 23UPSTA1E17/ 23UPSTA1E18 | Non - Parametric Inference/ Reliability Theory/ Applied Regression Analysis | 2 | 4 | 25 | 75 | 100 |
| | 27 | 23UPSTA1L04 | Statistics Practical – IV* | 2 | 4 | 40 | 60 | 100 |
| | 28 | 23UPSTA1X01 | Extension Activity | 1 | - | - | 100 | 100 |
| | 29 | 23UPSTA1S01 | Skill Enhancement course Statistical Analysis using MS Excel | 2 | 2 | 25 | 75 | 100 |
| | | | | **22** | **30** | **-** | **-** | **700** |
| | | | Total | **92** | | **-** | **-** | **2900** |
| Value Added Courses | | | | | | | | |
| | | 23UPSTA1V01 | Statistical Techniques using Open-Source Software | | | | | |
| | | 23UPSTA1V02 | Statistics for Researchers | | | | | |
| | | 23UPSTA1V03 | Computer Oriented Statistical Methods | | | | | |

* Practical examinations should be conducted at end of the respective semester

## 8. Programme Outcomes (PO) and Programme Specific Outcomes (PSO)

| | |
|---|---|
| | **PO1: Disciplinary Knowledge:** a good theoretical knowledge of the domain Statistics and its methods and techniques.<br>**PO2: Mathematical knowledge:** sharpening mathematical knowledge needed to understand higher levels of Statistics understand multidimensional issues of data.<br>**PO3: Application knowledge:** understanding application of Statistics in various domain. Also understand the interdisciplinary nature of Statistics while applying it. Industrial oriented programming languages are introducing to undertake and solve practical problem in industry.<br>**PO4: Critical Thinking:** examine basic statistical issues in a more logical and methodical manner in a real data given.<br>**PO5: Analytical Reasoning:** to develop capability to identify logical issues in practicing with data, analyze and synthesize data from a variety of sources and accordingly draw conclusions. To acquire capacity for taking central and state government comparative examination (UGC NET, SET, SLET, TNPSC, SSC, TRB, |

| | |
|---|---|
| **Programme Outcomes (POS)** | RBI, UPSC, ISS/IES, ICMR, ICAR etc.)<br>**PO6: Problem Solving skills:** The students will be able to examine various hypotheses involved, and will be able to identify and consult relevant resources to find their rational answers. Also get mathematical problem solving.<br>**PO7: Research Related Skills:** The students should be able to develop original thinking forformulating new problems and providing their solutions.<br>**PO8: Computational skills:** acquire computing skills necessary for solving real life problems in par with the requirement of a job<br>**PO 9 Team work:** experience in team work by engaging in team projects and team assignments. Also have original thinking and creative presentation<br>**PO 10: Communication and soft skills:** Interactive skills and presentation skills |

| | |
|---|---|
| **Programme Specific Outcomes (PSOs)** | **PSO1 – Placement:** To prepare the students who will demonstrate respectful engagement with others' ideas, behaviors, beliefs and apply diverse frames of reference to decisions and actions.<br>**PSO 2 – Entrepreneur:** To create effective entrepreneurs by enhancing their critical thinking, problem solving, decision making and leadership skill that will facilitate startups and high potential organizations.<br>**PSO3 – Research and Development:** Design and implement HR systems and practices grounded in research that comply with employment laws, leading the organization towards growth and development.<br>**PSO4 – Contribution to Business World:** To produce employable, ethical and innovative professionals to sustain in the dynamic business world.<br>**PSO 5 – Contribution to the Society:** To contribute to the development of the society by collaborating with stakeholders for mutual benefit. |

**Cognitive Domain**

(Lower levels: K1: Remembering; K2: Understanding; K3: Applying; Higher levels: K4: Analysing ; K5: Evaluating; K6: Creating)

## Template for PG Programme in Statistics - M.Sc. Statistics Curriculum Design

| Semester-I | Credit | Hours | Semester-II | Credit | Hours | Semester-III | Credit | Hours | Semester–IV | Credit | Hours |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.1 Core-I | 4 | 5 | 2.1 Core-IV | 4 | 5 | 3.1 Core-VII | 4 | 5 | 4.1 Core-XI | 4 | 5 |
| 1.2 Core-II | 4 | 5 | 2.2 Core-V | 4 | 5 | 3.2 Core-VIII | 4 | 5 | 4.2 Core-XII | 4 | 5 |
| 1.3 Core-III | 4 | 6 | 2.3 Core-VI | 4 | 5 | 3.3 Core – IX | 4 | 4 | 4.3 Statistics Practical – IV | 2 | 4 |
| 1.4 Discipline Centric Elective -I | 3 | 5 | 2.4 Discipline Centric Elective-III | 3 | 4 | 3.4 Core – X | 4 | 4 | 4.4 Project with Viva Voce | 7 | 12 |
| 1.5 Generic Elective-II | 3 | 5 | 2.5 Generic Elective-IV | 3 | 3 | 3.5 Discipline Centric Elective - V | 3 | 4 | 4.5 Elective - VI (Industry / Entrepreneurship) 20% Theory 80% Practical | 2 | 4 |
| 1.6 Statistics Practical-I | 2 | 4 | 2.6 Statistics Practical-II | 2 | 4 | 3.6 Statistics Practical – III | 2 | 4 | 4.6 Extension Activity | 1 | - |
| - | - | - | 2.7. NME I (MOOC/SWAYAM) | 2 | 2 | 3.7 NME II | 4 | 4 | 4.7 Skill Enhancement course / Professional Competency Skill | 2 | 2 |
| - | - | - | 2.8 Fundamentals of Human Rights | 1 | 2 | 3.8 Internship / Industrial Activity | 2 | - | - | - | - |
| **Total** | **20** | **30** | **-** | **23** | **30** | **-** | **27** | **30** | **-** | **22** | **30** |
| | | | | | | | | | | | **Total Credit Points - 92** |

## 9. Credit Distribution for M.Sc. Statistics

### First Year- Semester I

| | Courses | Credit | Hours per Week (L/T/P) |
|---|---|---|---|
| Part A | Core Courses 3 (CC1, CC2, CC3) | 12 | 16 |
| | Elective Courses 2(Generic / Discipline Specific) EC1, EC2 | 06 | 10 |
| Part B | Skill Enhancement Course -SEC 1 - Statistics Practical-I | 02 | 04 |
| | **Total** | **20** | **30** |

### Semester-II

| | Courses | Credit | Hours per Week (L/T/P) |
|---|---|---|---|
| Part A | Core Courses 3 (CC4, CC5, CC6) | 12 | 15 |
| | Elective Course 2 (Generic / Discipline Specific) EC3, EC4 | 06 | 07 |
| Part B | Skill Enhancement Course -SEC 2 – Statistics Practical - II | 02 | 04 |
| Part C | Non-Major Elective 1 (MOOC/SWAYAM) | 02 | 02 |
| | Fundamentals of Human Rights | 01 | 02 |
| | **Total** | **23** | **30** |

### Second Year – Semester - III

| | Courses | Credit | Hours per Week(L/T/P) |
|---|---|---|---|
| Part A | Core Courses 4 (CC7, CC8, CC9, CC10) | 16 | 18 |
| | Elective Course 1 (Generic / Discipline Specific) EC-5 | 03 | 04 |
| Part B | Skill Enhancement Course -SEC 3 – Statistics Practical - III | 02 | 04 |
| Part C | Non-Major Elective 2 | 04 | 04 |
| | Internship / Industrial Activity (Carried out in Summer Vacation at the end of I year – 30 hours) | 02 | - |
| | **Total** | **27** | **30** |

**Semester-IV**

| Part | Courses | Credit | Hours per Week(L/T/P) |
|---|---|---|---|
| Part A | Core Courses 2 (CC11, CC12) | 8 | 10 |
| | Elective Course 1 (Generic / Discipline Specific) EC-6 (20% Theory and 80% Practical) | 02 | 04 |
| | Project with Viva voce | 07 | 12 |
| Part B | Skill Enhancement Course - SEC- Statistics Practical-IV | 02 | 04 |
| | Skill Enhancement course / Professional Competency Skill | 02 | 02 |
| Part C | Extension Activity (Can be carried out from Sem II to Sem IV) | 01 | - |
| | Total | **22** | **30** |

**Part A and Part B component will be taken into account for CGPA calculation for the postgraduate programme and the other components Part B and Part C have to be completed during the duration of the programme as per the norms, to be eligible for obtaining the PG degree.**

**M.Sc. Statistics**

| | First Year Semester- I | Credit | Hours per Week (L/T/P) |
|---|---|---|---|
| Part A | CC1 - Real Analysis and Linear Algebra | 04 | 05 (4L+1T) |
| | CC2 - Sampling Methods | 04 | 05 (4L+1T) |
| | CC3 - Distribution Theory | 04 | 06 (5L+1T) |
| | Elective I (Generic / Discipline Specific) (One from Group A) | 03 | 05 (3L+2T) |
| | Elective II (Generic / Discipline Specific) (One from Group B) | 03 | 05 (3L+2T) |
| Part B | Skill Enhancement Course - SEC 1 Practical - I | 02 | 04P |
| | **Total** | **20** | **30** |

| | Semester-II | Credit | Hours per Week (L/T/P) |
|---|---|---|---|
| Part A | CC4 – Estimation Theory | 04 | 05 (4L+1T) |
| | CC5 – Measure and Probability Theory | 04 | 05 (4L+1T) |
| | CC6 - Time Series Analysis | 04 | 05 (3L+2T) |
| | Elective III (Generic / Discipline Specific) (One from Group C) | 03 | 04 (3L+1T) |
| | Elective-IV (Computer / IT related) (One from Group D) | 03 | 03 (3L) |
| Part B | Skill Enhancement Course -SEC 2, Practical – II | 02 | 04P |
| Part C | Non-Major Elective - I | 02 | 02 |
| | Fundamentals of Human Rights | 01 | 02 |
| | **Total** | **23** | **30** |

Internship during Summer Vacation. The Credits shall be awarded in Semester – III Statement of Marks

| | **Second Year - Semester-III** | **Credit** | **Hours per Week (L/T/P)** |
|---|---|---|---|
| Part A | CC7 - Testing of Statistical Hypothesis | 04 | 05 (4L+1T) |
| | CC8 - Linear Models | 04 | 05 (4L+1T) |
| | CC9 – Multivariate Analysis | 04 | 04 (4L) |
| | Elective V(Generic / Discipline Specific)(One from Group E) | 03 | 04 (3L+1T) |
| | Core Industry Module – Statistical Quality Control | 04 | 04 (3L+1T) |
| Part B | Skill Enhancement Course -SEC 3: Practical – III | 02 | 04P |
| Part C | Non-Major Elective - II | 04 | 04 |
| | Internship / Industrial Activity (Carried out in Summer Vacation at the end of I year – 30 hours) | 02 | - |
| | **Total** | **27** | **30** |

| | **Semester-IV** | **Credit** | **Hours per week (L/T/P)** |
|---|---|---|---|
| Part A | CC10 - Design of Experiments | 4 | 5 (4L+1T) |
| | CC11 - Stochastic Process | 4 | 5 (4L+1T) |
| | Elective VI (Generic / Discipline Specific) (One from Group F) | 2 | 4 (2L+2P) |
| | Core Project with viva voce | 7 | 12 |
| Part B | Skill Enhancement Course -SEC 4: Practical – IV | 2 | 4P |
| | Skill Enhancement course / Professional Competency Skill | 2 | 2L |
| Part C | Extension Activity | 1 | - |
| | **Total** | **22** | **30** |

**TOTAL CREDITS: 92**

**Consolidated Table for Credits Distribution**

| | Category of Courses | Credits for each Course | Number of Courses | Total Credits | Total Credits for the Programme |
|---|---|---|---|---|---|
| PART A | Core +<br>Elective +<br>Project with viva voce | **48+**<br>**17+**<br>**7** | **12 +**<br>**6 +**<br>**1** | **72** | **82 (CGPA)** |
| PART B | 1 Skill Enhancement Courses (Practical) | **8+** | **4+** | **10** | |
| | 2 Skill Enhancement course / Professional Competency Skill | **2** | **1** | | |
| PART C<br>(i)<br>(ii) | (NME I and NME II) +<br>Fundamentals of Human Rights | **(2+4) +**<br>**1** | **(1+1) +**<br>**1** | **10** | **10 (Non CGPA)** |
| | Summer Internship | **2** | **1** | | |

| | | | | | |
|---|---|---|---|---|---|
| (iii)<br>(iv) | Extension Activity | **1** | **1** | **1** | |
| | **Total Credits** | | | **92** | |

**Marks and Grades**

The following table gives the marks, grade points, letter grades and classification to indicate the performance of the candidate.

| Range of Marks | Grade Points | Letter Grade | Description |
|---|---|---|---|
| 90-100 | 9.0-10.0 | O | Outstanding |
| 80-89 | 8.0-8.9 | D+ | Excellent |
| 75-79 | 7.5-7.9 | D | Distinction |
| 70-74 | 7.0-7.4 | A+ | Very Good |
| 60-69 | 6.0-6.9 | A | Good |
| 50-59 | 5.0-5.9 | B | Average |
| 00-49 | 0.0-4.9 | U | Re-appear |
| **Absent** | **0.0** | **AAA** | **Absent** |

$C_i$ = Credits earned for course *i* in any semester.

$G_i$ = Grade point obtained for course *i* in any semester

*n* = Refers to the semester in which such courses were credited.

**a. Semester:**

GRADE POINT AVERAGE (GPA)

$$GPA = \frac{\text{Sum of the multiplication of grade points by the credits of the courses}}{\text{Sum of the credits of the courses in a semester}}$$

| GPA | *GRADE* | *CLASSIFICATION OF FINAL RESULT* |
|---|---|---|
| 9.5 - 10.0 | O+ | First class with Exemplary* |
| 9 and above but below 9.5 | O | |
| 8.5 and above but below 9.0 | D++ | First class with Distinction* |
| 8.0 and above but below 8.5 | D+ | |
| 7.5 and above but below 8.0 | D | |
| 7.0 and above but below 7.5 | A++ | First Class |
| 6.5and above but below 7.0 | A+ | |
| 6.0 and above but below 6.5 | A | |
| 5.5 and above but below 6.0 | B+ | Second class |
| 5.0 and above but below 5.5 | B | |
| 0.0 and above but below 5.0 | ***U*** | Re-appear |

**CUMULATIVE GRADE POINT AVERAGE (CGPA)**

$$CGPA = \frac{\text{Sum of the multiplication of grade points by the credits of the entire programme}}{\text{Sum of the credits of the courses of the entire programme}}$$

| CGPA | *GRADE* | *CLASSIFICATION OF FINAL RESULT* |
|---|---|---|
| 9.5 - 10.0 | O+ | First class with Exemplary* |
| 9 and above but below 9.5 | O | |
| 8.5 and above but below 9.0 | D++ | First class with Distinction* |
| 8.0 and above but below 8.5 | D+ | |
| 7.5 and above but below 8.0 | D | |
| 7.0 and above but below 7.5 | A++ | First Class |
| 6.5and above but below 7.0 | A+ | |
| 6.0 and above but below 6.5 | A | |
| 5.5 and above but below 6.0 | B+ | Second class |
| 5.0 and above but below 5.5 | B | |
| 0.0 and above but below 5.0 | ***U*** | Re-appear |

* The candidates who have passed in the first appearance and within the prescribed semester of the PG Programme (Core, Elective, Non-major Electives and Extra-Disciplinary courses alone) are eligible

**CORE COURSES - CC**

| S. No. | Course No. | Title of the Course |
|---|---|---|
| 1 | I | Real Analysis and Linear Algebra |
| 2 | II | Sampling Methods |
| 3 | III | Distribution Theory |
| 4 | IV | Estimation Theory |
| 5 | V | Measure and Probability Theory |
| 6 | VI | Time Series Analysis |
| 7 | VII | Testing of Statistical Hypotheses |
| 8 | VIII | Linear Models |
| 9 | IX | Multivariate Analysis |
| 10 | X | Industry Module -Statistical Quality Control |
| 11 | XI | Design of Experiments |
| 12 | XII | Stochastic Process |

**Elective Courses - ED**

| Group | No. | Title of the Course | |
|---|---|---|---|
| A | I | 1 | Categorical Data Analysis (Generic Specific) |
| | II | 2 | Population Studies (Generic Specific) |
| | III | 3 | Data Mining (Discipline Specific) |
| B | IV | 1 | Bayesian Inference (Discipline Specific) |
| | V | 2 | Clinical Trials (Generic Specific) |
| | VI | 3 | Statistical Analysis using R Programming (Generic Specific) |
| C | VII | 1 | Actuarial Statistics (Discipline Specific) |
| | VIII | 2 | Simulation Analysis (Discipline Specific) |
| | IX | 3 | Total Quality Management(Generic Specific) |
| D | X | 1 | Survival Analysis (Computer/IT related) |
| | XI | 2 | Econometrics (Computer/IT related) |
| | XII | 3 | Statistical Computation using Python (Computer/IT related) |
| E | XIII | 1 | Operations Research (Discipline Specific) |
| | XIV | 2 | Database Management System (Discipline Specific) |
| | XV | 3 | Research Methodology in Statistics (Generic Specific) |
| F | XVI | 1 | Non - Parametric Inference (Industry) |
| | XVII | 2 | Reliability Theory (Industry) |
| | XVIII | 3 | Applied Regression Analysis (Entrepreneurship) |

Semester I: Elective I to be chosen from Group A and Elective II to be chosen from Group B

Semester II: Elective III to be chosen from Group C and Elective IV to be chosen from Group D

Semester III: Elective V to be chosen from Group E.

Semester IV: Elective VI to be chosen from Group F.

**Skill Enhancement Courses SEC: Group G (Skill Enhancement Courses)**

| S. No. | Course No. | Title of the Course |
|---|---|---|
| 1 | I | Statistics Practical – I |
| 2 | II | Statistics Practical – II |
| 3 | III | Statistics Practical – III |
| 4 | IV | Statistics Practical –IV |
| 5 | IV | Skill Enhancement course<br>Statistical Analysis using MS Excel |

**Non-Major Elective Courses for other Departments (not for Statistics students) EDC**

Students from other Departments may also choose any one of the following as Extra Disciplinary Course.

| Semester | S. No. | Title of the Course |
|---|---|---|
| II | **Non- Major Elective – I** | |
| | 1 | Non-Major Elective 1 (MOOC/SWAYAM) (23UPSTA1N01) |

| | | |
|---|---|---|
| | **Non- Major Elective – II** | |
| III | 1 | Basic Statistical Methods (23UPSTA1N02) |
| | 2 | Statistics for Behavioural Sciences (23UPSTA1N03) |
| | 3 | Probability and Statistics for Scientists (23UPSTA1N04) |
| | 4 | Statistics Data Analysis using R (23UPSTA1N05) |

## 10. EXAMINATION PATTERN

For Theory papers: 100 marks

Internal 25 marks and External 75 marks

For Practical papers: 100 marks

Internal 40 marks and External 60 marks

**Internal Assessment**

**Theory Course:** For theory courses there shall be three tests conducted by the faculty concerned and the average of the best two can be taken as the Continuous Internal Assessment (CIA) for a maximum of 25 marks. The duration of each test shall be one / one and a half hour.

**Practical Courses:** For Practical oriented courses, there shall be two tests in Theory part and two tests in Laboratory part. Choose one best from Theory part and other best from the two Laboratory part. The average of the best two can be treated as the CIA for a maximum of 40 marks. The duration of each test shall be one / one and a half hour.

There is no improvement for CIA of both theory and laboratory, and, also for University End Semester Examinations.

