PERIYAR UNIVERSITY
PERIYAR PALKALAI NAGAR SALEM – 636 011

DEGREE OF MASTER OF SCIENCE

CHOICE BASE CREDIT SYSTEM

SYLLABUS FOR M. Sc STATISTICS

(SEMESTER SYSTEM UNDER OBE REGULATIONS)

(For The Students Admitted from The Academic Year 2026 -2027 Onwards)

Members of The Board

S. No.	Name & Address	Designation of the Board
1.	**Dr. R. Jagatheesan** Assistant Professor in Statistics PG and Research Dept. of Statistics Salem Sowdeswari College, Salem – 636 010 Mobil No.: 98430 84094., Mail ID: drrjstat@gmail.com	**Chairman**
2.	**Dr. R. Subathra** Assistant Professor in Statistics, Dept. of Statistics Govt. Arts College (Autonomous), Salem – 636 007 Mobil No.: 93611 96405 Mail ID: rsubathraarumugam@gmail.com	**Member**
3.	**Dr. L. Mariya Arulraj** Assistant Professor Govt. Arts and Science College, Mettur, Salem – 636 401 Mobil No.: 6374407085 Mail ID: mariyaarulraj1354@gmail.com	**Member**
4.	**Dr. M. Pachamuthu** Assistant Professor, Dept. of Statistics Periyar University, Salem – 636 011 Mobil No.: 9095288293 Mail ID: pachamuthu@periyaruniversity.ac.in	**University Nominee**
5.	**Dr. S. Deva Arul** Head and Associate Professor, Dept. of Statistics Govt. Arts College (Autonomous), Coimbatore – 641 018 Mobil No.: 9443376615 Mail ID: deardeva@gmail.com	**External Member**
6.	**Dr. V. Sangeetha** Assistant Professor, Dept. of Statistics PSG Arts and Science College Avinashi road, Civil Aerodrome Post, Coimbatore – 641 014 Mobil No.: 9994211670 Mail ID: sangee.stat07@gmail.com	**External Member**
7.	**Dr. S. Stanly Sagayaraj** SR Manager, HCL Technologies 8/18, Old Post office Road, Trichy – 620 001 Mobil No.: 9443594181 Mail ID: stans4s@gmail.com	**Industrial Expert**
8.	**Ms. S. Kokkilambigai** Ph. D. Research Scholar, Dept. of Statistics Periyar University, Salem – 636 011 Mobil No.: 8056680693 Mail ID: msamundiswariharini@gmail.com	**Alumni**

BRANCH – II STATISTICS

1 COURSE OBJECTIVES

- Demonstrate the ability to use Statistics skills for formulating and tackling real world problems.
- Recognize the importance of statistical modelling and computing.
- 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
- 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.

DURATION OF THE COURSE

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

3 SCHEME OF EXAMINATIONS

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

4 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:

Government Sector

Central Government Jobs	State Government Jobs
Indian Statistical Service (ISS)	Assistant Statistical Invigilator (Eco. and Stat. Dept.)
Senior Scientist, (CSRT)	Statistical Inspector (Eco. and Stat. Dept.)
Indian Institute of Crop Processing Technology	Assistant Director (Eco. and Stat. Dept.)
Scientist, (Indian Council of Medical Research)	Director/ Joint Director
Statistical Invigilator	Block Health Statistician
Research Officer	Additional Director – Administration & Schemes
Statistical Research Officer (RBI)	Deputy Director of Statistics
NSSO	Research and Scientific Officer
CSO	College/ University Professor
Indian Council of Agricultural Research (ICAR), etc..	Statistical Officer, etc..

Private Sectors

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

Future Scope

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

5 CURRICULUM DESIGN

Semester–I	C	H	Semester-II	C	H	Semester-III	C	H	Semester–IV	C	H
1.1. Core -I	5	6	2.1. Core -IV	5	6	3.1. Core -VII	5	6	4.1. Core -XI	5	6
1.2 Core -II	5	6	2.2 Core -V	5	6	3.2 Core -VIII	5	6	4.2 Core -XII	5	6
1.3 Core -III	5	6	2.3 Core -VI	5	6	3.3 Core -IX	5	6	4.3 Core - Practical - IV (Core X & XI Based on Python)	3	4
1.4 Core - Practical - I (Core II & III Based on R Programming)	3	4	2.4 Core - Practical - II (Core IV&VI Based on R Programming)	3	5	3.4 Core - Practical - III (Core VII,VIII and IX) Based on Python)	3	6	4.4 Project with Viva-Voce	5	10
1.5 Elective -I	3	4	2.5 Elective -II	3	4	3.5 Elective - V	3	4	4.5 Skill Enhancement Course -II	2	4
1.6 Skill Enhancement Course -I	2	4	2.6 *NME-I	2	2	3.6 NME* - II	2	2	4.6 Extension Activity	1	-
			2.7 Human Rights	1	1	3.7 Internship	1	Commanded / Highly Commanded			
	23	**30**		**24**	**30**		**24**	**30**		**21**	**30**
C - Credit H – Hours			*** Non Major Elective**						**Total Credit Points 92**		

6 COURSE STRUCTURE

Semester	Sl. No.	Course Code	Title of the Course	Credits	No. of Hrs. per Week	Int. Marks	Ext. Marks	Tot. Marks
I	1	Core	Real Analysis and Linear Algebra	5	6	25	75	100
	2	Core	Sampling Methods	5	6	25	75	100
	3	Core	Distribution Theory	5	6	25	75	100
	4	Core-Practical - I	Practical– I* (Core II & III Based on R Programming)	3	4	40	60	100
	5	Elective - I	1.Time Series Analysis / 2.Bayesian Inference	3	4	25	75	100
	6	SEC - I	Statistical Programming Using R	2	4	25	75	100
				23	**30**			**600**
II	7	Core	Estimation Theory	5	6	25	75	100
	8	Core	Measure and Probability Theory	5	6	25	75	100
	9	Core	Statistical Quality Control	5	6	25	75	100
	10	Core – Practical - II	Practical – II* (Core IV & VI Based on R Programming)	3	5	40	60	100
	11	Elective - II	1. Applied Regression Analysis / 2. Econometrics	3	4	25	75	100
	12	NME - I	NME - I	2	2	25	75	100
	13		Human Rights	1	1	25	75	100
				24	**30**			**700**

Semester	Sl. No.	Course Code	Title of the Course	Credits	Contact Hrs. per Week	Int. Marks	Ext. Marks	Tot. Marks
III	15	Core	Testing of Statistical Hypothesis	5	6	25	75	100
	16	Core	Design of Experiments	5	6	25	75	100
	17	Core	Multivariate Analysis	5	6	25	75	100
	18	Core Practical - III	Practical – III* (Core VII, VIII and IX Based on Python)	3	6	40	60	100
	19	Elective - III	1. Machine Learning Techniques / 2.Database Management System	3	4	25	75	100
		NME - II	NME - II	2	2	25	75	100
	21		Internship	1	Commanded/ Highly Commanded	-	-	-
				24	**30**			**600**

IV	21	Core	Stochastic Process	5	6	25	75	100
	22	Core	Advanced Operations Research	5	6	25	75	100
		Core	Core - Practical - IV (Core X & XI Based on Python)	3	4	40	60	100
	23	Core	Project with Viva-voce	5	10	25	75	100
	24	SEC - II	Reliability Theory	2	4	25	75	100
	26		Extension Activity	1	-	-	-	-
				21	**30**	**-**	**-**	**500**
			Total	**92**		**-**	**-**	**2400**

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

INTERNSHIP

Time duration

Student who wishes to claim these credits should undergo the internship for a duration of 15 days at the end of the second semester.

Eligible Agencies

The organization of internship shall be the governing body of either State or Central Government/ Quasi Government / autonomous research body/ Finance or Banking organization/ Any official statistics of State and central governments. The Multinational companies, Data practicing agencies of private, government are also considered.

Material of internship for Assessment

Students have to submit the internship in black and white reflecting any Data Analysis activity such as Data compilation, Data processing, Data Cleansing, Data Mining, Data Analysis Planning, Statistical Data Programming, Data Modeling, Prediction, Forecasting, Database Management, Structured Query Language Programming, Database Administration, Data Security, Data Warehousing, Data Mining, Data Networking and Cloud Computing, Online Data Analytical Processing, etc.

Faculty In-charge

A faculty in-charge from the department will be allotted to such students during the second semester work allotment. Students should register themselves under one faculty in-charge by applying the request to the HOD during the beginning of second semester. The allocated faculty in charge will be the responsible for the evaluation of viva-voce examinations along with the end semester examinations of third semester.

Evaluation

The internship result will be declared in the third semester Mark sheet. The internship programme does not carry any marks. The Mark sheet will be showing the report of the guide after the viva-voce Examination as Commended or Highly Commended.

Other Information

Each Faculty in-charge may be allotted a maximum of 10 internship students. The registrations with university have to be done along with the other courses of third semester. Non registered courses are not considered for any grade of this type of non-mandatory credits.

PROJECT WORK

Objectives

The aim of the course is to initiate students to write and present a statistical report, under the supervision of a faculty, on some area of social interest. The project work will provide hands-on training to the students to deal with data emanating from some real-life situation and propel them to do well on some theory or relate it to some theoretical concepts. The project should be prepared basing on the own idea and interpretation of the student. It should not be copied from anywhere. A student has to consult his / her supervisor for the preparation of the project.

Guidelines

1.It is an individual project work offered in 4^{th} semester with 4 credits.

2.The Project work shall be guided and supervised by a faculty member assigned in the beginning of the4^{th} semester.

