KANNUR UNIVERSITY

Four Year Under Graduate Programme (KU-FYUGP)

Syllabus

Major Discipline STATISTICS

May 2024

PREFACE

The undergraduate program in Statistics, leading to a Bachelor of Science (B.Sc.) in Statistics Honours or B.Sc. in Statistics Honours with Research, is designed to develop a deep understanding of the core principles of data analysis and interpretation. This comprehensive four-year curriculum is aimed at nurturing curious minds, fostering a profound appreciation for both the theoretical and practical aspects of statistics.

Spanning four years and divided into eight semesters, the curriculum is structured to build progressively on the knowledge gained in previous semesters, ensuring a cohesive and cumulative learning experience. The discipline-specific courses cover fundamental topics such as Probability Theory, Statistical Inference, Regression Analysis, Multivariate Analysis, Time Series Analysis, and Experimental Design. Advanced topics in specialized areas like Bayesian Statistics, Non-parametric Methods, Biostatistics, and Data Mining are also included, catering to students' diverse interests and career goals.

The B.Sc. Statistics Honours program emphasizes a robust theoretical foundation paired with extensive practical experience. Students will participate in hands-on projects that reinforce classroom learning and develop essential technical skills. Through practical work, they will learn to design experiments, use advanced software, and analyze data, effectively bridging the gap between theory and practice.

For those pursuing the B.Sc. Statistics Honours with Research track, the program offers an enriched experience with a strong focus on independent research. This track is tailored for students who wish to explore specific areas of interest in greater depth, culminating in a research thesis. Under the guidance of faculty members, students will conduct original research projects, enhancing their ability to perform scientific inquiries, think critically, and contribute to the field of statistics. This rigorous training prepares graduates for careers in academia, research institutions, and industry.

In an age where data-driven decision-making and statistical analysis are crucial to societal progress, a degree in statistics equips students with problem-solving abilities, analytical skills, and a systematic approach to tackling complex challenges. Whether you aim to work in academia, industry, healthcare, or government, the B.Sc. Statistics Honours and B.Sc. Statistics Honours with Research programs provide a strong foundation for a fulfilling and impactful career.

We are pleased to present the revised curriculum and syllabus for the four-year UG Statistics Programme of affiliated colleges of Kannur University, effective from the 2024 academic year onwards.

The successful revision of this curriculum is a result of the collective efforts and contributions from the BoS members, Ad-hoc committee members, Statistics academic council members, resource persons, and the unwavering support of Statistics faculty members from affiliated colleges. Their dedication and expertise have been instrumental in shaping a curriculum that is relevant, up-to-date, and aligned with international academic standards.

We warmly welcome all students embarking on this exciting journey and look forward to their future achievements in the field of Statistics.

Dr. Rejeesh C. John
Chairperson
Board of Studies in Statistics (UG)
Kannur University

ABOUT THE DISCIPLINE

In the modern era, statistics has transformed into an indispensable discipline that underpins the data-driven world. It encompasses the science of collecting, analysing, interpreting, and presenting data, empowering us to derive meaningful insights from vast amounts of information. This discipline is far from being just a collection of numbers; it is a dynamic and systematic framework that allows us to understand complex phenomena and make informed decisions.

The digital revolution has exponentially increased the volume of data generated daily, making the role of statistics even more crucial. This "age of big data" requires advanced statistical models and computational tools to manage and analyse complex datasets effectively. Fields such as machine learning and artificial intelligence heavily rely on statistical algorithms to extract valuable knowledge from these large data pools, driving innovation, efficiency, and advancements across various industries.

Statistics permeates nearly every aspect of modern life. In business, it guides marketing strategies, product development, and financial forecasting. Governments depend on it to assess economic trends, allocate resources efficiently, and formulate public policies based on demographic and healthcare data. In sports, statistics are used to analyse player performance, optimize training programs, and predict game outcomes.

Modern statistics education equips students with essential skills to navigate this data-rich environment. Courses delve into probability theory, covering concepts such as random events, probability distributions, and statistical inference. These fundamentals help students understand data patterns and make accurate predictions. Students also learn a diverse array of statistical methods, including hypothesis testing, regression analysis, time series analysis, and non-parametric statistics, enabling them to analyse real-world data and test hypotheses effectively.

Critical thinking and problem-solving are core components of statistical education. Students learn to identify relevant data, choose appropriate methods, and interpret results meaningfully. Effective communication of findings is also emphasized, with a focus on data visualization skills. Students are taught to present complex information clearly and compellingly using charts, graphs, and other visual tools, ensuring that data insights are accessible and actionable.

The demand for skilled statisticians is soaring across various sectors. Statistics courses prepare students for rewarding careers in data analysis, research, and decision-making in fields like finance, healthcare, marketing, government, and scientific research. Modern statistical education also includes training in specialized software such as R, Python, and spreadsheet tools, equipping students with the technical expertise to handle and analyse large datasets efficiently.

Statistics transcends disciplinary boundaries, encouraging collaboration with researchers and professionals from diverse fields. This interdisciplinary approach fosters a comprehensive understanding of how data can be effectively utilized in different contexts, making statisticians invaluable in the contemporary job market.

VISION AND MISSION OF KANNUR UNIVERSITY

Vision:

To establish a teaching, residential and affiliating University and to provide equitable and just access to quality higher education involving the generation, dissemination and a critical application of knowledge with special focus on the development of higher education in Kasargod and Kannur Revenue Districts and the Mananthavady Taluk of Wayanad Revenue District.

Mission:

• To produce and disseminate new knowledge and to find novel avenues for application of such knowledge.

• To adopt critical pedagogic practices which uphold scientific temper, the uncompromised spirit of enquiry and the right to dissent.

• To uphold democratic, multicultural, secular, environmental and gender sensitive values as the foundational principles of higher education and to cater to the modern notions of equity, social justice, and merit in all educational endeavours.

• To affiliate colleges and other institutions of higher learning and to monitor academic, ethical, administrative, and infrastructural standards in such institutions.

• To build stronger community networks based on the values and principles of higher education and to ensure the region's intellectual integration with national vision and international standards.

• To associate with the local self-governing bodies and other statutory as well as nongovernmental organizations for continuing education and also for building public awareness on important social, cultural and other policy issues.

COURSE STRUCTURE FOR FOUR YEAR UNDER GRADUATE PROGRAMME (FYUGP) IN STATISTICS

(2024 ADMISSION ONWARDS)

SEMESTER I

No	Title	Credit
1	AEC 1 (English)	3
2	AEC 2 (Additional Language)	3
3	MDC 1	3
4	DSC A1 (Major)	4
5	DSC B1 (Minor 1)	4
6	DSC C1 (Minor 2)	4
	Total Credits	**21**

SEMESTER II

No	Title	Credit
1	AEC 3 (English)	3
2	AEC 4 (Additional Language)	3
3	MDC 2	3
4	DSC A2 (Major)	4
5	DSC B2 (Minor 1)	4
6	DSC C2 (Minor 2)	4
	Total Credits	**21**

SEMESTER III

No	Title	Credit
1	MDC 3	3
2	VAC 1	3
3	DSC A3 (Major)	4
4	DSC A4 (Major)	4
5	DSC B3 (Minor 1)	4
6	DSC C3 (Minor 2)	4
	Total Credits	**22**

SEMESTER IV

No	Title	Credit
1	SEC 1	3
2	VAC 2	3
3	VAC 3	3
4	DSC A5 (Major)	4
5	DSC A6 (Major)	4
6	DSC A7 (Major)	4
	Total Credits	**21**

SEMESTER V

No	Title	Credit
1	SEC 2	3
2	DSC A8 (Major)	4
3	DSC A9 (Major)	4
4	DSC A10 (Major)	4
5	DSE 1 (A11)	4
6	DSE 2 (A12)	4
	Total Credits	**23**

SEMESTER VI

No	Title	Credit
1	SEC 3	3
2	DSC A13 (Major)	4
3	DSC A14 (Major)	4
4	DSC A15 (Major)	4
5	DSE 3 (A16)	4
6	DSE 4 (A17)	4
7	INTERNSHIP	2
	Total Credits	**25**

EXIT WITH UG DEGREE/PROCEED TO FOURTH YEAR WITH 133 CREDITS

17 Major courses 17 x 4 = 68
6 Minor courses 6 x 4 = 24
13 Foundation courses (AEC, SEC, VAC, MDC) 13 x 3 = 39
1 Internship 2 x1 = 2

Total = 133

SEMESTER VII

No	Title	Credit
1	DSC A18 (Major)	4
2	DSC A19 (Major)	4
3	DSC A20 (Major)	4
4	DSC A21 (Major)	4
5	DSC A22 (Major)	4
	Total Credits	**20**

SEMESTER VIII

No	Title	Credit
1	DSC A23 (Major)	4
2	DSC A24 (Major)	4
3	DSC A25 (Major)	4
4	PROJECT	12
	OR	
	DSC A26 (Major)	4
	DSC A27 (Major)	4
	DSC A28 (Major)	4
	Total Credits	**24**

FOUR-YEAR UNDERGRADUATE PROGRAMME IN STATISTICS

DETAILS OF COURSES OFFERED

LIST OF DISCIPLINE-SPECIFIC COURSES (DSC)

SEMESTER	COURSE CODE	COURSE NAME	MARKS				CREDIT	HOURS/WEEK
			THEORY		PRACTICAL	TOTAL		
			CA	ESE				
	DISCIPLINE SPECIFIC MAJOR COURSES							
I	KU1DSCSTA101	Basic Statistics	30	70	-	100	4	4
II	KU2DSCSTA102	Descriptive Statistics	30	70	-	100	4	4
III	KU3DSCSTA201	Probability Theory	25	50	25	100	4 (3L+1P)	5
	KU3DSCSTA202	Basic Linear Algebra	25	50	25	100	4 (3L+1P)	5
IV	KU4DSCSTA203	Bivariate Random Variables	25	50	25	100	4 (3L+1P)	5
	KU4DSCSTA204	Standard Probability Distributions	25	50	25	100	4 (3L+1P)	5
	KU4DSCSTA205	Introduction to R Programming	25	50	25	100	4 (3L+1P)	5
V	KU5DSCSTA301	Mathematical Analysis	25	50	25	100	4 (3L+1P)	5
	KU5DSCSTA302	Sampling Techniques	25	50	25	100	4 (3L+1P)	5
	KU5DSCSTA303	Estimation Theory	25	50	25	100	4 (3L+1P)	5
	KU5DSCSTA304	Introduction to Stochastic Processes	25	50	25	100	4 (3L+1P)	5
VI	KU6DSCSTA305	Testing of Hypotheses	25	50	25	100	4 (3L+1P)	5
	KU6DSCSTA306	Design of Experiments	25	50	25	100	4 (3L+1P)	5
	KU6DSCSTA307	Regression Analysis	25	50	25	100	4 (3L+1P)	5
	KU6DSCSTA308	Statistical Quality Control	25	50	25	100	4 (3L+1P)	5
	KU6INTSTA311	Internship	15	35	-	50	2	2
VII	KU7DSCSTA401	Advanced Analytical Tools in Statistics	25	50	25	100	4 (3L+1P)	5
	KU7DSCSTA402	Measure and Probability	25	50	25	100	4 (3L+1P)	5
	KU7DSCSTA403	Advanced Distribution Theory	25	50	25	100	4 (3L+1P)	5

	KU7DSCSTA404	Advanced Sampling Techniques & Design of Experiments	25	50	25	100	4 (3L+1P)	5
	KU7DSCSTA405	Time Series Analysis	25	50	25	100	4 (3L+1P)	5
VIII	KU8DSCSTA406	Advanced Statistical Inference	30	70	-	100	4	4
	KU8DSCSTA407	Multivariate Analysis	30	70	-	100	4	4
	KU8DSCSTA408	Advanced Regression Techniques	30	70	-	100	4	4
	KU8RPHSTA411	Project (Honours with Research Programme)	90	210	-	300	12	12
	DISCIPLINE SPECIFIC MINOR COURSES							
I	KU1DSCSTA121	Introductory Statistics	30	70	-	100	4	4
	KU1DSCSTA122	Statistical Methods	30	70	-	100	4	4
	KU1DSCSTA123	Introduction to Operations Research	30	70	-	100	4	4
	KU1DSCSTA124	Basic Statistics and Numerical Skills	30	70	-	100	4	4
II	KU2DSCSTA131	Probability and Random Variables	30	70	-	100	4	4
	KU2DSCSTA132	Probability and Bivariate Data Analysis	30	70	-	100	4	4
	KU2DSCSTA133	Time Series and Index Numbers	30	70	-	100	4	4
	KU2DSCSTA134	Quantitative Techniques in Data Analysis – I	30	70	-	100	4	4
III	KU3DSCSTA221	Probability Distributions	25	50	25	100	4 (3L+1P)	5
	KU3DSCSTA222	Statistical Inference	25	50	25	100	4 (3L+1P)	5
	KU3DSCSTA223	Inferential Statistics	25	50	25	100	4 (3L+1P)	5
	KU3DSCSTA224	Quantitative Techniques in Data Analysis – II	25	50	25	100	4 (3L+1P)	5

LIST OF DISCIPLINE-SPECIFIC ELECTIVE COURSES (DSE)