**Question Paper Pattern**

**Theory Papers**

**Marks for Internal**: (Max.Marks:25)

| **Internal marks distribution:** | | | |
|---|---|---|---|
| | Cycle test and model Exam | : | 15 marks |
| | Assignment | : | 05 marks |
| | Seminar | : | 05 marks |
| | **Total** | **:** | **25 marks** |

**Marks for External:** (Max.Marks:75)

| | |
|---|---|
| **Intended Learning Skills**<br><br>Memory Recall / Example/ Counter Example / Knowledge about the Concepts/ Understanding | **Maximum 75 Marks**<br>**Passing Minimum: 50%**<br>**Duration: Three Hours** |
| | **Part –A** (**20 x 1 = 20 Marks**)<br>Answer **ALL** questions<br>**Each Question carries 1 Marks** |
| | Four questions from each UNIT |
| | **Question 1 to Question 20** |
| Descriptions/ Application (problems) | **Part – B (3 x 5 = 15 Marks)**<br>Answer **any Three** questions (internal choice)<br>Each questions carries 5 Marks |
| | TWO questions from each UNIT<br>**Either - or Type**<br>Both parts of each question from the same UNIT |
| | **Question 26(a) or 26(b)**<br>**To**<br>**Question 30(a) or 30 (b)** |
| | **Part-C (5x 8 = 40 Marks)**<br>Answer **All** the questions<br>Each question carries 8 Marks |

**Practical papers**

| **TIME:3 Hours, Maximum Marks: 100 marks (40(IA) + 60(SE))** | | | |
|---|---|---|---|
| **Internal marks distribution:** | | | |
| | Model Exam | : | 10 marks |
| | Record work | : | 25 marks |
| | Attendance | : | 5 marks |
| | **Total** | **:** | **40 marks** |

**Question pattern for Practical**

Three questions are to be set with internal choice. All question carries equal marks.

| **Time: 3hrs** | | **Maximum marks: 60** | |
|---|---|---|---|
| **Part – A (3 x 20 = 60)**<br>Answer **ANY THREE** questions<br>(Internal choice) | | | |
| **External marks distribution:** | | | |
| | Write and Type the Programme (3 X 15) | : | 45 marks |
| | Run the Programme (3 X 3) | : | 09 marks |
| | Correct output (3 X 2) | **:** | 06 marks |
| | **Total** | : | **60 marks** |

**Project work:** (maximum marks): IA: 40 marks and SE: 60 marks Each question should carry the course outcome and cognitive level

## 11 SYLLABUS

### 11.1 Syllabus for Core Courses

<table>
<tr><th colspan="8">11.1.1 Real Analysis and Linear Algebra</th></tr>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Real Analysis and Linear Algebra</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">Core I</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">CourseCode</td><td rowspan="2">23UPSTA1C01</td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td>Tutorial</td><td colspan="2">Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">4</td><td>1</td><td colspan="2">--</td><td>5</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Undergraduate level Vector Algebra and Matrix Theory</td></tr>
<tr><td colspan="2">Objectives of theCourse</td><td colspan="6">1. To provide recollection as well as building Mathematical foundation in Real Analysis and Matrix Theory<br>2. To understand concepts and definition of metric space and theorems related to it<br>3. To know integration and differentiation concepts and its application, to know real functions in one variable as well as several variables, understand it on numerical problems<br>4. To know Linear space and its basis. Rank of a matrix, characteristic roots and its multiplicity, Different types of inverses, numerical examples and real-life application<br>5. To know Different types of matrices, orthogonality, canonical forms, decomposition of matrix, quadratic forms, numerical examples and real-life applications.</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">UNIT I: Metric Space – open, closed sets – Intervals (rectangles), Real valued Continuous functions- Discontinuities - Compact sets, Bolzano – Weirstrass theorem, Heine – Borel theorem.</td></tr>
<tr><td colspan="6">Unit II: Derivatives - maxima and minima - Riemann integral and Riemann – Stieltjes integral with respect an increasing integrator – properties of R.S. integral. Functions of several variables, constrained and unconstrained maxima – minima of functions, partial and total derivatives.</td></tr>
<tr><td colspan="6">Unit III: Basic properties of matrices (orthogonal, idempotent, Kronecker product, projection operators etc.); Linear dependence, independence and rank of a matrix; characteristic roots and polynomial, multiplicity of characteristic roots; Cayley Hamilton theorem; inverse of a matrix and determinants.</td></tr>
<tr><td colspan="6">Unit IV: Reduction of matrices, Echelon form, Hermite canonical form, diagonal reduction, rank factorization, triangular reduction Jordan form; Symmetric matrices and its properties; Decomposition like, singular value decomposition, spectral decomposition, Cholesky decomposition etc.</td></tr>
<tr><td colspan="6">Unit V: Matrix differentiation; Generalized inverse and its properties, Moore-Penrose inverse; Application of g-inverse; Quadratic forms, classification, definiteness, index and signature, extremum; transformation and reduction of quadratic form; applications of quadratic forms.</td></tr>
</table>

| | |
|---|---|
| Extended Professional Component (is a part of internal component only, not to be included in the External Examination question paper) | Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved. (To be discussed during the Tutorial hour) |
| Skills acquired from this Course | Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |

| | |
|---|---|
| **Recommended Text** | 1. Rudin, Walter (1976): Principles of Mathematical Analysis, McGraw Hill.<br>2. Apostol, T.M. (1985): Mathematical Analysis, Narosa, Indian Ed.<br>3. Graybill, F.A. (1983): Matrices with application in Statistics, 2nd ed. Wadsworth.<br>4. Rao, C. R. and Bhimasankaran, P. (1992): Linear algebra, Tata McGraw Hill Pub. Co. Ltd.<br>5. Searle, S.R. (1982) : Matrix Algebra useful for Statistics, John Wiley and Sons, Inc. |
| **Reference Books** | 1. Royden H.L. (1995): Real Analysis, 3rd edition, Prentice Hall of India.<br>2. Rangachari, M. S. (1996): Real Analysis, Part 1, New Century Book House.<br>3. Ash, R.B. (1972): Real analysis and probability, Academic press.<br>4. Biswas, S. (1984): Topics in Algebra of Matrices, Academic Publications.<br>5. David, A.Harville (1997) : Matrix algebra from a statistician's perspective, Springer.<br>6. Hoffman, K. and Kunze, R. (1971): Linear Algebra, 2nd ed. Prentice Hall, Inc. |
| **Website and e-Learning Source** | e-books, tutorials on MOOC/SWAYAM courses on the subject |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

**CLO 1:** Get a Mathematical foundation in real analysis and matrix theory to understand univariate and multivariate concepts in statistical theory.

**CLO 2:** Get a clear understanding R.S. integral, partial differentiation in several variable functions, get theoretical knowledge by understanding the need and application of theorems like Bolzano – Weirstrass theorem, Heine– Borel theorem.

**CLO 3:** Understand concepts in matrix theory -rank and factorization, inverse of matrix, *g*-inverses and its applications, characteristic roots and its multiplicity, canonical forms and decomposition of matrix, orthogonality, quadratic forms and its index, solving linear system.

**CLO 4:** Able to get solve numerical problems and evaluate and interpret outcome.

**CLO 5:** Analyze real life problems and explore research problems.

**CO-PO Mapping (Course Articulation Matrix)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | M | M | M | S | M | S | M | M |
| **CO2** | S | S | S | S | M | S | M | S | M | M |
| **CO3** | S | S | S | M | S | S | M | S | S | M |
| **CO4** | M | S | S | S | S | S | S | S | M | M |
| **CO5** | S | S | S | S | M | S | S | S | M | M |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

| 11.1.2 Sampling Methods | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Title of the Course** | **Sampling Methods** | | | | | | | |
| **Paper Number** | **Core II** | | | | | | | |
| **Category** | **Core** | **Year** | I | **Credits** | 4 | **Course Code** | **23UPSTA1C02** | |
| | | **Semester** | I | | | | | |
| **Instructional Hours per week** | **Lecture** | | **Tutorial** | | **Lab Practice** | | **Total** | |
| | 4 | | 1 | | -- | | 5 | |
| **Pre-requisite** | Undergraduate Statistical Inference | | | | | | | |
| **Objectives of the Course** | 1. To cover sampling design and analysis methods<br>2. To explain and compare various sampling procedures.<br>3. To understand the concepts of bias and sampling variability and strategies for reducingthe bias and sampling variability. | | | | | | | |
| **Course Outline** | **UNIT I:** Preliminaries – Need for Sampling – The Principal Advantages of Sampling – The Principal Steps in a sample surveys – Limitations Sampling - Simple Random Sampling – The Sample Mean – Variance of SRS - PPS selection methods. | | | | | | | |
| | **UNIT II:** Midzuno sampling method – PPSWR and PPSWOR sampling methods – Ordered andUnordered estimators | | | | | | | |
| | **UNIT III:** Stratified Sampling – Allocation Problems – Systematic Sampling Methods – Balanced, Modified and Centered systematic sampling methods – Yates corrected estimator. | | | | | | | |
| | **UNIT IV:** Ratio Estimation – Unbiased Ratio Type estimators – Regression Estimation - Double Sampling for Ratio and Regression Estimation | | | | | | | |
| | **UNIT V:** Multistage Sampling - Randomized Response Methods – Call Back Techniques | | | | | | | |
| Extended Professional Component (is a part of internal component only, not to be included in the External Examination question paper) | Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / applied survey techniques adopted in Economics and Statistics department of Tamil Nadu State Government.<br><br>(To be discussed during the Tutorial hour) | | | | | | | |
| Skills acquired from this course | Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill | | | | | | | |

| | |
|---|---|
| **Recommended Text** | 1. S.Sampath (2005):Sampling Theory and Methods, Narosha Publishing House.<br>2. W.G. Cochran (1965):Sampling Techniques, Wiley and Sons. |
| **Reference Books** | 1. M.N.Murthy(1967) : Sampling Theory and Methods: Statistical Publishing Society, Calcutta Parimal Mukhopadhyay (2005) : Theory and Methods of Survey Sampling , Prentice Hall of India.<br>2. P.V.Sukhatme, B.V.Sukhatme, S.Sukhatme and C.Asok (1984) Theory of Same Surveys with Applications, IASRI, New Delhi. |
| **Website and e-Learning Source** | e-books, online tutorials taken from MOOC/SWAYAM platform for thissubject. |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

1. To apply basics and advanced levels of sampling methods for different types of data.
2. To draw a conclusion about the best sampling procedure.
3. To use practical applications of ratio and regression method of estimations.
4. To analyze data from multi-stage sampling methods.
5. To estimate the hidden responses using randomized response techniques.

**CO-PO Mapping (Course Articulation Matrix)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | S | M | S | S | M | S | S | M |
| **CO2** | M | S | S | S | M | S | S | S | M | M |
| **CO3** | S | S | S | M | S | S | S | M | S | M |
| **CO4** | S | S | S | S | S | S | S | M | M | M |
| **CO5** | S | M | S | M | M | S | S | M | M | S |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

<table>
<tr><th colspan="8">11.1.3 Distribution Theory</th></tr>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Distribution Theory</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">Core III</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td>Course Code</td><td rowspan="2">23UPSTA1C03</td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td>Tutorial</td><td colspan="2">Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">4</td><td>1</td><td colspan="2">--</td><td>5</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Undergraduate level Mathematics.</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">1. To provide theoretical knowledge on the concept of functions of random variables andits usage.<br>2. To educate the knowledge on the both discrete and continuous distributions.<br>3. To acquire the knowledge on deriving its characteristics of distributions.</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">Unit I: Brief review of distribution theory, functions of random variables and their distributions using Jacobian of transformation, Laplace and Cauchy distribution, lognormal distribution, gamma, logarithmic series.</td></tr>
<tr><td colspan="6">Unit II: Bivariate Normal Distribution – Compound and truncated distributions of Binomial, Poisson and Normal distributions.</td></tr>
<tr><td colspan="6">Unit III: Sampling distributions, non-central chi-square distribution, t and F distributions and their properties, distributions of quadratic forms under normality and related distribution theory – Cochran’s and James theory.</td></tr>
<tr><td colspan="6">Unit IV: Order statistics their distributions and properties, Joint and marginal distributions of order statistics, extreme value and their asymptotic distributions, approximating distributions of sample moment, delta method.</td></tr>
<tr><td colspan="6">Unit V: Kolmogorov Smirnov distributions, life distributions, exponential, Weibull and extreme value distributions Mills ratio, distributions classified by hazard rate.</td></tr>
<tr><td colspan="2">Extended Professional Component (is a partof Internal component only, Not to be included in the External Examination question paper)</td><td colspan="6">Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved<br>(To be discussed during the Tutorial hour)</td></tr>
<tr><td colspan="2">Skills acquired from this course</td><td colspan="6">Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">1. Gibbons (1971) : Non-parametric inference, Tata McGraw Hill.<br>2. Rohatgi, V.K. and Md. Whsanes Saleh, A.K.(2002): An introduction to probability &Statistics, John Wiley and Sons.</td></tr>
</table>

| | |
|---|---|
| **Reference Books** | 1. Rao C.R. (1973): Linear statistical inference and its applications, 2nd, Wiley Eastern.<br>2. Mood, A.M. and Graybill, F.A. and Boes, D.C.: Introduction to the theory of statistics, McGraw Hill Johnson, S. & Kotz,(1972): Distributions in Statistics, Vol. I, II & III, Hougton and Miffin.<br>3. Dudewicz, E.J., Mishra, S.N. (1988): Modern mathematical statistics, John Wiley.Searle, S.R. (1971):Linear models, John Wiley.<br>4. Primal Mukopadhyay (2006) Mathematical Statistics, 3rd edition, New Central Book Agency. |
| **Website and e-Learning Source** | e-books, online tutorials taken from MOOC/SWAYAM platform for thissubject. |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

1. To understand the knowledge on importance of the random variables and its role in the distribution theory.
2. To interpret the properties of special univariate continuous distributions, truncated normal distribution and few non-central distributions.
3. To explain the moments for the data come from the univariate and bivariate distributions.
4. To interpret the distributions of order statistics with regard to Median, Sample Range and Joint distribution of order two.
5. To identify the data distribution based on One sample and two samples using KS tests.

**CO-PO Mapping (Course Articulation Matrix)**

| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | S | M | S | S | S | M | S | M |
| **CO2** | M | S | S | M | M | S | M | M | M | M |
| **CO3** | S | S | S | S | S | S | S | M | S | M |
| **CO4** | M | S | S | S | S | S | M | M | M | M |
| **CO5** | S | M | S | S | S | S | S | M | M | S |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| **CO /PO** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to POS** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

<table>
<tr><td colspan="8">11.1.4 Estimation Theory</td></tr>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Estimation Theory</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">Core IV</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1C04</td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td>Tutorial</td><td colspan="2">Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">4</td><td>1</td><td colspan="2">--</td><td>5</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Probability Theory</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">1. To make the students to understand the basic concepts of the statistical estimationtheory.<br>2. To study the properties of ideal estimators like unbiasedness, consistency, sufficiency,completeness.<br>3. To educate various estimation methods like method of moments, method of maximum likelihood, interval estimate, and Bayes estimate.</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">Unit I: Sufficient statistics, Neyman, Fisher Factorisation theorem, the existence and construction of minimal sufficient statistics, Minimal sufficient statistics and exponential family, sufficiency and completeness, sufficiency and invariance.</td></tr>
<tr><td colspan="6">Unit II: Unbiased estimation: Minimum variance unbiased estimation, locally minimum variance unbiased estimators, Rao Blackwell – theorem. Completeness- Lehmann Scheffe theorems,Necessary and sufficient condition for unbiased estimators.</td></tr>
<tr><td colspan="6">Unit III: Cramer- Rao lower bound, Bhattacharya system of lower bounds in the 1-parameter regular case. Chapman-Robbins inequality.</td></tr>
<tr><td colspan="6">Unit IV: Maximum likelihood estimation, computational routines, strong consistency of maximum likelihood estimators, Asymptotic Efficiency of maximum likelihood estimators, Best Asymptotically Normal estimators, Method of moments.</td></tr>
<tr><td colspan="6">Unit V: Bayes' and minimax estimation: The structure of Bayes' rules, Bayes' estimators for quadratic and convex loss functions, minimax estimation, interval estimation.</td></tr>
<tr><td colspan="2">Extended Professional Component (is a partof internal component only, Notto be included in theExternal Examination question paper)</td><td colspan="6">Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved<br>(To be discussed during the Tutorial hour)</td></tr>
<tr><td colspan="2">Skills acquired from this course</td><td colspan="6">Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">1. V.K. Rohatgi et.al.(2002) : An introduction to probability and statistics, John Wiley.Lehmann, E.L. (1983): Theory of point estimation, John Wiley.<br>2. M. Rajagopalan and P. Dhanavanthan (2012): Statistical Inference, PHI Learning Pvt Ltd, New Delhi.</td></tr>
</table>

| | |
|---|---|
| **Reference Books** | 1. Zacks, S. (1971): The theory of statistical inference, John Wiley.<br>2. Rao, C.R. (1973): Linear statistical inference and its applications, Wiley Eastern, 2nded.<br>3. Ferguson, T.S. (1967): Mathematical statistics, A decision theoretic approach,Academic press, New York and London.<br>4. Lindley, D.V. (1965): Introduction to probability and statistics, Part 2, Inference,Cambridge University Press. |
| **Website and e-Learning Source** | e-books, online tutorials taken from MOOC/SWAYAM platform for thissubject. |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

1. To understand the consistency, sufficiency and unbiasedness.
2. To understand the concepts and drive the uniformly minimum variance unbiased estimators.
3. To derive the inequality including CR inequality, KCR inequality and Bhattacharya inequality.
4. To estimate the parameter using method of moments, method of MLE, Interval estimation and shortest with confidence intervals.
5. To learn the concepts and to apply simple numerical illustration for Loss function, Risk function and Bayes estimate.

**CO-PO Mapping (Course Articulation Matrix)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | S | S | S | S | S | S | S | M |
| **CO2** | S | S | S | S | M | S | M | S | M | M |
| **CO3** | S | S | S | M | S | S | M | M | S | M |
| **CO4** | S | S | S | S | S | S | S | M | M | M |
| **CO5** | S | M | S | S | S | S | S | M | M | S |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to POS** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

<table>
<tr><td colspan="8">11.1.5 Measure and Probability Theory</td></tr>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Measure and Probability Theory</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">CORE V</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1C05</td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td colspan="2">Tutorial</td><td>Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">4</td><td colspan="2">1</td><td>--</td><td>5</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Undergraduate level Mathematics.</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">1. This paper provides mathematical background for the knowledge of Probability Theory extended from measure theoretical approach.<br>2. The students will be able to understand the basic concepts of the distribution function and random variables that help in understanding for estimation and testing problems in Statistical Inference.<br>3. The fundamentals of this course will pave the way for further research.</td></tr>
<tr><td colspan="2" rowspan="4">Course Outline</td><td colspan="6">Unit I: Measure Theory - Limits of sequence of sets, classes of sets – Field, Sigma Field and Monotone class, Measure and Measure Space – Measurable function.</td></tr>
<tr><td colspan="6">Unit II: Lebesgue – Stieltjes measure, Measure integral and its properties, Dominated convergence theorem – Radon–Nikodymn theorem, almost everywhere convergence, convergencein measure and convergence in mean.</td></tr>
<tr><td colspan="6">Unit III: Events, sample space, different approaches to probability, random variables and random vector, Distribution functions of random variables and random vector, Expectation and moments, basic, Markov, Chebyshev’s, Holder’s, Minkowski’s and Jensen’s inequalities.</td></tr>
<tr><td colspan="6">Unit IV: Independence of sequence of events and random variables, conditional probability, conditional expectation, Characteristic functions and their properties, inversion formula, convergence of random variables, convergence in probability, almost surely, in the r-th mean and in distribution, their relationships, convergence of moments, Helly-Bray theorem, continuity theorem and convolution of distributions.</td></tr>
<tr><td colspan="2"></td><td colspan="6">Unit V: Central limit theorem, statement of CLT, Lindeberg, Levy and Liapounov forms with proof and Lindeberg Feller’s form examples. Khintchine weak law of large numbers, Kolmogorov inequality, strong law of large numbers</td></tr>
</table>

| | |
|---|---|
| Extended Professional Component (is a partof Internal component only, Not to be included in theExternal Examination question paper) | Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved<br>(To be discussed during the Tutorial hour) |
| Skills acquired from this course | Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommend edText** | 1. Bhat, B.R. (1985): Modern probability theory, 2nd ed. Wiley Eastern.<br>2. Chow, Y.S. and Teicher, H. (1979): Probability theory, Springer Verlag.<br>3. Chung, K.L. et al: A course in probability theory, Academic press. |
| **Reference Books** | 1. Parthasarthy, K.R. (1977): Introduction to probability and measure, MacMillan Co.,Breiman, L. (1968): Probability, Addison Wesley.<br>2. Munroe, M.E. (1971): Measure and integration, 2nd ed. Addison Wesley. Halmos, P.R.(1974): Measure theory, East-West.<br>3. De Barr, G. (1987): Measure theory and integration, Wiley Eastern. |
| **Website and e-Learning Source** | e-books, online tutorials taken from MOOC/SWAYAM platform for thissubject. |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

1. Resolve problems that occur in the sequences of sets and classes of sets.
2. Provide critical thinking in Integrals and their application to Probability Theory.
3. Evaluate, integrate, and apply appropriate tools in Probability and Conditional Probability.
4. Demonstrate the ability to apply basic methods in analyzing the convergence in Probability and rth mean and in Distribution and Characteristics functions.
5. Demonstrate critical thinking skills, such as problem solving using weak and strong law of large numbers and different forms of Central Limit Theorems.

**CO-PO Mapping (Course Articulation Matrix)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | S | S | S | S | M | S | S | M |
| **CO2** | S | M | S | S | M | M | S | M | M | M |
| **CO3** | S | S | S | M | S | S | S | M | S | M |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO4** | S | S | S | S | S | S | S | M | M | M |
| **CO5** | S | M | S | S | S | S | S | M | M | S |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to POS** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

<table>
<tr><td colspan="8">11.1.6 Time Series Analysis</td></tr>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Time Series Analysis</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">Core VI</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1C06</td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td>Lecture</td><td colspan="2">Tutorial</td><td colspan="2">Lab Practice</td><td>Total</td></tr>
<tr><td>4</td><td colspan="2">1</td><td colspan="2">--</td><td>5</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">UG level time series modelling</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">1. Understanding of various components of time series and forecasting univariate time series<br>2. Apply different methods for fitting time series models<br>3. Understanding various important concepts in forecasting and smoothing methods<br>4. Understanding stationary and non-stationary nature of time series data</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">Unit I: Time Series – Introduction – components of time series – stationary and non-stationary time series - differencing method to convert non-stationary series – concept of co integration.</td></tr>
<tr><td colspan="6">Unit II: Standard statistical measures for Time Series analysis: Absolute measures – Mean absolute error, Mean error, Mean square error. Relative measures – Percentage error, Mean percentage error, Mean absolute percentage error.</td></tr>
<tr><td colspan="6">Unit III: Smoothing methods – Single exponential smoothing. Double exponential smoothing (Holt method). Triple exponential smoothing (Holt-Winter’s method).</td></tr>
<tr><td colspan="6">Unit IV: Decomposition method: Additive and Multiplicative decomposition – Forecast and Confidence Intervals – Kruskal-Wallis test for seasonality - Moving average Forecasting – Spencer’s and Henderson’s moving averages (without derivation). Stationary and Non-stationary Time series- Auto correlation function (ACF) and Partial Auto correlation function (PACF)- Portmanteau tests:Ljung–Box test and Box–Pierce test.</td></tr>
<tr><td colspan="6">Unit V: ARIMA models: Random model ARIMA (0,0,0), Non-Stationary Random model, ARIMA (0,1,0), Stationary Auto Regressive model of order one-ARIMA (1,0,0). Stationary Moving average model of order one-ARIMA (0,0,1). -A Simple Mixed model ARIMA (1,0,1), ARIMA (1,1,1). -Seasonal Time series ARIMA(p,d,q) (P, D,Q) with ARIMA (0,1,1)(0,1,1), ARCH and GARCH models: Description and properties of these models (Without proof).</td></tr>
</table>

| | |
|---|---|
| Extended Professional Component (is a partof Internal component only, not to be included in theExternal Examination question paper) | Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved<br>(To be discussed during the Tutorial hour) |
| Skills acquired from this course | Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended Text** | 1. Montgomery, D. C., Peck, E. A. and Vining, G. G. (2003) Introduction toLinear regression analysis, third edition, John Wiley and Sons, Inc.<br>2. Draper, N.R. and Smith, H. (2000): Applied Regression Analysis 2nd edition, John Wiley& Sons.<br>3. Spyros Makridakis, Steven C. Wheelwright and Victor E. McGee (2012), Forecasting Methods and Applications – Second Edition, John Wiley & Sons.<br>4. T.M.J.A.Cooray(2008): Applied Time Series Analysis and Forecasting, NAROSApublishing house Pvt.Ltd.<br>5. Box, G.E., Jenkins, G.M. and Reinsel, G.C. (2013) Time Series Analysis: Forecasting and Control. 4th Edition, John Wiley & Sons, Hoboken, 746 p. |
| **Reference Books** | 1. Chattergee S. and Betram Price (1977): Regression Analysis by Examples, John Wiley& Sons.<br>2. George E.P. Box and Gwilym M. Jenkins (1976): Time Series Analysis – Forecastingand Control, Holdne – Day Inc.<br>3. Johnston J. (1984): Econometric Methods, (3rd Edition), McGraw Hill InternationalBook Company, New Delhi.<br>4. Singh, Parashar and Singh (1997): Econometrics and Mathematical Economics (1st Edition), S. Chand & Co, New Delhi. |
| **Website and e-Learning Source** | http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, www.mathpages.com |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