3.The project work topics are to be selected in such a way that there is enough scope to apply and demonstrate the statistical techniques learnt in the course.

4. Report shall have the following format: Chapter I for Introduction for providing conceptual clarity, Chapter II for Review of Literature, Chapter III for Methodology, Chapter IV, V & VI for analysis and interpretations of each objective (Number of chapters can be reduced or increased depending upon the number of objectives), chapter VII for findings and suggestions.

5. At the end of the 4^{th} semester, before the last working day, project report should be submitted to the Department (two copies).

6.The project work will be assessed for 4 credits. Students have to give a seminar of their project report at the end of the 4^{th} semester and which will be evaluated internally.

7.There will be viva-voce examination by an internal and an external examiner during end semester examination in 4^{th} semester.

PROGRAMME OUTCOMES (PO) AND PROGRAMME SPECIFIC OUTCOMES (PSO)

Programme Outcomes (Pos)	**PO1: Disciplinary Knowledge:** a good theoretical knowledge of the domain Statistics and its methods and techniques. **PO2: Mathematical knowledge:** sharpening mathematical knowledge needed to understand higher levels of Statistics understand multidimensional issues of data. **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. **PO4: Critical Thinking:** examine basic statistical issues in a more logical and methodical manner in a real data given. **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, RBI, UPSC, ISS/IES, ICMR, ICAR etc.) **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. **PO7: Research Related Skills:** The students should be able to develop original thinking for formulating new problems and providing their solutions. **PO8: Computational skills:** acquire computing skills necessary for solving real life problems in par with the requirement of a job **PO 9 Team work:** experience in team work by engaging in team projects and team assignments. Also have original thinking and creative presentation **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. **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. **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. **PSO4 – Contribution to Business World** To produce employable, ethical and innovative professionals to sustain in the dynamic business world. **PSO 5 – Contribution to the Society** To contribute to the development of the society by collaborating with stakeholders for mutual benefit.

7 CREDIT DISTRIBUTION

First Year: Semester - I

Part	List of Courses	Credit	Hours per Week(L/T/P)
Part A	Core Courses 3	15	18
	Core Practical – I	3	4
	Elective Course - I	3	4
Part B	Skill Enhancement Course -SEC - I	2	4
		23	**30**

Semester-II

Part	List of Courses	Credit	Hours per Week(L/T/P)
Part A	Core Courses 3	15	18
	Core Practical – II	3	5
	Elective Course - II	3	4
Part B	(i) NME - I	2	2
	(ii) Human Rights	1	1
		24	**30**

Second Year: Semester-III

Part	List of Courses	Credit	Hours per Week(L/T/P)
Part A	Core Courses 3	15	18
	Core Practical – III	3	6
	Elective Course – III	3	4
Part B	(i) NME - I	2	2
	(ii) Internship	1	Commanded / Highly Commanded
		24	**30**

Semester-IV

Part	List of Courses	Credit	Hours per Week(L/T/P)
Part A	Core Courses 2	10	12
	Core Practical – IV	3	4
	Project with Viva voce	5	10
Part B	Skill Enhancement Course -SEC - II	2	4
Part C	Extension Activity	1	-
		21	**30**

(Internship during Summer Vacation of II Semester)

Component wise Credit Distribution

Credits		**Sem I**	**Sem II**	**Sem III**	**Sem IV**	**Total**
Part A	(CC, ED, CP, Viva-Voce)	21	21	21	18	81
Part B						
(i)	SEC	2	-	-	2	4
(ii)	NME	-	2	2	-	4
(iii)	Internship	-	-	1	-	1
Part C						
	Human Rights	-	1	-	-	1
	Extension Activity	-	-	-	1	1
Total		**23**	**24**	**24**	**21**	**92**

Part A component and Part B (i) will be taken into account for CGPA calculation for the postgraduate programme and the other components Part B (ii), (iii) 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.

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**

a. Semester:

GRADE POINT AVERAGE (GPA)

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

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

b. The Entire Programme:

CUMULATIVE GRADE POINT AVERAGE (CGPA)

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

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

8 DIFFERENT TYPES OF COURSES

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	Statistical Quality Control
7	VII	Testing of Statistical Hypotheses
8	VIII	Design of Experiments
9	IX	Multivariate Analysis
10	X	Stochastic Process
11	XI	Advanced Operations Research

Core Practical: CP

S. No.	Title of the Course
1	Practical – I
2	Practical – II
3	Practical – III
4	Practical – IV

Elective Courses: ED

Elective*	No.	Title of the Course
I	1	Time series Analysis
	2	Bayesian Inference
II	1	Applied Regression Analysis
	2	Econometrics
III	1	Machine Learning Techniques
	2	Database Management Systems

*Elective I, II and III should be selected either 1 or 2 of respective papers listed above.

Skill Enhancement Courses: SEC

S. No.	Course No.	Title of the Course
1	I	Statistical Programming Using R
2	II	Reliability Theory

Human Rights (Common to All)

Non- Major Elective Courses for other Departments (Not for Statistics students): NME

Students from other Departments may choose any one of the following as Non - Major Elective Course.

S. No.	Course No.	Title of the Course
1	I	Statistics for Life Sciences
2	II	Optimization Techniques
3	III	Statistical Methods
4	IV	Statistical Tools for Research

9 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

9.1. For Theory Papers

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

Internal marks distribution:		
Attendance	:	05 Marks
Cycle test and model Exam	:	10 marks
Assignment	:	05 marks
Seminar	:	05 marks
Total	**:**	**25 marks**

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

<table>
<tr><td rowspan="4">Intended Learning Skills

Memory Recall / Example/ Counter Example / Knowledge about the Concepts/ Understanding</td><td>Maximum 75 Marks
Passing Minimum: 50%
Duration : Three Hours</td></tr>
<tr><td>Part –A (15 x 1 = 15 Marks)
Answer ALL questions
(a), (b), (c), (d) Multiple choice
Each Question carries 1 Mark</td></tr>
<tr><td>Three questions from each UNIT</td></tr>
<tr><td>Question 1 to Question 15</td></tr>
<tr><td rowspan="3">Descriptions/ Application (problems)</td><td>Part – B (2 x 5 = 10 Marks)
Answer ANY TWO questions out of Five
Each questions carries 5 Marks</td></tr>
<tr><td>One question from each UNIT</td></tr>
<tr><td>Question 16 To Question 20</td></tr>
<tr><td></td><td>Part-C (5x 10 = 50 Marks)
Answer ALL the questions
Each question carries 10 Marks</td></tr>
<tr><td>Analysis /Synthesis / Evaluation</td><td>Either - or Type
Both parts of each question from the same UNIT</td></tr>
<tr><td></td><td>Question 21(a) or 21(b)
To
Question 25(a) or 25 (b)</td></tr>
</table>

9.2. Practical papers

9.2.1 Marks for Internal: (Max. Marks:40)

Internal marks distribution:		
Model Exam	:	20 marks
Record work	:	10 marks
Attendance	:	10 marks
Total	**:**	**40 marks**

9.2.2 Marks for External: (Max.Marks:60)

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) Answer **ANY THREE** out of **FIVE** questions			
External marks distribution:			
	Write and Type the Programme (3 X 10)	:	30 marks
	Run the Programme (3 X 5)	:	15 marks
	Correct output (3 X 5)	**:**	15 marks
	Total	:	**60 marks**

Project work: (maximum marks 100): IA: 40 marks, Project evaluation and Viva- Voce: 60 marks

Each question should carry the course outcome and cognitive level

10 SYLLABUS

10.1 Syllabus for Core Courses

10.1.1 Real Analysis and Linear Algebra

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">Real Analysis and Linear Algebra</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">I</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">CC</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">5</td><td rowspan="2">Course Code</td><td rowspan="2"></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 colspan="2">Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">5</td><td colspan="2">1</td><td colspan="2">-</td><td>6</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="8">Undergraduate level Vector Algebra and Matrix Theory</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8">1. To provide recollection as well as building Mathematical foundation in Real Analysis and Matrix Theory
2. To understand concepts and definition of metric space and theorems related to it
3. To know integration and differentiation concepts and its applications.</td></tr>
<tr><td colspan="2" rowspan="4">Course Outline</td><td colspan="8">UNIT I: Finite, countable and uncountable sets; sequences of real numbers, convergence of sequences, bounded sequences, monotonic sequences, Cauchy criterion for convergence; Series of real numbers, convergence, tests of convergence, alternating series, absolute and conditional convergence; Bolzano – Weierstrass theorem, Heine – Borel theorem.</td></tr>
<tr><td colspan="8">UNIT II: Functions of a real variable: Limit, continuity, monotone functions, uniform continuity, differentiability, Rolle’s theorem, mean value theorems, Taylor’s theorem. Riemann integration and its properties (Concept only).</td></tr>
<tr><td colspan="8">UNIT III: Functions of two real variables: Limit, continuity, partial derivatives, total derivative, maxima and minima, saddle point, method of Lagrange multipliers and double integrals and their applications.</td></tr>
<tr><td colspan="8">UNIT IV: Vector spaces, subspaces, span, linear independence, basis and dimension, row space and column space of a matrix, rank and nullity, row reduced echelon form, trace and determinant, inverse of a matrix.</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT V: Characteristic roots and characteristic vectors, characteristic polynomial, Cayley-Hamilton theorem, symmetric matrices, skew-symmetric matrices, orthogonal matrices and their characteristic roots, positive definite and positive semi-definite matrices and their properties.</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="8">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)</td></tr>
<tr><td colspan="2">Skills acquired from this Course</td><td colspan="8">Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill</td></tr>
</table>