SEMESTER	COURSE CODE	COURSE NAME	MARKS				CREDIT	HOURS/WEEK
			THEORY		PRACTICAL	TOTAL		
			CA	ESE				
V	KU5DSESTA309	Index Numbers and Time Series	25	50	25	100	4 (3L+1P)	5
	KU5DSESTA310	Statistical Data Analysis Using R	25	50	25	100	4 (3L+1P)	5
	KU5DSESTA311	Operations Research	25	50	25	100	4 (3L+1P)	5
	KU5DSESTA312	Actuarial Statistics	25	50	25	100	4 (3L+1P)	5
	KU5DSESTA313	Research Methodology	25	50	25	100	4 (3L+1P)	5
VI	KU6DSESTA314	Introduction to Biostatistics	25	50	25	100	4 (3L+1P)	5
	KU6DSESTA315	Vital and Official Statistics	25	50	25	100	4 (3L+1P)	5
	KU6DSESTA316	Population Statistics	25	50	25	100	4 (3L+1P)	5
	KU6DSESTA317	Financial Statistics	25	50	25	100	4 (3L+1P)	5
	KU6DSESTA318	Econometrics	25	50	25	100	4 (3L+1P)	5
	KU6DSESTA319	Statistical Decision Theory	25	50	25	100	4 (3L+1P)	5
VIII	KU8DSESTA421	Optimization Techniques	30	70	-	100	4	4
	KU8DSESTA422	Reliability Theory	30	70	-	100	4	4
	KU8DSESTA423	Survival Analysis	30	70	-	100	4	4
	KU8DSESTA424	Advanced Research Methodology	30	70	-	100	4	4
	KU8DSESTA425	Statistical Analysis and Business Intelligence	25	50	25	100	4 (3L+1P)	5

LIST OF MULTI-DISCIPLINARY COURSES (MDC)

SEMESTER	COURSE CODE	COURSE NAME	MARKS			CREDIT	HOURS/WEEK
			CA	ESE	TOTAL		
I	KU1MDCSTA141	Basics of Statistics	25	50	75	3	3
II	KU2MDCSTA151	Introduction to Data Analysis	25	50	75	3	3
III	KU3MDCSTA241	Introduction to Statistical Inference	25	50	75	3	3

LIST OF SKILL ENHANCEMENT COURSES (SEC)

SEMESTER	COURSE CODE	COURSE NAME	MARKS				CREDIT	HOURS/WEEK
			THEORY		PRACTICAL	TOTAL		
			CA	ESE				
IV	KU4SECSTA251	Statistical Computing and Data Visualization by MS Excel	15	35	25	75	3 (2L+1P)	4
V	KU5SECSTA341	Introduction to Data Analysis using R	15	35	25	75	3 (2L+1P)	4
VI	KU6SECSTA351	Statistical Techniques in Research Methodology	15	35	25	75	3 (2L+1P)	4

LIST OF VALUE-ADDED COURSES (VAC)

SEMESTER	COURSE CODE	COURSE NAME	MARKS				CREDIT	HOURS/WEEK
			THEORY		PRACTICAL	TOTAL		
			CA	ESE				
III	KU3VACSTA261	Data Visualization and Interpretation	15	35	25	75	3 (2L+1P)	4
IV	KU4VACSTA361	Big Data Analysis	25	50	-	75	3	3
IV	KU4VACSTA362	Study Design in Research	25	50	-	75	3	3

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KANNURUNIVERSITY

FOUR YEAR UNDERGRADUATE PROGRAMME

SYLLABUS FOR SINGLE MAJOR IN STATISTICS

PROGRAMME OUTCOMES (PO):

At the end of the graduate programme at Kannur University, a student would:

PO1	**Critical Thinking and Problem-Solving**	**Apply critical thinking skills to analyse information and develop effective problem-solving strategies for tackling complex challenges.**
PO2	**Effective Communication and Social Interaction**	**Proficiently express ideas and engage in collaborative practices, fostering effective interpersonal connections.**
PO3	**Holistic Understanding**	**Demonstrate a multidisciplinary approach by integrating knowledge across various domains for a comprehensive understanding of complex issues.**
PO4	**Citizenship and Leadership**	**Exhibit a sense of responsibility, actively contribute to the community, and showcase leadership qualities to shape a just and inclusive society.**
PO5	**Global Perspective**	**Develop a broad awareness of global issues and an understanding of diverse perspectives, preparing for active participation in a globalized world.**
PO6	**Ethics, Integrity and Environmental Sustainability**	**Uphold high ethical standards in academic and professional endeavours, demonstrating integrity and ethical decision-making. Also acquire an understanding of environmental issues and sustainable practices, promoting responsibility towards ecological well-being.**
PO7	**Lifelong Learning and Adaptability**	**Cultivate a commitment to continuous self-directed learning, adapting to evolving challenges, and acquiring knowledge throughout life.**

PROGRAMME SPECIFIC OUTCOMES (PSO):

At the end of the BSc Statistics program at Kannur University, a student would:

PSO 1	**Gain a thorough grasp of the concepts, principles, and theories in Statistics.**
PSO 2	**Utilize basic concepts in descriptive and inferential statistics for exploratory data analysis.**
PSO 3	**Develop expertise in utilizing statistical software to address the demands of employability, research, and development.**
PSO 4	**Recognize the potential applications of statistical theories in various fields.**
PSO 5	**Create statistical models to tackle real-world problems and derive solutions.**
PSO 6	**Blend analytical techniques with a critical mindset to address statistical challenges effectively.**
PSO 7	**Gain proficiency in classical statistical inference and decision-making fundamentals.**

DISCIPLINE SPECIFIC MAJOR COURSES

SEMESTER I

A1 – DISCIPLINE SPECIFIC MAJOR COURSE

KU1DSCSTA101: BASIC STATISTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
I	MAJOR	100 – 199	KU1DSCSTA101	4	60

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	-	-	30	70	100	2

Course Description: This course covers the fundamentals of statistics including the nature and scope of statistics, types of data, scales of measurement, methods of data collection and presentation, graphical representation, measures of central tendency, and measures of dispersion.

Course Prerequisite: HSE level Mathematics/Statistics Courses

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will be able to explain the definition, nature, and scope of statistics in various fields.	R
2	Students will demonstrate an understanding of different types of data, including quantitative, qualitative, geographical, and chronological, and their respective scales of measurement.	U
3	Students will be able to collect and classify data using primary and secondary sources, and present it effectively through classification, tabulation, and graphical representation techniques.	A
4	Students will analyse and interpret data using various measures of central tendency, including arithmetic mean, median, mode, geometric mean, and harmonic mean, as well as partition values such as quartiles, deciles, and percentiles.	An

5	Students will calculate and interpret measures of dispersion, including range, quartile deviation, mean deviation, and standard deviation, and understand relative measures of dispersion such as coefficient of range, quartile deviation, variation, and mean deviation.	E

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔					✔	
CO 2				✔		✔	
CO 3			✔		✔		✔
CO 4	✔		✔	✔		✔	✔
CO 5	✔	✔				✔	✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Introduction, collection and Presentation of Data**	**12**
	1	Statistics: Definition, nature and scope of statistics in various streams	
	2	Different types of data: quantitative, qualitative, geographical and chronological	
	3	Scales of measurement of data: nominal, ordinal, interval and ratio scale	
	4	Time series, cross sectional and longitudinal data	

2	**Statistical Methods**		**12**
	1	Collection of data: Primary and Secondary and their sources	
	2	Presentation of data: classification and tabulation of data	
	3	Line diagram, bar diagrams and pie diagrams	
	4	Histogram, frequency polygon, frequency curve and ogives	
3	**Measures of Central Tendency**		**12**
	1	Definition and properties of various measures of central tendency – Arithmetic Mean, Median, Mode, Geometric Mean and Harmonic Mean	
	2	Short-cut method for the evaluation of mean of raw and grouped data	
	3	Partition values - Quartiles, Deciles, Percentiles	
4	**Measures of Dispersion**		**12**
	1	Measures of Dispersion: Range, Quartile deviation, Mean Deviation and Standard deviation	
	2	Properties and relative measures of dispersion (Coefficient of range, Coefficient of quartile deviation, Coefficient of variation, Coefficient of mean deviation)	
5	**Open End**		**12**
	Practical using MS Excel		
	History of Statistics, Data entry using MS Excel, Understanding the usage of various statistical and mathematical functions in Excel, Preparation of diagrams and analysis of data using methods explained in Module 2 to 4 by Excel, Preparation and submission of a report.		

Essential Readings:

1. Gupta, S. C. & Kapoor, V. K. (1980). ***Fundamentals of Mathematical Statistics***, Sultan Chand & Sons, New Delhi.
2. Gupta, S. C. & Kapoor, V. K. (1994). ***Fundamentals of Applied Statistics***, Sultan Chand & Sons, New Delhi.
3. Gupta, S. P. (2004). ***Statistical Methods***, Sultan Chand & Sons, New-Delhi.

Suggested Readings:

1. Spiegel, M. R. and Stephens, L. J. (2017). ***Schaum's Outline of Statistics***, 6th Edn., McGraw-Hill Education.
2. Gun, A. M., Gupta, M.K. and Dasgupta, B. (2008). ***Fundamentals of Statistics.*** India: World Press.
3. Armitage, P., Berry, G., and Matthews, J. N. S. (2008). ***Statistical Methods in Medical Research***. John Wiley & Sons.

Assessment Rubrics:

Evaluation Type		Marks
End Semester Evaluation		**70**
Continuous Evaluation		**30**
a)	Test Paper- 1	**5**
b)	Test Paper-2	**5**
c)	Assignment	**10**
d)	Seminar	**-**
e)	Book/ Article Review	-
f)	Viva-Voce	**-**
g)	Field Report/Practical	**10**
Total		**100**

SEMESTER II

A2 – DISCIPLINE SPECIFIC MAJOR COURSE

KU2DSCSTA102: DESCRIPTIVE STATISTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
II	MAJOR	100 – 199	KU2DSCSTA102	4	60

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	-	-	30	70	100	2

Course Description: This course covers fundamental statistical concepts and techniques including moments, curve fitting, correlation analysis, and simple linear regression, providing students with the tools to analyse data and understand relationships between variables.

Course Prerequisite: HSE level Mathematics/Statistics Courses

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will understand the relationship between raw moments and central moments, and be able to calculate and interpret measures of skewness and kurtosis.	U
2	Students will grasp the principle of least squares and apply it to fit linear, quadratic, and exponential curves to data sets.	A
3	Students will differentiate between types of correlation, utilize scatter diagrams and Karl Pearson correlation coefficient to analyse correlation, and solve problems related to rank correlation coefficient.	An
4	Students will comprehend the process of fitting regression lines and interpret regression coefficients, understanding their definitions and properties.	E
5	Students will demonstrate the ability to calculate and interpret partial and multiple correlation coefficients in a tri-variate context.	C

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔			✔		✔	✔
CO 2	✔		✔	✔		✔	
CO 3			✔		✔		✔
CO 4		✔		✔			
CO 5	✔		✔		✔		✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1	**Moments**		12
	1	Definition and relationship between raw moments and central moments	
	2	Skewness: Definition and various measures of skewness	
	3	Kurtosis - Definition and various measures of kurtosis	
2	**Curve fitting**		12
	1	Principle of least squares	
	2	Fitting of linear and quadratic curves	
	3	Fitting of exponential curves (ab^X , $a\,X^b$, $a\,e^{bX}$)	

3	**Correlation Analysis**		**12**
	1	Definition and types of correlation	
	2	Methods of studying correlation: Scatter diagram, Karl Pearson correlation coefficient	
	3	Rank correlation coefficient-formula and problems only	
	4	Definitions of partial and multiple correlation coefficients (tri-variate case only)	
4	**Simple linear regression**		**12**
	1	Fitting of regression lines	
	2	Regression coefficients: Definition, properties and examples	
5	**Open End**		**12**
	Practical using MS Excel		
	Understanding the usage of various statistical and mathematical functions in Excel, Analysis of data using methods explained in Module 1 to 4 by Excel, Preparation and submission of a report.		

Essential Readings:

1. Gupta, S. C. and Kapoor, V. K. (2002): ***Fundamentals of Mathematical Statistics***, Sultan Chand & Co.
2. Gupta, S. C (1984): ***Fundamentals of Statistics***, Himalayan Publishing House.
3. Agrawal, B. L. (2013): ***Basic Statistics***, New Age International Publishers.

Suggested Readings:

1. Mood A. M., Graybill F. A., Bose, D C (2007): ***Introduction to the theory of statistics***, Tata Magrow Hill.
2. Gun, A. M., Gupta, M.K. and Dasgupta, B. (2008). ***Fundamentals of Statistics.*** India: World Press.
3. Croxton, F. E. and Cowden, D. J. (1973): ***Applied General Statistics***, Printice Hall of India.

Assessment Rubrics:

Evaluation Type		Marks
End Semester Evaluation		**70**
Continuous Evaluation		**30**
a)	Test Paper- 1	**5**
b)	Test Paper-2	**5**
c)	Assignment	**10**
d)	Seminar	**-**
e)	Book/ Article Review	-
f)	Viva-Voce	**-**
g)	Field Report/Practical	**10**
Total		**100**

SEMESTER III

A3 – DISCIPLINE SPECIFIC MAJOR COURSE
KU3DSCSTA201: PROBABILITY THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
III	MAJOR	200 – 299	KU3DSCSTA201	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course provides a comprehensive understanding of probability theory, random variables, mathematical expectation, and generating functions, including classical and axiomatic approaches, conditional probability, probability distributions, and properties of generating functions.