1. Structuring the time series data based on seasonal and non-seasonal nature.
2. Identifying the sationarity of the time series
3. Modelling time series using exponential methods and Box-Jenkings model
4. Fitting time series model and evaluating goodness of fit

**CO-PO Mapping (Course Articulation Matrix)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | S | S | S | S | S | M | S | M |
| **CO2** | M | S | S | S | M | S | S | M | M | M |
| **CO3** | S | S | S | M | S | S | S | M | S | M |
| **CO4** | S | S | S | S | S | S | S | M | M | M |
| **CO5** | S | M | S | S | S | S | S | M | M | S |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

<table>
<tr><td colspan="8">11.1.7 Testing of Statistical Hypothesis</td></tr>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Testing of Statistical Hypothesis</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">Core VII</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1C07</td></tr>
<tr><td>Semester</td><td>III</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td colspan="2">Tutorial</td><td>Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">4</td><td colspan="2">1</td><td>--</td><td>5</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Probability Theory</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">1. To get theoretical knowledge in Statistical Testing procedure<br>2. To provide knowledge about Most Powerful test and how to build it<br>3. To understand concepts Unbiasedness for hypotheses testing, invariance, LikelihoodRatio tests and SPRT test<br>4. To develop analytical thinking in statistical testing of hypothesis</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">Unit I: Uniformly most powerful tests, the Neyman-Pearson fundamental Lemma, Distributions with monotone likelihood ratio Problems</td></tr>
<tr><td colspan="6">Unit II: Generalization of the fundamental lemma, two sided hypotheses, testing the mean andvariance of a normal distribution.</td></tr>
<tr><td colspan="6">Unit III: Unbiasedness for hypotheses testing, similarly and completeness, UMP unbiased tests for multi parameter exponential families, comparing two Poisson or Binomial populations, testingthe parameters of a normal distribution (unbiased tests), comparing the mean and variance of twonormal distributions.</td></tr>
<tr><td colspan="6">Unit IV: Symmetry and invariance, maximal invariance, most powerful invariant tests.</td></tr>
<tr><td colspan="6">Unit V: SPRT procedures, likelihood ratio tests, locally most powerful tests, the concept of confidence sets, non-parametric tests.</td></tr>
<tr><td colspan="2">Extended Professional Component (is a part of Internal component only, Notto be included in theExternal Examination question paper)</td><td colspan="6">Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved<br>(To be discussed during the Tutorial hour)</td></tr>
<tr><td colspan="2">Skills acquired from this course</td><td colspan="6">Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">1. V.K.Rohatgi et a l(2002): An introduction to probability and statistics, John Wiley.<br>2. Lehmann, E.L. (1986): Testing of statistical hypothesis, John Wiley.</td></tr>
</table>

| | |
|---|---|
| **Reference Books** | 1. Ferguson, T.S. (1967): Mathematical statistics, A decision theoretic approach, Academic press.<br>2. Rao, C.R. (1973): Linear statistical inference and its applications, Wiley Eastern, 2nd ed.<br>3. Gibbons, J.D. (1971): Non-parametric statistical inference, McGraw Hill. |
| **Website and e-Learning Source** | e-books, online tutorials taken from MOOC/SWAYAM platform for thissubject. |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

1. To do Most Powerful test for randomized and nonrandomized test.
2. To understand and classify unbiasedness and invariance concepts in testing.
3. To understand theory of LR and SPRT testing and able to solve problems on it.
4. To do numerical problems and able to get critical thinking to solve real life problems
5. To create suitable statistical hypothesis and identify its testing procedure for real life problems.

**CO-PO Mapping (Course Articulation Matrix)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | S | S | S | S | S | S | M | M |
| **CO2** | M | S | S | S | M | S | S | M | M | M |
| **CO3** | S | S | S | M | S | S | S | S | S | M |
| **CO4** | S | S | S | S | S | S | S | M | M | M |
| **CO5** | S | M | S | S | S | S | S | M | M | S |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to POS** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

<table>
<tr><td colspan="8">11.1.8 Linear Models</td></tr>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Linear Models</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">Core VIII</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1C08</td></tr>
<tr><td>Semester</td><td>III</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td colspan="2">Tutorial</td><td>Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">4</td><td colspan="2">1</td><td>--</td><td>5</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">UG level linear regression analysis and Statistical Inference</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">1. To model cross sectional data using minimum number of parameters<br>2. To estimate unbiased estimators for model parameters<br>3. To estimate standard errors of estimates to construct the confidence intervals.<br>4. To test the goodness of fit of the models</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">Unit I: Linear Models – Classification, Estimability. The General Linear Hypothesis of Full Rank – Point Estimation (Estimation Under Normal Theory) – Gauss–Markov theorem, Tests of Hypothesis – Testing the Hypothesis β = β*.</td></tr>
<tr><td colspan="6">Unit II: Introduction to Generalized Linear Models: Components of Generalized Linear Model, Binomial Logit Model, Poisson Loglinear Model, Deviance, Linear Probability Model, Logistic Regression Model, Probit and Inverse CDF Link Function, GLM for Counts, Inference for GLM, Deviance and Goodness of Fit, Deviance for Poisson and Binomial Models.</td></tr>
<tr><td colspan="6">Unit III: Methods of Estimations – ordinary least squares, generalized least square, maximize likelihood, BLUE.</td></tr>
<tr><td colspan="6">Unit IV: General Linear Hypothesis – four common hypotheses – reduced models – null model – saturated model.</td></tr>
<tr><td colspan="6">Unit V: Regression and dummy variables – grouped variables – unbalanced data - describing linear models- 1-way classification, 2- way classification, 3-way classification – main and interaction effects - Models not of full rank.</td></tr>
<tr><td colspan="2">Extended Professional Component (is a part of internal component only, Notto be included in theExternal Examination question paper)</td><td colspan="6">Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved<br>(To be discussed during the Tutorial hour)</td></tr>
<tr><td colspan="2">Skills acquired from this course</td><td colspan="6">Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">1. S.R. Searle, Linear Models, John Wiley, 1971.</td></tr>
</table>

| | |
|---|---|
| **Reference Books** | 1. Alan Agresti, (2002): Categorical Data Analysis, WileyInterscience, John Wiley & Sons.<br>2. Radhakrishna Rao, "Linear Statistical Inference and its Applications" Wiley-Inter science, 2nd \| 2001 \| ISBN: 0471218758. |
| **Website and e-Learning Source** | e-books, online tutorials taken from MOOC/SWAYAM platform for this subject. |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

1. Understand about statistical modelling
2. To model the given cross-sectional data
3. To evaluate the model
4. Interpret the model based on the variables involved
5. To predict using fitted model

**CO-PO Mapping (Course Articulation Matrix)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | S | S | S | S | S | M | S | M |
| **CO2** | M | S | S | S | M | S | S | M | M | M |
| **CO3** | S | S | S | M | S | S | S | M | S | M |
| **CO4** | S | S | S | S | S | S | S | M | M | M |
| **CO5** | S | M | S | S | S | S | S | M | M | S |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to POS** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

<table>
<tr><td colspan="8">11.1.9 Multivariate Analysis</td></tr>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Multivariate Analysis</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">Core IX</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1C09</td></tr>
<tr><td>Semester</td><td>III</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td colspan="2">Tutorial</td><td>Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">4</td><td colspan="2">1</td><td>--</td><td>5</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Univariate and Multivariate distribution theory + Linear Algebra</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">1. To impart basic theoretical knowledge about multivariate normal distribution, its properties to deal with multi-dimension data. To Derive inference based on multi- variate statistical analysis concerning Mean vector and Covariance matrix.<br>2. To provide requisite knowledge to handle multi-dimensional data with regard to dimensionality reduction using Principal Component and Factor Analysis. To imbibe skills to classify and assign a new item/object to any of the two or more populations using Discrimination and Classification.<br>3. To instruct theoretical knowledge to group variables or items that belong to multi- dimensional data using Cluster algorithms</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">Unit I: Multivariate Normal Distribution and Its Properties. Maximum Likelihood Estimators of Parameters, Distribution of Sample Mean Vector, Sample Dispersion Matrix.</td></tr>
<tr><td colspan="6">Unit II: Partial and multiple correlation coefficients- Null distribution - Application in testing. Null distribution of Hotelling’s T2 statistics. Application in tests on mean vector for one and more multivariate normal populations and also on equality of the components of a mean vector in a multivariate normal population.</td></tr>
<tr><td colspan="6">Unit III: Classification and discrimination procedures for discrimination between two multivariate normal populations – Linear Discriminant function, Mahalanobis Distance, tests associated with Discriminant functions, probabilities of misclassification and their estimation, classification into more than two multivariate normal populations.</td></tr>
<tr><td colspan="6">Unit IV: Principal component Analysis, Canonical variables and canonical correlation, clustering- similarity measures- hierarchical algorithms- Single Linkage, Non-hierarchical Clustering.</td></tr>
<tr><td colspan="6">Unit V: Contingency Tables, Correspondence Analysis for Two Dimension Contingency Table.</td></tr>
</table>

| | |
|---|---|
| Extended Professional Component (is a partof internal component only, Notto be included in theExternal Examination question paper) | Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved<br>(To be discussed during the Tutorial hour) |
| Skills acquired from this course | Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended Text** | 1. Anderson, T.W. (1983): An Introduction to Multivariate Statistical Analysis. 2nd Ed. Wiley.<br>2. Johnson,R.& Wichern(2008): Applied Multivariate Statistical Analysis, Pearson, 6th Ed. |
| **Reference Books** | 1. Brain S. Everitt and Graham Dunn (2001): Applied Multivariate Data Analysis, 2nd Ed. (Chap 4)<br>2. Neil H.Timm (2002): Applied Multivariate Analysis –Springer-Verlag.<br>3. Dallas E.Johnson (1998) : Applied Multivariate Methods For Data Analysts- DuxburyPress.<br>4. William R Dillon and Mathew Goldstein (1984): Multivariate Analysis Methods AndApplications, John Weily |
| **Website and e-Learning Source** | e-books, online tutorials taken from MOOC/SWAYAM platform for thissubject. |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

1. To explain and interpret the importance of data that come from high dimensional setupusing appropriate properties.
2. To draw inference based on multi-variate statistical analysis concerning Mean vector and Covariance matrix.
3. To reduce dimensions and identify factors from multi-dimensional data using Principal Component and Factor Analysis respectively.
4. To classify and assign a new item/object to any of the two or more populations using Discrimination and Classification.
5. To group variables or items that belong to multi-dimensional data using Cluster algorithms.

**CO-PO Mapping (Course Articulation Matrix)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | S | S | S | S | S | S | M | M |
| **CO2** | S | S | S | M | M | S | S | M | M | M |
| **CO3** | S | S | S | M | S | S | S | M | S | M |
| **CO4** | S | S | S | S | S | S | S | M | M | M |
| **CO5** | S | M | S | S | S | S | S | M | M | S |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

<table>
<tr><td colspan="8">11.1.10 Statistical Quality Control</td></tr>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Statistical Quality Control</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">Core X</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1C10</td></tr>
<tr><td>Semester</td><td>III</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td colspan="2">Tutorial</td><td>Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">4</td><td colspan="2">1</td><td>--</td><td>5</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Basics in Probability distributions, sampling, testing of hypotheses, control charts and inspection sampling plans.</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">1. Understand the application of statistics in industrial environment.<br>2. Acquire knowhow on manufacturing process changes and process variability.<br>3. Attain proficiency in process capability analysis,<br>4. Instruct theory and practice of product control methodology.<br>5. Comprehend the importance of reliability theory in industries.</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">Unit I: Introduction - Shewhart Control Charts for $\overline{X}$ , R, $\sigma$ ,np, p, c and their uses, OC and ARL of Control Charts, Control Charts based on C.V., Modified Control Charts, CUSUM procedures, use of V-mask, Derivation of ARL.</td></tr>
<tr><td colspan="6">Unit II: Decision Interval Schemes for CUSUM charts – Economic Designs of Control Charts, Pre-control, Relative Precision and Process Capability analysis and Gauge capability analysis, Multivariate Control charts and Hotelling $T^2$.</td></tr>
<tr><td colspan="6">Unit III: Basic Concepts of Acceptance Sampling, Single, Double, Multiple and Sequential Sampling Plans for Attributes, Curtailed and Semi Curtailed Sampling - Dodge-Romig Tables-LTPD and AOQL Protection (Single Sampling Plan Only) - MIL-STD-105D.</td></tr>
<tr><td colspan="6">Unit IV: Variable Sampling: Assumptions, Single and Double Variable Sampling Plans. Application of Normal and Non-central t – Distributions in Variable Sampling - Continuous Sampling Plans: CSP-1, CSP-2 and CSP-3. Special Purpose Plans: Chain Sampling Plans, Skip-lot Plans.</td></tr>
<tr><td colspan="6">Unit V: Quality Policy and Objective – Planning and organization for Quality – Quality Policy Deployment – Quality Function deployment – Quality Audit – Need for ISO 9000 Systems – Clauses – Documentation – Implementation – Introduction to QS 9000 – Implementation of Quality Management System - Six Sigma – Evaluation of Six Sigma.</td></tr>
</table>

| | |
|---|---|
| Extended Professional Component (is a partof internal component only, Notto be included in theExternal Examination question paper) | Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved<br>(To be discussed during the Tutorial hour) |
| Skills acquired from this course | Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended Text** | 1. Montgomery, D.C. (2009). Introduction to Statistical Quality Control, Sixth Edition, Wiley India, New Delhi.<br>2. John T. Burr, (2004) Elementary Statistical Quality Control (Second Edition), Marcel Dekker New York.<br>3. Duncan, A.J. (2003). Quality Control and Industrial Statistics, Irwin - Illinois. |
| **Reference Books** | 1. Grant, E.L., and Leavenworth, R.S. (2000). Statistical Quality Control, Seventh Edition, Tata McGraw Hill, New Delhi.<br>2. Juran, J.M., and De Feo, J.A. (2010). Juran's Quality control Handbook – The Complete Guide to Performance Excellence, Sixth Edition, Tata McGraw-Hill, New Delhi.<br>3. Mahajan, M. (2002). Statistical Quality Control, (Third Edition), Dhanpat Rai and Co., Delhi.<br>4. Schilling, E. G., and Nuebauer, D.V. (2009). Acceptance Sampling in Quality Control Second Edition, CRC Press, New York.<br>5. Wetherill, G.B. (1977). Sampling Inspection and Quality Control, Second Edition, Chapman and Hall, London. |
| **Website and e-Learning Source** | e-books, online tutorials taken from MOOC/SWAYAM platform for thissubject. |

Course Learning Outcome (for Mapping with POs and PSOs)

After the successful completion of the course, the students will be able to:
1. Construct control charts for large and smaller shifts in the process parameters
2. Effectively interpret the results from the control charts
3. Carry out process capability analysis
4. Adopt appropriate sampling inspection plans for given conditions
5. Find failure rate, identify failure rate distributions, compute reliability of components and systems

**CO-PO Mapping (Course Articulation Matrix)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | S | S | S | S | S | S | M | M |
| **CO2** | S | S | S | M | M | S | S | M | M | M |
| **CO3** | S | S | S | M | S | S | S | M | S | M |
| **CO4** | S | S | S | S | S | S | S | M | M | M |
| **CO5** | S | M | S | S | S | S | S | M | M | S |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

<table>
<tr><td colspan="8">11.1.11 Design of Experiments</td></tr>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Design of Experiments</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">Core XI</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1C11</td></tr>
<tr><td>Semester</td><td>IV</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td colspan="2">Tutorial</td><td>Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">4</td><td colspan="2">1</td><td>--</td><td>5</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Matrix Algebra and Linear Models.</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">1. To get theoretical knowledge in Statistical Design of Experiments and analysis of variance.<br>2. To build strong theoretical foundation in Orthogonal Latin squares, Hyper Graeco Latin squares, factorial and fractional factorial experiments, PIBD, inter and intra blocks, split plot, analysis covariance, Response surface methodology.<br>3. To develop analytical thinking in problem solving skills.</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">Unit I: Review of basic designs; Orthogonal Latin squares, Hyper Graeco Latin squares – analysis of variance – multiple comparisons – multiple range tests - Missing plot technique.</td></tr>
<tr><td colspan="6">Unit II: General factorial experiments, study of 2 and 3 factorial experiments in randomized blocks; complete and partial confounding; Fractional designs for symmetric factorials; basic ideaof asymmetric factorials</td></tr>
<tr><td colspan="6">Unit III: General block design and its information matrix (C), criteria for connectedness, balancedand orthogonality; BIBD – recovery of interblock information; PBIBD(2).- Association scheme, Intrablock analysis, Lattice Design –analysis; Youden design – intrablock analysis.</td></tr>
<tr><td colspan="6">Unit IV: Nested and split plot designs – Two stage nested designs, split plot designs, split plot plot designs, strip-split designs, Analysis of covariance with one, two covariates; clinical trials.</td></tr>
<tr><td colspan="6">Unit V: Response surface methodology - first order and second order rotatable designs, applications.</td></tr>
<tr><td colspan="2">Extended Professional Component (is a partof internal component only, Not to be included in theExternal Examination question paper)</td><td colspan="6">Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved<br>(To be discussed during the Tutorial hour)</td></tr>
<tr><td colspan="2">Skills acquired from this course</td><td colspan="6">Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">1. Das, M.N. and Giri, N. (1979): Design and analysis of experiments, Wiley Eastern.</td></tr>
</table>

| | |
|---|---|
| | 2. John, P.W.M. (1971): Statistical design and analysis of experiments, Macmillan. |
| **Reference Books** | 1. Montgomery,C.D. (2001): Design and analysis of experiments, John Wiley, NewYork.<br>2. Robert, O., Kuelhl(2000) : Design of experiments. Statistical principles of researchdesign and analysis, Duxbury.<br>3. Federer, W.T.(1963) : Experimental design; Theory and application, Oxford & IBHpublishing Co. |
| **Website and e-Learning Source** | e-books, online tutorials taken from MOOC/SWAYAM platform for thissubject. |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

1. To understand analysis of variance and experimental designs
2. To have strong theoretical knowledge in Orthogonal Latin squares, Hyper Graeco Latin squares, factorial and fractional factorial experiments, PIBD, inter and intra blocks, split plot, analysis covariance
3. To understand clinical trial concepts and Response surface methodology
4. To do numerical problems and able to get critical thinking to solve problems
5. To choose suitable experiment and do it for real life problems.

**CO-PO Mapping (Course Articulation Matrix)**

| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | S | S | S | S | S | S | S | M |
| **CO2** | S | S | M | S | M | S | S | S | M | M |
| **CO3** | S | S | S | M | S | S | S | S | S | M |
| **CO4** | S | S | S | S | S | S | S | M | M | M |
| **CO5** | S | S | S | M | M | S | S | S | M | S |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| **CO /PO** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

<table>
<tr><td colspan="8">11.1.12 Stochastic Process</td></tr>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Stochastic Process</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">Core XII</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1C12</td></tr>
<tr><td>Semester</td><td>IV</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td colspan="2">Tutorial</td><td>Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">4</td><td colspan="2">1</td><td>--</td><td>5</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Probability theory and Distribution theory</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">1. To expose the basic concepts of the theory of stochastic processes and develops the mathematical theory of random processes.<br>2. It provides the fundamentals and advanced concepts of probability theory and help them appreciate and understand the application of the mathematical tool.<br>3. To describe the advanced topics related to continuous and discrete time randomprocesses.</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">Unit I: Definition of Stochastic process – Specification of Stochastic Processes. Stationary Processes – Second order process, Stationarity, Gaussian processes. Martingales: Definition and properties,. Martingales in discrete time - Supermartingales and submartingales - Continuous Parameter Martigales- Martingale convergence theorem and its applications.</td></tr>
<tr><td colspan="6">Unit II: Markov chains – Definitions and examples. Higher order transition probabilities: Chapman – Kolmogrov equation. Classification of States and Chains – Determination of Higher order Transition Probabilities -Aperiodic Chain: Limiting Behaviour. Stability of a Markov system.</td></tr>
<tr><td colspan="6">Unit III: Poisson process – Poisson process and related distributions. Pure Birth Process – Birth and Death process – Simple examples. Branching process – properties of generating function of branching process – Probability of extinction – fundamental theorem of branching process.</td></tr>
<tr><td colspan="6">Unit IV: Renewal theory - Renewal equation - Stopping time - Wald’s equation - Elementary renewal theorem and its applications - Renewal reward processes - Residual and Excess life times - Markov renewal and Semi Markov processes</td></tr>
<tr><td colspan="6">Unit V: Queuing model M/M/1: Steady State Behaviour - Steady State Solution, Waiting time distribution. Queueing Model M/M/S - Steady State Solution, Waiting time distributions – simple problem.</td></tr>
</table>

| | |
|---|---|
| Extended Professional Component (is a partof internal component only, Notto be included in theExternal Examination question paper) | Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved<br>(To be discussed during the Tutorial hour) |
| Skills acquired from this course | Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended Text** | 1. Medhi, J. (1984): Stochastic Processes, New Age International Publishing Limited, New Delhi. (Reprint 2002).<br>2. Karlin, S. and Taylor H.M. (1996): First Course in Stochastic Process, Academic Press. |
| **Reference Books** | 1. Prabhu. N.U. (1965): Stochastic Process, Macmillan, New York.<br>2. Ross, S.M (1996): Stochastic Processes, 2nd Edition, John Wiley & Sons, New Delhi. |
| **Website and e-Learning Source** | e-books, online tutorials taken from MOOC/SWAYAM platform for thissubject. |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

1. To equip their knowledge with theoretical and practical skills which are necessary for the analysis of stochastic dynamical system in economic, financial mathematics, engineering, business and other fields.
2. To attain knowledge about stochastic process in the time domain such as Markov processes with a discrete state space, including Markov chains, Poisson processes andbirth and death processes.
3. To demonstrate the specific applications to Poisson and Gaussian processes.
4. To carry out derivations involving conditional probability distributions and conditional expectations.
5. To define basic concepts from the theory of Markov chains and present proofs for the most important theorems.