Recommended Text Books	1. Rudin, Walter (1976): Principles of Mathematical Analysis, McGraw Hill. Apostol, T.M. (1985): Mathematical Analysis, Narosa, Indian Ed. 2. Graybill, F.A. (1983): Matrices with application in Statistics, 2nd ed. Wadsworth. 3. Rao, C.R. & Bhimasankaran, P. (1992): Linear algebra, Tata McGraw Hill Pub. Co. Ltd. 4. Searle, S.R. (1982): Matrix Algebra useful for Statistics, John Wiley and Sons, Inc. 5. Richard R. Goldberg (2017): Methods of Real Analysis, Oxford & IBH Publishing.
Reference Books	1. Royden, H.L. (1995): Real analysis, 3ed., Prentice Hall of India. 2.Rangachari, M.S. (1996): Real Analysis, Part 1, New Century Book House. Ash, 3.R.B. (1972): Real analysis and probability, Academic press. 4.Biswas, S. (1984): Topics in Algebra of Matrices, Academic Publications. 5.David, A. Harville (1997): Matrix algebra from a statistician's perspective, Springer. 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)

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

1. Get a Mathematical foundation in Real analysis and Matrix Theory to understand univariate and multivariate concepts in Statistical Theory
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
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
4. Able to get solve numerical problems and evaluate and interpret outcome

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	M	M	S	S	M	S	S	M
CO4	M	S	M	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

10.1.2 Sampling Methods

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Sampling Methods</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">II</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">CC</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">5</td><td rowspan="2">Course Code</td><td rowspan="2"></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">5</td><td colspan="2">1</td><td>-</td><td>6</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Undergraduate level Sampling Techniques</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">1. To cover sampling design and analysis methods
2. To explain and compare various sampling procedures.
3. To understand the concepts of bias and sampling variability and strategies for reducing the bias and sampling variability.</td></tr>
<tr><td colspan="2" rowspan="3"></td><td colspan="6">UNIT I: Preliminaries – Simple Random Sampling, Stratified sampling, and systematic sampling.</td></tr>
<tr><td colspan="6">UNIT II: PPS selection methods - PPSWR and PPSWOR sampling methods – Sen-Midzuno sampling method – Ordered and Unordered estimators.</td></tr>
<tr><td colspan="6">UNIT III: Cluster Sampling- Equal cluster sampling – Estimators of mean and variance, optimum cluster size, Unequal cluster sampling – Estimators of mean and variance.</td></tr>
<tr><td colspan="2" rowspan="2"></td><td colspan="6">UNIT IV: Ratio Estimation – Unbiased Ratio Type estimators – Regression Estimation - Double Sampling for Ratio and Regression Estimation</td></tr>
<tr><td colspan="6">UNIT V: Sources of errors in Surveys – A mathematical model of the effects of call-backs – a mathematical model of the errors of measurement – Interpenetrating subsampling method.</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.

(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 Books</td><td colspan="6">1. S. Sampath (2005): Sampling Theory and Methods, Narosha Publishing House.
2. W.G. Cochran (1965): Sampling Techniques, Wiley and Sons
3. Desraj (1976): Sampling Theory, McGraw Hill, New York.</td></tr>
</table>

Reference Books	1. M.N. Murthy (1967): Sampling Theory and Methods: Statistical Publishing Society, Calcutta Parimal 2. Mukhopadhyay (2005): Theory and Methods of Survey Sampling, Prentice Hall of India 3. P.V.Sukhatme, B.V. Sukhatme, S.Sukhatme and C. Asok (1984) L Theory of Same Surveys with Applications, IASRI, New Delhi
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. 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	M	M	M	S	M	S	M	M
CO2	S	S	S	S	M	S	M	S	M	M
CO3	S	S	M	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

10.1.3 Distribution Theory

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="7">Distribution Theory</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="7">III</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">CC</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">5</td><td rowspan="2">Course Code</td><td rowspan="2"></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 colspan="2">Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">5</td><td colspan="2">1</td><td colspan="2">-</td><td>6</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="7">Undergraduate level Distribution Theory.</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="7">1. To provide theoretical knowledge on the concept of functions of random variables and its usage.
2. To educate the knowledge on the both discrete and continuous distributions.
3. To acquire the knowledge on deriving its characteristics of distributions.</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="7">UNIT I: Brief review of distribution theory, functions of random variables and their distributions using Jacobian transformation, Laplace and Cauchy distribution, lognormal distribution, gamma, logarithmic series.</td></tr>
<tr><td colspan="7">UNIT II: Bivariate Normal Distribution – Compound and truncated distributions of Binomial, Poisson and Normal distributions.</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td colspan="7">UNIT IV: Kolmogorov Smirnov distributions, life distributions, exponential, Weibull and extreme value distributions Mills ratio, distributions classified by hazard rate.</td></tr>
<tr><td colspan="7">UNIT V: Order statistics their distributions and properties, Joint and marginal distributions of order statistics, extreme value and their asymptotic distributions.</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 / others to be solved
(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. Gibbons (1971): Non-parametric inference, Tata McGraw Hill.
2. Rohatgi, V.K. and Md. Whsanes Saleh, A.K. (2002): An introduction to probability &Statistics, John Wiley and Son’s.</td></tr>
</table>

Reference Books	1. Rao, C.R. (1973): Linear statistical inference and its applications, 2ed, Wiley Eastern. 2. Mood, A.M. & Graybill, F.A. and Boes, D.C. (1972): Introduction to the theory of statistics, McGraw Hill. Johnson,S. & Kotz: Distributions in Statistics, Vol. I, II & III, Hougton & Miffin. 3. Dudewicz, E.J., Mishra, S.N. (1988): Modern mathematical statistics, John Wiley. Searle, S.R. (1971): Linear models, John Wiley. 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 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. 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	M	M	M	M	M	S	M	M
CO2	S	M	S	S	M	M	M	S	M	M
CO3	S	S	S	M	S	M	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

10.1.4 Estimation Theory

<table>
<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">IV</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">CC</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">5</td><td rowspan="2">Course Code</td><td rowspan="2"></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">5</td><td colspan="2">1</td><td>-</td><td>6</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Undergraduate level 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 estimation theory.
2. To study the properties of ideal estimators like unbiasedness, consistency, sufficiency, completeness.
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: Brief introduction to Estimation theory, Sufficient statistics, Neyman, Fisher Factorization 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 part of internal component only, Notto 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
(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 Books</td><td colspan="6">1. V.K. Rohatgi et.al (2002): An introduction to probability and statistics, John Wiley.</td></tr>
</table>

	2. Lehmann, E.L. (1983): Theory of point estimation, John Wiley. 3. M. Rajagopalan and P. Dhanavanthan (2012): Statistical Inference, PHI Learning Pvt Ltd, New Delhi.
Reference Books	1. Zacks, S. (1971): The theory of statistical inference, John Wiley. 2. Rao, C.R. (1973): Linear statistical inference and its applications, Wiley Eastern, 2^{nd} ed. 3. Ferguson, T.S. (1967): Mathematical statistics, A decision theoretic approach, Academic press, New York and London. 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 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. 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 estimate the parameter using Baye's minimax technique.

CO-PO Mapping (Course Articulation Matrix)

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

10.1.5 Measure and Probability Theory

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">Measure and Probability Theory</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">V</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">CC</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">5</td><td rowspan="2">Course Code</td><td rowspan="2"></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 colspan="2">Total</td></tr>
<tr><td colspan="2">5</td><td colspan="2">1</td><td>-</td><td colspan="2">6</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="8">Undergraduate level Mathematics, Probability and Random Variables.</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8">1. This paper provides mathematical background for the knowledge of Probability Theory extended from measure theoretical approach.
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.
3. The fundamentals of this course will pave the way for further research.</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="8">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="8">UNIT II: Lebesgue – Stieltjes measure, measure integral and its properties, Dominated convergence theorem –almost everywhere convergence, convergence in measure and convergence in mean- Radon–Nikodymn theorem and Fubni’s theorem (statement only)- Helly-Bray theorem, continuity theorem.</td></tr>
<tr><td colspan="8">UNIT III: Events, sample space, different approaches to probability, random variables and random vector, Distribution functions of random variables and random vector, Expectation and Moment inequalities - Markov, Chebyshev’s, Holder’s, Minkowski’s and Jensen’s inequalities.</td></tr>
<tr><td colspan="8">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,</td></tr>
<tr><td colspan="8">UNIT V: Central limit theorem- CLT of Lindeberg-Levy, Liapounov and Lindeberg- Feller’s- Khintchine Weak law of large numbers, Kolmogorov inequality, Strong law of large numbers.</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 Books	1. Bhat, B.R. (1985): Modern probability theory, 2nd ed. Wiley Eastern. 2. Chow, Y.S. and Teicher, H. (1979): Probability theory, Springer Verlag. Chung, K.L. et al: A course in probability theory, Academic press. 3. Billingsley, P. (2012): Probability and Measure, John Wiley & Sons, Inc., Publication.
Reference Books	1. Parthasarthy, K.R. (1977): Introduction to probability and measure, MacMillan Co., 2. Breiman, L. (1968): Probability, Addison Wesley. 3. Munroe, M.E. (1971): Measure and integration, 2nd ed. Addison Wesley. 4. Halmos, P.R. (1974): Measure theory, East-West. 5. 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 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. 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 r^{th} 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	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