Course Prerequisite: Foundation Courses (Level 100 – 199)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will understand the concepts of random experiments, sample points, sample spaces, events, and the algebra of events, and apply them to construct probability spaces.	U
2	Students will differentiate between classical, frequency, and axiomatic approaches to probability, and apply conditional probability, addition theorem, multiplication theorem, Bayes' theorem, and Boole's inequalities to solve probability problems.	A
3	Students will be able to define and distinguish between discrete and continuous random variables, and calculate probability mass functions, probability density functions, and distribution functions along with solving related problems.	An
4	Students will comprehend mathematical expectation and its properties, apply addition and multiplication theorems on the expectation, compute conditional expectation and conditional variance, and understand the relationship between moments, raw moments, and central moments.	U
5	Students will demonstrate proficiency in understanding moment generating functions, cumulant generating functions, characteristic functions, and probability generating functions along with their definitions, properties, and application examples.	E

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔		✔	✔			✔
CO 2			✔		✔	✔	✔
CO 3		✔		✔		✔	✔
CO 4	✔		✔		✔		✔
CO 5	✔		✔		✔		✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Probability**	12
	1	Random experiment, Sample point, Sample space, Events, Algebra of events, Probability Space	
	2	Classical definition, Frequency and axiomatic approaches to probability	
	3	Conditional probability, Theorems on probability- Addition theorem, Multiplication theorem, Baye's theorem	
	4	Boole's inequalities	
2		**Random Variables**	11
	1	Definition of random variables - Discrete and continuous random variables	
	2	Probability mass function- definition and problems	
	3	Probability density function – definition and problems	

	4	Distribution function – definitions and properties	
3	**Mathematical Expectation**		**12**
	1	Mathematical expectation, Definition and properties, expectation of functions of random variables	
	2	Addition and multiplication theorems on expectation	
	3	Conditional expectation and conditional variance	
	4	Moments, relation between raw and central moments	
4	**Generating Functions**		**10**
	1	Moment generating function (mgf)- definition, properties and examples	
	2	Cumulant generating function - definition, properties and examples	
	3	Characteristic function - definition, properties and examples	
	4	Probability generating function(pgf) - definition, properties and examples	
5	**Open End (Practical)**		**30**
	History of probability, paradoxes in probability, basic set theory for probability, representation of sets in Venn diagram, operations of sets- union, intersection, complementation, basic principle of counting, problems related to permutation and combination.		

Essential Readings:

1. Gupta, S. C. & Kapoor, V. K. (1980). ***Fundamentals of Mathematical Statistics***, Sultan Chand & Sons, New Delhi.
2. Gupta, S. P. (2004). ***Statistical Methods***, Sultan Chand & Sons, New-Delhi.
3. Spiegel, M. R., Schiller, J. J., and Srinivasan, R. A. (2013). ***Schaum's outline of Probability and Statistics***. McGraw-Hill Education.

Suggested Readings:

1. Mukhopadhyay, P. (2012). ***Theory of Probability***. New Central Book Agency.
2. Dr. Rajeshwar Singh. (2012). ***An Introduction to Probability and Probability Distributions***, Books and Allied(p) Ltd.

Assessment Rubrics:

Evaluation Type		Marks	Evaluation Type		Marks	Total
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER III

A4 – DISCIPLINE SPECIFIC MAJOR COURSE

KU3DSCSTA202: BASIC LINEAR ALGEBRA

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
III	MAJOR	200 – 299	KU3DSCSTA202	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course covers fundamental concepts in linear algebra including vector spaces, matrix algebra, solutions of simultaneous equations, and rank and quadratic forms, providing students with a solid foundation in the subject.

Course Prerequisite: Foundation Courses (Level 100 – 199)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will demonstrate an understanding of vector spaces, including definitions, subspaces, and concepts of linear independence and dependence, and apply these concepts to solve problems.	U
2	Students will be able to identify and classify different types of matrices such as symmetric, skew-symmetric, idempotent, Hermitian, skew Hermitian, orthogonal, unitary, involutory, and nil-potent matrices, and perform matrix operations including finding the trace of a matrix.	R
3	Students will solve systems of simultaneous equations using various methods including the method of inverse of a square matrix, determinants, and row reduction with echelon forms.	E
4	Students will determine the rank of a matrix using standard theorems and understand the concepts of characteristic roots and vectors, Cayley Hamilton theorem, and quadratic forms.	U
5	Students will apply their understanding of singular and non-singular matrices to find their properties and calculate inverses, and grasp the concepts of characteristic roots and vectors, Cayley Hamilton theorem, and quadratic forms.	A

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1		✔	✔		✔		✔
CO 2	✔	✔		✔			✔
CO 3			✔		✔		
CO 4	✔		✔		✔		
CO 5		✔		✔		✔	✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1	**Vector Spaces**		**12**
	1	Vector Spaces-Definition, subspaces, Linear independence and dependence	
	2	Basis and dimension	
	3	Linear transformations	
2	**Matrix Algebra**		**12**
	1	Matrices-types- symmetric, skew-symmetric matrices, idempotent matrix, Hermitian and skew Hermitian matrices, orthogonal matrices, definition and examples	
	2	Matrix operations, Trace of a matrix- Properties	
	3	Unitary matrix, involuntary matrix, nil-potent matrix, adjoint of matrices, determinant of matrices	
	4	Singular and non-singular matrices- their properties, inverse of a matrix	

3	**Solution of simultaneous equations AX=B**		**11**
	1	Solution by using method of Inverse of a square matrix of order 3	
	2	Solution by using determinants	
	3	Solution by row reduction and echelon forms	
4	**Rank and Quadratic forms**		**10**
	1	Rank of a Matrix-Definition and Standard theorems, rank of sum and product of matrices	
	2	Characteristic roots and vectors	
	3	Cayley Hamilton theorem	
	4	Quadratic forms (concept only)	
5	**Open End (Practical)**		**30**
	Numerical computation of various characteristics and operations of matrices and solution of system of linear equations.		

Essential Readings:

1. Shanthi Narayan, & Mittal P.K. (2010). ***A Text Book of Matrices***, S. Chand and Company Pvt. Ltd.
2. Mittal P.K. (2007). ***Matrices***, Vrinda Publications Pvt. Ltd.
3. James R Schott. (2016). ***Matrix Analysis for Statistics*** (Third Edition). A Wiley-Interscience Publication, John Wiley & Sons, Inc.

Suggested Readings:

1. K.B. Datta. (2007). ***Matrix and Linear Algebra***, Prentice Hall of India Pvt. Ltd.
2. A.R. Vasishtha. (1996). ***Matrices***, Krishna Prakasan Media Pvt. Ltd.

Assessment Rubrics:

Evaluation Type		Marks	Evaluation Type		Marks	Total
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER IV

A5 – DISCIPLINE SPECIFIC MAJOR COURSE

KU4DSCSTA203: BIVARIATE RANDOM VARIABLES

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
IV	MAJOR	200 – 299	KU4DSCSTA203	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course provides a comprehensive understanding of bivariate random variables, conditional expectation, bivariate generating functions, and limit theorems, focusing on their definitions, properties, and applications in probability theory.

Course Prerequisite: Foundation Courses (Level 100 – 199)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will understand the concept of two-dimensional random variables, including discrete and continuous types, and be able to calculate joint and marginal probability density functions (pdfs) and probability mass functions (pmfs), as well as understand independence of random variables.	U
2	Students will apply bivariate transformations and understand conditional expectation and conditional variance, along with the theorems related to them.	A
3	Students will be able to define and compute bivariate moment generating functions, product moments, correlation, and covariance.	R
4	Students will apply Chebyshev's inequality and Markov's inequality to bound probabilities, understand convergence in distribution and probability, grasp the importance of the Weak Law of Large Numbers (WLLN), and comprehend the Central Limit Theorem (CLT) for independent and identically distributed (iid) variables along with solving related problems.	U
5	Students will demonstrate the ability to apply statistical concepts such as Chebyshev's inequality, Markov's inequality, convergence, and the Central Limit Theorem to analyse and solve problems in probability and statistics.	R

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔		✔		✔		✔
CO 2	✔		✔	✔			✔
CO 3		✔		✔	✔		
CO 4	✔		✔		✔		✔

CO 5		✔		✔		✔	✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1	**Bivariate Random Variables**		12
	1	Two dimensional random variables - definition, discrete and continuous type	
	2	Joint and marginal pdf	
	3	Conditional pmf and pdf	
	4	Independence of random variables	
2	**Conditional Expectation**		12
	1	Bivariate transformation and illustration	
	2	Conditional expectation and conditional variance	
	3	Theorems on Conditional expectation and conditional variance	
3	**Bivariate Generating functions**		10
	1	Bi-variate Moment generating Function	
	2	Product moments	
	3	Correlation and covariance	
4	**Limit Theorems**		11
	1	Chebychevs inequality, Markov inequality	

	2	Convergence in distribution and probability	
	3	Weak law of large numbers-Importance and related problems	
	4	Central limit theorem for iid variables, importance and related problems	
5	**Open End (Tutorial)**		**30**
	Numerical computation of various characteristics based on Module 1 to 4.		

Essential Readings:

1. Gupta, S. C., & Kapoor, V. K. (2020). ***Fundamentals of Mathematical Statistics***. Sultan Chand & Sons.
2. Bhat, B. R. (2023). ***Modern Probability theory - An Introductory Text Book*** (Fifth Edition), New Age International Pvt. Ltd.
3. Rohatgi, V. K. & Md. Ehsanes Saleh A.K. (2011). ***An Introduction to Probability and Statistics*** (second Edition), John Wiley & Sons.

Suggested Readings:

1. Goon A.M., Gupta M. K., & Dasgupta B. (2016). ***An Outline of Statistical Theory*** (volume 1), The World Press Pvt. Ltd.
2. Suddhendu Biswas, & Vijay Kumar Sehgal. (1991). ***Topics in Statistical Methodology***, Wiley Eastern Ltd.
3. Feller, W. (1991). **An Introduction to Probability Theory and Its Applications**, *(Volume 1)*. John Wiley & Sons.
4. Chandra, T. K., & Chatterjee, D. (2005). ***A First Course in Probability*** (Third Edition), Alpha Science International Ltd.

Assessment Rubrics:

Evaluation Type		Marks	Evaluation Type		Marks	Total
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER IV

A6 – DISCIPLINE SPECIFIC MAJOR COURSE

KU4DSCSTA204: STANDARD PROBABILITY DISTRIBUTIONS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
IV	MAJOR	200 – 299	KU4DSCSTA204	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course provides a comprehensive overview of discrete and continuous probability distributions, including their properties, applications, and the bivariate normal distribution, focusing on theoretical concepts and practical applications in various fields.

Course Prerequisite: Foundation Courses (Level 100 – 199)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will demonstrate an understanding of various discrete distributions including degenerate, discrete uniform, Bernoulli, binomial, Poisson, and geometric distributions, and their properties and applications.	U
2	Students will comprehend the properties and applications of various continuous distributions including rectangular, exponential, gamma, and beta distributions of the first and second kind.	U
3	Students will be able to analyse the properties and applications of continuous distributions such as the normal distribution, log-normal distribution, and Cauchy distribution.	An
4	Students will understand the bivariate normal distribution including its probability density function (pdf) and moment generating function (mgf), conditional distributions, properties, and applications.	R
5	Students will apply their knowledge of various distributions to solve practical problems in statistics, including modelling real-world phenomena, making predictions, and understanding data variability.	A

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1		✔		✔		✔	
CO 2	✔		✔		✔		✔
CO 3		✔		✔		✔	
CO 4	✔	✔		✔		✔	✔
CO 5	✔		✔		✔		✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1	**Discrete Distributions**		12
	1	Degenerate distribution, Discrete Uniform - properties and applications	
	2	Bernoulli distribution, Binomial distribution- properties and applications	
	3	Poisson distribution - properties and applications	
	4	Geometric distribution- properties and applications	
2	**Continuous Distributions-I**		12
	1	Rectangular distribution- properties and applications	
	2	Exponential distribution- properties and applications	
	3	Gamma distribution- properties and applications	
	4	Beta distribution first and second kind- properties and applications	
3	**Continuous Distributions-II**		11
	1	Normal distribution- properties and applications	
	2	Log normal distribution	
	3	Cauchy distribution	
4	**Bivariate Normal Distribution**		10
	1	Probability density function (pdf) and Moment generating function (mgf)	
	2	Conditional distributions	

	3	Properties and applications	
5	**Open End (Practical)**		**30**
	Numerical computation of various characteristics based on Module 1 to 4. Random variate generation from standard discrete and continuous distributions and fitting of the distributions using generated data. Fitting of a probability distribution for a real-life data		

Essential Readings:

1. Gupta. S. C and Kapoor. V. K. (2002): ***Fundamentals of Mathematical Statistics***, Sultan Chand & Sons (P) Ltd. New Delhi
2. Krishnamoorthy, K. (2015). ***A Handbook on Statistical Distributions with Applications***. Chapman and Hall/CRC, New York.
3. Dr. Rajeshwar Singh. (2012). ***An Introduction to Probability and Probability Distributions***, Books and Allied(p) Ltd.