**CO-PO Mapping (Course Articulation Matrix)**

| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | S | M | S | S | S | S | M | M |
| **CO2** | S | S | S | M | M | S | S | S | M | M |
| **CO3** | S | S | S | M | S | S | S | S | S | M |
| **CO4** | S | S | S | S | S | M | S | M | M | M |
| **CO5** | S | M | S | S | S | S | S | M | M | S |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to POS** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

**Elective Courses**
**Semester I: Elective I and Elective II**
**Elective I to be chosen from Group A and Elective II to be chosen from Group B**
**Group A:**

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Categorical Data Analysis</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">I</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">ED</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1E01</td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td>Lecture</td><td>Tutorial</td><td>Lab Practice</td><td colspan="3">Total</td></tr>
<tr><td>3</td><td>1</td><td>--</td><td colspan="3">4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Undergraduate Level Statistical Models</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">1. The course covers models for categorical data, two way and multi way contingency tables, homogeneity and independence<br>2. Generalized linear models for categorial data, logistic regression, log linear models for categorial data and diagnostics of models.<br>3. Write clear and precise proofs.<br>4. Communicate effectively in both written and oral form.<br>5. Demonstrate the ability to read and learn mathematics and/or statistics independently.</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">Unit I: Models for Binary Response Variables, Log Linear Models, Fitting Log linear and Logic Models-Building and applying Log Linear Models, Log- Linear- Logit Models for Ordinal Variables.</td></tr>
<tr><td colspan="6">Unit II: Multinomial Response Models - Models for Matched Pairs- Analyzing Repeated Categorical Response Data - Asymptotic Theory for Parametric Models - Estimation Theory for Parametric Models.</td></tr>
<tr><td colspan="6">Unit III: Classical treatments of 2 and 3-way contingency tables- Tests for independence and homogeneity of proportions- measures of association and nonparametric methods - Generalized linear models - Logistic regression for binary - multinomial and ordinal data – Log - linear models - Modeling repeated measurements- generalized estimating equations.</td></tr>
<tr><td colspan="6">Unit IV: Introduction to contingency tables: 2×2 and r×c tables - Fishers exact test - Odds ratio and Logit, other measures of association - Introduction to 3 - way tables – full independence and conditional independence - collapsing and Simpsons paradox.</td></tr>
<tr><td colspan="6">Unit V: Polytomous logit models for ordinal and nominal response- Log-linear models (and graphical models) for multi-way tables - Causality, repeated measures, generalized least squares - mixed models, latent-class models, missing data, and algebraic statistics approach.</td></tr>
</table>

| | |
|---|---|
| Extended Professional Component (is a partof internal component only, Not to be included in theExternal Examination question paper) | Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved<br>(To be discussed during the Tutorial hour) |
| Skills acquired from this course | Knowledge, Problem Solving, Analytical ability,Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended Text** | 1. Agresti, Alan (1996). An Introduction to Categorical Data Analysis, Wiley. |
| **Reference Books** | 1. Bergsma, W., Croon, M.A. and Hagenaars, J.A. (2009). Marginal Models: For Dependent, Clustered, and Longitudinal Categorical Data. Springer.<br>2. Bishop, Y.M., Fienberg, S.E. and Holland, P.W. (1975). Discrete Multivariate Analysis: Theory and Practice, MIT Press.<br>3. Edwards, D. (2000). Introduction to Graphical Modeling Second Edition). Springer.<br>4. Fienberg, S.E. (1980). The Analysis of Cross-Classified Categorical Data.MIT Press.<br>5. Wasserman, L. (2004). All of Statistics: A Concise Course in Statistical Inference. Springer.<br>6. Whittaker, J. (1990). Graphical Models in Applied Multivariate Statistics.Wiley. |
| **Website and e-Learning Source** | e-books, online tutorials taken from MOOC/SWAYAM platform for thissubject. |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

1. The student who successfully completes this course should have a reasonable grasp of the theoretical foundations of categorical data analysis and have sufficient skills to apply categorical data analysis methods.
2. The student will be able to derive and work with sampling distributions of binary or categorical measures.
3. Students will be familiar with a variety of methods for analyzing categorical or count data.

**CO-PO Mapping (Course Articulation Matrix)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | M | M | M | S | M | S | M | M |
| **CO2** | S | S | S | S | M | S | M | S | M | M |
| **CO3** | S | S | S | M | S | S | M | S | S | M |
| **CO4** | M | S | S | S | S | S | S | S | M | M |
| **CO5** | S | S | S | S | M | S | S | S | M | M |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Population Studies</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">II</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">ED</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1E02</td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td>Lecture</td><td colspan="2">Tutorial</td><td>Lab Practice</td><td colspan="2">Total</td></tr>
<tr><td>3</td><td colspan="2">1</td><td>-</td><td colspan="2">4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Undergraduate level Vital Statistics concepts</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">1. This course aims to provide students with basic knowledge on the determinants of population.<br>2. The course will also help in studying Population growth and population projection.<br>3. This course will provide complete knowledge on calculations and ratios of fertility and mortality.<br>4. To know the importance of migrations in population studies.</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">UNIT I: Sample Registration System, Sources of demographic data. Errors in demographic data. Population growth and Growth rates. Inter – censal / Post – censal estimates of population. Chandrasekharan - Deming formula to check completeness of registration data, adjustment of age data- use of Whipple, Myer and UN indices.</td></tr>
<tr><td colspan="6">UNIT II: Mortality - Basic measurements - Crude, specific, standardized death rates - Life table - construction, use and interpretation - abridged life tables. Measurements of morbidity.</td></tr>
<tr><td colspan="6">UNIT III: Fertility - Basic measurements - Gross and Net Reproduction rate. Nuptiality and its measurements. Migration - Human migration and its types. Net Migration and Migration Rate.</td></tr>
<tr><td colspan="6">Unit IV: Age - Sex Structure. Dependency ratio - Ageing population - Population Projections: Meaning, Types and Importance. Inter - relationship between population growth, environment and sustainable development with special reference to India. Demographic transition.</td></tr>
<tr><td colspan="6">Unit V: Population policies in the context of growth, structure, distribution and quality of life Policies related to medical termination of pregnancy (MTP), age at marriage. National and State population policies in India. Evolution of Family Welfare Program in India. Program components and organization at different levels. Goals and achievements of the Family Welfare Programme.</td></tr>
<tr><td colspan="2">Extended Professional Component (is a part of internal component only, Not to be included in theExternal Examination question paper)</td><td colspan="6">Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved<br>(To be discussed during the Tutorial hour)</td></tr>
</table>

| | |
|---|---|
| **Skills acquired from this course** | Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended Text** | 1. Kumar, R. (1986): Technical Demography, Wiley Eastern Ltd.<br>2. Benjamin, B. (1969): Demographic Analysis, George, Allen and Unwin. |
| **Reference Books** | 1. Cox, P.R. (1970): Demography, Cambridge University Press.<br>2. Keyfitz, N. (1977): Introduction to the Mathematics of Population-with Revisions, Addison-Wesley, London.<br>3. Spiegelman, M. (1969): Introduction to Demographic Analysis, Harvard University Press.<br>4. Wolfenden, H.H. (1954): Population Statistics and Their Compilation, Am Actuarial Society. |
| **Website and e-Learning Source** | e-books, online tutorials taken from MOOC/SWAYAM platform for thissubject. |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

1. Learn about different methods of demographic data collection and related errors.
2. Learn about the fertility/ mortality models.
3. Understand Life Tables and their construction.
4. Learn about the theory of stable population, population projection and about the concept of migration theory.
5. To explore various aspects of the population policy and to study its impact on socio economic issues

**CO-PO Mapping (Course Articulation Matrix)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | M | M | M | S | M | S | M | M |
| **CO2** | S | S | S | S | M | S | M | S | M | M |
| **CO3** | S | S | S | M | S | S | M | S | S | M |
| **CO4** | M | S | S | S | S | S | S | S | M | M |
| **CO5** | S | S | S | S | M | S | S | S | M | M |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">Data Mining</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">III</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">ED</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1E03</td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td colspan="2">Tutorial</td><td colspan="2">Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">3</td><td colspan="2">1</td><td colspan="2">-</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="8">Basic knowledge in quality control and its properties</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8">The main objectives of this course are to:<br>1. Interpret the contribution of data warehousing and data mining to the decision-support level of organizations.<br>2. Evaluate different models used for OLAP and data pre-processing categorize and carefully differentiate between situations for applying different data-mining techniques: frequent pattern mining, association, correlation, classification, prediction, and cluster and outlier analysis.<br>3. Design and implement systems for data mining.<br>4. Evaluate the performance of different data-mining algorithms.<br>5. Propose data-mining solutions for different applications.</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="8">Unit I: Data mining- Kinds of data – Data mining Functionalities - Classification of Data mining Systems - Major Issues on Data mining - Introduction to OLAP - OLAP technology for Data Mining - Data warehousing - Data warehousing to Data mining - Optimizing Data for mining - Data pre-processing.</td></tr>
<tr><td colspan="8">UNIT II: Data mining Query language - Association Rules in large - Data mining - KDD Process - Fuzzy sets and logic - Classification and Prediction: Information retrieval - Dimensional Modelling of Data - Pattern Matching - Estimation Error- EM and MLE.</td></tr>
<tr><td colspan="8">UNIT III: Bayes Theorem - Chi square Statistics Regression - Decision Tree - Neural Networks - Genetic Algorithms - Cluster Analysis – Outlier - Cluster vs Classification - Clustering Issues - Impact of Outliers on clustering- Clustering problems - Clustering Approaches.</td></tr>
<tr><td colspan="8">UNIT IV: Hierarchical algorithm – Single Linkage - MST Single Linkage - Complete Linkage - Average Linkage. Dendrogram - Partition Algorithm – MST - Squared Error – K - Means - Nearest Neighbor – PAM – BEA – GA - Categorical algorithm - Large Database.</td></tr>
<tr><td colspan="8">UNIT V: Introduction - Webdata - Web Knowledge Mining Taxonomy - Web Content mining - Web Usage Mining Research - Ontology based web mining Research - Web mining Applications.</td></tr>
<tr><td colspan="2">Extended Professional Component (is a part of internal component only, not</td><td colspan="8">Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / applied survey techniques adopted in Economics and Statistics department of Tamil Nadu State Government.<br>(To be discussed during the Tutorial hour)</td></tr>
</table>

| | |
|---|---|
| to be included in the External Examination question paper) | |
| **Skills acquired from this course** | Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended Text Books** | 1. Adriaans, P., and Zantinge, D. (1996). Data Mining, First Edition, Addison WesleyProfessional, London<br>2. Agneswaran, V. S. (2014). Big Data Analytics Beyond Hadoop, First Edition, Pearson FTPress.<br>3. Gupta, G. K. (2014). Introduction to Data Mining with Case Studies, Third Edition, PHI Learning Private Limited, New Delhi. |
| **Reference Books** | 1. Berry, J.A., and Linoff, G.S. (2011). Data Mining Techniques, Third Edition, John Wiley and Sons, New York.<br>2. Chattamvelli, R. (2009). Data mining Methods, Alpha Science International.<br>3. Dunham, M.H. (2006). Data Mining: Introductory and Advanced Topics, Pearson Education India.<br>4. Gorunescu, F. (2010). Data mining Concepts, Models andTechniques, Springer.<br>5. Han, J., and Kamber, M. (2001). Data mining Concepts and Techniques, Seventh Edition, Morgan Kaufmann Publications.<br>6. Hand, D., Mannila, H., and Smyth, P. (2001). Principles of Data mining, MIT press.<br>7. Larose, D.T. (2005). Discovering Knowledge in Data: An Introduction to Data Mining. John Wiley and Sons, Canada.<br>8. Pujari, A.K. (2001). Data Mining Techniques, Universities Press.<br>9. Sivanandam, S.N., and Sumathi, S. (2006). Data Mining Concepts, Tasks and Techniques, Springer. |
| **Website and e-Learning Source** | e-books, online tutorials taken from MOOC/SWAYAM platform for this subject. |

**Course Learning Outcome (for Mapping with POs and PSOs)**

After the successful completion of the course, the students will be able to:

1. Demonstrate an understanding of the importance of data mining and the principles of business intelligence.
2. Organize and prepare the data needed for data mining using pre-processing techniques.
3. Perform exploratory analysis of the data to be used for mining.
4. Implement the appropriate data mining methods like classification, clustering or Frequent Pattern mining on large data sets.
5. Define and apply metrics to measure the performance of various data mining algorithms.

**CO-PO Mapping (Course Articulation Matrix)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | M | M | M | S | M | S | M | M |
| **CO2** | S | S | S | S | M | S | M | S | M | M |
| **CO3** | S | S | S | M | S | S | M | S | S | M |
| **CO4** | M | S | S | S | S | S | S | S | M | M |
| **CO5** | S | S | S | S | M | S | S | S | M | M |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

### 11.2.2 Group B:

### 11.2.2.1 Bayesian Inference

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Bayesian Inference</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">IV</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">ED</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1E04</td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td>Lecture</td><td colspan="2">Tutorial</td><td>Lab Practice</td><td colspan="2">Total</td></tr>
<tr><td>3</td><td colspan="2">1</td><td>-</td><td colspan="2">4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Probability models, parametric and non-parametric inference</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">1. Estimation using pre-knowledge about the parameters.<br>2. To learn and develop scientific view to study the statistical challenges of clinical comparison of two or more treatment</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">Unit1: Statistical decision theory – loss functions – 0-1, absolute error, squared error and LINEX loss functions – risk function – minimax solution – prior distribution – Bayes risk – Bayes solution to decision problems.</td></tr>
<tr><td colspan="6">Unit II: Subjective probability – its interpretation and evaluation - Subjective determination of prior distributions - Improper prior, noninformative prior, invariant prior, Jeffrey’s non-informative prior and natural conjugate prior-family of distributions admitting natural conjugate prior.</td></tr>
<tr><td colspan="6">Unit III: 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.</td></tr>
<tr><td colspan="6">Unit IV: Interval estimation – credible interval, highest posterior density region - Comparison of interpretation of the confidence coefficient of an interval by Bayesian and frequentist methods – simple problems.</td></tr>
<tr><td colspan="6">Unit V: Bayesian testing of statistical hypotheses – 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.</td></tr>
<tr><td colspan="2">Extended Professional Component (is a part of internal component only, Not to be included in theExternal Examination question paper)</td><td colspan="6">Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved<br>(To be discussed during the Tutorial hour)</td></tr>
<tr><td colspan="2">Skills acquired from this course</td><td colspan="6">Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill</td></tr>
</table>

| | |
|---|---|
| **Recommended Text** | 1. Bansal, A.K. (2007) Bayesian Parametric Inference, Narosa, New Delhi.<br>2. Berger, J.O. (1985) Statistical Decision Theory and Bayesian Analysis,2/e, Springer, New York. |
| **Reference Books** | 1. Bernardo, J.M. and Smith, A.F.M. (2000) Bayesian Theory, Wiley, New York.<br>2. Gelman, A. Carlin, J.B. Stern, H.B. and Rubin, D.B. (2013) Bayesian Data Analysis,3/e, CRC press, London<br>3. Ghosh, J.K. Delampady, M. and Samanta, T. (2010) An Introduction to Bayesian Analysis: Theory and Methods, Springer, New York.<br>4. Lee, P.M. (2012) Bayesian Statistics – An Introduction,4/e,Wiley, London.<br>5. Leonard, T. and J.S.J. Hsu. (1999) Bayesian Methods: An Analysis for Statisticians and Interdisciplinary Researchers, Cambridge University Press, London |
| **Website and e-Learning Source** | e-books, online tutorials taken from MOOC/SWAYAM platform for thissubject. |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

1. Explain in detail the Bayesian framework for data analysis and its flexibility and be able to demonstrate when the Bayesian approach can be beneficial.
2. Develop, analytically describe, and implement both single and multi- parameter probability models in the Bayesian framework.
3. Demonstrate the role of the prior distribution in Bayesian inference and be able to articulate the usage of non-informative priors and conjugate priors.
4. Show high level Interpretation of Bayesian Analysis Results and be able to readily perform Bayesian model evaluation and assessment

**CO-PO Mapping (Course Articulation Matrix)**

| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | M | M | M | S | M | S | M | M |
| **CO2** | S | S | S | S | M | S | M | S | M | M |
| **CO3** | S | S | S | M | S | S | M | S | S | M |
| **CO4** | M | S | S | S | S | S | S | S | M | M |
| **CO5** | S | S | S | S | M | S | S | S | M | M |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="7">Clinical Trials</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="7">V</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">ED</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1E05</td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td>Lecture</td><td colspan="2">Tutorial</td><td colspan="2">Lab Practice</td><td>Total</td></tr>
<tr><td>3</td><td colspan="2">1</td><td colspan="2">-</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="7">Undergraduate Level Statistical Models.</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="7">1. The course stresses on the concepts of statistical design and analysis in biomedical research, with special emphasis on clinical trials.<br>2. To learn and develop scientific view to study the statistical challenges of clinical comparison of two or more treatment</td></tr>
<tr><td colspan="2" rowspan="4">Course Outline</td><td colspan="7">Unit 1: Introduction to clinical trials: need and ethics of clinical trials, bias and random error in clinical studies, conduct of clinical trials, overview of Phase I-IV trials, multicenter trials. Data management: data definitions, case report forms, database design, data collection systems for good clinical practice. Bioavailability, pharmacokinetics and pharmacodynamics, two-compartment model.</td></tr>
<tr><td colspan="7">Unit II: Design of clinical trials: parallel vs. cross-over designs, cross-sectional vs. longitudinal designs, objectives and endpoints of clinical trials, design of Phase I trials, design of single stage and multi-stage Phase II trials.</td></tr>
<tr><td colspan="7">Unit III: Design and monitoring of Phase III trials with sequential stopping, design of bio-equivalence trials. Inference for 2x2 crossover design: Classical methods of interval hypothesis testing for bioequivalence, Bayesian methods, nonparametric methods.</td></tr>
<tr><td colspan="7">Unit IV: Power and sample size determination, multiplicative (or log-transformed) model, ML method of estimation, assessment of inter and intra subject variabilities, detection of outlying subjects. Optimal crossover designs: Balaams design, Two-sequence dual design. Optimal four period designs. Assessment of bioequivalence for more than two drugs, Williams design.</td></tr>
<tr><td colspan="2"></td><td colspan="7">Unit V: Designs based on clinical endpoints: Weighted least squares method, log-linear models, generalized estimating equations. Drug interaction study, dose proportionality study, steady state analysis. Interim analysis and group sequential tests, alpha spending functions. Analysis of categorical data.</td></tr>
<tr><td colspan="2">Extended Professional Component (is a part ofinternal component only, Not to be included in the External Examination question paper)</td><td colspan="7">Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved<br>(To be discussed during the Tutorial hour)</td></tr>
</table>

| | |
|---|---|
| **Skills acquired from this course** | Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended Text Books** | 1. Agresti, Alan. (1996) An Introduction to Categorical Data Analysis, Wiley, New York.<br>2. Marubeni. E. and Valsecchi M. G. (1994). Analyzing Survival Data from Clinical Trials and Observational Studies, Wiley. |
| **Reference Books** | 1. Chow S.C. and Liu J.P. (2009). Design and Analysis of Bioavailability and bioequivalence. 3rd Edn. CRC Press.<br>2. Chow S.C. and Liu J.P. (2004). Design and Analysis of Clinical Trials. 2nd Edn Marcel Dekkar.<br>3. Fleiss J. L. (1989). The Design and Analysis of Clinical Experiments. Wiley.<br>4. Friedman L. M. Furburg C. Demets D. L. (1998). Fundamentals of Clinical Trials, Springer.<br>5. Jennison .C. and Turnbull B. W. (1999). Group Sequential Methods with Applications to Clinical Trials, CRC Press. |
| **Website and e-Learning Source** | e-books, online tutorials taken from MOOC/SWAYAM platform for thissubject. |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

1. Students can understand the key statistical components involved in the planning and conduct of clinical trials.
2. Awareness of different populations for analysis and understand which is appropriate to address specific research
3. Students will be familiar with the use of the cross-over design.

**CO-PO Mapping (Course Articulation Matrix)**

| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | M | M | M | S | M | S | M | M |
| **CO2** | S | S | S | S | M | S | M | S | M | M |
| **CO3** | S | S | S | M | S | S | M | S | S | M |
| **CO4** | M | S | S | S | S | S | S | S | M | M |
| **CO5** | S | S | S | S | M | S | S | S | M | M |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to POS** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

<table>
<tr><td>Title of the Course</td><td colspan="6">Statistical Analysis using R Programming</td></tr>
<tr><td>Paper Number</td><td colspan="6">VI</td></tr>
<tr><td rowspan="2">Category Core</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1E06</td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td rowspan="2">Instructional Hours per week</td><td>Lecture</td><td>Tutorial</td><td>Lab Practice</td><td colspan="3">Total</td></tr>
<tr><td>5</td><td>1</td><td>--</td><td colspan="3">6</td></tr>
<tr><td>Pre-requisite</td><td colspan="6"></td></tr>
<tr><td>Objectives of the Course</td><td colspan="6">Upon successful completion of this course, the students will be able to:<br>1. Apply R programming and understand different data sets<br>3. Apply R Programme and construct graphs, charts and descriptive statistics<br>4. Analyze the data and know probability and sampling by using R Programming<br>5. Apply R Programming to test the hypothesis of the study<br>6. Predict the data and take decisions through R programming.</td></tr>
<tr><td rowspan="5">Course Outline</td><td colspan="6">Unit I: Introduction to R programming: What is R? - Installing R and R Studio-R Studio Overview - Working in the Console - Arithmetic Operators - Logical Operations - Using Functions - Getting Help in R and Quitting R Studio Installing and loading packages. Data structures, variables, and data types in R: Creating Variables - Numeric, Character and Logical Data - Vectors - Data Frames - Factors -Sorting Numeric, Character, and Factor Vectors - Special Values.</td></tr>
<tr><td colspan="6">Unit II: Data Visualization using R: Diagrammatic representation of data -Scatter Plots - Box Plots - Scatter Plots and Pie diagram. Descriptive statistics in R: Measures of central tendency - Measures of variability - Skewness and kurtosis - Summary functions, describe functions, and descriptive statistics by group.</td></tr>
<tr><td colspan="6">Unit III: Basic Probability in R: Discrete Random Variables -Binomial Random Variable - Continuous Random Variables. Sampling in R: Types of Samples - Simple Random Sampling (SRS) - Systematic Sampling - Stratified Sampling - Cluster Sampling.</td></tr>
<tr><td colspan="6">Unit IV: Testing of Hypothesis using R: T-test, Paired Test, Chi Square test, Analysis of Variance and Correlation.</td></tr>
<tr><td colspan="6">Unit V: Predictive Analytics in R: linear Regression model, Non-Linear Least Square, multiple regression analysis, Logistic Regression.</td></tr>
<tr><td>Recommended Text</td><td colspan="6">1. W. N. Venable, D. M. Smith (1999-2023), “An introduction to R” Version 4.3.1.</td></tr>
</table>

| | |
|---|---|
| | 2. Crawley, M. J. (2006), “Statistics - An introduction using R”, John Wiley, London 32.<br>3. Jane M Horgan (2020), “Probability with R”, John Wiley and Sons Inc.<br>4. Purohit, S.G.; Gore, S.D. and Deshmukh, S.R. (2015), “Statistics using R”, second edition. Narosa Publishing House, New Delhi.<br>5. Shahababa B. (2011), “Biostatistics with R”, Springer, New York.<br>6. Braun & Murdoch (2007), “A first course in statistical programming with R”, Cambridge University Press, New Delhi.<br>7. G. Jay Kerns, (2010), “Introduction to probability and Statistics Using R” first editions. |

**Course Learning Outcome (for Mapping with POs and PSOs)**
After successfully completing the course, a student should be able to demonstrate…

1. Understanding and implementing Linear Mixed Models (LMM).
2. Implementation of statistical procedures within the R environment.
3. Data manipulation - acquiring skills in flexible matrix manipulation.
4. Scripting - programming an analysis in such a way that the script can be used with minimal effort for similar datasets and analyses and for especially large datasets
5. Data visualization - learning how to create high-quality figures, especially associated with more complex analyses (e.g. three-dimensional scatter plots, Trellis displays, etc.).