10.1.6 Statistical Quality Control

<table>
<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">VI</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">CC</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">5</td><td rowspan="2">Course Code</td><td rowspan="2"></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>Lab Practice</td><td colspan="2">Total</td></tr>
<tr><td>5</td><td colspan="2">1</td><td>--</td><td colspan="2">6</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">The main objectives of this course are to:
1. Understand the application of statistics in industrial environment.
2. Acquire knowhow on manufacturing process changes and process variability.
3. Attain proficiency in process capability analysis,
4. Instruct theory and practice of product control methodology.
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 Statistical process control: Moving average control chart – EWMA Control chart. Basic principles and design of CUSUM control chart – two sided and one-sided procedures – V-mask technique, Tabular CUSUM and decision interval.</td></tr>
<tr><td colspan="6">Unit II: Acceptance sampling – lot formation – sampling inspection by attributes – single and double– operations and its uses – OC, ASN, ATI and AOQ forms, AOQ, LTPD, procedures risk and consumers risk and OC curve.</td></tr>
<tr><td colspan="6">Unit III: Multiple sampling plans - operations and its uses – OC, ASN, ATI and AOQ forms, AOQ, LTPD, procedures risk and consumers risk and OC curve.</td></tr>
<tr><td colspan="6">Unit IV: Sampling inspection by variable – merits and demerits of Variable sampling plan- known and unknown sigma variable sampling plan – derivation of OC curve and the parameters of the plan.</td></tr>
<tr><td colspan="6">Unit V: Continuous sampling plan by attributes – CSP-I and its modifications – concept of AOQL in CSPs – OC and ASN function – Sequential Sampling plans by attributes – OC and ASN function.</td></tr>
<tr><td colspan="2">Extended Professional Component (is a part of internal component only, Notto 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
(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. Montgomery, D.C. (2009): Introduction to Statistical Quality Control, Sixth Edition, Wiley India, New Delhi. 2. John T. Burr, (2004): Elementary Statistical Quality Control (Second Edition), Marcel Dekker New York. 3. 4. 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. 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. 3. Mahajan, M. (2002): Statistical Quality Control, (Third Edition), Dhanpat Rai and Co., Delhi. 4. Schilling, E. G., and Nuebauer, D.V. (2009): Acceptance Sampling in Quality Control Second Edition, CRC Press, New York. 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 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. 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	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

10.1.7 Testing of Statistical Hypothesis

<table>
<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">VII</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">CC</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">5</td><td rowspan="2">Course Code</td><td rowspan="2"></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">5</td><td colspan="2">1</td><td>-</td><td>6</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Under Graduate Level Probability Theory and Testing of Statistical Hypothesis.</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">1. To get theoretical knowledge in Statistical Testing procedure
2. To provide knowledge about Most Powerful test and how to build it.
3. To understand Hypothesis testing concepts.
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: Test of hypothesis – Concept of critical region, test function, two kinds of errors, power function, level of significance. Most powerful test- Neymann – Pearson’s fundamental lemma.</td></tr>
<tr><td colspan="6">UNIT II: Monotone likelihood ratio property- UMP test for simple hypothesis against one- sided alternative in one parameter exponential family. Non- existence of UMP test for simple versus two - sided alternative in one parameter exponential family.</td></tr>
<tr><td colspan="6">UNIT III: Generalized Neymann – Pearson’s lemma- two-sided hypothesis- UMP unbiased tests- similarity and completeness- Neymann structure test- Likelihood Ratio test.</td></tr>
<tr><td colspan="6">UNIT IV: Sequential Probability Ratio Test procedure- Optimum properties of SPRT- Wald’s equation- efficiency of SPRT- OC and ASN function SPRT.</td></tr>
<tr><td colspan="6">UNIT V: Non parametric tests- Chi-square tests goodness of fit, independence of attributes, homogeneity in contingency tables, sign test, Wilcoxon signed rank test, Mann-Whitney U-test, linear rank tests for location and scale problems, Kruskal-Walli’s test.</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 Books	1. V.K. Rohatgi et a l(2002): An introduction to probability and statistics, John Wiley. 2. Lehmann, E.L. (2005): Testing of statistical hypothesis, 3rd Edn., John Wiley. 3. M. Rajagopalan and P. Dhanavanthan (2012): Statistical Inference, PHI Learning Pvt Ltd, New Delhi.
Reference Books	1. Ferguson, T.S. (1967): Mathematical statistics, A decision theoretic approach, Academic press. 2. Rao, C.R. (1973): Linear statistical inference and its applications, Wiley Eastern, 2nd ed. 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 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. 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	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

10.1.8 Design of Experiments

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">Design of Experiments</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">VIII</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">CC</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">5</td><td rowspan="2">Course Code</td><td rowspan="2"></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">5</td><td colspan="2">1</td><td colspan="2">-</td><td>6</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="8">Matrix algebra & Linear Models.</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8">1. To get theoretical knowledge in Statistical Design of Experiments and analysis of variance
2. To build strong theoretical foundation in Orthogonal
3. Latin squares, factorial and fractional factorial experiments, BIBD, inter and intra blocks, split plot, analysis covariance,
4. To develop analytical thinking in problem solving skills</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="8">UNIT I: Analysis of variance in one-way and two-way classification in fixed effects model, principles of design of experiments, completely randomized design, randomized block design.</td></tr>
<tr><td colspan="8">UNIT II: Latin square design, missing plot techniques-one missing values in RBD, LSD-two missing values in RBD, LSD. Factorial experiments- $2^2, 2^3$.</td></tr>
<tr><td colspan="8">UNIT III: confounding in factorial experiments, Incomplete block designs and its intra-block and inter-block analysis,</td></tr>
<tr><td colspan="8">UNIT IV: Connectedness and orthogonality of block designs, balanced incomplete block design (BIBD), inter-block analysis and recovery of intra-block information of BIBD.</td></tr>
<tr><td colspan="8">UNIT V: Nested and split plot designs – Two stage nested designs, split plot designs, split plot designs, strip-split designs, Analysis of covariance with one, two covariates.</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="8">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)</td></tr>
<tr><td colspan="2">Skills acquired from this course</td><td colspan="8">Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill</td></tr>
<tr><td colspan="2">Recommended Text Books</td><td colspan="8">1. Das, M.N. and Giri, N. (1979): Design and analysis of experiments, Wiley Eastern.
2. John, P.W.M. (1971): Statistical design and analysis of experiments, Macmillan.</td></tr>
</table>

Reference Books	1. Montgomery, C.D. (2001): Design and analysis of experiments, John Wiley, New York. 2. Robert, O., Kuelhl, (2000): Design of experiments. Statistical Principles of Research Design and analysis, Duxbury. 3. Federer, W.T. (1963): Experimental design; Theory and application, Oxford & IBH publishing Co.
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. To understand analysis of variance and experimental designs
2. To have strong theoretical knowledge in Orthogonal Latin squares, Hyper Greco 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	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

10.1.9 Multivariate Analysis

<table>
<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">IX</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">CC</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">5</td><td rowspan="2">Course Code</td><td rowspan="2"></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">5</td><td colspan="2">1</td><td>-</td><td>6</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.
2. To provide requisite knowledge to handle multi-dimensional data with regard to dimensionality reduction using Principal Component and Factor Analysis.
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 T^2 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>
<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 / others to be solved
(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. Anderson, T.W. (1983): An Introduction to Multivariate Statistical Analysis. 2nd Ed. Wiley. 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) 2. Neil H. Timm (2002): Applied Multivariate Analysis –Springer-Verlag 3. Dallas E. Johnson (1998): Applied Multivariate Methods For Data Analysts- Duxbury Press 4. William R Dillon and Mathew Goldstein (1984): Multivariate Analysis Methods and Applications, John Weily
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. To explain and interpret the importance of data that come from high dimensional set up using 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	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

10.1.10 Stochastic Process

<table>
<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">X</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">CC</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">5</td><td rowspan="2">Course Code</td><td rowspan="2"></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">5</td><td colspan="2">1</td><td>-</td><td>6</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.
2. To understand the applications of Stochastic Process as a Mathematical tool.
3. To describe the advanced topics related to continuous and discrete time random processes.</td></tr>
<tr><td colspan="2">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. Simple Random walk- Gambler’s ruin problem- Martingales in discrete time – Super martingales and sub martingales - Continuous Parameter Martingales- Martingale convergence theorem and its applications.</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT II: Markov chains – Definitions and examples. Higher order transition probabilities: Chapman – Kolmogorov equation. Classification of States and Chains – Determination of Higher Order Transition Probabilities -Aperiodic Chain: Limiting Behavior. Stability of a Markov system.</td></tr>
<tr><td colspan="2"></td><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="2"></td><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="2"></td><td colspan="6">UNIT V: Queuing model M/M/1: Steady State Behavior - Steady State Solution, Waiting time distribution. Queueing Model M/M/S - Steady State Solution, Waiting time distributions – simple problems.</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 Books	1. Medhi, J. (2017): Stochastic Processes, New Age International Publishing Limited, New Delhi. (Reprint 2002). 2. Karlin, S. and Taylor H.M. (1996): First Course in Stochastic Process, Academic Press. 3. Cox. D.R and Muller (1984) The Theory of Stochastic Process Chapman & Hall/crc, Boca Raton London New York.
Reference Books	1. Prabhu. N.U. (1965): Stochastic Process, Macmillan, New York. 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 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. 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	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