Suggested Readings:

1. Mukhopadhyay, P. (2012). ***Theory of Probability***, New Central Book Agency (P) Limited.
2. Bhuyan, K. C. (2010). ***Probability Distribution Theory and Statistical Inference***, New Central Book Agency (P) Limited.

Assessment Rubrics:

Evaluation Type		**Marks**	**Evaluation Type**		**Marks**	**Total**
Lecture		**75**	**Practical**		**25**	
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	**100**
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER IV

A7 – DISCIPLINE SPECIFIC MAJOR COURSE

KU4DSCSTA205: INTRODUCTION TO R PROGRAMMING

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
IV	MAJOR	200 – 299	KU4DSCSTA205	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course provides a comprehensive introduction to R programming, covering topics such as data manipulation, basic mathematical operations, matrices and arrays, conditional statements, loops, functions, descriptive statistics, graphical representation, probability distributions, and methods for generating random variables using R.

Course Prerequisite: Foundation Courses (Level 100 – 199)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Demonstrate proficiency in using R for data manipulation tasks including data input, accessing, and storing, as well as utilizing functions and packages.	U
2	Apply basic mathematical operations and manipulate vectors, sequences, and matrices in R for various analytical tasks.	A
3	Implement programming constructs such as conditional statements, loops, and user-defined functions in R programming.	C
4	Utilize R for descriptive statistics including graphical representation of data, computation of summary statistics, and analysis of central tendency, dispersion, skewness, and kurtosis.	R
5	Apply probability concepts in R to analyse probability distributions, including discrete distributions (Binomial, Poisson) and continuous distributions (Normal, exponential), and generate random variables using common probability distribution methods.	An

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔			✔		✔	
CO 2		✔		✔			✔
CO 3	✔		✔			✔	✔
CO 4	✔		✔		✔	✔	
CO 5	✔	✔		✔			✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Introduction to R**	12
	1	R as a Statistical Software and language, R preliminaries, Method of data input, Data accessing or indexing, Data frames and lists	
	2	Functions, Saving, Storing and retrieving work, work space and files, using scripts, using packages	
	3	R for basic Math – Arithmetic, Logarithms and Exponentials, Vectors, sequences, Repetition, Sorting and Lengths.	
2		**Matrices and Arrays**	12
	1	Defining a Matrix, Row and Column bindings (Rbind & Cbind), Matrix dimensions, row, column and diagonal extractions. Omitting and overwriting	
	2	Matrix operations and algebra (transpose, identity matrix, scalar multiple, addition, subtraction, multiplication)	
	3	Determinant and trace of matrix, Inverse of a matrix	

	4	R Programming: conditional statements – if and if else; loops – for, while, do-while; functions – built-in and user defined	
3	**Descriptive Statistics Using R**		**11**
	1	Numeric Variables and Categorical variables. Graphical representation of data, Bar plots, Pie charts, Box plots, scatter plot	
	2	Obtaining summary statistics; generating tables, Measures of central tendency (Mean, Median, Mode)	
	3	Measures of dispersion, Measures of skewness and Kurtosis, Partition values (Quantiles, Percentiles)	
	4	Covariance, Correlation and simple linear Regression	
4	**Probability**		**10**
	1	Definition and properties, Some special discrete distributions (Binomial, Poisson)	
	2	Continuous probability distribution, some special continuous distributions (Normal, exponential)	
	3	Methods for generating random variables – Introduction, Random generation of common probability distribution in R, the inverse method	
5	**Open End (Practical)**		**30**
	Introduction to R-Studio and R Markdown. Practical using R to obtain graphical representation of data, summarization of data and tabulated form of data.		

Essential Readings:

1. Davies, T. M. (2016). ***The Book of R: A First Course in Programming and Statistics***, No Starch Press, San Francisco.
2. Peter Dalgaard (2008). ***Introductory Statistics with R***, 2nd edition, Springer.
3. Purohit, S. G., Gore, S. D. and Deshmukh, S. R. (2008). ***Statistics Using R***, Narosa Publishing House.
4. Rizzo, M. L. (2007). ***Statistical Computing with R***, CRC Press.

Suggested Readings:

1. Maria D.U., Ana F.M. and Alan T.A. (2008*):* ***Probability and Statistics with R.*** CRC Press.
2. Crawley, M, J. (2012). The R Book, 2nd Edition. John Wiley & Sons.

Assessment Rubrics:

Evaluation Type		Marks	Evaluation Type		Marks	Total
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER V

A8 – DISCIPLINE SPECIFIC MAJOR COURSE

KU5DSCSTA301: MATHEMATICAL ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
V	MAJOR	300 – 399	KU5DSCSTA301	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course provides a comprehensive introduction to fundamental concepts of real analysis, convergence tests for infinite series, differential calculus, and the Riemann integral, with a focus on theoretical understanding and application in various mathematical contexts.

Course Prerequisite: Intermediate Level Courses (Level 200 – 299)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will understand the fundamentals of real analysis, including the representation of real numbers on the line, bounded and unbounded sets, neighbourhoods, limit points, supremum and infimum, derived sets, open and closed sets, sequences, and convergence.	U
2	Students will be able to analyse series using various convergence tests including the comparison test, Cauchy's root test, D'Alembert's ratio test, Raabe's test, logarithmic test, Leibniz test, and understand absolute and conditional convergence.	An
3	Students will grasp the concepts of limits of functions, continuity, types of continuity, uniform continuity, derivatives, Darboux's theorem, Rolle's theorem, mean value theorem, and Taylor's theorem.	R
4	Students will comprehend the Riemann Integral, including its definition, existence, conditions of integrability, properties, and relation to sums, as well as integrability of continuous and monotonic functions, and the relationship between integration and differentiation. They will also understand the first mean value theorem and the fundamental theorem of integral calculus.	U
5	Students will apply their knowledge of real analysis to solve problems related to convergence, continuity, derivatives, and integration, and understand the theoretical underpinnings of calculus and analysis.	A

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔		✔		✔		
CO 2	✔		✔		✔		✔
CO 3		✔		✔		✔	
CO 4	✔		✔		✔		✔
CO 5	✔	✔		✔		✔	

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Fundamentals of Real Analysis**	12
	1	Real Analysis: Representation of real numbers as points on the line and the set of real numbers as complete ordered field	
	2	Bounded and unbounded sets, neighbourhoods and limit points, Superimum and infimum, derived sets, open and closed sets, sequences and their convergence	
	3	Limits of some special sequences such as and Cauchy's general principle of convergence, Cauchy's first theorem on limits. Bolzano Weierstrass theorem	
	4	Monotonic sequences, limit superior and limit inferior of a bounded sequence	
2		**Convergence Tests for Infinite Series**	12
	1	Definition, positive term series, comparison test	
	2	Cauchy's root test, D'Alembert's ratio test, Raabe's test	
	3	Logarithmic test, alternative series	

	4	Lebnitz test, absolute convergence and conditional convergence	
3	**Foundations of Differential Calculus**		**11**
	1	Limits of a function, continuous function, continuity at a point, continuity in closed interval	
	2	Types of continuity, uniform continuity	
	3	Derivatives, Darboux's theorem, Rolle's Theorem	
	4	Mean value theorem, Taylor's theorem	
4	**The Riemann Integral and Fundamental Theorems of Calculus**		**10**
	1	The Riemann Integral - Definition and existence of the integral, Refinement of partitions	
	2	Conditions of integrability, properties of Riemann integral, integral as a limit of sums	
	3	Integrability of continuous and monotonic functions, Integration and differentiation (the primitive)	
	4	First mean value theorem and fundamental theorem of integral calculus	
5	**Open End (Tutorial)**		**30**
	Introduction to complex analysis, complex number system, Complex functions-analytic function, Cauchy- Riemann equation, harmonic function, necessary condition for a function to be analytic, sufficient condition for function to be analytic. Complex integration.		

Essential Readings:

1. Malik S.C. and Savita Arora (1994): ***Mathematical Analysis***, Second Edition, Wiley Eastern Limited, New Age International Limited, New Delhi.
2. Somasundram D. and Chaudhary B. (1987): ***A First Course in Mathematical Analysis***, Narosa Publishing House, New Delhi.

Suggested Readings:

1. Appostol T.M. (1987): ***Mathematical Analysis***, Second Edition, Narosa Publishing House, NewDelhi.
2. Shanti Narayan (1987): ***A course of Mathematical Analysis***, 12th revised Edition, S. Chand & Co. (Pvt.) Ltd., New Delhi.
3. Bartle, R. G. and Sherbert, D. R. (2002): ***Introduction to Real Analysis*** (3rd Edition), John Wiley and Sons (Asia) Pvt. Ltd., Singapore. 22

4. Ghorpade, Sudhir R. and Limaye, Balmohan V. (2006): ***A Course in Calculus and Real Analysis***, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint.

Assessment Rubrics:

Evaluation Type		**Marks**	**Evaluation Type**		**Marks**	**Total**
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER V

A9 – DISCIPLINE SPECIFIC MAJOR COURSE

KU5DSCSTA302: SAMPLING TECHNIQUES

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
V	MAJOR	300 – 399	KU5DSCSTA302	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course provides a comprehensive overview of sampling methods and errors, including simple random sampling, stratified random sampling, and systematic sampling, with a focus on their applications, estimation techniques, and comparison.

Course Prerequisite: Intermediate Level Courses (Level 200 – 299)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will understand the concepts of variables and attributes, including parameters, statistics, population, and sample, and be able to differentiate between census and sampling, and identify sampling and non-sampling errors.	U
2	Students will demonstrate proficiency in simple random sampling techniques (SRSWOR, SRSWR), and understand the estimation of population mean, total, and attributes under simple random sampling, including the expression for the variance of the estimator.	R
3	Students will be able to describe and apply the method of selecting stratified sampling, understand the estimation of parameters and allocation of sample size, and compare stratified random sampling with simple random sampling.	A
4	Students will comprehend the method of selecting systematic samples, including linear and circular systematic sampling, estimation of parameters, and expression for the variance of the estimator under linear systematic sampling, and compare systematic sampling with stratified and simple random sampling.	E
5	Students will be able to analyse and evaluate different sampling methods, including simple random sampling, stratified sampling, and systematic sampling, and understand their advantages and disadvantages in various situations.	An

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔		✔		✔	✔	
CO 2			✔	✔		✔	✔
CO 3		✔		✔	✔		✔
CO 4	✔		✔		✔		
CO 5	✔	✔		✔		✔	✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Introduction to Sampling Methods and Errors**	12
	1	Variables and attributes - parameter, statistic, population, sample	
	2	Census and sampling - principal steps in sampling	
	3	Sampling and non-sampling errors	
	4	Different types of sampling - probability sampling, non-probability sampling, mixed sampling	
2		**Simple Random Sampling**	12
	1	Simple Random Sampling - SRSWOR, SRSWR and method of sampling	
	2	Estimation of population mean and population total, expression for variance of estimator under SRSWOR and SRSWR	
	3	Estimation of attributes under SRS	

	4	Estimation of sample size	
3	**Stratified Random Sampling**		**11**
	1	Method of selecting a stratified sampling	
	2	Estimation of parameters	
	3	Allocation of sample size- proportional and optimum allocations, estimation of population characteristics and their variance	
	4	Comparison of stratified random sampling with SRS	
4	**Systematic Sampling**		**10**
	1	Method of selecting Systematic sample	
	2	Linear Systematic sampling and Circular Systematic sampling (Concept only)	
	3	Estimation of parameters, expression for variance of estimator under linear Systematic sampling	
	4	Comparison of Systematic sampling, Stratified sampling, Simple Random Sampling	
5	**Open End (Practical)**		**30**
	Computational illustration of above concepts using R packages for sampling. Sample size calculation using specified packages.		

Essential Readings:

1. Singh, D. and Chaudhary, F. S. (1986): ***Theory and Analysis of Sample Survey Designs***, John Wiley and Sons
2. Mukhopadhyay, P. (2008). ***Theory and Methods of Survey Sampling***. PHI Learning Pvt. Ltd.
3. Gupta, S. P. (2021): ***Statistical Methods***, Sultan Chand and Sons
4. Goon, A. M., Gupta, M. K., Das Gupta (1998): ***Fundamentals of Statistics,*** Vol. II, Word Press Pvt. Ltd. Kolkata.

Suggested Readings:

1. Cochran, W. G. (1992). ***Sampling Techniques***, Wiley Eastern, New York
2. Gupta, S. C. and Kapoor, V. K. (2010). ***Fundamentals of Applied Statistics***, Sultan Chand & Sons

Assessment Rubrics:

Evaluation Type		Marks	Evaluation Type		Marks	Total
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER V

A10 – DISCIPLINE SPECIFIC MAJOR COURSE

KU5DSCSTA303: ESTIMATION THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
V	MAJOR	300 – 399	KU5DSCSTA303	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course covers sampling distributions, point estimation, methods of estimation, and interval estimation, focusing on understanding the properties and applications of estimators, confidence intervals, and Bayesian estimation techniques.