**CO-PO Mapping (Course Articulation Matrix)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | S | M | S | S | S | S | M | M |
| **CO2** | S | S | S | M | M | S | S | S | M | M |
| **CO3** | S | S | S | M | S | S | S | S | S | M |
| **CO4** | S | S | S | S | S | M | S | M | M | M |
| **CO5** | S | M | S | S | S | S | S | M | M | S |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO’s and CO’s**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |

| | | | | | |
|---|---|---|---|---|---|
| **Weighted percentage of Course Contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

Semester II: Elective III and Elective IV

Elective III to be chosen from Group C and Elective IV to be chosen from Group D

11.2.3 Group C: 11.2.3.1 Actuarial Statistics

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Title of the Course** | | **Actuarial Statistics** | | | | | |
| **Paper Number** | | **VII** | | | | | |
| **Category** | **ED** | **Year** | I | **Credits** | 3 | **Course Code** | **23UPSTA1E07** |
| | | **Semester** | II | | | | |
| **Instructional Hours per week** | | **Lecture** | **Tutorial** | **Lab Practice** | **Total** | | |
| | | 3 | 1 | - | 4 | | |
| **Pre-requisite** | | Undergraduate Level Statistical Models. | | | | | |
| **Objectives of the Course** | | 1. Know the significance of mathematics in financial management.<br>2. Inculcate knowledge in computation of measures such as interest, discount, inflation, etc.<br>3. Understand the notions of Actuarial statistics | | | | | |
| **Course Outline** | | **Unit I:** The life table: Basic definitions, probabilities, construction of life tables, life expectancy, Life annuities: Introduction, calculating annuity premium, interest and survivorship discount function, guaranteed payments, deferred annuities. | | | | | |
| | | **Unit II:** Introduction, calculation of life insurance premiums, types of life insurance, combined benefits, insurances viewed as annuities, Insurance and annuity reserves: The general pattern reserves, recursion, detailed analysis of an insurance. | | | | | |
| | | **Unit III:** Fractional durations: Life annuities paid monthly, immediate annuities, fractional period premium and reserves, reserves at fractional durations, Continuous payments: Continuous annuities, force of discount, force of mortality, Insurance payable at the moment of death, premiums and reserves. | | | | | |
| | | **Unit IV:** Joint life status, joint annuities and insurances, last survivor annuities and insurances, moment of death insurances. The general two life annuity and insurance contracts, contingent insurances. | | | | | |
| | | **Unit V:** Basic model, insurances, Determination of the models from the forces of decrement. Stochastic approach to insurance and annuities; Stochastic approach to insurance and annuity benefits, deferred contracts, Stochastic approach to reserves and premiums, variance formula | | | | | |
| Extended Professional | | Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC | | | | | |

| | |
|---|---|
| Component (is a part of internal component only, Not to be included in the External Examination question paper) | / others to be solved<br>(To be discussed during the Tutorial hour) |
| **Skills acquired from this course** | Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended Text Books** | 1. Promislow, S.D(2006): Fundamentals of Actuarial Mathematics, John Willey, Chapters 2- 11&14.<br>2. Newton L. Bowers, Jr, Hans U. Gerber, James C. Hickmann, Donald A. Jones and Cecil<br>3. J. Nesbitt (1997): Actuarial Mathematics, The Society of Actuaries<br>4. Borowiak, D.S., and A. F. Shapiro. (2013). Financial and Actuarial Statistics: An Introduction, Second Edition. CRC Press.<br>5. Spurgeon, E.T. (2011), Life Contingencies, Third Edition, Cambridge University Press |
| **Reference Books** | 1. Neill, A. (1977): Life contingencies, Heinemann, London.<br>2. King, G. Institute of Actuaries Text Book. Part 11, Second edition, Charles and Edwin Layton, London.<br>3. Donald D.W.A. (1970): Compound Interest and Annuities, Heinemann, London.<br>4. Jordan, C.W. Jr. (1967): Life Contingencies, Second edition, Chicago Society of Actuaries.<br>5. Hooker, P.F. and Longley Cook, L.W. (1953): Life and other Contingencies, Volume I and Volume II (1957) Cambridge University Press. |
| **Website and e-Learning Source** | e-books, online tutorials taken from MOOC/SWAYAM platform for thissubject. |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

1. To understand how actuarial science is used in finance, investments, banking and insurance.
2. Explain the concept of survival models
3. Describe estimation procedures for lifetime distributions.
4. To understand the statistical behavior of actuarial indicators.
5. To solve the problems related to the benefit amounts in insurance, annuities, premiums and reserves.

**CO-PO Mapping (Course Articulation Matrix)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | M | M | M | S | M | S | M | M |
| **CO2** | S | S | S | S | M | S | M | S | M | M |
| **CO3** | S | S | S | M | S | S | M | S | S | M |
| **CO4** | M | S | S | S | S | S | S | S | M | M |
| **CO5** | S | S | S | S | M | S | S | S | M | M |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to POS** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Simulation Analysis</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">VIII</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">ED</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1E08</td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td>Lecture</td><td colspan="2">Tutorial</td><td colspan="2">Lab Practice</td><td>Total</td></tr>
<tr><td>3</td><td colspan="2">1</td><td colspan="2">-</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Undergraduate Level Statistical Models.</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">1. Define the basics of simulation modeling and replicating the practical situations in organizations<br>2. Generate random numbers and random variates using different techniques.<br>3. Develop simulation model using heuristic methods.<br>4. Analysis of Simulation models using input analyzer, and output analyzer.<br>5. Explain Verification and Validation of simulation model</td></tr>
<tr><td colspan="2" rowspan="4">Course Outline</td><td colspan="6">Unit I: Introduction to Simulation: Simulation, Advantages, Disadvantages, Areas of application, System environment, components of a system, Model of a system, types of models, steps in a simulation study. Simulation Examples: Simulation of Queuing systems, Simulation of Inventory System, Other simulation examples.</td></tr>
<tr><td colspan="6">Unit II: General Principles: Concepts in discrete - event simulation, event scheduling/ Time advance algorithm, simulation using event scheduling. Random Numbers: Properties, Generations methods, Tests for Random number- Frequency test, Runs test, Autocorrelation test.</td></tr>
<tr><td colspan="6">Unit III: Random Variate Generation: Inverse Transform Technique Exponential, Uniform, Weibull, Triangular distributions, Direct transformation for Normal and log normal Distributions, convolution methods- Erlang distribution, Acceptance Rejection Technique Optimization Via Simulation: Meaning, difficulty, Robust Heuristics, Random Search.</td></tr>
<tr><td colspan="6">Unit IV: Analysis of Simulation Data Input Modelling: Data collection, Identification and distribution with data, parameter estimation, Goodness of fit tests, Selection of input models without data, Multivariate and time series analysis. Verification and Validation of Model – Model Building, Verification, Calibration and Validation of Models.</td></tr>
<tr><td colspan="2"></td><td colspan="6">Unit V: Output Analysis – Types of Simulations with Respect to Output Analysis, Stochastic Nature of output data, Measures of Performance and their estimation, Output analysis of terminating simulation, Output analysis of steady state simulations. Simulation Software’s: Selection of Simulation Software, Simulation packages, Trend in Simulation Software.</td></tr>
</table>

| | |
|---|---|
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) | Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved<br>(To be discussed during the Tutorial hour) |
| **Skills acquired from this course** | Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended Text Books** | 1. Barcley G.W. (1970) Techniques of Population Analysis, Wiley, New York. Borowiak, D.S. and Shapiro, A.F. (2013) Financial and Actuarial Statistics: An Introduction, CRC Press, London.<br>2. Shailaja R Deshmukh (2009) "Actuarial Statistics", University Press (India) Private Limited, Hyderabad. |
| **Reference Books** | 1. Jerry Banks, John S Carson, II, Berry L Nelson, David M Nicol, Discrete Event system Simulation, Pearson Education, Asia, 4th Edition, 2007, ISBN: 81-203- 2832-9.<br>2. Geoffrey Gordon, System Simulation, Prentice Hall publication, 2nd Edition, 1978, ISBN: 81-203-0140-4.<br>3. Averill M Law, W David Kelton, Simulation Modelling & Analysis, McGraw Hill International Editions – Industrial Engineering series, 4th Edition, ISBN: 0-07-100803-9. Narsingh Deo, Systems Simulation with Digital Computer, PHI Publication (EEE), 3rd Edition, 2004, ISBN: 0-87692-028-8. |
| **Website and e-Learning Source** | e-books, online tutorials taken from MOOC/SWAYAM platform for thissubject. |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

1. Describe the role of important elements of discrete event simulation and modeling paradigm.
2. Conceptualize real world situations related to systems development decisions, originating from source requirements and goals.
3. Develop skills to apply simulation software to construct and execute goal-driven system models.
4. Interpret the model and apply the results to resolve critical issues in a real-world environment.

**CO-PO Mapping (Course Articulation Matrix)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | M | M | M | S | M | S | M | M |
| **CO2** | S | S | S | S | M | S | M | S | M | M |
| **CO3** | S | S | S | M | S | S | M | S | S | M |
| **CO4** | M | S | S | S | S | S | S | S | M | M |
| **CO5** | S | S | S | S | M | S | S | S | M | M |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to POS** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="7">Total Quality Management</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="7">IX</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">ED</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1E09</td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td>Lecture</td><td colspan="2">Tutorial</td><td colspan="2">Lab Practice</td><td>Total</td></tr>
<tr><td>3</td><td colspan="2">1</td><td colspan="2">-</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="7">Basic knowledge in quality control and its properties</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="7">The main objectives of this course are to:<br>1. Develop a thinking towards Quality systems and thinking.<br>2. Understand Quality in Manufacturing, Service, Health care and Education.<br>3. Relate to Quality in Public Sector.</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="7">Unit I: Need for TQM, evolution of quality, Definition of quality, TQM philosophy – Contributions of Deming, Juran, Crosby, Taguchi and Ishikawa.</td></tr>
<tr><td colspan="7">Unit II: Vision, Mission, Quality policy and objective, Planning and Organization for quality, Quality policy Deployment, Quality function deployment, Analysis of Quality Costs.</td></tr>
<tr><td colspan="7">Unit III: Customer focus, Leadership and Top management commitment, Employee involvement – Empowerment and Team work, Supplier Quality Management, Continuous process improvement, Training, performance, Measurement and customer satisfaction.</td></tr>
<tr><td colspan="7">Unit IV: PDSA, The Seven QC Tools of Quality, New Seven management tools, Concept of six sigma, FMEA, Bench Marking, JIT, POKA YOKE, 5S, KAIZEN, Quality circles.</td></tr>
<tr><td colspan="7">Unit V: Need for ISO 9000 Systems, clauses, Documentation, Implementation, Introduction to QS 9000, Implementation of QMS, Case Studies.</td></tr>
<tr><td colspan="2">Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)</td><td colspan="7">Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / applied survey techniques adopted in Economics and Statistics department of Tamil Nadu State Government.<br><br>(To be discussed during the Tutorial hour)</td></tr>
<tr><td colspan="2">Skills acquired from this course</td><td colspan="7">Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill</td></tr>
<tr><td colspan="2">Recommended Text Books</td><td colspan="7">1. James R. Evans and William M. Lindsay, “The Management and Control of Quality”, 8th edition, First Indian Edition, Cengage Learning, 2012.<br>2. Suganthi.L and Anand Samuel, “Total Quality Management”, Prentice Hall (India) Pvt. Ltd., 2006.<br>3. Janakiraman. B and Gopal.R.K., “Total Quality Management – Text and Cases”, Prentice Hall (India) Pvt. Ltd., 2006.</td></tr>
</table>

| | |
|---|---|
| | 4. Dale H.Besterfiled (2002): "Total Quality Management", Pearson Education Asia<br>5. Oakland.J.S (1989): "Total Quality Management", Butterworth–Hcinemann Ltd., Oxford |
| **Reference Books** | 1. Narayana V. and Sreenivasan, N.S. (1996): "Quality Management – Concepts and Tasks", New Age International.<br>2. Zeiri (1991): "Total Quality Management for Engineers", Wood Head Publishers.<br>3. Juran J.M and Frank M.Gryna Jr.(1982): "Quality Planning and Analysis", TMH, India.<br>4. Brain Rethery (1993): ISO 9000, Productivity and Quality Publishing Pvt.Ltd.<br>5. D.Mills(1993): Quality Auditing, Chapman and Hall |
| **Website and e-Learning Source** | e-books, online tutorials taken from MOOC/SWAYAM platform for this subject. |

**Course Learning Outcome (for Mapping with POs and PSOs)**

After the successful completion of the course, the students will be able to:

1. Understand the elements of reliability, hazard function and its applications.
2. Understand the concept of censoring, life distributions and ageing classes.
3. Estimate nonparametric survival function of the data.
4. Explain test of exponentiality against nonparametric classes, two sample problems.

**CO-PO Mapping (Course Articulation Matrix)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | M | M | M | S | M | S | M | M |
| **CO2** | S | S | S | S | M | S | M | S | M | M |
| **CO3** | S | S | S | M | S | S | M | S | S | M |
| **CO4** | M | S | S | S | S | S | S | S | M | M |
| **CO5** | S | S | S | S | M | S | S | S | M | M |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

11.2.4 Group D:
11.2.4.1 Survival Analysis

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Survival Analysis</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">X</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">ED</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1E10</td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td colspan="2">Tutorial</td><td>Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">3</td><td colspan="2">1</td><td>-</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Basic knowledge in linear models and their properties</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">The main objectives of this course are to:<br>1. To learn the analysis of survival data.<br>2. To distinguish censored and uncensored data.<br>3. To visualize and communicate time-to event data, to fit and interpret failure time model.</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">Unit I: Concepts of time, Order and random Censoring, likelihood in these cases. Life distributions- Exponential, Gamma, Weibull, Lognormal, Pareto, Linear Failure rate. Parametric inference (Point estimation, scores, MLE)</td></tr>
<tr><td colspan="6">Unit II: Life tables, failure rate, mean residual life and their elementary properties. Concept of Ageing, Types of Ageing classes and their properties and relationship between them, Bathtub Failure rate, Concept of Inverse Hazard rate.</td></tr>
<tr><td colspan="6">Unit III: Estimation of survival function Actuarial Estimator, Kaplan- Meier Estimator, Estimation under the assumption of IFR / DFR. Tests of exponentiality against non- parametric classes- Total time on test, Despande test.</td></tr>
<tr><td colspan="6">Unit IV: Two sample problem- Gehan test, Log rank test. Mantel Haenszel test, Tarone Ware tests. Introduction to Semi-parametric regression for failure rate, Cox’s proportional hazards(PH) model with one and several covariates and estimation problems in Cox’s PH Model. Rank test for the regression coefficients.</td></tr>
<tr><td colspan="6">Unit V: Introduction to Competing risks analysis and estimation problems in competing risk model for parametric and non-parametric semi parametric set up. Ideas of Multiple decrement life table and its applications.</td></tr>
<tr><td colspan="2">Extended Professional Component (is a part of internal component only, not to be included in the External Examination question paper)</td><td colspan="6">Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / applied survey techniques adopted in Economics and Statistics department of Tamil Nadu State Government.<br>(To be discussed during the Tutorial hour)</td></tr>
</table>

| | |
|---|---|
| **Skills acquired from this course** | Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended Text Books** | 1. Miller, R.G. (1981): Survival analysis (John Wiley).<br>2. Cox, D.R. and Oakes, D. (1984) : Analysis of Survival Data, Chapman and Hall, New York. |
| **Reference Books** | 1. Elisha T Lee, John Wenyu Wang and Timothy Wenyu Patt (2003): Statistical Methods for Survival data Analysis, 3/e, Wiley Inter Science.<br>2. Gross, A.J. and Clark, V.A. (1975) : Survival distribution : Reliability applications in the Biomedical Sciences, John Wiley and Sons.<br>3. Elandt Johnson, R.E. Johnson N.L.: Survival Models and Data Analysis, John Wiley and sons.<br>4. Kalbfleisch J.D. and Prentice R.L.(1980), The Statistical Analysis of Failure Time Data, JohnWiley. |
| **Website and e-Learning Source** | e-books, online tutorials taken from MOOC/SWAYAM platform for this subject. |

**Course Learning Outcome (for Mapping with POs and PSOs)**

After the successful completion of the course, the students will be able to:

5. Understand the elements of reliability, hazard function and its applications.
6. Understand the concept of censoring, life distributions and ageing classes.
7. Estimate nonparametric survival function of the data.
8. Explain test of exponentiality against nonparametric classes, two sample problems.

**CO-PO Mapping (Course Articulation Matrix)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | M | M | M | S | M | S | M | M |
| **CO2** | S | S | S | S | M | S | M | S | M | M |
| **CO3** | S | S | S | M | S | S | M | S | S | M |
| **CO4** | M | S | S | S | S | S | S | S | M | M |
| **CO5** | S | S | S | S | M | S | S | S | M | M |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="7">Econometrics</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="7">XI</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">ED</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1E11</td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td colspan="2">Tutorial</td><td colspan="2">Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">3</td><td colspan="2">1</td><td colspan="2">-</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="7">Basic knowledge in linear models and their properties</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="7">The main objectives of this course are to:<br>1. Develop knowledge on concepts of methodology, nature and scope of Econometric analysis<br>2. Inculcate the ideas of applications of econometrics<br>3. Understand and explore the concepts of linear models<br>4. Explore prominent estimation methods for linear regression model and simultaneous equation models.</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="7">UNIT I: Nature and scope of Econometrics - Illustrative Examples Production and cost analysis - Theory and analysis of consumer demand specification - Estimation of demand function- Price and income elasticity of demand - Price elasticity’s of supply - Torquivists model of demand for inferior goods models building bias in construction of models.</td></tr>
<tr><td colspan="7">UNIT II: Single equation linear model: static case - Ordinary least square model and generalized least squares model: Introduction - estimation and prediction - Problem of multi collinearity and heteroscedasticity – Causes, consequences and solutions of and estimation.</td></tr>
<tr><td colspan="7">UNIT III: Autocorrelation: Causes, consequences and testing for autocorrelated disturbances - Autoregressive series of order 1 (AR(1)) - Lagged variables and distributed log methods - Errors in variable models and Instrumental variables. Economical Forecasting – long term and short term.</td></tr>
<tr><td colspan="7">UNIT IV: Simultaneous equations model- Concept, structure and types - Identification Problem with restrictions on variance and covariance - Rank and order conditions of identifiability – Methods of estimation- Indirect least square method, two-stage least squares method of estimation and Estimation of Limited Information Maximum Likelihood (LIML).</td></tr>
<tr><td colspan="7">UNIT V: K-Class estimators - Full information estimators - Full Information Maximum Likelihood (FIML) - Three stage least squares estimators (3-SLS) and its Properties - Comparison of various estimation methods.</td></tr>
<tr><td colspan="2">Extended Professional Component (is a part of internal component only, Not to be included in the</td><td colspan="7">Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / applied survey techniques adopted in Economics and Statistics department of Tamil Nadu State Government.<br><br>(To be discussed during the Tutorial hour)</td></tr>
</table>

| | |
|---|---|
| External Examination question paper) | |
| **Skills acquired from this course** | Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended Text Books** | 1. Castle, J. and Shephard, N. (2009) The Methodology and Practice of Econometrics. Oxford University Press, London.<br>2. Goldberger, A.S. (1964) Econometrics theory, Wiley, New York. |
| **Reference Books** | 1. Kelejion, H. H. and Oates, W.E. (1988) Introduction to Econometrics, Principles and Applications. Harper and Row, New York.<br>2. Maddala, G.S. and KajalLagari. (2009) Introduction to Econometrics, Wiley, New York.<br>3. Madnani, G.M.K. (2008) Introduction to Econometrics: Principles and Applications. Oxford and IBH, New Delhi.<br>4. Wooldridge, J. (2012) Introduction Econometrics: A Modern Approach. Cengage Learning, New Delhi.<br>5. Gujarati, D. N., Dawn C Porter and Sangeetha Kunasekar, (2016), Basic Econometrics, Fifth Edition, McGraw Hill Publisher, New York.<br>6. Johnston, J., and J. Dinardo,.( 1997). Econometric Methods, McGraw-Hill. |
| **Website and e-Learning Source** | e-books, online tutorials taken from MOOC/SWAYAM platform for this subject. |

**Course Learning Outcome (for Mapping with POs and PSOs)**

After the successful completion of the course, the students will be able to:

1. Understand the basic concepts of Econometrics, methodology and limitations of using Econometric theory.
2. Derive Generalized Least square estimators and its properties.
3. Address the problem of violation of basic assumptions of GLS.
4. Find the solution for structural and reduced form models.
5. Obtain viable, reliable and optimal solution under simultaneous equation models.