10.1.11 Advanced Operations Research

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">Advanced Operations Research</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">XI</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">CC</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">5</td><td rowspan="2">Course Code</td><td rowspan="2"></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 colspan="2">Tutorial</td><td colspan="2">Lab Practice</td><td colspan="2">Total</td></tr>
<tr><td>5</td><td colspan="2">1</td><td colspan="2">--</td><td colspan="2">6</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="8">Undergraduate Level Linear Programming Problems</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8">1. Optimization techniques that will be useful in the personal and professional life.
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="8">UNIT I: Introduction and formulation of linear programming program (LPP) - Solving of LPP by graphical method -–Simplex, Big M and Two-Phase methods.</td></tr>
<tr><td colspan="8">UNIT II: Integer Programming Problem (IPP) - Gomory’s cutting plane algorithm– Mixed IPP – Branch and Bound technique.</td></tr>
<tr><td colspan="8">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="8">UNIT IV: Non- Linear Programming: Constrained and Unconstrained Problems of Maxima and minima, Constraints in the form of equations (Lagrangian Method) and inequations (Kuhn-Tucker conditions).</td></tr>
<tr><td colspan="8">UNIT V: C P M a n d PERT: Applications, Basic Steps in CPM/ PERT techniques; Time estimates and Critical Path in Network Analysis.</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="8">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)</td></tr>
<tr><td colspan="2">Skills acquired from this course</td><td colspan="8">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. 2. Taha. H. A (2017): Operations Research: an introduction, 10th Edn. Pearson Edn Ltd. 3. Kanti Swarup, P.K. Gupta and Man Mohan (2004): Operations Research, Sultan Chand and Sons, New Delhi. 4. 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. 2. Devi Prasad (2015), Operations Research, Narosa Publishing House 3. Kapoor V.K. (2008): Operations Research, 8/e, Sultan Chand & Sons 4. Sharma S.D(1999): Operation Research, Kedar Nath Ram Nath & Co., Meerut. 5. Hamdy A. Taha (1987): Operations Research – An Introduction, 4/e, Prentice Hall of India, Private Ltd, New Delhi. 6. Sujit K. Bose (2012), Operations Research Methods, 2/e, Narosa Publishing House 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.
2. Solve linear programming problems using graphical method.
3. Apply simplex method to solve real life problems.
4. Solve LPP by using artificial variable technique, duality theory, revised simplex method, sensitivity analysis, transportation and assignment problems.
5. 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

10.3 CORE PRACTICAL COURSES

10.3.1 Practical I – (Based on R Programming)

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Practical I – (Based on R Programming)</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">I</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">CP</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td>Course</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>I</td><td>Code</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">-</td><td>1</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Fundamentals of Sampling Techniques and Distribution Theory</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">The main objectives of this course are to:
1. Understand the notions of Sampling by using R.
2. Impart application of Distribution Theory in various domains.</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">Core II. Sampling Theory
1. Simple random sampling methods of drawing sample – Estimation of the population total and variance estimation.
2. Linear and circular systematic sampling
3. Stratified sampling – SRS
4. Stratified sampling – PPSWR
5. Stratified sampling –PPSWOR
6. Cluster sampling – of equal sizes
7. Ratio, Regression and Difference estimation estimators.
8. PPSWR – Hurwitz Thompson estimator.
Core III Distribution theory
9. Truncated Binomial and Poisson
10. Truncated Normal distributions
11. Compound Binomial and Poisson
12. Compound Normal distributions.
13. Life distributions: exponential, Weibull.
14. Millsratio, distributions classified by hazard rate
15. Graphing the distribution of order statistics</td></tr>
<tr><td colspan="2">Recommended Text Books</td><td colspan="6">1. Quick, J. M. (2010). Statistical Analysis with R, Packt Publishing Ltd., UK.
2. Purohit, S. G., Gore, S. D., and Deshmukh, S. R. (2009). Statistics Using R, Narosa
3. Dalgaard, P. (2008). Introductory Statistics with R, Second Edition, Springer</td></tr>
</table>

Reference Books	1. Everitt, B. S., and Hothorn, T. (2010). A Handbook of Statistical Analyses Using R, Second Edition, Chapman and Hall, CRC Press. 2. Crawley, M, J. (2007). The R Book, John Wiley and Sons Private Ltd., NY.
Website and e-Learning Source	1. https://swayam.gov.in/nd1_noc19_ma33/preview. 2. https://swayam.gov.in/nd2_aic20_sp35/preview. 3. https://nptel.ac.in/courses/111/104/111104100/

10.3.2 Practical II – (Based on R Programming)

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">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">CP</td><td>Year</td><td>I</td><td>Credits</td><td>3</td><td>Course Code</td><td></td></tr>
<tr><td>Semester</td><td>II</td><td colspan="3"></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">-</td><td>2</td><td colspan="2">5</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Basic knowledge of Estimation theory & Time Series Analysis</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">The main objectives of this course are to:
1. Understand the notions of Estimation theory by using R.
2. Impart application of SQC in various domains of R.</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">Core IV: Estimation theory
1. MLE and Standard error of ML estimators.
2. MLE through the method of successive approximation.
3. MLE for truncated distribution.
4. Method of Moments
5. Method of Minimum Chi-square
6. Method of Least square
7. Interval estimation: Confidence interval for mean,
8. Interval estimation - difference of means
9. Interval estimation - variance and ratio of variances
Core V: Statistical Quality Control
10. Moving average control chart – EWMA Control chart.
11. Single Sampling plan- OC, ASN, ATI and AOQ procedures risk and consumer’s risk
12. Double Sampling plan- OC, ASN, ATI and AOQ procedures risk and consumer’s risk
13. Multiple sampling plans -OC, ASN, ATI and AOQ forms, AOQ, LTPD
14. Sampling inspection by variable.
15. Continuous sampling plan by attributes.</td></tr>
<tr><td colspan="2">Recommended Text Books</td><td colspan="6">1. Quick, J. M. (2010). Statistical Analysis with R, Packt Publishing Ltd., UK.
2. Purohit, S. G., Gore, S. D., and Deshmukh, S. R. (2009). Statistics Using R, Narosa
3. Dalgaard, P. (2008). Introductory Statistics with R, Second Edition, Springer</td></tr>
</table>

Reference Books	1. Everitt, B. S., and Hothorn, T. (2010). A Handbook of Statistical Analyses Using R, Second Edition, Chapman and Hall, CRC Press. 2. Crawley, M, J. (2007). The R Book, John Wiley and Sons Private Ltd., NY.
Website and e-Learning Source	1. https://swayam.gov.in/nd1_noc19_ma33/preview. 2. https://swayam.gov.in/nd2_aic20_sp35/preview. 3. https://nptel.ac.in/courses/111/104/111104100/

10.3.3 Practical III – (Based on Python)

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Practical III – (Based on Python)</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">III</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">CP</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2"></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>2</td><td colspan="2">6</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Basic knowledge of Testing Statistical Hypothesis, Multivariate Statistical Analysis & Time Series Analysis</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">The main objectives of this course are to:
1. Understand the notions of Testing Statistical Hypothesis by using Python.
2. Impart application of Design of Experiments in Python.
3. Learn and write customized program for Multivariate Statistical Analysis through Python.</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">Core VII: Testing Statistical Hypothesis
1. Construction of randomized and nonrandomized MP, UMP and UMPU tests of hypotheses and drawing the power curves.
2. Construction of SPRT and its OC and ASN curves.
3. Non parametric tests: Kolmogorov Smirnov test, Mann-Whitney U test, Median test for k-sample problem, Kruskal Wallis test and Friedman’s test.
Core VIII: Design of Experiments
4. Multiple Comparison tests (Least Significant Difference (LSD) test, Bonferroni’s test)
5. Missing Data Analysis- one and two observations in RBD, LSD
6. 2^3 factorial experiments
7. Fractional factorial experiments
8. Complete confounding in 2^3 factorial experiments
9. Split plot design
10. BIBD
Core IX: Multivariate Statistical Analysis
11. Test for equality of mean vectors when covariance matrix is unknown (Hotelling’s T^2 test)
12. Test for Two Covariance matrices
13. Canonical correlation and canonical variables
14. One Way MANOVA with Post hoc tests (DMRT and Tukey’s).
15. Discriminant Analysis, Principal Component Analysis and Factor Analysis</td></tr>
<tr><td colspan="2">Recommended Text Books</td><td colspan="6">1. Python for Data Analysis by O’Reilly Media (Second Edition).
2. How to think like a computer scientist learning with Python by Allen Downey
3. Python for Data Analysis by Armando Fernandgo</td></tr>
</table>

Reference Books	1. H. Brian, A Practical Introduction to Python Programming, Creative Commons Attribution, 2012. 2. A. Saha, Doing Math with Python: Use Programming to Explore Algebra, Statistics, Calculus, and More, No Starch Press, 2015 3. T. Hall, J. P. Stacey, Python 3 for absolute beginners, A press, 2010.
Website and e-Learning Source	1.https://swayam.gov.in/nd1_noc19_ma33/preview. 2.https://swayam.gov.in/nd2_aic20_sp35/preview. 3.https://nptel.ac.in/courses/111/104/111104100/

10.3.3 Practical IV – (Based on Python)

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Practical IV- (Based on Python)</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">IV</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">CP</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2"></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">-</td><td>1</td><td>4</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">CORE X: Stochastic Processes
1. Simple Random walk- Gambler’s ruin problem.
2. Martingales in discrete time – Super martingales and sub martingales.
3. Transition probability matrix.
4. Higher Order Transition Probabilities using Chapman – Kolmogorov equation.
5. Birth and Death process.
6. M/M/1 Queuing model.
CORE XI: Advanced Operations Research
7. Solution of LPP by Graphical method.
8. Solution of LPP by Simplex method.
9. Solution of LPP by Big M method.
10. Solution of LPP by Two-Phase method
11. Integer Programming Problem by Gomory’s cutting plane method.
12. Non- Linear Programming – Lagrangian method
13. Non- Linear Programming – Kuhn-Tucker condition
14. Critical Path Method
15. Programme evaluation review technique</td></tr>
<tr><td colspan="2">Recommended Text Books</td><td colspan="6">1. Python for Data Analysis by O’Reilly Media (Second Edition).
2. How to think like a computer scientist learning with Python by Allen Downey
3. Python for Data Analysis by Armando Fernandgo</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. H. Brian, A Practical Introduction to Python Programming, Creative Commons Attribution, 2012.
2. A. Saha, Doing Math with Python: Use Programming to Explore Algebra, Statistics, Calculus, and More, No Starch Press, 2015
3. T. Hall, J. P. Stacey, Python 3 for absolute beginners, A press, 2010.</td></tr>
<tr><td colspan="2">Website and e-Learning Source</td><td colspan="6">1. https://swayam.gov.in/nd1_noc19_ma33/preview.
2. https://swayam.gov.in/nd2_aic20_sp35/preview.
3. https://nptel.ac.in/courses/111/104/111104100/</td></tr>
</table>