Course Prerequisite: Intermediate Level Courses (Level 200 – 299)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will understand sampling distributions, including standard error and the distribution of sample mean and variance, and demonstrate knowledge of Chi-square distribution, Student's t distribution, and F-distribution, along with their mean, variance, moment generating function, and additive property.	U
2	Students will grasp the concept of point estimation and its desirable properties such as unbiasedness, consistency, sufficiency, and efficiency, and be able to identify minimum variance unbiased estimators (MVUE) and uniformly minimum variance unbiased estimators (UMVUE), and apply Cramér-Rao inequality and minimum variance bound (MVB) estimators.	R
3	Students will apply different methods of estimation including the method of moments, method of maximum likelihood, method of minimum variance, and method of least squares, and understand the properties of moment estimators and maximum likelihood estimators.	A
4	Students will be able to construct confidence intervals for parameters such as mean, proportion, and variance of a normal population, as well as for the difference of means, proportions, and ratio of variances of two normal populations, and understand the basic concepts of interval estimation for parameters of exponential and Poisson distributions in large sample cases.	E
5	Students will comprehend the fundamental concepts of Bayes estimation, including prior and posterior distributions, loss function, Bayes' risk, and Bayes' estimator, and apply these concepts to solve estimation problems.	An

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1		✔		✔		✔	✔
CO 2	✔		✔		✔		✔
CO 3		✔		✔	✔	✔	
CO 4	✔		✔			✔	✔
CO 5	✔	✔		✔	✔	✔	

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Sampling Distributions**	12
	1	Sampling distribution, standard error; distribution of sample mean and variance	
	2	Chi square distribution-mean and variance, MGF, additive property	
	3	Student's *t* distribution – mean and variance; *F*-distribution– mean and variance	
	4	Inter-relationships between Chi square, *t*, and *F* distributions	
2		**Point Estimation**	12
	1	Definition, Desirable properties of a good estimator-unbiasedness, consistency	
	2	Sufficiency, efficiency; minimum variance unbiased estimator (MVUE), UMVUE	
	3	Cramer Rao inequality and MVB estimators	

	4	Fisher's Information and related problems	
3	**Methods of Estimation**		**10**
	1	Method of moments, Properties of moment estimators (Statement only)	
	2	Method of Maximum Likelihood, Properties of MLE (statement only)	
	3	Method of minimum variance	
	4	Method of least squares	
4	**Interval Estimation**		**11**
	1	Concept of confidence interval, Confidence coefficient, Confidence intervals for mean, proportion, variance of normal population	
	2	Confidence interval for the difference of means, proportions and ratio of variances of two normal populations	
	3	Confidence intervals for parameters of one parameter exponential distribution and Poisson distribution in the large sample case	
	4	Basic idea of Bayes estimation, Prior and posterior distributions, loss function, Bayes' Risk, Bayes' estimator	
5	**Open End (Practical)**		**30**
	Sample generations from standard distributions using R, computation of estimators and confidence intervals using generated samples.		

Essential Readings:

1. Goon A.M., Gupta M.K., Das Gupta. B. (2005), ***Fundamentals of Statistics***, Vol. I, World Press, Calcutta.
2. Manoj Kumar Srivastava, Abdul Hamid Khan, Namita Srivastava. (2014), ***Statistical Inference: Theory of Estimation***, PHI Learning Private Limited, Delhi.
3. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): ***An Introduction to Probability and Statistics***, 2nd Edn. (Reprint) John Wiley and Sons.
4. Miller, I. and Miller, M. (2002): ***John E. Freund's Mathematical Statistics*** (6th addition, low price edition), Prentice Hall of India

Suggested Readings:

1. Dudewicz, E. J., and Mishra, S. N. (1988): ***Modern Mathematical Statistics***, John Wiley & Sons.

2. Mood A.M, Graybill F.A. and Bose D.C. (2017): ***Introduction to the Theory of Statistics***, McGraw Hill.
3. Bhat, B.R., Srivenkatramana, T. and Rao Madhava K.S. (1997): ***Statistics: A Beginner's Text***, Vol. I, New Age International (P) Ltd.
4. Snedecor G.W and Cochran W.G. (1967): ***Statistical Methods***, lowa State University Press

Assessment Rubrics:

Evaluation Type		**Marks**	**Evaluation Type**		**Marks**	**Total**
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER V

A11 – DISCIPLINE SPECIFIC MAJOR COURSE

KU5DSCSTA304: INTRODUCTION TO STOCHASTIC PROCESSES

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
V	MAJOR	300 – 399	KU5DSCSTA304	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course introduces students to stochastic processes, covering topics such as the definition and examples of stochastic processes, Markov chains, Poisson processes, birth-death processes, and their applications in queuing theory.

Course Prerequisite: Intermediate Level Courses (Level 200 – 299)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Understand the concept of stochastic processes and identify various examples of stochastic processes.	U
2	Analyse the parameter space and state space of stochastic processes, recognizing independent increment processes.	An
3	Differentiate between stationary and non-stationary stochastic processes, and identify wide sense and strict sense stationary processes.	R
4	Classify stochastic processes based on their properties and examples, with a focus on Markov processes.	E
5	Apply the theory of Markov chains to analyze transition probabilities, stationary distributions, and ergodic theorems for various states in the system.	A

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔		✔		✔		✔
CO 2		✔		✔		✔	
CO 3	✔		✔		✔		✔
CO 4	✔	✔		✔	✔		
CO 5		✔	✔	✔		✔	✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1	**Introduction to Stochastic Processes**		**12**
	1	Definition and examples of stochastic processes	
	2	Parameter space, state space, independent increment	
	3	Stochastic process with stationary and independent increments, Stationary process- wide sense and strict sense	
	4	Classification of stochastic processes with examples. Markov Process	
2	**Markov Chains-Theory and Applications**		**12**
	1	Markov chain, transition probability, stationary transition probability, transition probability matrix	
	2	Chapman-Kolmogorov equation, stochastic matrix, double stochastic matrix	
	3	Classification of states recurrent, transient and periodic, properties, closed set of states	
	4	Stationary distribution and ergodic theorem (statement of theorems and simple problems)	
3	**Poisson Process and its Applications**		**11**
	1	Poisson process-postulates, definition, examples	
	2	Inter arrival times-its distributions	
	3	Relation of Poisson process with binomial distribution	
	4	Relation of Poisson process with uniform distribution	
4	**Birth-Death Processes and Queuing Theory**		**10**
	1	Birth death process, Kolmogorov forward and backward differential	

		equations	
	2	Queuing System: General concept, steady state distribution	
	3	Queuing model, M/M/1 with finite and infinite system capacity, Little's formula	
	4	Queuing model, M/M/S with infinite system capacity- steady state probability	
5	**Open End (Practical)**		**30**
	Computational illustration of above concepts using R		

Essential Readings:

1. Medhi, J. (1984). ***Stochastic Processes***, Wiley Eastern Ltd, New Delhi
2. Ross, S. M. (1996). ***Stochastic Processes***, John Wiley & Sons

Suggested Readings:

1. Bailey, N. T. J. (1964). ***Elements of Stochastic Process with Applications to the Natural Sciences,*** Wiley, New York.
2. Bartlett, M. S. (1955). ***An Introduction to Stochastic Processes***, Cambridge University Press.
3. Bhat, U.N. and Miller, G.K. (2002). ***Elements of Applied Stochastic Processes***, Third Edition, John Wiley, New York
4. Box, G. E. P and Jenkins, G. M. (1976). ***Time Series Analysis: Forecasting and Control***, Holden- Day, San Francisco.
5. Cinlar, E. (1975). ***Introduction to Stochastic Processes***, Prentice Hall, Inc, New York.
6. Samuel Karlin (1972). ***A First Course in Stochastic Process,*** Academic Press, New York.
7. Feller, W. (1968). ***Introduction to Probability Theory and Applications***, Vol. I, John Wiley, New York.

Assessment Rubrics:

Evaluation Type		Marks	Evaluation Type		Marks	Total
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER VI

A12 – DISCIPLINE SPECIFIC MAJOR COURSE

KU6DSCSTA305: TESTING OF HYPOTHESES

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
VI	MAJOR	300 – 399	KU6DSCSTA305	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course provides an in-depth understanding of hypothesis testing, covering null and alternative hypotheses, critical regions, type I and type II errors, as well as most powerful tests and p-values, along with applications such as Neymann-Pearson Lemma; further, it explores tests concerning mean, proportion, correlation coefficient, chi-square tests for goodness of fit and independence of attributes, and tests for variance and normality assessment using various techniques such as Box plot, Q-Q plot, and Shapiro Wilks's Test.

Course Prerequisite: Intermediate Level Courses (Level 200 – 299)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will understand the concepts of null and alternative hypotheses, simple and composite hypotheses, critical regions, Type I and Type II errors, level of significance, and power of a test, and be able to calculate p-values.	U
2	Students will be able to apply most powerful and uniformly most powerful tests, understand the Neymann-Pearson Lemma, and apply it in hypothesis testing based on Binomial, Poisson, Normal, and Exponential distributions.	A
3	Students will be proficient in conducting hypothesis tests for mean, equality of means, paired t-tests, significance of correlation coefficients, testing for significant differences between correlation coefficients, tests for proportions, and equality of proportions.	An
4	Students will be able to perform chi-square tests for goodness of fit, tests for independence of attributes, and tests for the significance of variance, including the F-test for equality of variances.	R
5	Students will understand and apply tests for normality using graphical methods such as box plots and Q-Q plots, and statistical tests such as the Shapiro-Wilk's test for normality of data.	E

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔	✔		✔		✔	
CO 2		✔		✔			✔
CO 3	✔		✔		✔	✔	
CO 4	✔		✔	✔			✔
CO 5	✔	✔			✔		✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Fundamentals of Hypothesis Testing**	12
	1	Null and Alternative hypotheses, Simple and Composite Hypotheses, Critical Region, Type I and Type II errors, level of significance and power of a test	
	2	Most powerful and uniformly most powerful tests, p-value	
	3	Neymann –Pearson Lemma and its applications in testing of Hypothesis based on Binomial, Poisson, Normal and Exponential distributions	
2		**Test concerning mean, proportion and correlation coefficient**	12
	1	Test for mean	
	2	Test for equality of means, paired t test	
	3	Test for significance of correlation coefficient	
	4	Test for proportion, equality of proportions	

3	**Chi-square Tests**		**10**
	1	Chi-square test for goodness of fit	
	2	Test for independence of attributes	
4	**Tests for Variance and Normality Assessment**		**11**
	1	Tests for significance of variance	
	2	F test for equality of variances	
	3	Test for normality - Box plot, Q-Q plot, Shapiro Wilks's Test for normality of data	
5	**Open End (Practical)**		**30**
	Computational illustration of above concepts using simulated data from standard distributions using R.		

Essential Readings:

1. S. C. Gupta & V. K. Kapoor (2002): ***Fundamentals of Mathematical Statistics***, Sulthan Chand & Sons.
2. Manoj Kumar Sreevastava & Namitha Sreevastava (2009). ***Statistical Inference: Testing of Hypotheses***, PHI Learning Pvt. Limited.
3. Buyan, K. C. (2010). ***Probability Theory and Statistical Inference,*** First Edn. New Central Book Agency.

Suggested Readings:

1. Goon A. M, Gupta M. K and Das Gupta B (1986). ***Fundamentals of Statistics***, Vol I. The World Press Pvt Ltd.
2. Kandethody M. Ramachandran (2009). ***Mathematical Statistics with Applications***, Elsevier
3. Mukhopadhaya. P (1996). ***Mathematical Statistics***, New Central Book Agency (P) Ltd., Calcutta.

Assessment Rubrics:

Evaluation Type		Marks	Evaluation Type		Marks	Total
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER VI

A13 – DISCIPLINE SPECIFIC MAJOR COURSE

KU6DSCSTA306: DESIGN OF EXPERIMENTS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
VI	MAJOR	300 – 399	KU6DSCSTA306	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course covers linear regression and estimation, including topics such as linear parametric functions, estimability, and Gauss-Markov's theorem; one-way and two-way ANOVA with analysis and estimation of variance; experimental design principles and analysis including CRD, RBD, and LSD; and advanced techniques like Greaco-Latin square design, auxiliary variables, and analysis of covariance.