**CO-PO Mapping (Course Articulation Matrix)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | M | M | M | S | M | S | M | M |
| **CO2** | S | S | S | S | M | S | M | S | M | M |
| **CO3** | S | S | S | M | S | S | M | S | S | M |
| **CO4** | M | S | S | S | S | S | S | S | M | M |
| **CO5** | S | S | S | S | M | S | S | S | M | M |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

| Title of the Course | | Statistical Computations Using Python | | | | | |
|---|---|---|---|---|---|---|---|
| Paper Number | | XII | | | | | |
| Category | Core | Year | II | Credits | 4 | Course Code | 23UPSTA1E12 |
| | | Semester | III | | | | |
| Instructional Hours per week | | Lecture | Tutorial | Lab Practice | Total | | |
| | | 4 | 1 | -- | 5 | | |
| Pre-requisite | | | | | | | |
| Objectives of the Course | | The main objectives of this course are to:<br>1. To understand the basic programming principles of Python language<br>2. To be familiar with the operations of data<br>3. To analyze data which includes knowing how to import data, explore it, analyze it,learn from it, visualize it, and ultimately generate easily shareable reports.<br>4. Explore and execute the machine learning concepts for real time data using Python | | | | | |
| Course Outline | | **Unit I:** Basics of Python Type of variables, data types, lists, control statements, functions, classes, files and exceptions. Program to implement Functions. Program to perform Basic Operations on Sequence objects. | | | | | |
| | | **Unit II:** Essential Modules in Python Jupyter Notebook, Numpy, Scipy, Matplotlib, Pandas, mglearn. Program to perform Operations on Sequence annotation objects. Program to perform Operations on Sequence Input/Output. Program to perform Operations on Multiple Sequence Alignmentobjects. | | | | | |
| | | **UNIT III** Supervised Learning Classificationand Regression, k-Nearest Neighbors, k-Nearest Neighbors, Decision Trees, Neural Networks. | | | | | |
| | | **UNIT IV** Unsupervised Learning – 1 Pre-processing and Scaling, Scaling training, Dimensionality Reduction, Feature Extraction, and Manifold Learning. | | | | | |
| | | **UNIT V** Unsupervised Learning -2 Clustering: k- Means clustering, Agglomerative Clustering. | | | | | |

| | |
|---|---|
| Extended Professional Component (is a partof internal component only, Notto be included in theExternal Examination question paper) | Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved<br>(To be discussed during the Tutorial hour) |
| Skills acquired from this course | Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended** | 1. Introduction to Machine Learning with Python – A Guide for Data Scientists by AndreasC.Muller & Sarah Guido |

| | |
|---|---|
| **Text** | (2017), O'Reilly<br>2. Machine Learning in Python: Essential Techniques for Predictive Analysis by Micheal Bowles (2015), Wiley Python Crash Course: A hands-on, Project- Based Introduction to Programming by EricMathes (2016), no starch presshi. |
| **Reference Books** | 1. Python for Probability, Statistics and Machine Learning (second edition) (2019) by JoseUnpingco, Springer<br>2. Practical Statistics for Data Scientists (second edition) (2020) by Peter Bruce, Andrew Bruce & Peter Gedeck, O'Reilly |
| **Website and e-Learning Source** | e-books, online tutorials taken from MOOC/SWAYAM platform for thissubject. |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

1. Understand the concepts of Python and its operations.
2. Performing the operations of Python by essential modules.
3. Evaluate supervised learning by different techniques.
4. Enumerate the process of unsupervised learning by pre-processing of data.
5. Enumerate the process of unsupervised learning by pre-processing of data

**CO-PO Mapping (Course Articulation Matrix)**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | M | S | S | M | S | M | S | S |
| **CO2** | S | M | M | M | M | S | M | M | S | M |
| **CO3** | S | M | S | L | S | M | M | L | M | M |
| **CO4** | M | M | S | M | S | L | L | L | S | L |
| **CO5** | S | S | M | L | L | M | S | S | S | L |

*S – Strong, M- Medium, L- Low

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Operations Research</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">XIII</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">ED</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1E13</td></tr>
<tr><td>Semester</td><td>III</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td>Lecture</td><td colspan="2">Tutorial</td><td colspan="2">Lab Practice</td><td>Total</td></tr>
<tr><td>3</td><td colspan="2">1</td><td colspan="2">-</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Basic knowledge in quality control and its properties</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">The main objectives of this course are to:<br>1. Optimization techniques that will be useful in the personal and professional life.<br>2. To learn the mathematical formulation of complex decision-making problems and arrives at optimal or near-optimal solutions using different techniques of operations research.</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">Unit I: Mathematical Programming - Solving of LPP by graphical method - Linear Programming Problem (LPP)– Simplex, Big M and Two-Phase methods –Solving LPP using Duality - Dual Simplex method.</td></tr>
<tr><td colspan="6">Unit II: Post Optimality and Sensitivity Analysis–Variation in cost vector and requirement vector– Addition and deletion of single variable and single constraint - Integer Programming Problem (IPP) - Gomory’s cutting plane algorithm– Mixed IPP – Branch and Bound technique.</td></tr>
<tr><td colspan="6">Unit III: Dynamic programming problem (DPP) - Bellman’s principle of optimality - General formulation - computation methods and application of DPP - Solving LPP through DPP approach.</td></tr>
<tr><td colspan="6">Unit IV: Non-Linear Programming: Constrained and Unconstrained Problems of Maxima and minima, Constraints in the form of equations (Lagrangian Method) and in equations (KuhnTucker conditions), Quadratic programming: Beale's and wolf's methods simplex method for quadratic programming.</td></tr>
<tr><td colspan="6">Unit V: PERT - CPM: Applications, Basic Steps in PERT/CPM techniques; Time estimates and Critical Path in Network Analysis; Optimum and minimum duration cost, PERT, Resource Allocations.</td></tr>
<tr><td colspan="2">Extended Professional Component (is a part of internal component only, not to be included in the External Examination question paper)</td><td colspan="6">Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / applied survey techniques adopted in Economics and Statistics department of Tamil Nadu State Government.<br><br>(To be discussed during the Tutorial hour)</td></tr>
<tr><td colspan="2">Skills acquired from this course</td><td colspan="6">Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill</td></tr>
</table>

| | |
|---|---|
| **Recommended Text Books** | 1. Hillier FS and Libermann GJ (2002): Introduction to Operations Research,7 th Edition, McGraw Hill.<br>2. Kanti Swarup,P.K.Gupta and Man Mohan(2004):Operations Research, Sultan Chand and Sons, New Delhi.<br>3. Gross D, Shortle J.F. Thompson J.M. and Harris C.M. (2011): Fundamentals of Queuing Theory, John Wiley & Sons. |
| **Reference Books** | 1. Sinha SM (2006):Mathematical Programming: Theory and Methods, Elsevier Publications.<br>2. Devi Prasad (2015), Operations Research, Narosa Publishing House<br>3. Kapoor V.K.(2008):Operations Research, 8/e, Sultan Chand & Sons<br>4. Sharma .S.D(1999): Operation Research , Kedar Nath RamNath & Co., Meerut.<br>5. Hamdy A.Taha(1987):Operations Research – An Introduction, 4 /e, Prentice Hall of India, Private Ltd, New Delhi.<br>6. Sujit K. Bose (2012), Operations Research Methods, 2/e, Narosa Publishing House<br>7. K. Chandrasekhara Rao and Shanti Lata Misra (2012), Operations Research, Narosa Publishing House |
| **Website and e-Learning Source** | e-books, online tutorials taken from MOOC/SWAYAM platform for this subject. |

**Course Learning Outcome (for Mapping with POs and PSOs)**

After the successful completion of the course, the students will be able to:

1. Understand basics and formulation of linear programming problems and appreciate their limitations; solve linear programming problems using graphical method.
2. Apply simplex method to solve real life problems.
3. Solve artificial variable technique, duality theory, revised simplex method, sensitivity analysis, transportation and assignment problems.
4. Understand the concept of Game theory, PERT/ CPM, simulation, investment analysis with real life applications.

**CO-PO Mapping (Course Articulation Matrix)**

| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | M | M | M | S | M | S | M | M |
| **CO2** | S | S | S | S | M | S | M | S | M | M |
| **CO3** | S | S | S | M | S | S | M | S | S | M |
| **CO4** | M | S | S | S | S | S | S | S | M | M |
| **CO5** | S | S | S | S | M | S | S | S | M | M |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">Data Base Management System</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">XIV</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">ED</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2" colspan="2">23UPSTA1E14</td></tr>
<tr><td>Semester</td><td>III</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td colspan="2">Tutorial</td><td colspan="2">Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">3</td><td colspan="2">1</td><td colspan="2">-</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="8">Basic knowledge in quality control and its properties</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8">The main objectives of this course are to:<br>1. To Understand the basic concepts and the applications of database systems<br>2. To Master the basics of SQL and construct queries using SQL<br>3. To understand the relational database design principles<br>4. To become familiar with the basic issues of transaction processing and concurrency control<br>5. To become familiar with database storage structures and access techniques</td></tr>
<tr><td colspan="2" rowspan="4">Course Outline</td><td colspan="8">Unit I: Data base System Applications, Purpose of Database Systems, View of Data – Data Abstraction. Instances and Schemas – data Models – the ER Model – Relational Model – Other Models – Database Languages – DDL – DML – database Access for applications Programs – data base Users and Administrator – Transaction Management – data base Architecture – Storage Manager – the Query Processor. Data base design and ER diagrams – ER Model - Entities, Attributes and Entity sets – Relationships and Relationship sets – ER Design Issues – Concept Design – Conceptual Design for University Enterprise. Introduction to the Relational Model – Structure – Database Schema, Keys – Schema Diagrams.</td></tr>
<tr><td colspan="8">Unit II: Relational Query Languages, Relational Operations. Relational Algebra – Selection and projection set operations – renaming – Joins – Division – Examples of Algebra overviews – Relational calculus – Tuple relational Calculus – Domain relational calculus. Overview of the SQL Query Language – Basic Structure of SQL Queries, Set Operations, Aggregate Functions – GROUPBY – HAVING, Nested Sub queries, Views, Triggers.</td></tr>
<tr><td colspan="8">Unit III: Normalization – Introduction, Non loss decomposition and functional dependencies, First, Second, and third normal forms – dependency preservation, Boyee/Codd normal form. Higher Normal Forms - Introduction, Multi-valued dependencies and Fourth normal form, Join dependencies and Fifth normal form.</td></tr>
<tr><td colspan="8">Unit IV: Transaction Concept- Transaction State- Implementation of Atomicity and Durability – Concurrent – Executions – Serializability Recoverability – Implementation of Isolation – Testing for serializability Lock –Based Protocols –</td></tr>
</table>

| | |
|---|---|
| | Timestamp Based Protocols- Validation- Based Protocols – Multiple Granularity. Recovery and Atomicity – Log – Based Recovery – Recovery with Concurrent Transactions – Buffer Management – Failure with loss of nonvolatile storage-Advance Recovery systems- Remote Backup systems. |
| | **Unit V**: File organization: File organization – various kinds of indexes. Query Processing – Measures of query cost - Selection operation – Projection operation, - Join operation – set operation and aggregate operation – Relational Query Optimization – Transacting SQL queries – Estimating the cost – Equivalence Rules. |
| Extended Professional Component (is a part of internal component only, not to be included in the External Examination question paper) | Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / applied survey techniques adopted in Economics and Statistics department of Tamil Nadu State Government.<br><br>(To be discussed during the Tutorial hour) |
| **Skills acquired from this course** | Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended Text Books** | 1. Data base System Concepts, Silberschatz, Korth, McGraw hill, Sixth Edition.<br>2. Data base Management Systems, Raghurama Krishnan, Johannes Gehrke, TATA McGraw Hill 3rd Edition. |
| **Reference Books** | 1. Fundamentals of Database Systems, Elmasri Navathe Pearson Education.<br>2. An Introduction to Database systems, C.J. Date, A.Kannan, S.Swami Nadhan, Pearson, Eight Edition. |
| **Website and e-Learning Source** | e-books, online tutorials taken from MOOC/SWAYAM platform for this subject. |

**Course Learning Outcome (for Mapping with POs and PSOs)**

After the successful completion of the course, the students will be able to:

1. Demonstrate the basic elements of a relational database management system
2. Ability to identify the data models for relevant problems
3. Ability to design entity relationship and convert entity relationship diagrams into RDBMS and formulate SQL queries on the respect data
4. Apply normalization for the development of application software's.

**CO-PO Mapping (Course Articulation Matrix)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | M | M | M | S | M | S | M | M |
| **CO2** | S | S | S | S | M | S | M | S | M | M |
| **CO3** | S | S | S | M | S | S | M | S | S | M |
| **CO4** | M | S | S | S | S | S | S | S | M | M |
| **CO5** | S | S | S | S | M | S | S | S | M | M |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Research Methodology in Statistics</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">XV</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1E15</td></tr>
<tr><td>Semester</td><td>III</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td colspan="2">Tutorial</td><td>Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">3</td><td colspan="2">1</td><td>--</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6"></td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">1. To understand the importance of Research problem in Statistics, and significance of report writing.<br>2. Learning some statistical methodology for random variables.<br>3. Acquiring knowledge of R software for statistical Computation.</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">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.</td></tr>
<tr><td colspan="6">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.</td></tr>
<tr><td colspan="6">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</td></tr>
<tr><td colspan="6">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.</td></tr>
<tr><td colspan="6">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.</td></tr>
</table>

| | |
|---|---|
| Extended Professional Component (is a partof internal component only, Notto be included in theExternal Examination question paper) | Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved<br>(To be discussed during the Tutorial hour) |
| Skills acquired from this course | Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended Text** | 1. Jonathan, Anderson et al. (1977). Thesis and Assignment Writing, Wiley Eastern Ltd, New York.<br>2. Pannerselvam, R. (2006). Research Methodology, Prentice-Hall of India Private Limited, New Delhi. |
| **Reference Books** | 1. Kanti Swarup, Gupta, P.K., & Man Mohan. (2008). Operations Research Sultan Chand & Sons, (Publications), New Delhi.<br>2. Maria L.Rizzo.(2007). Statistical Computing with R, Chapman & Hall/CRC, Taylor and Francis Group.<br>3. Sudha.G.Purohit, Sharad.D.Gore and Shailaja R.Deshmukh.(2008). Statistics Using R, Narosa, Publishing House, New Delhi. |
| **Website and e-Learning Source** | e-books, online tutorials taken from MOOC/SWAYAM platform for thissubject. |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

1. 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.
2. Generalise the statistical studies using the data measurement scales, (nominal, ordinal, ratio and interval scales).
3. Apply the sources of error in measurement compare the scaling technique (likert type scaling ,cumulative scaling).
4. Summarize the knowledge of simulation Concept and its Advantages with respect to Simulation Algorithm and anlayse the simulation techniques with random number generation.
5. Describe the R language and interpret the statistical computation. Manipulate the R coding to categorize the cumulative probabilities using Binomial and Poisson models.

**CO-PO Mapping (Course Articulation Matrix)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | S | S | S | S | S | S | M | M |
| **CO2** | M | S | S | S | M | S | S | M | M | M |
| **CO3** | S | S | S | M | S | S | S | S | S | M |
| **CO4** | S | S | S | S | S | S | S | M | M | M |
| **CO5** | S | M | S | S | S | S | S | M | M | S |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

**Elective VI to be chosen from Group F**
**11.2.6 Group F:**
**11.2.6.1 Non - Parametric Inference**

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">Non - Parametric Inference</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">XVI</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1E16</td></tr>
<tr><td>Semester</td><td>IV</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td colspan="2">Tutorial</td><td colspan="2">Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">3</td><td colspan="2">1</td><td colspan="2">--</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="8"></td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8">1. To familiarize the concepts of non- parametric tests<br>2. To Characterize, compare, and contrast different non-parametric hypothesis tests.<br>2. To Present and communicate, both orally and in written form, the results of statistical analyses of non-parametric data.</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="8">Unit I: Nonparametric vs. Parametric statistical tests - Fundamental differences - Appropriate situations for use of nonparametric methods vs. parametric methods - Advantages and disadvantages of parametric tests - Power-efficiency of nonparametric tests relative to similar parametric tests.</td></tr>
<tr><td colspan="8">Unit II: The one-sample case - Binomial test, Chi-Square test for goodness of fit, Kolmogorov -Smirnov test, runs test.</td></tr>
<tr><td colspan="8">Unit III: The case of two related samples – McNemar, Sign, Wilcoxon, Walsh tests - The case of two independent samples - fisher exact-probability test, Chi-Square test for independent samples, Median test, Mann-Whitney Utest, Kolmogorov-Smirnov test, Wald-Wolfowitz test.</td></tr>
<tr><td colspan="8">Unit IV: The case of k related samples - Cochrane Q - test, Friedman two way analysis of variance by ranks. The case of k independent samples Chi Square test for k independent samples, Kruskal-Wallis one-way analysis of variance by ranks.</td></tr>
<tr><td colspan="8">Unit V: Nonparametric correlation - the contingency coefficient C, Spearman rank correlation, Kendall rank correlation, Kendall partial correlation coefficient - nonparametric linear regression.</td></tr>
</table>

| | |
|---|---|
| Extended Professional Component (is a partof internal component only, Notto be included in theExternal Examination question paper) | Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved<br>(To be discussed during the Tutorial hour) |
| Skills acquired from this course | Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended Text** | 1. A Distribution-Free Theory of Nonparametric Regression (Springer Series in Statistics) Paperback – Import, 4 December 2010.<br>2. Gibbons J.D. (1971): Nonparametric Inference, McGraw- Hill. |
| **Reference Books** | 1. Hardle (1990): Applied Non-parametric Regression, Cambridge University Press.<br>2. Hart J.D. (1997): Non-parametric Smoothing and Lack of Fit Tests, Springer Verlag.<br>3. Takezawa K. (2005): Introduction to Non-parametric Regression - Wiley Series in Probability and Statistics, John Wiley and Sons. |
| **Website and e-Learning Source** | e-books, online tutorials taken from MOOC/SWAYAM platform for this subject. |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

1. Identify when not to use a non-parametric method.
2. Different non-parametric methods in estimation, testing, model fitting, and in analyses.
3. Summarize data using both graphical and numerical methods for use in non-parametric statistical methods.
4. Formulate, test and interpret various hypothesis tests for location, scale, and independence problems.

**CO-PO Mapping (Course Articulation Matrix)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | S | S | S | S | S | S | M | M |
| **CO2** | M | S | S | S | M | S | S | M | M | M |
| **CO3** | S | S | S | M | S | S | S | S | S | M |
| **CO4** | S | S | S | S | S | S | S | M | M | M |
| **CO5** | S | M | S | S | S | S | S | M | M | S |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Reliability Theory</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">XVII</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1E17</td></tr>
<tr><td>Semester</td><td>IV</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td colspan="2">Tutorial</td><td>Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">3</td><td colspan="2">1</td><td>--</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6"></td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">1. Provide an insight into various tools and techniques of Reliability.<br>2. Review the various mathematical, physical and logical modeling tools for estimation and evaluation of component and system level reliability.<br>3. Appraise failure phenomena and there by provide valuable inputs for product design to achieve higher levels of reliability standards.<br>4. Assessment and evaluation of reliability goals and their improvements.</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">Unit I: Introduction to Reliability and its needs; Structural properties of coherent system: components and systems, coherent structures, representation of coherent systems in terms of paths and cuts, relevant & irrelevant structure; Modules of coherent systems; Reliability of a coherent systems; Reliability importance of components; Bounds on System Reliability.</td></tr>
<tr><td colspan="6">Unit II: Life Distributions: Concept of distribution function, hazard function, Reliability function, MTTF, Bathtub failure rate; loss of memory property of Exponential distribution – parametric families of some common life distributions – Exponential, Weibull and Gamma and its characterization - Reliability estimation of parameters in these models.</td></tr>
<tr><td colspan="6">Unit III: Notions of Ageing; Classes of life distributions and their duals - preservation of life distribution classes for reliability operation - Formation of coherent systems, convolutions and mixtures.</td></tr>
<tr><td colspan="6">Unit IV: Univariate stock models and life distributions arising out of them: cumulative damage model, shock models leading to univariate IFR, Successive shock model; bivariate shock models; common bivariate exponential distributions due to shock and their properties. Maintenance and replacement policies; availability of reparable systems; modeling of a repairable system by a non-homogeneous Poisson process.</td></tr>
<tr><td colspan="6">Unit V: Stress-Strength reliability - Concepts and its estimation for exponential, Weibull and gamma distributions; Reliability growth models; probability plotting techniques; Hollander – Proschan and Despande tests for exponentially – Basic ideas of accelerated life testing.</td></tr>
</table>

| | |
|---|---|
| Extended Professional Component (is a partof internal component only, Notto be included in theExternal Examination question paper) | Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved<br>(To be discussed during the Tutorial hour) |
| Skills acquired from this course | Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended Text** | 1. Barlow, R.E. and Proschan F. (1985) Statistical Theory of Reliability and Life Testing; Rinehart and Winston.<br>2. Lawless, J.F. (2003): Statistical Models and Methods of Life Time Data; John Wiley. |
| **Reference Books** | 1. Bain L.J. and Max Engelhardt (1991): Statistical Analysis of Reliability and Life Testing Models; Marcel Dekker.<br>2. Nelson, W (1982): Applied Life Data Analysis; John Wiley.<br>3. Zacks, S(1992): Introdcution to Reliability Analysis, Springer Verlag.<br>4. Marshall, A.W. and Olkin I(2007): Life Distributions, Spring. |
| **Website and e-Learning Source** | e-books, online tutorials taken from MOOC/SWAYAM platform for thissubject. |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

1. Develop an appreciation of basic terminologies as applied to reliability.
2. Enhance ability to design systems and process for reliability improvement.
3. Analyze failure phenomenon of components and systems so as to develop strategies for eliminating/minimizing product failures.
4. Generate estimates for reliability through different modeling approaches for component and system level reliability in real life contexts.