10.4 Elective Courses

10.4.1 For Semester I(any one of the following two courses)

Elective I: 1. Time Series Analysis

<table>
<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">1</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"></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">3</td><td colspan="2">1</td><td>-</td><td>4</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
2. Apply different methods for fitting time series models
3. Understanding various important concepts in forecasting and smoothing methods
4. Understanding stationary and non-stationary nature of time series data</td></tr>
<tr><td colspan="2" rowspan="4">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 (HoltWinter’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 - Stationary and Nonstationary Time series- Autocorrelation function (ACF) and Partial Autocorrelation function (PACF)- Portmanteau tests: Ljung–Box test and Box–Pierce test.</td></tr>
</table>

	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).
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 Books	1. Montgomery, D. C., Peck, E. A. and Vining, G. G. (2003): Introduction to Linear regression analysis, third edition, John Wiley and Sons, Inc. 2. Draper, N.R. and Smith, H. (2000) : Applied Regression Analysis, 2nd edition, John Wiley & Sons. 3. Spyros Makridakis, Steven C. Wheelwright and Victor E. McGee (2012), Forecasting Methods and Applications – Second Edition, John Wiley & Sons. 4. T.M.J.A.Cooray(2008): Applied Time Series Analysis and Forecasting, NAROSA publishing house Pvt.Ltd 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. 2. George E.P. Box and Gwilym M. Jenkins (1976): Time Series Analysis – Forecasting and Control, Holdne – Day Inc. 3. Johnston J. (1984) : Econometric Methods, (3rd Edition), McGraw Hill International Book Company, New Delhi. 4. Singh, Parashar and Singh (1997): Econometrics and Mathematical Economics (1st Edition), S. Chand & Co, New Delhi.
Website and e-Learning Source	1. http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, 2. http://www.opensource.org, www.mathpages.com

Course Learning Outcome (for Mapping with POs and PSOs)

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

1. Structuring the time series data based on seasonal and non-seasonal nature.
2. Identifying the stationarity of the time series.
3. Modelling time series using exponential methods.
4. Time series modelling using Box-Jenkings model .
5. 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	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

2.Bayesian Inference

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">Bayesian Inference</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">2</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"></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 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">Probability models, parametric and non-parametric inference.</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8">1. Estimation using pre-knowledge about the parameters.
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="8">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="8">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="8">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="8">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="2"></td><td colspan="8">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>
</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 Books	1. Bansal, A.K. (2007) Bayesian Parametric Inference, Narosa, New Delhi. 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. 2. Gelman, A. Carlin, J.B. Stern, H.B. and Rubin, D.B. (2013) Bayesian Data Analysis,3/e, CRC press, London 3. Ghosh, J.K. Delampady, M. and Samanta, T. (2010) An Introduction to Bayesian Analysis: Theory and Methods, Springer, New York. 4. Lee, P.M. (2012) Bayesian Statistics – An Introduction,4/e,Wiley, London. 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 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. 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
5. 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

10.4.2 For Semester II (any one of the following two courses)

Elective II: 1. Applied Regression Analysis

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Applied Regression Analysis</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">1</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"></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>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">Basic skills in correlation and regression</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">The main objectives of this course are to:
1. To develop a deeper understanding of the linear and non-linear regression model and its limitations.
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="6">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.</td></tr>
<tr><td colspan="6">UNITII: 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.</td></tr>
<tr><td colspan="6">UNIT III: Model building problem-Variable Selection-Stepwise regression methods. Multicollinearity - Sources and Effects of multicollinearity.</td></tr>
<tr><td colspan="6">UNIT IV: Polynomial regression. Polynomial model in one variable. Piecewise Polynomial fitting (Splines) - Non parametric regression. Kernel regression – Locally Weighted regression. Non-linear regression-non-linear least square transformation to linear model-parameter estimation.</td></tr>
<tr><td colspan="6">UNIT V: Generalized Linear Models (GLM). Logistic Regression Estimation of parameters in logistic regression Models-Interpretation of parameters in logistic regression models.</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 / applied survey techniques adopted in Economics and Statistics department of Tamil Nadu State Government. (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. Montgomery. D.C. Peck E.A. Vining. G.G. (2003), Introduction to Linear Regression Analysis, John Wiley &sons, Inc, New York. 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. 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.

Course Learning Outcome (for Mapping with POs and PSOs)

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

1. Apply simple linear regression model to real life examples.
2. Understand multiple linear regression models with applications and
3. concept of Multicollinearity and autocorrelation.
4. Compute multiple and partial correlation and checking residual diagnostic to validate model.
5. Apply Logistic and Non-linear regression models and its implementation in real life situation.

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

2. Econometrics

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">Econometrics</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8"></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"></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 linear models and their properties</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8">The main objectives of this course are to:
1. Develop knowledge on concepts of methodology, nature and scope of Econometric analysis
2. Inculcate the ideas of applications of econometrics
3. Understand and explore the concepts of linear models
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="8">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="8">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="8">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="8">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="8">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>
</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 / applied survey techniques adopted in Economics and Statistics department of Tamil Nadu State Government. (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. Castle, J. and Shephard, N. (2009) The Methodology and Practice of Econometrics. Oxford University Press, London. 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. 2. Maddala, G.S. and KajalLagari. (2009) Introduction to Econometrics, Wiley, New York. 3. Madnani, G.M.K. (2008) Introduction to Econometrics: Principles and Applications. Oxford and IBH, New Delhi.
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

10.4.3 For Semester III (any one of the following two courses)

Elective III: 1. Machine Learning Techniques

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Machine Learning Techniques</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">1</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">ED</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2"></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">UG level Programming skill, Regression analysis</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">1. Acquire theoretical knowledge on setting hypothesis for pattern recognition.
2. Apply suitable machine learning techniques for data handling and to gain knowledge from it.
3. Evaluate the performance of algorithms and to provide solution for various real-world applications.</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">UNIT I: Data types – Measures of similarity and dissimilarity Hierarchical Clustering Methods – k-means and k-medoids clustering methods – Clustering Validity measures.</td></tr>
<tr><td colspan="6">UNIT II: Fuzzy c-means – Fuzzy Clustering Validity Measures – Decision Trees – Building a decision tree – Tree induction algorithm – Splitting of nodes based on information gain and Gini index - Nearest Neighbor classifiers – KNN algorithm – Naïve Bayesian classifier.</td></tr>
<tr><td colspan="6">UNIT III: Association rules mining – Basics – A priori algorithm – Pruning and candidate generation – Rule mining. Machine learning – Introduction - Examples of various Learning Paradigms, Perspectives and Issues, Version Spaces, Finite and Infinite Hypothesis Spaces.</td></tr>
<tr><td colspan="6">UNIT IV: Learning a Class from Examples, Linear, Non-linear, Decision Trees: ID3, Classification and Regression Trees (CART), Neural Networks: Introduction, Perceptron, Multilayer Perceptron, Support vector machines: Linear and Non- Linear.</td></tr>
<tr><td colspan="6">UNIT V: Ensemble Learning Model Combination Schemes, Voting, Error-Correcting Output Codes, Bagging: Random Forest Trees, Boosting: Ada-boost, Stacking.</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 Books	1. Tan, T., Steinbach, M. and Kumar, V. (2006): Introduction to Data Mining, Pearson Education. 2. Gupta, G.K. (2008): Introduction to Data Mining with case studies, Prentice – Hall of India Pvt. Ltd. 3. Daniel T. Larose (2006): Data Mining: Methods and Models, John Wiley and Sons. 4. Han, J. and Kamber, M. (2006): Data Mining: Concepts and Techniques, 2nd Edition, Morgan Kaufmann Publishers.
Reference Books	1. Paolo Gludici (2003): Applied Data Mining: Statistical Methods for Business and Industry, John Wiley and sons. 2. Rajan Chattamvelli (2009): Data Mining Methods, Narosa Publishing House, New Delhi. 3. Wayne,W.David(1987) : A foundation for analysis in Health Sciences 4th ed., John Wiley & Sons. Jerrold H.Zar (1984) : Bio statistical analysis, Prentice hall 2nd ed. 4. Susan Milton, J.(1992) : Statistical methods in the biological and health sciences, McGraw Hill. Jain,J.R.(1982) : Statistical techniques in quantitative genetics, Tata 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. Recognize the characteristics of machine learning strategies.
2. Apply various supervised learning methods to appropriate problems.
3. Identify and integrate more than one technique to enhance the performance of learning.
4. Create probabilistic and unsupervised learning models for handling unknown pattern
5. Analyze the co-occurrence of data to find interesting frequent patterns.