Course Prerequisite: Intermediate Level Courses (Level 200 – 299)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will understand linear parametric functions and their estimability, and be able to apply Best Linear Unbiased Estimation (BLUE) principles.	U
2	Students will be able to define, analyse, and estimate variance in one-way and two-way ANOVA models, understanding the assumptions and models used in these analyses.	R
3	Students will comprehend the principles of experimentation including randomization, replication, and local control, and analyse completely randomized designs, randomized block designs, and Latin square designs, including advantages, disadvantages, and relative efficiencies.	An
4	Students will grasp the concepts of Greaco-Latin square design, auxiliary variables, and analysis of covariance, and apply analysis of covariance in one-way classified data, understanding its uses and interpretation.	U
5	Students will be able to apply their knowledge of experimental design and analysis to solve practical problems and make informed decisions about experimental designs and data analysis techniques.	A

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1		✔		✔		✔	✔
CO 2	✔		✔		✔		✔
CO 3		✔		✔	✔		
CO 4	✔		✔			✔	✔
CO 5		✔		✔	✔		✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Linear Regression and Estimation**	12
	1	Linear parametric function	
	2	Estimability and BLUE	
	3	Necessary and sufficient conditions for estimability of a linear parametric function	
	4	Linear hypothesis, Gauss Markov's theorem and simple problem	
2		**One-way and Two-way ANOVA**	12
	1	Definition, assumptions and models used in one way ANOVA	
	2	Analysis and estimation of variance in one-way classified data	
	3	Definition, assumptions and models used in two-way ANOVA	
	4	Analysis and estimation of variance in two-way classified data	

3	**Experimental Design and Analysis**		**11**
	1	Comparative and absolute experiments, treatments, experimental units, yield and experimental error Principles of Experimentation- Randomization, Replication and Local control	
	2	Completely Randomized Design-Analysis, advantages and disadvantages; Randomized Block design- Analysis, estimation of missing observations, advantages and disadvantages	
	3	Latin Square design - Analysis, estimation of missing observations, advantages and disadvantages	
	4	Relative efficiencies of CRD, RBD and LSD	
4	**Advanced Experimental Design and Analysis Techniques**		**10**
	1	Greaco-Latin square design (definition only)	
	2	Definition and use of auxiliary variables	
	3	Definition and uses of Analysis of covariance	
	4	Analysis of covariance in one-way classified data	
5	**Open End (Practical)**		**30**
	Computational illustration of above concepts using R		

Essential Readings:

1. Cochran, W.G. and Cox, G.M. (1959): ***Experimental Design***, Asia Publishing House.
2. Das, M.N. and Giri, N.C. (1986): ***Design and Analysis of Experiments***, Wiley Eastern Ltd.
3. Gupta, S. C., & Kapoor, V. K. (2007). ***Fundamentals of Applied Statistics***, Sultan Chand & Sons.
4. Montgomery, D. C. (2017). ***Design and Analysis of Experiments***, John wiley & sons.

Suggested Readings:

1. D.D. Joshy (1990). ***Linear Estimation and Design of Experiments***, Wiley Eastern.
2. Panneerselvam, R. (2012). ***Design and Analysis of Experiments***, PHI Learning Pvt. Limited, New Delhi.
3. Kempthorne, O. (1965): ***The Design and Analysis of Experiments***, John Wiley.

Assessment Rubrics:

Evaluation Type		Marks	Evaluation Type		Marks	Total
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER VI

A14 – DISCIPLINE SPECIFIC MAJOR COURSE

KU6DSCSTA307: REGRESSION ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
VI	MAJOR	300 – 399	KU6DSCSTA307	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course provides a comprehensive understanding of linear regression analysis, covering topics such as model fitting, hypothesis testing, prediction intervals, advanced regression models including multiple linear regression and polynomial regression, and diagnostics such as multicollinearity, outliers, heteroscedasticity, and residual analysis.

Course Prerequisite: Intermediate Level Courses (Level 200 – 299)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will understand the steps involved in regression analysis, including the formulation of mathematical and statistical equations, and be able to fit simple linear regression models, interpreting the meaning of intercept, slope, and error term.	U
2	Students will be able to test hypotheses about the slope and intercept, construct confidence intervals for these parameters, and make predictions of both average and individual values, including prediction intervals.	A
3	Students will comprehend the assumptions of simple linear regression and the properties of least square estimates, and understand measures of model fit such as R^2, MSE, MAE, and MAPE. They will also be able to test the normality of the error term using graphical methods and maximum likelihood estimation.	R
4	Students will learn multiple linear regression models, estimation of parameters using matrix notation, testing overall and individual significance of regression coefficients, and introduction to polynomial and logistic regression.	An
5	Students will understand and apply techniques for dealing with issues such as multicollinearity using dummy variables and diagnostics like VIF, detection and removal of outliers using Cook's distance, and identification of heteroscedasticity and autocorrelation, as well as interpret residual plots.	A

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔		✔		✔		✔
CO 2		✔		✔		✔	
CO 3	✔		✔	✔			✔
CO 4	✔	✔			✔	✔	
CO 5	✔		✔		✔	✔	✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Fundamentals of Linear Regression Analysis**	12
	1	Introduction to Regression – Steps involved in regression analysis - Mathematical and Statistical Equation	
	2	Simple linear regression – Model fitting - Meaning of Intercept and Slope – Error term	
	3	Assumptions of simple linear regression - Properties of least square estimates	
	4	Measures of model fit – Meaning and interpretation of R^2, MSE, MAE, and MAPE	
2		**Linear Regression Analysis and Inference**	12
	1	Hypothesis testing of slope and intercept, confidence interval for slope and intercept	
	2	Prediction of average value– prediction of actual value - prediction interval	
	3	Testing of Normality of error term - QQ Plot, Histogram	

	4	Maximum likelihood estimation	
3	**Advanced Regression Models**		**11**
	1	Multiple linear regression model – matrix notation - estimation of parameters	
	2	Testing Significance overall significance of Overall fit of the model	
	3	Testing for Individual Regression Coefficients, confidence interval	
	4	Introduction and basic concepts to polynomial and logistic regression	
4	**Diagnostics and Remedial Measures**		**10**
	1	Dummy variables – Multicollinearity problem – diagnostics through VIF	
	2	Effect of outliers – Detection and removal of outliers – Cook's distance	
	3	Heteroscedasticity - Autocorrelation (definition and their effects)	
	4	Residual analysis – understanding residual plots – standardized and studentized residual	
5	**Open End (Practical)**		**30**
	Computational illustration of above concepts using R		

Essential Readings:

1. Montgomery, D. C., Peck, E. A., & Vining, G. G. (2021). ***Introduction to Linear Regression Analysis***, John Wiley & Sons.
2. Seber, G. A., & Lee, A. J. (2012). ***Linear Regression Analysis***, John Wiley & Sons.
3. Faraway, J. J. (2002). ***Practical Regression and ANOVA Using R*** **(Vol. 168)**, University of Bath.

Suggested Readings:

1. Kutner, M. H., Nachtsheim, C. J., Neter, J., & Li, W. (2005). ***Applied Linear Statistical Models,*** McGraw-hill.
2. Abraham, B and Ledolter, J. (2005). ***Introduction to Regression Modelling***, Duxbury Press.
3. Monahan, J. F. (2008). ***A Primer on Linear Models***. CRC Press.
4. Khuri, A. I. (2009). ***Linear Model Methodology***. Chapman and Hall/CRC.

Assessment Rubrics:

Evaluation Type		Marks	Evaluation Type		Marks	Total
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER VI

A15 – DISCIPLINE SPECIFIC MAJOR COURSE

KU6DSCSTA308: STATISTICAL QUALITY CONTROL

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
VI	MAJOR	300 – 399	KU6DSCSTA308	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course covers fundamental concepts in Statistical Quality Control (SQC), including the definition of quality, historical perspectives, and the importance of SQC, as well as types of variation, statistical tools such as control charts, process capability analysis, acceptance sampling, and quality improvement techniques over 4 units. Students will learn about control chart construction and interpretation, process capability indices, process performance vs. process capability, and acceptance sampling methods and plans, including OC curves and sample size considerations.

Course Prerequisite: Intermediate Level Courses (Level 200 – 299)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Understand the definition and historical perspective of statistical quality control (SQC) and recognize its importance in various industries.	U
2	Differentiate between common cause variation and special cause variation, and identify sources of variation in a process.	An
3	Apply statistical tools such as control charts, process capability analysis, acceptance sampling, and quality improvement techniques to monitor and improve process quality.	A
4	Construct and interpret control charts including X-bar chart, R chart, p-chart, np-chart, and c-chart, and detect process shifts and trends using control chart patterns.	E
5	Calculate process capability indices (Cp, Cpk, and Cpmk), interpret their values, and understand the relationship between process capability and specification limits.	R

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1			✔		✔		✔
CO 2	✔		✔			✔	
CO 3	✔			✔	✔		✔
CO 4			✔	✔		✔	✔
CO 5	✔	✔			✔		✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Basic Concepts**	12
	1	Definition of quality, historical perspective of statistical quality control (SQC), importance of SQC in various industries	
	2	Types of Variation: Common cause variation, special cause variation, understanding sources of variation	
	3	Statistical Tools in SQC: Control charts, process capability analysis, acceptance sampling, quality improvement techniques	
2		**Introduction to Control Charts**	12
	1	Purpose and benefits of control charts	
	2	Types of control charts, X-bar chart, R chart, p-chart, np-chart, c-chart. Construction and Interpretation of Control Charts: Calculation of control limits, interpretation of control chart patterns	
	3	Detecting process shifts and trends	

	4	Control Chart Selection: Factors influencing control chart selection, considerations for variable and attribute data	
3	**Process Capability Indices**		**11**
	1	Definition of process capability indices, Cp, Cpk and Cpmk, interpretation of capability indices, relationship between process capability and specification limits	
	2	Process Performance vs. Process Capability: Differentiating between process performance and process capability, practical implications	
	3	Assessing Process Capability: Methods for assessing process capability, estimation of process capability indices	
4	**Introduction to Acceptance Sampling**		**10**
	1	Purpose of acceptance sampling	
	2	Types of acceptance sampling plans, single, double and multiple sampling	
	3	Sampling Plans and operating characteristic (OC) curves	
	4	Relationship between producer's risk, consumer's risk, and sample size, designing acceptance sampling plans	
5	**Open End (Practical)**		**30**
	Computational illustration of above concepts using R		

Essential Readings:

1. Montgomery, D. C. (2019). ***Introduction to Statistical Quality Control (8th Edition)***, John Wiley & Sons.
2. Grant, E. L. and Leavenworth, R. S. (2017). ***Statistical Quality Control,*** McGraw Hill.

Suggested Readings:

1. Duncan, A. J. (1986). ***Quality Control and Industrial Statistics.*** Wiley.
2. Mittage, H. J. and Rinne, H. (1993). ***Statistical Methods for Quality Assurance.*** Chapman and Hall.
3. Oakland, J. S.and Follorwel, R. F. (1990). ***Statistical Process Control***. East-West Press.
4. Schilling, E.G. (1982). ***Acceptance Sampling in Quality Control***. Marcel Dekker.

Assessment Rubrics:

Evaluation Type		Marks	Evaluation Type		Marks	Total
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER VII

A16 – DISCIPLINE SPECIFIC MAJOR COURSE

KU7DSCSTA401: ADVANCED ANALYTICAL TOOLS IN STATISTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
VII	MAJOR	400 – 499	KU7DSCSTA401	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course provides an in-depth study of linear algebra and transformations, advanced matrix theory and generalized inverses, eigenvalues and matrix decompositions, and the classification and decomposition of quadratic forms, covering essential concepts such as vector spaces, orthogonalization, special matrices, eigenvalues, the Cayley-Hamilton theorem, and spectral decomposition.

Course Prerequisite: Higher Level Courses (Level 300 – 399)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will be able to comprehend the concepts of linear vector spaces, subspaces, linear dependence and independence, basis, and dimensions, as well as inner product spaces and orthogonal vectors. They will also be skilled in applying the Gram-Schmidt orthogonalization process and understanding various linear and orthogonal transformations, including matrices with special structures.	A
2	Students will gain expertise in solving systems of linear equations and understanding theorems related to linear equations. They will learn to partition matrices, compute the inverse of partitioned matrices, and explore the properties and computations of generalized inverses, reflexive g-inverses, and Moore-Penrose (M-P) g-inverses.	U
3	Students will be proficient in determining eigenvalues and characteristic vectors, understanding characteristic subspaces, and applying the Cayley-Hamilton theorem. They will be able to distinguish between algebraic and geometric multiplicity of characteristic roots, and perform various matrix decompositions including diagonal forms, triangular forms, and Jordan canonical forms.	An
4	Students will understand the classification and properties of quadratic forms, including positive definite, positive semi-definite, negative definite, negative semi-definite, and indefinite forms. They will be able to reduce quadratic forms using canonical and orthogonal reduction methods and perform spectral decomposition of real symmetric matrices.	R
5	Students will develop the ability to apply the theoretical concepts learned in linear algebra, matrix theory, and quadratic forms to solve practical problems in various fields of science and	A

	engineering. This includes performing matrix computations, analysing system stability, optimizing quadratic forms, and implementing algorithms for eigenvalue problems and matrix decompositions.	

**** Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate I, Create (C)***

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1		✔	✔		✔		✔
CO 2	✔			✔		✔	
CO 3			✔		✔	✔	
CO 4	✔		✔		✔		✔
CO 5	✔	✔		✔		✔	

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Fundamentals of Linear Algebra and Transformations**	12
	1	Linear vector space and sub spaces, dependence and independence, basis and dimensions	
	2	Inner product and orthogonal vectors, orthogonal basis, Gram-Schmidt orthogonalization	
	3	Linear transformation and orthogonal transformation, Matrices with special structures	
	4	Rank, Nullity and inverse of a matrix, Rank-Nullity theorem, Sylvester's law of nullity	

2	**Advanced Matrix Theory and Generalized Inverses**		**12**
	1	Linear equations, solution of system of linear equations and related theorems	
	2	Partition of a matrix, inverse of a partitioned matrix	
	3	Generalized inverse and its properties, reflexive g-inverse and its properties, computation of g inverse and reflexive g-inverse	
	4	M-P g-inverse, properties of M-P g-inverse, computation of M-P g inverse	
3	**Eigen Values and Matrix Decompositions**		**11**
	1	Eigen values, characteristic roots and vectors	
	2	Characteristic subspace of a matrix, characteristic roots of some special types of matrices	
	3	Cayley- Hamilton theorem, minimal polynomial, algebraic and geometric multiplicity of a characteristic root	
	4	Diagonal forms, triangular forms, Jordan canonical form, diagonalisation	
4	**Classification and Decomposition of Quadratic Forms**		**10**
	1	Quadratic forms, rank and signature, positive definite and non-negative definite matrices	
	2	Classification of quadratic forms: positive definite, positive semi definite, negative definite, negative semi definite and indefinite quadratic forms	
	3	Reduction of quadratic forms: canonical and orthogonal reduction. Derivative of quadratic forms	
	4	Similarity and spectral decomposition of real symmetric matrices	
5	**Open End (Practical)**		**30**
	Computational illustration of above concepts using R		

Essential Readings:

1. Biswas, S. (2012). ***Text Book of Matrix Algebra***, PHI Learning.
2. Mathai, A. M. (1999). ***Linear Algebra Part I, II & III***, Centre for Mathematical Sciences
3. Narayan, S. and Mittal, P. K. (2010). ***A Text Book of Matrices***, S. Chand & Company Ltd.

Suggested Readings:

1. Strang, G. (2005). ***Linear Algebra and its Applications***, Cengage India Pvt. Ltd.
2. Hoffman K. and Kunze R. (2014). ***Linear Algebra***, PHI Learning.
3. Pringle, R. M. (1970). ***Generalised Inverse of Matrices with Application to Statistics***, Macmillan Publishing Company.
4. Rao, C. R. (2002). ***Linear Statistical Inference and its Applications***, John Wiley & Sons, New York.
5. Rao, A.R. and Bhimasankaram, P. (2002). ***Linear Algebra***, Second edition, Springer.

Assessment Rubrics:

Evaluation Type		**Marks**	**Evaluation Type**		**Marks**	**Total**
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER VII

A17 – DISCIPLINE SPECIFIC MAJOR COURSE

KU7DSCSTA402: MEASURE AND PROBABILITY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
VII	MAJOR	400 – 499	KU7DSCSTA402	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course provides a comprehensive study of measure theory and probability spaces, covering foundational concepts such as sigma fields and various measures, exploring random variables and distribution functions, delving into advanced topics in Lebesgue integration and measure theory, and examining inequalities, independence, and characteristic functions in probability theory.

Course Prerequisite: Higher Level Courses (Level 300 – 399)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will understand the foundational concepts of measure theory, including sigma fields, Borel sets, and different types of measures, and will be able to explain the properties and extensions of these measures.	U
2	Students will be proficient in defining and manipulating measurable functions and random variables, and will be able to describe and decompose distribution functions, including those for vector-valued random variables.	An
3	Students will be able to apply the principles of Lebesgue integration and related theorems such as the Monotone Convergence Theorem and Fatou's Lemma, and understand the applications of the Radon-Nikodym theorem and Lebesgue decomposition.	A
4	Students will be able to evaluate and apply various inequalities	E

	involving moments, such as Hölder's and Jensen's inequalities, and understand the concepts of independence of events and random variables, including the application of Kolmogorov's 0-1 law and the Borel-Cantelli Lemma.	
5	Students will understand the definition, properties, and applications of characteristic functions in probability theory, and will be able to use them to derive moments and apply the inversion theorem and Taylor series expansion for characteristic functions.	R

**** Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate I, Create (C)***

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1		✔		✔		✔	
CO 2		✔	✔		✔		✔
CO 3	✔			✔		✔	
CO 4		✔	✔		✔		✔
CO 5	✔		✔		✔		✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1	**Foundations of Measure Theory and Probability Spaces**		**12**
	1	Class of sets, fields and sigma fields, Borel class and Borel fields in one and higher dimensions	
	2	Limits of sequence of sets, monotone sequence of sets. Set function, additive and sub-additive set functions. Measure, axioms of measure, measure space	

	3	Different types of measures-Counting measure, probability measure, properties, probability space, continuity theorem, extension of probability measure, Caratheodory extension theorem (without proof)	
	4	Lebesgue- Stieltjes measure. Product space and product measure, Conditional probability measure and independence of events	
2	**Random Variables and Distribution Functions in Probability Theory**		**12**
	1	Measurable function, Random variables, simple, non-negative and arbitrary random variables	
	2	Inverse function and properties, Sequence of random variables and limit	
	3	Distribution function, decomposition of distribution function	
	4	Vector valued random variables and its distribution function, induced probability space of a random variable	
3	**Advanced Topics in Lebesgue Integration and Measure Theory**		**11**
	1	Lebesgue integration and properties (without proof), Monotone convergence theorem, Fatou's lemma (without proof)	
	2	Dominated convergence theorem, Lebesgue-Stieltjes integral, Expectation as Lebesgue-Stieltjes integral	
	3	Absolute continuity of a measure with respect to another measure	
	4	Radon-Nikodym theorem (without proof) and its applications. Lebesgue decomposition theorem	
4	**Inequalities, Independence, and Characteristic Functions in Probability Theory**		**10**
	1	Inequalities involving Moments-Holder and Jensen inequalities, Cr-inequality, basic inequality, Markov inequality, Liapounov's inequality	
	2	Independence of events, classes of events, Independence of random variables, Kolmogorov's 0-1 law, Borel –Cantelli Lemma	
	3	Characteristic function -definition, properties, Inversion theorem	
	4	Characteristic function and moments, Taylor's series for characteristic functions	
5	**Open End (Practical)**		**30**

	Computational illustration of above concepts using R	

Essential Readings:

1. Basu, A. K. (1999). ***Measure Theory and probability***, Prentice Hall of India Pvt. Ltd., New Delhi
2. Bhat B.R. (2014). ***Modern Probability Theory (An Introductory Text Book)***, Fourth edition, New Age International Publishers.
3. Jain, P.K. & Gupta, V. P. and Jain, P. (2011). ***Lebesgue Measure and Integration***, New Age International Publishers.
4. Rao, C. R. (2002). ***Linear Statistical Inference and its Applications***, John Wiley & Sons.

Suggested Readings:

1. Billingsley, P. (1995). ***Probability and Measure***, 3rd Edn., John Wiley, New York.
2. Chung, K. L. (2001). ***A Course in Probability Theory***, 3rd Edn., Academic Press, London.
3. Gut, A. (2005). ***Probability: A Graduate Course***. Springer-Verlag, New York.
4. Laha, R.G. and Rohatgi, V. K. (1979). ***Probability Theory***, Wiley-Blackwell.
5. Loeve, M. (1977). ***Probability Theory***, Fourth edition, Springer-Verlag.
6. Rohatgi, V.K. and Saleh, M. (2015). ***An Introduction to Probability and Statistics***, Third edition, John Wiley & Sons.

Assessment Rubrics:

Evaluation Type		**Marks**	**Evaluation Type**		**Marks**	**Total**
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER VII

A18 – DISCIPLINE SPECIFIC MAJOR COURSE

KU7DSCSTA403: ADVANCED DISTRIBUTION THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
VII	MAJOR	400 – 499	KU7DSCSTA403	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course explores discrete and continuous probability distributions, modes of convergence, and fundamental theorems in probability, covering topics such as probability generating functions, various discrete and continuous distributions, transformations of random variables, sampling distributions, modes of convergence, infinitely divisible distributions, laws of large numbers, central limit theorems, and the properties and distributions of order statistics.

Course Prerequisite: Higher Level Courses (Level 300 – 399)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will understand and apply probability generating functions, convolution techniques, and factorial moments to analyse discrete distributions, including power series, logarithmic series, negative binomial, multinomial, and hypergeometric distributions, as well as generate random samples from these distributions.	R
2	Students will be able to describe and work with various continuous distributions such as Pareto, Lognormal, Logistic, Weibull, and Laplace distributions, including their convolutions, compound and mixture distributions, and transformations involving random variables and vectors, with considerations for censoring and truncation.	An
3	Students will comprehend the properties and applications of key sampling distributions, including the Chi-square, t, and F distributions, as well as the Pearson and exponential families of distributions, enabling them to perform joint distributions of means	U

	and variances from normal populations.	
4	Students will learn the various modes of convergence (in probability, almost sure, in r^{th} mean, in distribution) and their interrelationships, and apply theorems like Slutsky's, Helly Bray, and the continuity theorem, along with understanding and working with infinitely divisible distributions and conditional expectations.	E
5	Students will grasp the weak and strong laws of large numbers, including Khinchin's and Kolmogorov's laws, understand the Glivenko-Cantelli Lemma, and apply the central limit theorem in its various forms (Lindberg-Levy, Liapounov, Lindberg-Feller) to order statistics and asymptotic distributions of sample median, range, and midrange.	A

**** Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate I, Create (C)***

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔			✔		✔	✔
CO 2	✔	✔		✔			✔
CO 3		✔			✔	✔	
CO 4	✔		✔			✔	✔
CO 5		✔		✔	✔		

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Discrete distributions**	**12**
	1	Probability generating functions, convolution, distribution of random sum of random variables, factorial moments	

	2	Simple properties and applications of the following distributions- Power series distributions, Logarithmic series distributions and their particular cases	
	3	Negative Binomial, multinomial, hyper geometric and its applications	
	4	Generation of random samples from various distributions	
2	**Continuous distributions**		**12**
	1	Pareto, Lognormal, Logistic, Weibull and Laplace distributions; Convolution of distributions, compound and mixture distributions	
	2	Functions of random variables, random vectors and transformations, censoring and truncation of distributions	
	3	Sampling distributions: Joint distributions of mean and variance from normal population, Chi-square, t and F distributions (central and non-central without derivation) - their properties and applications	
	4	Pearson family of distributions, Exponential family of distributions	
3	**Different modes of convergence**		**11**
	1	Convergence in probability, almost sure convergence, convergence in r^{th} mean, convergence in distribution, relationships among different forms of convergence	
	2	Slutsky's theorem, Helly Bray theorem and Helly Bray lemma (statements only), Continuity theorem joint characteristic functions – applications	
	3	Infinitely divisible distributions, Definition, elementary properties and examples	
	4	Conditional expectation and properties	
4	**Law of large numbers**		**10**
	1	LLN, WLLN and SLLN-Khinchin's weak law of large numbers, Kolmogrov's strong law of large numbers I and II (without proof)	
	2	Glivenko –Cantelli Lemma (Concept and statement only), Central Limit theorem (CLT)- CLT as a generalization of law of large numbers, Lindberg –Levy form, Liapounov's form (without proof), Lindberg-	

		Feller form (without proof)	
	3	Order statistics and their distributions: - Joint, marginal and conditional distributions	
	4	Asymptotic distributions of sample median, range and midrange (Exponential and uniform)	
5	**Open End (Practical)**		**30**
	Computational illustration of above concepts using R		

Essential Readings:

1. Balakrishnan, N. and Rao, C. R. (2003). ***Handbook of Statistics***, Vol. 16, Elsevier.
2. Johnson, Kotz and Balakrishnan. (2000). ***Distributions in Statistics***, Vol. 1, 2 & 3, John Wiley
3. Rohatgi, V. K. (1976). ***An Introduction to Probability Theory and Mathematical Statistics***, John Wiley & Sons.
4. Arnold B.C., Balakrishnan, N. and Nagaraja, H. N. (1992). ***A First Course in Order Statistics***, Society for Industrial and Applied Mathematics.

Suggested Readings:

1. Kendall, M. G and Stuart, A. (1977). ***The Advanced Theory of Statistics, Vol. I: Distribution Theory***, Charles Griffin & Co. Ltd.
2. Ord, J. K. (1972). ***Families of Frequency Distributions***, Lubrecht & Cramer Ltd.
3. Rao, C. R (2002). ***Linear Statistical Inference and its Applications***, John Wiley & Sons.
4. Karian, Z. A. and Dudewicz, E. J. (2010). ***Fitting of Statistical distributions with R***, CRC Press.

Assessment Rubrics:

Evaluation Type		Marks	Evaluation Type		Marks	Total
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER VII

A19 – DISCIPLINE SPECIFIC MAJOR COURSE

KU7DSCSTA404: ADVANCED SAMPLING TECHNIQUES & DESIGN OF EXPERIMENTS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
VII	MAJOR	400 – 499	KU7DSCSTA404	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course covers advanced topics in sampling methods, ratio and regression estimators, factorial experiments, analysis of covariance, and incomplete block designs, including cluster and multistage sampling, PPS sampling, various estimators, factorial and fractional factorial designs, ANCOVA, split and strip plot designs, BIBD, PBIBD, and optimality criteria for experimental design.