**CO-PO Mapping (Course Articulation Matrix)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | S | S | S | S | S | S | M | M |
| **CO2** | M | S | S | S | M | S | S | M | M | M |
| **CO3** | S | S | S | M | S | S | S | S | S | M |
| **CO4** | S | S | S | S | S | S | S | M | M | M |
| **CO5** | S | M | S | S | S | S | S | M | M | S |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="7">Applied Regression Analysis</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="7">XVIII</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1E18</td></tr>
<tr><td>Semester</td><td>IV</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td colspan="2">Tutorial</td><td>Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">3</td><td colspan="2">1</td><td>--</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="7"></td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="7">1. To develop a deeper understanding of the linear and non-linear regression model and its limitations.<br>2. To learn how to develop regression model and apply for the specific perspective data appropriate manner.</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="7">Unit I: Multiple Linear Regression. Estimation of Model parameters. Least square estimation of the regression coefficients-properties of least square estimators. Maximum likelihood Estimation-Tests for the significance of regression- test on individual regression coefficients – Confidence interval on the regression coefficients- Confidence interval estimation of mean Response-Prediction –Standard regression coefficients UNIT normal scaling-UNIT length scaling.</td></tr>
<tr><td colspan="7">Unit II: Residual analysis. Definition and properties of residuals-methods of scaling Residuals-Residual plots- PRESS statistic-formal test for lack of fit. Variance -Stabilizing transformation-transformations to linearize Models-Generalized and weighted least squares. Indicator variables-concept and use.</td></tr>
<tr><td colspan="7">Unit III: Model building problem-variable Selection-Stepwise regression methods. Multicollinearity - sources and effects of multicollinearity – Diagnostics and methods for detecting multicollinearity.</td></tr>
<tr><td colspan="7">Unit IV: Polynomial regression. Polynomial model in one variable. Piecewise Polynomial fitting (Splines) - Non-parametric regression. Kernel regression – Locally Weighted regression. Polynomial model in two or more variables. Non-linear regression-nonlinear least square transformation to linear model-parameter estimation.</td></tr>
<tr><td colspan="7">Unit V: Generalized Linear Models (GLM). Logistic Regression Estimation of parameters in logistic regression Models-Interpretation of parameters in logistic regression models. Poisson regression-GLM-link function and linear prediction-parameter estimation in GLM.</td></tr>
</table>

| | |
|---|---|
| Extended Professional Component (is a partof internal component only, Notto be included in theExternal Examination question paper) | Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved<br>(To be discussed during the Tutorial hour) |
| Skills acquired from this course | Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended Text** | 1. Montgomery. D.C. Peck E.A. Vining. G.G. (2003), Introduction to Linear Regression Analysis, John Wiley &sons, Inc, New York.<br>2. Draper. N.R. and Smith. H. (1998) Applied regression Analysis, John Wiley. |
| **Reference Books** | 1. Montgomery. D.C. Peck E.A. Vining. G.G. (2003) Introduction to Linear Regression Analysis, John Wiley &sons, Inc, New York.<br>2. Draper. N.R. and Smith. H. (1998) Applied regression Analysis, John Wiley 3. Hosmer, D.W, Lemeshow, S., and Sturdivant, R. X. (2013) Applied Logistic Regression, Third Edition, John Wiley and Sons. |
| **Website and e-Learning Source** | e-books, online tutorials taken from MOOC/SWAYAM platform for thissubject. |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

1. Develop an appreciation of basic terminologies as applied to reliability.
2. Enhance ability to design systems and process for reliability improvement.
3. Analyze failure phenomenon of components and systems so as to develop strategies for eliminating/minimizing product failures.
4. Generate estimates for reliability through different modeling approaches for component and system level reliability in real life contexts.

**CO-PO Mapping (Course Articulation Matrix)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | S | S | S | S | S | S | M | M |
| **CO2** | M | S | S | S | M | S | S | M | M | M |
| **CO3** | S | S | S | M | S | S | S | S | S | M |
| **CO4** | S | S | S | S | S | S | S | M | M | M |
| **CO5** | S | M | S | S | S | S | S | M | M | S |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

**Skill Enhancement Courses SEC:**
**Practical I – (Based on R Programming)**

<table>
<tr><td>Title of the Course</td><td colspan="7">Statistics Practical I – (Based on R Programming)</td></tr>
<tr><td>Paper Number</td><td colspan="7">I</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">2</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1L01</td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td colspan="2">Tutorial</td><td>Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">1</td><td colspan="2">-</td><td>1</td><td>2</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6"></td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">1. Understand the notions of Sampling by using R.<br>2. Impart application of Distribution Theory in various domains.</td></tr>
<tr><td colspan="2" rowspan="2">Course Outline</td><td colspan="6">Core II. Sampling Theory<br>1. Simple Random Sampling with and without replacement.<br>2. Sampling with probabilities proportional to size.<br>3. Stratified sampling<br>4. Systematic sampling<br>5. Probability-proportional-to-size sampling with replacement.<br>6. Probability-proportional-to-size sampling without replacement.<br>7. Ratio Estimation and Regression Estimation.</td></tr>
<tr><td colspan="6">Core III Distribution theory<br>8. Fitting of Binomial, Poisson, Normal Distribution<br>9. Fitting of Simulations using a Discrete and Continuous Distribution<br>10. Fitting of Weibull Distribution.<br>11. Fitting of Bivariate Normal Distribution<br>12. Fitting of Chi-square, t, F distribution</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">1. Lu, Y., & Lohr, S. L. (2021). R Companion for Sampling: Design and Analysis. CRC Press.<br>2. Dalgaard, P. (2008). Introductory statistics with R. springer publication.<br>3. Kerns, G. J. (2010). Introduction to probability and statistics using R. Lulu. com.</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. Everitt, B. S., and Hothorn, T. (2010). A Handbook of Statistical Analyses Using R, SecondEdition, Chapman and Hall, CRC Press.<br>2. Crawley, M, J. (2007). The R Book, John Wiley and Sons Private Ltd., NY.</td></tr>
<tr><td colspan="2">Website and e-Learning Source</td><td colspan="6">1. https://swayam.gov.in/nd1_noc19_ma33/preview.<br>2. https://swayam.gov.in/nd2_aic20_sp35/preview.<br>3. https://nptel.ac.in/courses/111/104/111104100/</td></tr>
</table>

**Practical II – (Based on R Programming)**

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Statistics Practical II– (Based on R Programming)</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">II</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">2</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1L02</td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td colspan="2">Tutorial</td><td>Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">1</td><td colspan="2">-</td><td>1</td><td>2</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6"></td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">1. Understand the notions of Sampling by using R.<br>2. Impart application of Distribution Theory in various domains.</td></tr>
<tr><td colspan="2" rowspan="2">Course Outline</td><td colspan="6">Core IV: Estimation theory<br>1. Point Estimation<br>2. Confidence interval for mean, Difference of Means, Standard Deviations<br>3. Confidence interval for Variance and Ratio of Variances.<br>4. Maximum likelihood estimation</td></tr>
<tr><td colspan="6">Core VI: Time Series Analysis<br>5. Standard statistical measures for Time Series analysis: Absolute measures – Mean absolute error, Mean error, Mean square error. Relative measures - Percentage error, Mean percentage error, Mean absolute percentage error.<br>6. Smoothing methods – Single exponential smoothing. Double exponential smoothing (Holt method).<br>7. Triple exponential smoothing (Holt-Winter’s method).<br>8. Autocorrelation function (ACF) and Partial Autocorrelation function (PACF)<br>9. ARMA and ARIMA models<br>10. Portmanteau tests: Ljung–Box test and Box–Pierce test.</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">1. Kerns, G. J. (2010). Introduction to probability and statistics using R. Lulu. com.<br>2. Ding-Geng (Din) Chen and Karl E. Peace (2011). Clinical Trial Data Analysis Using R. Taylor & Francis Group.<br>3. Quick, J.M. (2010). Statistical Analysis with R, Packt Publishing Ltd., UK.<br>4. Robert H. Shumway David S. Stoffer. (2017). Time series Analysis and its Applications: With R Examples, Fourth Edition, Springer Nature.</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. Everitt, B. S., and Hothorn, T. (2010). A Handbook of Statistical Analyses Using R, SecondEdition, Chapman and Hall, CRC Press.<br>2. Crawley, M, J. (2007). The R Book, John Wiley and Sons Private Ltd., NY.</td></tr>
</table>

| | |
|---|---|
| **Website and e-Learning Source** | 1. https://swayam.gov.in/nd1_noc19_ma33/preview.<br>2. https://swayam.gov.in/nd2_aic20_sp35/preview.<br>3. https://nptel.ac.in/courses/111/104/111104100/ |

**Practical III – (Based on R Programming)**

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Statistics Practical III - (Based on R Programming)</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">III</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">2</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1L03</td></tr>
<tr><td>Semester</td><td>III</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td colspan="2">Tutorial</td><td>Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">1</td><td colspan="2">-</td><td>1</td><td>2</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Basic knowledge of Testing Statistical Hypothesis, Multivariate Statistical Analysis and Time Series Analysis</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">1. Impart knowledge on statistical computation using real data sets.<br>2. To familiarize the students in solving problems in testing of hypotheses, non-parametric tests through R software.<br>3. Understand the theory through practical oriented training.<br>4. The concept of Applied Regression analysis were incorporated.<br>5. Write programming codes for the methods in Statistical quality control.</td></tr>
<tr><td colspan="2" rowspan="2">Course Outline</td><td colspan="6">Core VII: Testing Statistical Hypothesis<br>1. Most powerful test - Uniformly most powerful test- Likelihood ratio test- Chi-Square Test, Sequential Probability Ratio Test – OC and ASN function.<br>2. Non-parametric test - Chi-Square test, Wilcoxon’s Signed-Rank test, Mann-Whitney U test, Kolmogorov Smirnov test, Kruskal Wallis test, Friedman Test and Rank Correlation.</td></tr>
<tr><td colspan="6">Exercise under Multivariate Analysis<br>1. Maximum likelihood estimators of mean vector and dispersion Matrix.<br>2. Test for mean vector when dispersion matrix Σ is known. Hotelling's $T^2$ statistic<br>3. Test for covariance matrix Principal component analysis.<br>4. Canonical correlation.<br>Discrimination and Classification problems. Factor Analysis, Cluster Analysis<br>Exercise under Applied Regression Analysis<br>1. Multiple Linear Regression<br>2. Logistic Regression<br>3. Polynomial regression<br>4. Generalized Linear Models<br>Exercise under Statistical Quality Control<br>1. Control Chart for X bar Chart<br>2. Control Chart for R Chart<br>3. S – Chart<br>4. C-Chart<br>5. P-Chart<br>6. np- Control Chart</td></tr>
</table>

| | |
|---|---|
| | **7.** U-chart |
| **Recommended Text** | 1. M.Rajagopalan and P.Dhanavanthan., Statistical inference, PHI Learning Private Limited, New Delhi,2012).<br>2. Lehman, E.L. and J.P. Romano, Testing Statistical Hypotheses, 3rd ed., Springer 2005.<br>3. Gibbons, J.D. and S.Chakraborty, Nonparametric Statistical Inference, 3rd ed., Marcel Dekker,2010.<br>4. McGibney, D. P. (2023). Applied Linear Regression for Business Analytics with R: A Practical Guide to Data Science with Case Studies (Vol. 337). Springer Nature.<br>5. Peihua Qiu, (2014). Introduction to Statistical Process Control, CRC Press, Taylor and Francis Group. |
| **Reference Books** | 1. H. Brian, A Practical Introduction to Python Programming, Creative Commons Attribution, 2012.<br>2. A. Saha, Doing Math with Python: Use Programming to Explore Algebra, Statistics, Calculus, and More! No Starch Press, 2015<br>3. T. Hall, J. P. Stacey, Python 3 for absolute beginners, A press, 2010. |

**Practical IV – (Based on R and Python Programming)**

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Statistics Practical IV – (Based on R and Python Programming)</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">IV</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">2</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1L04</td></tr>
<tr><td>Semester</td><td>IV</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td>Lecture</td><td>Tutorial</td><td>Lab Practice</td><td colspan="3">Total</td></tr>
<tr><td>1</td><td>-</td><td>1</td><td colspan="3">2</td></tr>
<tr><td colspan="2" rowspan="2">Course Outline</td><td colspan="6">Core XI: Design of Experiments<br>1. One way – Two way ANOVA, CRD, RBD and LSD - Confounding- $2^2$ , $2^3$ and $2^k$ Factorial Experiments - BIBD - PBIBD - Lattice Designs.</td></tr>
<tr><td colspan="6">Exercise under Python<br>1. Descriptive Statistics<br>2. One sample t-test<br>3. Paired t-test<br>4. Independent sample t-test<br>5. ANOVA -One way and Two way<br>6. Chi-square test<br>7. Analysis for Correlation<br>8. Analysis for Regression<br>9. Augmented Dickey Fuller test<br>10. Autoregressive Moving Average Model<br>11. Autoregressive Integrated Moving Average Model<br>12. Classification and Regression<br>13. K-Nearest Neighbors<br>14. Decision trees</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">1. Everitt, B. S., and Hothorn, T. (2010). A Handbook of Statistical Analyses Using R, Second Edition, Chapman and Hall/CRC Press.<br>2. Quick, J. M. (2010). Statistical Analysis with R, Packt Publishing Ltd., UK.<br>3. B.V. Vishwas and A. Patel. (2020). Hands-on-Time series Analysis with Python: From Basics to bleeding Edge Techniques. A press.<br>4. Thomas Haslwanter. (2016). An Introduction to Statistics with Python: with Applications in the life Sciences. Austria, Springer Nature.<br>5. Robert H. Shumway David S. Stoffer. (2017). Time series Analysis and its Applications: With R Examples, Fourth Edition, Springer Nature.</td></tr>
</table>

| | |
|---|---|
| **Reference Books** | 1. H. Brian, A Practical Introduction to Python Programming, Creative Commons Attribution, 2012.<br>2. A. Saha, Doing Math with Python: Use Programming to Explore Algebra, Statistics, Calculus, and More! No Starch Press, 2015<br>3. T. Hall, J. P. Stacey, Python 3 for absolute beginners, A press, 2010. |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Title of the Course** | | **Fundamentals of Human Rights** | | | | | |
| **Paper Number** | | **I** | | | | | |
| **Category** | **Core** | **Year** | II | **Credits** | 1 | **Course Code** | 23UPPGC1H01 |
| | | **Semester** | IV | | | | |
| **Instructional Hours per week** | | **Lecture** | **Tutorial** | **Lab Practice** | **Total** | | |
| | | 2 | - | -- | 2 | | |
| **Pre-requisite** | | | | | | | |
| **Objectives of the Course** | | 1. To learn about Basic Facets of Human Rights.<br>2. To know the various rights pertaining to marginalized and other disadvantaged people.<br>3. To help the students to know various human rights movements.<br>4. To make the students to be aware of human rights redressal mechanisms. | | | | | |
| **Course Outline** | | **Unit I: Introduction**: Meaning and Definitions of Human Rights – Characteristics and Importance of Human Rights – Evolution of Human Rights – Formation, Structure and Functions of the UNO - Universal Declaration of Human Rights – International Covenants – Violations of Human Rights in the Contemporary Era. | | | | | |
| | | **Unit II: Human Rights in India**: Development of Human Rights in India – Constituent Assembly and Indian Constitution – Fundamental Rights and its Classification – Directive Principles of State Policy – Fundamental Duties. | | | | | |
| | | **Unit III: Rights of Marginalized and other Disadvantaged People**: Rights of Women – Rights of Children – Rights of Differently Abled – Rights of Elderly - Rights of Scheduled Castes – Rights of Scheduled Tribes – Rights of Minorities – – Rights of Prisoners – Rights of Persons Living with HIVAIDS – Rights of LGBT. | | | | | |
| | | **Unit IV: Human Rights Movements**: Peasant Movements (Tebhaga and Telangana) – Scheduled Caste Movements (Mahar and Ad-Dharmi) – Scheduled Tribes Movements (Santhal and Munda) – Environmental Movements ( Chipko and Narmada Bachao Andolan) – Social Reform Movements (Vaikom and Self Respect). | | | | | |

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|---|---|
| | **Unit V: Redressal Mechanisms**: Protection of Human Rights Act, 1993 (Amendment 2019) – Structure and Functions of National and State Human Rights Commissions – National Commission for SCs – National Commission for STs – National Commission for Women – National Commission for Minorities – Characteristics and Objectives of Human Rights Education. |

| | |
|---|---|
| **Recommended Text** | 1. Sudarshanam Gankidi, Human Rights in India: Prospective and Retrospective, Rawat Publications, Jaipur, 2019.<br>2. Satvinder Juss, Human Rights in India, Routledge, New Delhi, 2020.<br>3. Namita Gupta, Social Justice and Human Rights in India, Rawat Publications, Jaipur, 2021.<br>4. Mark Frezo, The Sociology of Human Rights, John Willy & Sons, U.K. 2014.<br>5. Chiranjivi J. Nirmal, Human Rights in India: Historical, Social and Political Perspectives, Oxford University Press, New York, 2000. |
| **Reference Books** | 1. Dr. S. Mehartaj Begum, Human Rights in India: Issues and perspectives, APH Publishing Corporation, New Delhi, 2010.<br>2. Asha Kiran, The History of Human Rights, Mangalam Publications, Delhi, 2011.<br>3. Bani Borgohain, Human Rights, Kanishka Publishers & Distributors, New Delhi-2, 2007.<br>4. Jayant Chudhary, A Textbook of Human Rights, Wisdom Press, New Delhi, 2011.<br>5. Anju Soni, Human Rights in India, Venus Publication, New Delhi, 2019. |
| **Website and e-Learning Source** | www.un.org/rights/HRToday |
| | www.amnesty.org |
| | www.hrweb.org |
| | https://www.youtube.com/watch?v=vDizUvyQTuo |
| | https://www.youtube.com/watch?v=WJsUfck01Js |

| **Methods of Evaluation** | | |
|---|---|---|
| **Internal Evaluation** | Continuous Internal Assessment Test | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| **External Evaluation** | End Semester Examination | 75 Marks |
| | Total | 100 Marks |
| **Methods of Assessment** | | |
| **Recall (K1)** | Simple definitions, MCQ, Recall steps, Concept definitions | |
| **Understand /** | MCQ, True/False, Short essays, Concept explanations, short summary or overview | |

| | |
|---|---|
| **Comprehend (K2)** | |
| **Application (K3)** | Suggest idea/concept with examples, suggest formulae, solve problems, Observe, Explain |
| **Analyze (K4)** | Problem-solving questions, finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| **Evaluate (K5)** | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| **Create (K6)** | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |

### Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

1. Develop an appreciation of basic terminologies as applied to reliability.
2. Enhance ability to design systems and process for reliability improvement.
3. Analyze failure phenomenon of components and systems so as to develop strategies for eliminating/minimizing product failures.
4. Generate estimates for reliability through different modeling approaches for component and system level reliability in real life contexts.

**Mapping with Programme Outcomes:**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **CO 2** | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO 3** | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO 4** | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| **CO 5** | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 3 | 3 | 3 |

**CO-PO-PSO Mapping**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 3 |
| **CO 2** | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 3 |
| **CO 3** | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 |
| **CO 4** | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 1 | 3 |
| **CO 5** | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 |
| | | | | | | | | | | |

**S-Strong (3) M-Medium (2) L-Low (1)**

# Non- Major Elective – I (MOOC/Swayam) –23UPSTA1N01

# Non- Major Elective – II List

<table>
<tr><td>Title of the Course</td><td colspan="6">Basic Statistical Methods</td></tr>
<tr><td>Paper Number</td><td colspan="6">1</td></tr>
<tr><td rowspan="2">Category NME ii</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1N02</td></tr>
<tr><td>Semester</td><td>III</td></tr>
<tr><td rowspan="2">Instructional Hours Per week</td><td>Lecture</td><td>Tutorial</td><td>Lab Practice</td><td colspan="3">Total</td></tr>
<tr><td>3</td><td>1</td><td>-</td><td colspan="3">4</td></tr>
<tr><td>Pre-requisite</td><td colspan="6">Basic skills in correlation and Non parametric tests</td></tr>
<tr><td>Objectives of the Course</td><td colspan="6">The main objectives of this course are to:<br>1. Demonstrate knowledge of probability and the standard statistical distributions.<br>2. Demonstrate knowledge of fixed-sample and large-sample statistical properties of point and interval estimators.<br>3. Demonstrate knowledge of the properties of parametric, semi-parametric and nonparametric testing procedures.<br>4. Demonstrate the ability to perform complex data management and analysis.<br>5. Demonstrate the ability to apply linear, nonlinear and generalized linear models.<br>6. Demonstrate understanding of how to design experiments and surveys for efficiency.<br>7. Demonstrate knowledge of classical and repeated measures multivariate methods and computational techniques.</td></tr>
<tr><td>Course outline</td><td colspan="6">Unit I: Definition of Statistics and its applications in various disciplines - Collection of Data - classification, Tabulation and Graphical representation of data - construction of univariate and Bivariate frequency distribution - Measures of central tendency - Measures of dispersion - coefficient of variation.<br><br>Unit II: Random experiment - sample space - events - mathematical and statistical definition of probability - conditional probability – Bayes' theorem - Random variables - Distribution functions - moments - Binomial distribution - Poisson distribution - Normal distribution and their properties.<br><br>Unit III: Scatter diagram - Karl Pearson's coefficient of correlation- concurrent deviation method - coefficient of determination - Spearman's Rank correlation -Linear regression–fitting of regression lines.<br><br>Unit IV: Tests of significance - hypotheses - two types' of errors - power function - critical region - level of significance – small sample tests based on t and F distributions. Chi-square test of goodness of fit - contingency table -Test of independence of factors - Large sample tests.<br><br>Unit V: Test of equality of several population means one way and two way</td></tr>
</table>

| | |
|---|---|
| | analysis of variance - Non-parametric tests Sign, Run and Median tests - two sample rank test - Sampling and its uses, sampling methods - Simple random sampling, systematic and stratified. |
| Extended Professional Component (is a part of internal Component only, Not to be included in the External Examination Question paper) | Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /applied survey techniques adopted in Economics and Statistics department of Tamil Nadu State Government.<br><br>(To be discussed during the Tutorial hour) |
| **Skills acquired from This course** | Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended Text Books** | 1. Agarwal, B.L. (2013). Basic statistics. Anshan Publications.<br>2. Sharma, J.K. (2007). Business Statistics (Second Edition). Pearson Education, New Delhi.<br>3. Sokal, P.R. and Rohlf, F.J. (1969). Bio Statistics. W.H. Freeman and Co., San Francisco. |

**Course Learning Outcome (for Mapping with Pos and PSOs)**

After successfully completing the course, a student should be able to demonstrate…

1. Recognize and apply some common probability distributions, and assess if underlying assumptions for the distribution seem reasonable.
2. Be able to perform basic statistical calculations and graphical analyses.
3. Analyze research questions based on statistical data, draw relevant conclusions, and be familiar with the limitations of particular statistical methods.
4. Be able to discuss and reflect upon ethical topics relevant to statistical methods