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

2. Database Management System

<table>
<tr><td>Title of the Course</td><td colspan="5">Database Management Systems</td></tr>
<tr><td>Paper Number</td><td colspan="5">2</td></tr>
<tr><td rowspan="2">Category ED</td><td>Year</td><td>II</td><td>Credits</td><td>3.</td><td>Course Code</td></tr>
<tr><td>Semester</td><td>III</td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td>Tutorial</td><td>Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">3</td><td>1</td><td>-</td><td>4</td></tr>
<tr><td>Pre-requisite</td><td colspan="5">Basic knowledge in linear models and their properties</td></tr>
<tr><td>Objective of the Course</td><td colspan="5">The main objectives of this course are to:
1. To Understand the basic concepts and the applications of database systems
2. To Master the basics of SQL and construct queries using SQL
3. To understand the relational database design principles
4. To become familiar with the basic issues of transaction processing and concurrency control
5. To become familiar with database storage structures and access techniques</td></tr>
<tr><td rowspan="3">Course Outline</td><td colspan="5">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="5">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="5">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>
</table>

	UNIT IV: Transaction Concept- Transaction State- Implementation of Atomicity and Durability – Concurrent –Executions – Serializability- Recoverability – Implementation of Isolation – Testing for serializability Lock –Based Protocols – 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. (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. 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. 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

10.5 Skill Enhancement Course (SEC):

10.5.1 SEC I: Statistical Programming Using R

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Statistical Programming Using R</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">I</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">SEC</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"></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>2</td><td colspan="2">2</td><td colspan="2">-</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Undergraduate Level Probability distributions & Queueing models.</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">1. To understand the fundamentals of R programming and its applications in data analysis.
2. To develop programming skills using R data structures, functions, and control statements.
3. To import, manipulate, analyze, and visualize data using R packages.
4. To apply R for survival analysis and clinical trial data analysis.
5. To build and evaluate predictive analytics and machine learning models using R.</td></tr>
<tr><td colspan="2" rowspan="4">Course Outline</td><td colspan="6">UNIT I: Introduction to R and its applications in statistics and data science, installation of R and RStudio, R environment and workspace, basic syntax, comments, variables, data types, operators, input and output functions, and writing simple R programs.</td></tr>
<tr><td colspan="6">UNIT II: Vectors, matrices, arrays, lists, data frames, and factors; indexing and subsetting data; control structures including if, if-else, switch statements; loops (for, while, repeat); user-defined functions; built-in functions; and workspace management.</td></tr>
<tr><td colspan="6">UNIT III: Importing and exporting data from CSV, Excel, and text files; data cleaning and handling missing values; data manipulation using basic R functions and dplyr; sorting, filtering, merging, and summarizing data; introduction to graphical functions; creating bar charts, histograms, box plots, pie charts, scatter plots, line graphs, and basic visualization using ggplot2.</td></tr>
<tr><td colspan="6">UNIT IV: Time-to-event data, censoring, Kaplan–Meier survival estimation, log-rank test, Cox proportional hazards regression, recurrent event analysis, longitudinal data analysis, generalized linear models, mixed-effects models.</td></tr>
</table>

	UNIT V: Data preprocessing, feature selection, supervised and unsupervised learning techniques, classification, regression, clustering, decision trees, random forests, support vector machines, principal component analysis (PCA), model evaluation and cross-validation.
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 Books	1. Crawley, M.J. (2022). *The R Book* (3rd Edition). Wiley. 2. Kabacoff, R.I. (2015). *R in Action: Data Analysis and Graphics with R* (2nd Edition). Manning Publications. 3. Wickham, H., & Grolemund, G. (2017). *R for Data Science*. O'Reilly Media. 4. James, G., Witten, D., Hastie, T., & Tibshirani, R. (2021). *An Introduction to Statistical Learning with Applications in R* (2nd Edition). Springer. 5. Dirk F. Moore (2016). *Applied Survival Analysis Using R*. Springer.
Reference Books	1. Venables, W.N., & Ripley, B.D. (2002). *Modern Applied Statistics with S* (4th Edition). Springer. 2. Everitt, B., & Hothorn, T. (2010). *A Handbook of Statistical Analyses Using R* (2nd Edition). CRC Press. 3. Therneau, T.M., & Grambsch, P.M. (2000). *Modeling Survival Data: Extending the Cox Model*. Springer. 4. Hosmer, D.W., Lemeshow, S., & May, S. (2008). *Applied Survival Analysis: Regression Modeling of Time-to-Event Data* (2nd Edition). Wiley. 5. Klein, J.P., & Moeschberger, M.L. (2003). *Survival Analysis: Techniques for Censored and Truncated Data* (2nd Edition). Springer. 6. Kuhn, M., & Johnson, K. (2019). *Feature Engineering and Selection: A Practical Approach for Predictive Models*. CRC Press. 7. Lantz, B. (2019). *Machine Learning with R* (3rd Edition). Packt Publishing. 8. Gareth James, Daniela Witten, Trevor Hastie, & Robert Tibshirani. *An Introduction to Statistical Learning with Applications in R* (2nd Edition). Springer

Website and e-Learning Source	e-books, online tutorials taken from MOOC/SWAYAM platform for this subject.

Course Outcomes (for Mapping with POs and PSOs)

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

1. Demonstrate proficiency in the fundamentals of R programming and its programming environment.
2. Apply R data structures and programming concepts to develop efficient R programs.
3. Import, manipulate, analyze, and visualize data using appropriate R packages.
4. Perform survival analysis and clinical trial data analysis using R.
5. Develop and evaluate predictive analytics and machine learning models using R for real-world 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

10.5.2 SEC II: Reliability Theory

<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">II</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">SEC</td><td>Year</td><td>II</td><td>Credits</td><td>2</td><td>Course Code</td><td></td></tr>
<tr><td>Semester</td><td>IV</td><td></td><td></td><td></td><td></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>2</td><td colspan="2">2</td><td colspan="2">-</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Undergraduate Level Probability distributions & Queueing models.</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.
2. Review the various mathematical, physical and logical modeling tools for estimation and evaluation of component and system level reliability.
3. Appraise failure phenomena and there by provide valuable inputs for product design to achieve higher levels of reliability standards.</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">UNIT I: Introduction to Reliability - Need and Importance of Reliability - Failure Mechanisms and Failure Modes - Reliability Terminology - Components and Systems - Series, Parallel and Mixed Systems - Reliability Block Diagrams - Reliability of Simple Systems</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</td></tr>
<tr><td colspan="6">UNIT III: Estimation of Reliability - Parameter Estimation for Exponential, Weibull and Gamma distributions - Maximum Likelihood Estimation - Confidence Interval for Reliability - Censored Life Data (Concept only)</td></tr>
<tr><td colspan="6">UNIT IV: Univariate stock models and life distribution Cumulative damage models. Maintenance Concepts - Preventive Maintenance - Corrective Maintenance - Replacement Policies - Availability and Maintainability - Repairable Systems - Basic Maintenance Cost Models- Industrial Applications.</td></tr>
<tr><td colspan="6">UNIT V: Stress–Strength Reliability Concept - Estimation under Exponential and Weibull Models - Reliability Growth (Introduction)- Accelerated Life Testing (Basic Concepts) - Applications in Manufacturing Industries.</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 Books	1. Barlow, R.E. and Proschan F. (1985) Statistical Theory of Reliability and Life Testing; Rinehart and Winston. 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. 2. Nelson, W (1982): Applied Life Data Analysis; John Wiley. 3. Zacks, S(1992): Introduction to Reliability Analysis, Springer Verlag. 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 this subject.

Course Outcomes (for Mapping with POs and PSOs)

After the successful completion of the course, the 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.
5. Analyze by using Reliability growth 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

10.6 Non-Major Elective Course (NME):

For the other Departments (not for PG Statistics Students)

10.6.1 Statistics for Life Sciences

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Statistics For Life Sciences</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">I</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">NME</td><td>Year</td><td></td><td rowspan="2">Credits</td><td rowspan="2">2</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td></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>1</td><td colspan="2">1</td><td colspan="2">--</td><td>2</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Basics in Probability distributions, sampling, testing of hypotheses.</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">The main objectives of this course are to:
1. Understand the application of statistics in Life sciences
2. To learn the Biological Assays.
3. Attain proficiency categorical data analysis.</td></tr>
<tr><td colspan="2" rowspan="4">Course Outline</td><td colspan="6">Unit I: Statistical Methods in Clinical Trials: Introduction to clinical trial and it’s phases I, II, III and IV, statistical designs-fixed sample trials: simple randomized design, stratified randomized crossover design; Sequential design - open and close sequential design. Randomization Dynamic randomization, Permuted block randomization; Blinding-Single, double and triple.</td></tr>
<tr><td colspan="6">Unit II: Biological Assays: Introduction, parallel-line assay, slope- ratio assays and quantile- response assay, Feller’s theorem. Dose-response relationships-qualitative and quantitative response, dose response relation- estimation of median effective dose – PK-PD Analysis.</td></tr>
<tr><td colspan="6">Unit III: Categorical Data Analysis: Categorical response data, logistic regression-odds ratio, Wald’s statistic, logistic regression and its diagnostics, - Poison regression – Estimation of relative risk and its applications.</td></tr>
<tr><td colspan="6">Unit IV: ROC Curve analysis - Estimation of Binomial Model and the Area under the Curve, its applications – Properties of ROC curve - Kullback –Leibler Divergence (KLD)– definition – functional relationship between Kullback –Leibler Divergence and the slope of the ROC curve – derivations of KLD expressions for Bi-normal ROC model.</td></tr>
<tr><td colspan="2"></td><td colspan="6">Unit V: Repeated Measures ANOVA – One Way and Two Classified Data –Measures of disease frequency – incidence – prevalence – relative risk – Epidemiological study designs – Cohort study design and its analysis – Case control study design and its analysis – concept of bias – information bias and selection bias.</td></tr>
</table>

Extended Professional Component (is a part of internal component only, Notto 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 Books	1. Myra L. Samuels, Jeffrey A. Witmer (2010): Statistics for Life Sciences, 5th edn,. 2. Andrew Schaffner, Jeffrey A. Witmer (2015): Statistics for Life Sciences, Global edn.
Reference Books	1. Anusha Illukkumbura (2021): Introduction to Categorical Data Analysis. 2. Michael C. Whitlock, Dolph Schluter: The Analysis of Biological Data, 2nd edn, (2015) W. H. Freeman and Company. Ben Roberts Pvt Ltd. 3. Elisa T.Lee & John Wenyu Wang (2003): Statistical methods for Survival Data analysis, 3rd Edition, John Wiley 3. Jerrold H. Zar (1999): Biostatistical Analysis, 4th edition. 4. Armitage, P, Berry G and Mathews J.N.S (2002): Statistical Methods in Medical Research, 4/e, Blackwell Scientific Publications 5. Krzanowski, W and Hand, D.J.(2009): ROC Curves for Continuous Data, Chapman and Hall
Website and e-Learning Source	1. https://www.academia.edu/43317940/The Analysis of Biological Data Second Edition.