**CO-PO Mapping (Course Articulation Matrix)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | M | M | M | S | M | S | M | M |
| **CO2** | S | S | S | S | M | S | M | S | M | M |
| **CO3** | S | S | S | M | S | S | M | S | S | M |
| **CO4** | M | S | S | S | S | S | S | S | M | M |
| **CO5** | S | S | S | S | M | S | S | S | M | M |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 |
| CO2 | 3 | 3 | 3 | 3 | 3 |
| CO3 | 3 | 3 | 3 | 3 | 3 |
| CO4 | 3 | 3 | 3 | 3 | 3 |
| CO5 | 3 | 3 | 3 | 3 | 3 |
| Weightage | 15 | 15 | 15 | 15 | 15 |
| Weighted percentage of Course Contribution to Pos | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Title of the Course** | **Statistics for Behavioral Sciences** | | | | | | |
| **Paper Number** | **II** | | | | | | |
| **Category** | **NME ii** | **Year** | **II** | **Credits** | 4 | **Course Code** | **23UPSTA1N03** |
| | | **Semester** | **III** | | | | |
| **Instructional Hours Per week** | **Lecture** | | **Tutorial** | | **Lab Practice** | | **Total** |
| | 3 | | 1 | | - | | 4 |
| **Pre-requisite** | Basic skills in basic statistics and measure of central tendency | | | | | | |
| **Objectives of the Course** | The main objectives of this course are to:<br>1. Distinguish among different scales of measurement and their implications;<br>2. Interpret data displayed in tables and graphically;<br>3. Apply concepts of sample space and probability;<br>4. Calculate measures of central tendency and variation for a given data set;<br>5. Identify the standard methods of obtaining data and identify advantages and disadvantages of each. | | | | | | |
| **Course outline** | **Unit I:** Nature and scope of Statistics - characteristics and limitation of Statistics - statistical investigation - preparation of questionnaire - design of sampling - simple random, stratified and systematic sampling - collection of data - primary and secondary data.<br><br>**Unit II:** Processing and presentation of data - Classification of data - tabulation of data - Formation of frequency tables - Diagrammatic presentation of statistical data - bar diagrams - pie diagrams and pictograms - simple problems – Graphical presentation of statistical data - Histogram, frequency curves and Ogive curve- simple problems.<br><br>**Unit III:** Measures of central tendency - mean, median, mode - simple problems - measures of dispersion - range, mean deviation, quartile deviation and standard deviation - relative measures of dispersion - simple problems.<br><br>**Unit IV:** Concept of Skewness and Kurtosis - Karl Pearson's and | | | | | | |

| | |
|---|---|
| | Bowley's coefficients of Skewness- moments- coefficients of Skewness and Kurtosis - simple problems.<br><br>**Unit V:** Correlation: Scatter diagram - simple correlation, Rank correlation. Regression - simple regression lines (without proof) - Tetrochoric correlation, Phi coefficient and Kendall's co-efficient - simple problems. |
| Extended Professional Component (is a part of internal Component only, Not to be included in the External Examination Question paper) | Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /applied survey techniques adopted in Economics and Statistics department of Tamil Nadu State Government.<br><br>(To be discussed during the Tutorial hour) |
| **Skills acquired from This course** | Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended Text Books** | 1. Camphell, R.C. (1989). Statistics for Biologists, Cambridge University Press, London.<br>2. Garret, H. E., and Woodworth, R. S. (2006). Statistics in Psychology and Education. Cosmo Publications, New Delhi.<br>3. Goon, A. M., Gupta, M. K., and Dasgupta, B. (2008). Fundamentals of Statistics, Volume-I, World Press Ltd, Calcutta.<br>4. Gupta, S. C., and Kapoor, V. K. (2000). Fundamentals of Mathematical Statistics, Tenth Edition, Sultan Chand and Sons, New Delhi.<br>5. Saxena, H. C. (1967). Elementary Statistics, Sultan Chand & Co., New Delhi.<br>6. Tate, M. W. (1964). Statistics in Education. Macmillan Co., New York. Y |

**Course Learning Outcome (for Mapping with Pos and PSOs)**

Students who successfully complete the course should:

1. Explain the major concepts, theoretical perspectives and empirical findings in psychology
2. Evaluate the major methods of inquiry and statistical analysis in psychology
3. Discuss the ways in which diversity influences psychological processes
4. Critically analyze existing literature on a topic in psychology
5. Design research studies, including the application of statistical procedures
6. Discuss how psychological principles can be used to explain social issues, address pressing societal needs and/or inform public policy (aligns with new core and social behavioral inquiry)

**CO-PO Mapping (Course Articulation Matrix)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | M | M | M | S | M | S | M | M |
| **CO2** | S | S | S | S | M | S | M | S | M | M |
| **CO3** | S | S | S | M | S | S | M | S | S | M |
| **CO4** | M | S | S | S | S | S | S | S | M | M |
| **CO5** | S | S | S | S | M | S | S | S | M | M |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

<table>
<tr><td>Title of the Course</td><td colspan="6">Probability and Statistics for Scientists</td></tr>
<tr><td>Paper Number</td><td colspan="6">III</td></tr>
<tr><td rowspan="2">Category NME ii</td><td>Year</td><td>I</td><td>Credits</td><td>4</td><td>Course Code</td><td>23UPSTA1N04</td></tr>
<tr><td>Semester</td><td>II</td><td colspan="4"></td></tr>
<tr><td>Instructional Hours Per week</td><td>Lecture</td><td>Tutorial</td><td colspan="2">Lab Practice</td><td>Total</td></tr>
<tr><td></td><td>3</td><td>1</td><td colspan="2">-</td><td>4</td></tr>
<tr><td>Pre-requisite</td><td colspan="6">Basic skills in Probability and testing</td></tr>
<tr><td>Objectives of the Course</td><td colspan="6">The main objectives of this course are to:<br><br>Knowledge<br>1. Apply probability theory to set up tree diagrams.<br>2. Apply probability theory via Bayes' Rule.<br>Skills<br>1. Able to apply the central limit theorem to sampling distribution<br>2. Able to use estimation technique to determine point estimates confidence interval and sample size.<br>Attitudes<br>1. Able to solve problems independently.<br>2. Able to appreciate the diversity of the applications of central limit theorem.<br>3. Able to appreciate the diversity of the applications of hypothesis testing</td></tr>
<tr><td>Course outline</td><td colspan="6">Unit I: Sample spaces – events – Probability axioms – Conditional Probability – Independent events – Baye's formula - Random Variables - Distribution functions – Marginal distributions, Conditional distribution – Stochastic Independence - Expectation – Conditional expectation and Conditional Variance. Moment generating functions – Cumulant generating functions.<br><br>Unit II: Probability distributions – Binomial, Poisson, geometric, uniform, exponential, normal, gamma, beta (generating function, Mean, variance and Simple problems). Sampling distributions - t, f, Chi-square distributions- properties.<br><br>Unit III: Estimation: Point estimation – Characteristics of estimation – Interval estimation – Interval estimates of Mean, Standard deviation, proportion, difference in means and ratios of standard deviations.<br><br>Unit IV: Test for means, Variances & attributes using the above distributions large sample tests – tests for means, variances and proportions. Analysis of Variance: One way and two way classifications – Complete Randomized blocks – Randomized Block Design and Latin Square Design (Only Problems).</td></tr>
</table>

| | |
|---|---|
| | **Unit V:** Statistical quality control – Statistical basis for control charts – Control limits – Control Charts for variables and attributes – mean chart, range chart, standard deviation chart - charts for defectives, defects – *p*, *np*, *c* charts. |
| Extended Professional Component (is a part of internal Component only, Not to be included in the External Examination Question paper) | Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /applied survey techniques adopted in Economics and Statistics department of Tamil Nadu State Government.<br><br>(To be discussed during the Tutorial hour) |
| **Skills acquired from This course** | Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended Text Books** | 1 Gupta, S.C., and Kapoor, V. K. (1977). Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi.<br>2. Montgomery, D.C. (2009). Introduction to Statistical Quality Control, Sixth Edition, Wiley India, New Delhi.<br>3. Montgomery, D.C., and Runger, G. C. (2010), Applied Statistics and Probability for Engineers, Fifth Edition, John Wiley & Sons, New York. |

**Course Learning Outcome (for Mapping with Pos and PSOs)**

After successfully completing the course, a student should be able to demonstrate…

1. Apply key concepts of probability, including discrete and continuous random variables, probability distributions, conditioning, independence, expectations, and variances.
2. Define and explain the different statistical distributions (e.g., Normal, Binomial, Poisson) and the typical phenomena that each distribution often describes.
3. Apply the basic rules and theorems in probability including Bayes's theorem and the Central Limit Theorem (CLT).
4. Define and demonstrate the concepts of estimation and properties of estimators.
5. Apply the concepts of interval estimation and confidence intervals.

**CO-PO Mapping (Course Articulation Matrix)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | M | M | M | S | M | S | M | M |
| **CO2** | S | S | S | S | M | S | M | S | M | M |
| **CO3** | S | S | S | M | S | S | M | S | S | M |
| **CO4** | M | S | S | S | S | S | S | S | M | M |
| **CO5** | S | S | S | S | M | S | S | S | M | M |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Statistical Data Analysis using R</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">IV</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">NME ii</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2">23UPSTA1N05</td></tr>
<tr><td>Semester</td><td>III</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td>Lecture</td><td colspan="2">Tutorial</td><td>Lab Practice</td><td colspan="2">Total</td></tr>
<tr><td>4</td><td colspan="2">--</td><td>--</td><td colspan="2">4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6"></td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">Upon successful completion of this course, the students will be able to:<br>1. Apply R programming and understand different data sets.<br>2. Apply R Programme and construct graphs, charts and descriptive statistics.<br>3. Analyze the data and know probability and sampling by using R Programming<br>4. Apply R Programming to test the hypothesis of the study.<br>5. Predict the data and take decisions through R programming.</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UNIT I: Introduction to R programming: What is R? - Installing R and R Studio-R Studio Overview - Working in the Console - Getting Help in R and Quitting R Studio Installing and loading packages. Data structures, variables, and data types in R: Creating Variables - Numeric, Character and Logical Data - Vectors - Matrix- Data Frames - Factors -Sorting Numeric, Character, and Factor Vectors - Special Values.</td></tr>
</table>

| | |
|---|---|
| | **UNIT II: Data Visualization using R:** Diagrammatic representation of data -Scatter Plots - Box Plots - Scatter Plots and Pie diagram. **Descriptive statistics in R:** Measures of central tendency - Measures of variability - Skewness and kurtosis - Summary functions, and descriptive statistics by group. |
| | **UNIT III: Basic Probability in R:** Discrete Random Variables - Binomial Random Variable - Continuous Random Variables. **Sampling in R:** Types of Samples - Simple Random Sampling (SRS) - Systematic Sampling - Stratified Sampling - Cluster Sampling. |
| | **UNIT IV: Testing of Hypothesis using R**: T-test, Paired Test, Chi Square test, Analysis of Variance and Correlation. |
| | **UNIT V: Predictive Analytics in R:** linear Regression model, Non-Linear Least Square, multiple regression analysis, Logistic Regression. |
| **Recommended Text** | 8. W. N. Venable, D. M. Smith (1999-2023), "An introduction to R" Version 4.3.1.<br>9. Crawley, M. J. (2006), "Statistics - An introduction using R", John Wiley, London 32.<br>10. Jane M Horgan (2020), "Probability with R", John Wiley and Sons Inc.<br>11. Purohit, S.G.; Gore, S.D. and Deshmukh, S.R. (2015), "Statistics using R", second edition. Narosa Publishing House, New Delhi.<br>12. Shahababa B. (2011) , "Biostatistics with R", Springer, New York.<br>13. Braun & Murdoch (2007), "A first course in statistical programming with R", Cambridge University Press, New Delhi.<br>14. G. Jay Kerns, (2010), " Introduction to probability and Statistics Using R" first editions. |

**Course Learning Outcome (for Mapping with POs and PSOs)**

After successfully completing the course, a student should be able to demonstrate…

1. Understanding and implementing Linear Mixed Models (LMM).
2. Implementation of statistical procedures within the R environment.
3. Data manipulation - acquiring skills in flexible matrix manipulation.
4. Scripting - programming an analysis in such a way that the script can be used with minimal effort for
   similar datasets and analyses and for especially large datasets
5. Data visualization - learning how to create high-quality figures, especially associated with more complex
   analyses (e.g. three dimensional scatter plots, Trellis displays, etc.).

**CO-PO Mapping (Course Articulation Matrix)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | S | M | S | S | S | S | M | M |
| **CO2** | S | S | S | M | M | S | S | S | M | M |
| **CO3** | S | S | S | M | S | S | S | S | S | M |
| **CO4** | S | S | S | S | S | M | S | M | M | M |
| **CO5** | S | M | S | S | S | S | S | M | M | S |

**S-Strong, M-Medium, W-Weak**

**Level of Correlation between PSO's and CO's**

| CO /PO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course Contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

| | |
|---|---|
| **SEMESTER 4: 23UPSTA1S01** | **Skill Enhancement course Statistical Analysis using MS Excel** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Title of the Course** | | **Statistical Analysis using MS Excel** | | | | | |
| **Paper Number** | | **IV** | | | | | |
| **Category** | **NME ii** | **Year** | II | **Credits** | 2 | **Course Code** | 23UPSTA1S01 |
| | | **Semester** | III | | | | |
| **Instructional Hours per week** | | **Lecture** | | **Tutorial** | **Lab Practice** | **Total** | |
| | | 2 | | -- | -- | 2 | |
| **Pre-requisite** | | | | | | | |
| **Objectives of the Course** | | 1. To learn fundamentals and concepts of statistical methods, in particular, with reference to frequency distribution and measures of central tendency, measures of dispersion, skewness and kurtosis,<br>2. To solve problems on theory of probability, linear | | | | | |

| | |
|---|---|
| | programming problems, transportation, assignment and game problems.<br>3. To learn important theorems, different formulae and practical applications of these statistical and optimization methods in the field of Computer Sciences and Applications. |
| **Course Outline** | **UNIT I: Descriptive statistics:**<br>Introduction to Computing - Computer Codes and Arithmetic Overview of BASIC - Sampling and Frequency Distribution - Measures of Central Tendency - Measures of Dispersion - Moments - Computation of Moments – Simple Problems. |
| | **UNIT II: Discrete Probability Distribution:**<br>Discrete Probability Distributions: Probability - Characteristics of Probability - Discrete Distributions - Binomial Distribution - Poisson Distribution - Hypergeometric Distribution – Properties and Numerical problems. |
| | **UNIT III: Curve Fitting:**<br>Curve Fitting: Linear Regression - Least Squares Fit - Nonlinear Fit - Fitting a Polynomial Function. |
| | **UNIT IV: Correlation and Its properties:**<br>Correlation : Coefficient of Correlation - Properties of Correlation Coefficient - Rank Correlation - Multiple Correlation - Partial Correlation. |
| | **UNIT V: Test of Significance:**<br>Tests of Significance: Small sample and large sample tests - t Test, F Test and $\chi 2$ test - ANOVA one way and two way classifications simple problems using Excel. |
| **Recommended Text** | 1. Balagurusamy, E. (2000): Computer Oriented Statistical and Numerical Methods, Macmillan Publishers India Limited.<br>2. Enslein, K., Ralston, A., and Wilf, H.S. (1976): Statistical Methods for Digital Computers. John Wiley & Sons, New York. |

| Internship/ Industrial Activity – Sem III |
|---|
| Project with Viva Voce – Sem IV |
| Extension Activity – Sem IV |

## 12. VALUE ADDED COURSE

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Title of the Course** | | **Statistical Techniques Using Open Source Software** | | | | | |
| **Paper Number** | | **I** | | | | | |
| **Category** | **VA** | **Year** | | **Credits** | 3 | **Course Code** | **23UPSTA1V01** |
| | | **Semester** | **II** | | | | |
| **Instructional Hours Per week** | | **Lecture** | **Tutorial** | | **Lab Practice** | **Total** | |
| | | 3 | 1 | | - | 4 | |
| **Pre-requisite** | | Basic skills in basic statistics and non parametric tests | | | | | |
| **Objectives of the Course** | | The main objectives of this course are to:<br>1. Identify and utilize relevant previous work that supports their research<br>2. Articulate a timely and important research question or creative objective<br>3. Identify and utilize appropriate methodologies to address the research question or creative objective<br>4. Meet the relevant field's standards for the responsible conduct of research, and effectively navigate challenges that arise in the research process<br>5. Work collaboratively with other researchers, demonstrating effective communication and problem-solving skills<br>6. Present the research effectively in a conference setting and a written publication | | | | | |
| **Course outline** | | **UNIT I:**<br>Overview of R **-** Basic fundamentals - Installation and use of software, data editing, Importing data into R – Use of R as a calculator - Components of R console-Use of Packages<br><br>**UNIT II:**<br>R Data types - Data management with vectors indexing, lists, factors, strings, Data frame - Arithmetic, Relational and Logical operators-Matrix | | | | | |

| | |
|---|---|
| | operations.<br><br>**UNIT III:**<br>Graphics and plots - creating simple graphic application for Statistical problems.<br><br>**UNIT IV:**<br>Statistical functions for Central tendency, Variation, Skewness and Kurtosis- Correlation and Regression.<br><br>**UNIT V:**<br>Statistical Tests - t, F, chi square - programming and illustration with examples. |
| Extended Professional Component (is a part of internal Component only, not to be included in the External Examination Question paper) | Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /applied survey techniques adopted in Economics and Statistics department of Tamil Nadu State Government.<br>(To be discussed during the Tutorial hour) |
| **Skills acquired from This course** | Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended Text Books** | 1. W. N. Venable, D. M. Smith (1999-2023), "An introduction to R" Version 4.3.1.<br>2. Crawley, M. J. (2006), "Statistics - An introduction using R", John Wiley, London 32.<br>3. Jane M Horgan (2020), "Probability with R", John Wiley and Sons Inc.<br>4. Purohit, S.G.; Gore, S.D. and Deshmukh, S.R. (2015), "Statistics using R", second edition. Narosa Publishing House, New Delhi. |

| **Title of the Course** | | **Statistics for Researchers** | | | | | |
|---|---|---|---|---|---|---|---|
| **Paper Number** | | **II** | | | | | |
| **Category** | **VA** | **Year** | **II** | **Credits** | 3 | **Course Code** | **23UPSTA1V02** |
| | | **Semester** | **III** | | | | |
| **Instructional Hours Per week** | | **Lecture** | | **Tutorial** | **Lab Practice** | **Total** | |
| | | 3 | | 1 | - | 4 | |

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| **Pre-requisite** | Basic skills in basic statistics and non parametric tests |
| **Objectives of the Course** | The main objectives of this course are to:<br>1. Identify and utilize relevant previous work that supports their research<br>2. Articulate a timely and important research question or creative objective<br>3. Identify and utilize appropriate methodologies to address the research question or creative objective<br>4. Meet the relevant field's standards for the responsible conduct of research, and effectively navigate challenges that arise in the research process<br>5. Work collaboratively with other researchers, demonstrating effective communication and problem-solving skills<br>6. Present the research effectively in a conference setting and a written publication |
| **Course outline** | **Unit I:** Definition of Statistics and its applications in various disciplines - Collection of Data -Classification, Tabulation and graphical representation of data- Construction of univariate and bivariate frequency distribution-measures of central tendency-measures of dispersion coefficient of variation.<br><br>**Unit II:** Random experiment-sample space-events-mathematical and statistical definition of probability-conditional probability - Baye's theorem - random variable - distribution function - moments - Binomial distribution - Poisson distribution - normal distribution and their properties<br><br>**Unit III:** Scatter diagram - Karl Pearson's coefficient of correlation - concurrent deviation method coefficient of determination - Spearman's Rank correlation - Linear regression - regression lines.<br><br>**Unit IV:** Tests of significance - types of hypotheses - two types of errors - critical region - level of significance, small sample tests based on t, F distribution, Chi - square test of goodness of fit, contingency table - test of independence of factors - Large sample tests.<br><br>**Unit V:** Test of equality of several population means, one way and two way analysis of variance. Non-parametric tests - sign, run and median tests - two sample rank test - sampling and its uses, sampling methods - unrestricted Random sampling (SRS) - Restricted Sampling (Stratified and Systematic). |
| Extended Professional Component (is a part of internal Component only, | Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /applied survey techniques adopted in Economics and Statistics department of Tamil Nadu State Government. |

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| Not to be included in the External Examination Question paper) | (To be discussed during the Tutorial hour) |
| **Skills acquired from This course** | Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended Text Books** | 1. Agarwal (1980). Basic Statistics, Wiley Eastern.<br>2. Goon,A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Volume-I, World Press Ltd, Calcutta.<br>3. Gupta, S. C., and Kapoor, V. K. (2000). Fundamentals of Mathematical Statistics, Tenth Edition, Sultan Chand and Sons, New Delhi.<br>4. Sokal, P. R., and Rohlf, F. J. (1969). Bio Statistics, W.H. Freedom & Co, San Francisco.<br>5. Snedecor, G. W., and Cochran, W. G. (1967). Statistical Methods, Oxford-IBH, Pvt Co. |

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| **Title of the Course** | | **Computer Oriented Statistical Methods** | | | | | |
| **Paper Number** | | **III** | | | | | |
| **Category** | **VA** | **Year** | **II** | **Credits** | 3 | **Course Code** | **23UPSTA1V03** |
| | | **Semester** | **III** | | | | |
| **Instructional Hours Per week** | | **Lecture** | | **Tutorial** | | **Lab Practice** | **Total** |
| | | 3 | | 1 | | - | 4 |
| **Pre-requisite** | | Basic skills in correlation and regression | | | | | |
| **Objectives of the Course** | | The main objectives of this course are to:<br>1. To learn fundamentals and concepts of statistical and optimization methods, in particular, with reference to frequency distribution and measures of central tendency, measures of dispersion, skewness and kurtosis,<br>2. To solve problems on theory of probability, linear programming problems, transportation, assignment and game problems.<br>3. To learn important theorems, different formulae and practical applications of these statistical and optimization methods in the field of Computer Sciences and Applications. | | | | | |

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| **Course outline** | **Unit I:** Introduction to Computing - Computer Codes and Arithmetic Overview of BASIC - Sampling and Frequency Distribution - Measures of Central Tendency - Measures of Dispersion - Moments - Computation of Moments – Simple Problems.<br><br>**Unit II:** Discrete Probability Distributions: Probability - Characteristics of Probability - Discrete Distributions - Binomial Distribution - Poisson Distribution - Hypergeometric Distribution – Properties and Numerical problems.<br><br>**Unit III:** Curve Fitting: Linear Regression - Least Squares Fit - Nonlinear Fit - Fitting a Polynomial Function.<br><br>**Unit IV:** Correlation : Coefficient of Correlation - Properties of Correlation Coefficient - Rank Correlation - Multiple Correlation - Partial Correlation.<br><br>**Unit V:** Tests of Significance: Small sample and large sample tests - t Test, F Test and $\chi^2$ test - ANOVA one way and two way classifications simple problems using Excel. |
| Extended Professional Component (is a part of internal Component only, Not to be included in the External Examination Question paper) | Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /applied survey techniques adopted in Economics and Statistics department of Tamil Nadu State Government.<br><br>(To be discussed during the Tutorial hour) |
| **Skills acquired from This course** | Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended Text Books** | 1. Balagurusamy, E. (2000): Computer Oriented Statistical and Numerical Methods, Macmillan Publishers India Limited.<br>2. Enslein, K., Ralston, A., and Wilf, H.S. (1976): Statistical Methods for Digital Computers. John Wiley & Sons, New York. |