Course Learning Outcome (for Mapping with POs and PSOs)

On the successful completion of the course, student will be able to:

1. Use logical, mathematical and/or statistical concepts and methods to represent real world situations
2. Students understand basic concepts of statistics and probability
3. Students comprehend methods needed to analyze
4. Critically evaluate statistical arguments.
5. Cohort study design and its analysis

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

10.6.2 Optimization Techniques

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Optimization Techniques</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">II</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">NME</td><td>Year</td><td></td><td rowspan="2">Credits</td><td rowspan="2">2</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td></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>1</td><td colspan="2">1</td><td colspan="2">--</td><td>2</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Basics in operations research.</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">The main objectives of this course are to:
1. Understand the problem formulation by using linear, dynamic programming, game theory and queuing models
2. Acquire knowledge on stochastic models for discrete and continuous variables to control inventory and simulation of manufacturing models for the production decision making
3. Formulation of mathematical models for quantitative analysis of managerial problems in industry</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">Unit I: Development, definition, characteristics and phases, types of operation research models, applications; linear programming, problem formulation, graphical solution, simplex method.</td></tr>
<tr><td colspan="6">Unit II: Transportation problem: Formulation, Initial solutions by using NWCR, LC, VAM methods – Balanced and unbalanced transportation problems. Optimal solution by MODI method.</td></tr>
<tr><td colspan="6">Unit III: Assignment problem, formulation, optimal solution by Hungarian method, variants of assignment problem, traveling salesman problem.</td></tr>
<tr><td colspan="6">Unit IV: Theory of Games: Introduction – Terminology, Solution of games with saddle points and without saddle points, 2×2 games, dominance principle, m X 2 & 2 X n games, Graphical method.</td></tr>
<tr><td colspan="6">Unit V: Sequencing: Introduction, flow, shop sequencing, n jobs through two machines, n jobs through three machines, job shop sequencing, and two jobs through “m” machines.</td></tr>
<tr><td colspan="2">Extended Professional Component (is a part of internal component only, Notto 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
(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. J. K. Sharma (2012): "Operations Research", Macmillan, 5th Edition, 2. R. Pannerselvan (2006): "Operations Research", 2nd Edition, PHI Publications.
Reference Books	1. M. Natarajan (2013): P. Balasubramani, A. Tamilarasi, "Operations Research", Pearson Education. 2. Maurice Saseini, Arhur Yaspan, Lawrence Friedman (1959): "Operations Research: Methods & Problems", 1 st Edition.
Website and e-Learning Source	1. https://www.aicte-india.org/flipbook/p&ap/Vol.%20II%20UG/UG_2.html#p= 2. https://www.britannica.com/topic/operations-research

Course Learning Outcome (for Mapping with POs and PSOs)

1. Recall the theoretical foundations of various issues related to linear programming modeling.
2. Formulate real-world problems as a L P Model Effectively interpret the results from the control charts
3. Identify appropriate optimization method to solve complex problems involved in various industries.
4. Find the appropriate algorithm for allocation of resources to optimize the process of assignment.
5. Explain the theoretical workings of sequencing techniques for effective scheduling of jobs on machines.

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; 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

10.6.3 Statistical Methods

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Statistical Methods</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">III</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">NME</td><td>Year</td><td></td><td rowspan="2">Credits</td><td rowspan="2">2</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td></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>1</td><td colspan="2">1</td><td colspan="2">--</td><td>2</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Basics in Statistics.</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">The main objectives of this course are to:
1. Understand basic definitions in statistics.
2. To introduce basic concepts in Statistics and develop data reduction techniques.</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">Unit I: Nature and scope of statistical methods – Limitations – Types of data – Classification and tabulation of data – Construction of frequency distribution – Diagrammatic and graphical representation of data.</td></tr>
<tr><td colspan="6">Unit II: Definitions – Mean – Median – Mode – Geometric mean – Harmonic mean – Characteristics of a good average – Merits and demerits.</td></tr>
<tr><td colspan="6">Unit III: Range – Quartile deviation – Mean deviation and their coefficients – Standard deviation – Coefficient of variation – Merits and demerits.</td></tr>
<tr><td colspan="6">Unit IV: Definitions – Types and methods of measuring correlation - Scatter diagram – Karl Pearson’s coefficient of correlation – Spearman’s rank correlation co-efficient, Partial and Multiple Correlation.</td></tr>
<tr><td colspan="6">Unit V: Regression – Simple linear Regression equations – Method of least squares – Multiple Regression – Simple Problems.</td></tr>
<tr><td colspan="2">Extended Professional Component (is a part of internal component only, Notto 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
(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 Books</td><td colspan="6">1. Gupta S. P. (2001), Statistical Methods, Sultan Chand & Sons, New Delhi.
2. Gupta. S. C. and Kapoor. V. K. (2022) Fundamentals of Applied Statistics, Sultan Chand & Sons, New Delhi
3. Pillai R. S. N. And Bagavathi. V. (2005), Statistics, S. Chand & Company Ltd., New Delhi</td></tr>
</table>

Reference Books	1. Sancheti D. C. And Kapoor. V. K (2005), Statistics (7th Edition), Sultan Chand & Sons, New Delhi. 2. Arora P. N, Comprehensive Statistical Methods, Sultan Chand & Sons, New Delhi. 3. Murthy M. N (1978), Sampling Theory and Methods, Statistical Publishing Society, Kolkata
Website and e-Learning Source	1. https://www.aicte-india.org/flipbook/p&ap/Vol.%20II%20UG/UG_2.html#p= 2. https://www.britannica.com/topic/operations-research

Course Learning Outcome (for Mapping with POs and PSOs)

1. Know the basic concepts of statistics.
2. Analyze the statistical data and its usage in the measures of location.
3. Analyze the statistical data and its usage in the measures of dispersion.
4. Understand the relationship between variables.
5. Forecasting the future values.

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; 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

10.6.4 Statistical Tools for Research

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Statistical Tools for Research</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</td><td>Year</td><td></td><td rowspan="2">Credits</td><td rowspan="2">2</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td></td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td>Lecture</td><td>Tutorial</td><td colspan="2">Lab Practice</td><td colspan="2">Total</td></tr>
<tr><td>1</td><td>1</td><td colspan="2">--</td><td colspan="2">2</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Basics in Statistics.</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">The main objectives of this course are to:
1. To equip students with theoretical knowledge for testing tools
2. To learn the concepts of testing of hypothesis, significance of large and small sample tests</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">Unit I: Concept of Population and sample – Types of population – Hypothesis – Types of Hypothesis – Type I and Type II Errors – Sampling distribution and Standard Error - Level of significance.</td></tr>
<tr><td colspan="6">Unit II: Large sample Tests – Based on means and Variances – Proportions.</td></tr>
<tr><td colspan="6">Unit III: Small sample tests - t – test for means – difference between two means – t - test for correlation co- efficient.</td></tr>
<tr><td colspan="6">Unit IV: Chi – Square test – test for single variance – for independence of attributes – goodness of fit. ANOVA for one – way and two – way classification.</td></tr>
<tr><td colspan="6">Unit V: Multivariate analysis – Factor analysis – Discriminant analysis - Cluster analysis. Structural Equation Models – Diagram symbols – Modeling using Path analysis (Concept Only).</td></tr>
<tr><td colspan="2">Extended Professional Component (is a part of internal component only, Notto 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
(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 Books</td><td colspan="6">1. Gupta C. B (1978), An Introduction to Statistical Methods, Vikas Publishing House, New Delhi.
2. Snedecor G.W and Cochran W.G., Statistical Methods, Oxford Press and IBH.
3. Rex Kline (2023), Principles and Practice of Structural Equation Modelling,</td></tr>
</table>

Reference Books	1. Pillai R. S. N. And Bagavathi. V. (2005), Statistics, S. Chand & Company Ltd., New Delhi. 2. Sancheti D. C. And Kapoor. V. K (2005), Statistics (7th Edition), Sultan Chand & Sons, New Delhi. 3. Arora P. N, Comprehensive Statistical Methods, Sultan Chand & Sons, New Delhi.
Website and e-Learning Source	➢ https://www.investopedia.com/terms/c/chi-square-statistic.asp

Course Learning Outcome (for Mapping with POs and PSOs)

1. Analyze the statistical data by using statistical testing tools
2. Understand the concept of small sample tests
3. Analyze by using the concept of large sample tests
4. Multivariate analysis
5. Modeling using Path analysis

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; 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

****