Course Prerequisite: Higher Level Courses (Level 300 – 399)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will understand and apply methods for cluster sampling with equal and unequal cluster sizes, estimate means and variances, and conduct two-stage, multistage, and multiphase sampling, including the concept of double sampling and PPS sampling.	A
2	Students will be able to use ordered and unordered estimators such as Desraj's ordered estimator, Horvitz-Thompson, Yates-Grundy, and Murthy's unordered estimators for effective estimation in complex sampling designs.	R
3	Students will gain proficiency in calculating and comparing the biases and variances of ratio and regression estimators, including applications in stratified sampling, and will be able to compare these estimators with mean per unit estimators.	U
4	Students will be capable of designing and analysing 2^n and 3^n factorial experiments, managing total and partial confounding, applying the concept of fractional replication, and performing Analysis of Covariance (ANCOVA) in Randomized Block Design (RBD) and Latin Square Design (LSD).	An
5	Students will understand the analysis of split and strip plot designs, Balanced Incomplete Block Designs (BIBD), and Partially Balanced Incomplete Block Designs (PBIBD) with two associate classes, including intra- and inter-block analysis, missing plot analysis, and criteria for the connectedness, orthogonality, and optimality of experimental designs.	E

**** Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate I, Create (C)***

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔		✔		✔		✔
CO 2			✔		✔		✔
CO 3	✔	✔		✔		✔	
CO 4			✔		✔		✔
CO 5	✔	✔		✔		✔	

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Cluster Sampling and Sampling with Varying Probabilities**	12
	1	Cluster sampling with equal and unequal cluster size, estimation of their mean and variance	
	2	Two stage sampling with equal first stage units, estimation of its mean and variance, concept of double sampling, multistage and multiphase sampling	
	3	PPS sampling with and without replacement, Midzuno scheme of sampling	
	4	Ordered and unordered estimators- Desraj's ordered estimator, Horvitz-Thompson and Yates-Grundy estimators, Murthy's unordered estimator	
2		**Ratio and Regression Estimators**	12
	1	Ratio estimator, bias of ratio estimator, approximate variance of ratio estimator	

	2	Comparison of ratio estimator with mean per unit, unbiased ratio estimator	
	3	Linear regression estimator, bias of regression estimator, approximate variance of regression estimator	
	4	Comparison of regression estimator with mean per unit and ratio estimator. Ratio and regression estimation in stratified sampling	
3	**Factorial Experiments and ANCOVA**		**11**
	1	2^n and 3^n factorial experiments	
	2	Total and partial confounding in symmetrical factorial designs, concept of fractional replication	
	3	Analysis of Covariance in RBD and LSD	
	4	Mixed plot analysis, estimation of residual effects	
4	**Incomplete Block Designs**		**10**
	1	Analysis of split plot design	
	2	Analysis of strip plot design	
	3	BIBD and the concept of PBIBD with only two associate classes, intra and inter block analysis of BIBD	
	4	Connectedness and orthogonality of designs, optimality criteria for experimental design	
5	**Open End (Practical)**		**30**
	Computational illustration of above concepts using R		

Essential Readings:

1. Cochran,W. G. (1992). ***Sampling Techniques***, Wiley Eastern, New York.
2. Desraj. (1979). ***Sampling Theory***, Tata Mc-Graw Hill.
3. Singh, D and Chowdhary, F. S. (1986). ***Theory and Analysis of Sample Survey Designs***, New Age International, New Delhi.
4. Das, M. N and Giri, N. C. (2002). ***Design and Analysis of Experiments***, 2nd edition, New Age International Pvt. Ltd., New Delhi.

5. Douglas, C. Montgomery. (1976). ***Design and Analysis of Experiments***, John Wiley & Sons.

Suggested Readings:

1. Hansen, M. H., Hurwitz, W. N. and Madow, W. G. (I 993). ***Sample Survey Methods and Theory***, Wiley-Interscience.
2. Murthy, M. N. (1967). ***Sampling Theory and Methods***, Statistical Publishing Society, Calcutta.
3. Mukopadhyay, P. (2008). ***Theory and Methods of Survey Sampling***, Prentice Hall of India Learning Pvt. Ltd.
4. Gupta, S. P. and Kapoor, V. K. (2010). ***Fundamentals of Applied Statistics***, Sulthan Chand & Sons.
5. Cochran, W. G. and Cox, G. M. (1957). ***Experimental Designs***, Wiley International.
6. Federer, W. T. (1963). ***Experimental Design-Theory & Applications***, Oxford & IBH Publishing Company.
7. Giri, N. (1986). ***Analysis of Variance***, South Asian Publishers.

Assessment Rubrics:

Evaluation Type		**Marks**	**Evaluation Type**		**Marks**	**Total**
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER VII

A20 – DISCIPLINE SPECIFIC MAJOR COURSE

KU7DSCSTA405: TIME SERIES ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
VII	MAJOR	400 – 499	KU7DSCSTA405	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course covers the fundamentals and advanced concepts in time series analysis, including components and models, trend and seasonality estimation, smoothing methods, stochastic processes, ARMA and ARIMA models, estimation and testing for stationarity, model selection, spectral analysis, and advanced models such as seasonal ARIMA, ARCH, and GARCH.

Course Prerequisite: Higher Level Courses (Level 300 – 399)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will be able to identify and describe the components of time series data, apply additive, multiplicative, and mixed models, and estimate and eliminate trends and seasonality.	An
2	Students will demonstrate proficiency in forecasting using smoothing techniques such as simple and weighted moving averages, simple exponential smoothing, Holt's exponential, and Holt-Winter's exponential smoothing methods.	A
3	Students will gain an understanding of time series as discrete parameter stochastic processes, including auto-covariance and auto-correlation functions, and will be able to model AR, MA, ARMA, and ARIMA processes.	U
4	Students will learn to estimate ARMA models using Yule-Walker, maximum likelihood, and least squares methods, test for	R

	stationarity, and apply model identification, selection criteria (AIC, BIC), and diagnostic checking using the Box-Jenkins methodology.	
5	Students will acquire skills to compute and interpret the spectral density of stationary time series and ARMA processes, understand periodograms and correlograms, and explore advanced models including seasonal ARIMA, ARCH, and GARCH models.	E

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate I, Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1		✔		✔		✔	
CO 2	✔		✔		✔		✔
CO 3		✔		✔		✔	
CO 4	✔		✔		✔		✔
CO 5		✔		✔		✔	✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1	**Time Series Analysis and Forecasting Techniques**		**12**
	1	Time Series (definition), components of time series, mathematical methods for time series (additive model, multiplicative model, mixed models)	
	2	Estimation and elimination of trend and seasonality	
	3	Forecasting based on smoothing: moving average (simple and weighted), exponential smoothing; simple exponential	

	4	Holt's exponential and Holt - Winter's exponential smoothing	
2	**Stochastic Processes and Stationary Time Series Models**		**12**
	1	Time series as a discrete parameter stochastic process, auto-covariance and auto-correlation function and their properties	
	2	General linear process (Wold process), auto-covariance function of Wold process, auto-covariance generating function	
	3	Detailed study of stationary process: Auto Regressive (AR), Moving Average (MA) processes	
	4	Detailed study of Auto Regressive Moving Average (ARMA) and Auto Regressive Integrated Moving Average (ARIMA) processes	
3	**Estimation, Model Selection, and Forecasting in ARMA Models**		**11**
	1	Estimation of ARMA models; Yule-Walker estimation of AR process, M.L.E. and least square estimation for ARMA process	
	2	Choice of AR and MA periods, Test for stationarity (unit root test, Dickey-Fuller test, KPSS test)	
	3	Model identification, Model selection criteria (AIC, BIC), diagnostic checking. Box- Jenkins Modelling Procedure	
	4	Forecast using ARMA model; MMSE method (l- step ahead forecast of ARIMA (p, d, q), ARMA (1,1), AR (1) process)	
4	**Spectral Analysis and Advanced Time Series Models**		**10**
	1	Spectral density of stationary time series and its elementary properties with proof	
	2	Spectral density of an ARMA process; spectrum of AR (1), AR (2), MA (1), MA (2) and ARMA (1,1) processes	
	3	Periodogram and correlogram (definition only), Herglotz's theorem with proof	
	4	Seasonal ARIMA model (basic concept only), ARCH and GARCH model (basic concept only)	
5	**Open End (Practical)**		**30**

	Computational illustration of above concepts using R	

Essential Readings:

1. Box, G. E. P., Jenkins, G.M. and Reinsel, G. C. (2007). ***Time Series Analysis: Forecasting and Control***, Pearson Education.
2. Brockwell, P. J. and David R. A. (2002). ***Introduction to Time Series and Forecasting***, 2nd edition, Springer.

Suggested Readings:

1. Abraham, B., and Ledolter, J. (2009). ***Statistical Methods for Forecasting***, John Wiley & Sons.
2. Anderson, T. W. (2011). ***The Statistical Analysis of Time Series***, John Wiley & Sons.
3. Fuller, W. A. (2009). ***Introduction to Statistical Time Series***, John Wiley & Sons.
4. Hamilton, J. D. (2020). ***Time Series Analysis*****,** Princeton University Press.

Assessment Rubrics:

Evaluation Type		**Marks**	**Evaluation Type**		**Marks**	**Total**
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER VIII

A21 – DISCIPLINE SPECIFIC MAJOR COURSE

KU8DSCSTA406: ADVANCED STATISTICAL INFERENCE

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
VIII	MAJOR	400 – 499	KU8DSCSTA406	4	60

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	-	-	30	70	100	2

Course Description: This course covers advanced statistical inference topics including the Fisher-Neyman factorization theorem, minimal sufficiency, completeness, exponential families, ancillary statistics, Basu's theorem, Rao-Blackwell and Lehmann-Scheffé theorems, CAN and BAN estimators, confidence intervals, randomized and non-randomized tests, Neyman-Pearson Lemma, MLR property, unbiased and invariant tests, likelihood ratio tests, and the sequential probability ratio test.

Course Prerequisite: Higher Level Courses (Level 300 – 399)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will understand the Fisher-Neyman factorization theorem, minimal sufficiency, completeness and related problems, exponential families, ancillary statistics, and Basu's theorem.	U
2	Students will grasp the concept of the Rao-Blackwell theorem and related problems, the Lehmann-Scheffé theorem and related problems, CAN and BAN estimators, shortest confidence intervals, unbiased confidence intervals, and confidence intervals for large samples.	A
3	Students will understand randomized and non-randomized tests, the Neyman-Pearson Lemma and related problems, the MLR property and related problems, unbiased tests, and invariant tests.	U
4	Students will master the concepts and applications of likelihood	E

	ratio tests and related problems, as well as the properties of likelihood ratio tests.	
5	Students will comprehend the fundamental concepts of the Sequential Probability Ratio Test (SPRT) and the properties of SPRT.	R

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate I, Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1		✔	✔		✔		
CO 2		✔		✔	✔		✔
CO 3	✔		✔			✔	✔
CO 4		✔		✔	✔		
CO 5	✔		✔			✔	✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1	**Advanced Concepts in Statistical Sufficiency**		12
	1	Fisher - Neyman factorization theorem, minimal sufficiency	
	2	Completeness and related problems	
	3	Exponential families	
	4	Ancillary statistics, Basu's theorem	
2	**Advanced Estimation Techniques and Confidence Intervals**		

	1	Rao- Blackwell theorem and related problems	**12**
	2	Lehmann- Scheffe theorem and related problems	
	3	CAN and BAN estimators	
	4	Pivotal Quantity Method of finding confidence intervals, shortest confidence and unbiased confidence intervals, confidence intervals for large samples	
3	**Advanced Hypothesis Testing Methods**		**12**
	1	Randomized and non-randomized tests	
	2	Neyman-Pearson lemma and related problems	
	3	MLR property and related problems	
	4	Unbiased tests and invariant tests	
4	**Likelihood Ratio Tests and Sequential Probability Ratio Test**		**12**
	1	Likelihood ratio tests and related problems	
	2	Properties of likelihood ratio tests	
	3	Sequential probability ratio test (SPRT)	
	4	Properties of SPRT (statements only)	
5	**Open End (Practical)**		**12**
	Computational illustration of above concepts using R		

Essential Readings:

1. Rohatgi, V. K. and Saleh, A. K. Md. E. (2009): ***An Introduction to Probability and Statistics***, 2nd Edn. (Reprint), John Wiley & Sons.
2. Srivastava, M. K., Khan, A. H. and Srivastava, N. (2014). ***Statistical Inference: Theory of Estimation***, PHI Learning Pvt. Ltd.
3. Srivastava, M. K., Khan, A. H. and Srivastava, N. (2009). ***Statistical Inference: Testing of Hypotheses***, PHI Learning Pvt. Ltd.

Suggested Readings:

1. Casella, G., and Berger, R. L. (2021). ***Statistical Inference***, Cengage India Pvt. Ltd.
2. Kale, B. K. and Muralidharan, K. (2015): ***Parametric Inference-An Introduction***, Alpha Science International Ltd.
3. Rao, C. R. (2003). ***Linear Statistical Inference and its Applications***, John Wiley& Sons.
4. Kale, B. K. (2000). ***A First Course on Parametric Inference***, Narosa Publishing House.

Assessment Rubrics:

Evaluation Type		Marks
End Semester Evaluation		**70**
Continuous Evaluation		**30**
a)	Test Paper- 1	**5**
b)	Test Paper-2	**5**
c)	Assignment	**10**
d)	Seminar	**-**
e)	Book/ Article Review	-
f)	Viva-Voce	**-**
g)	Field Report/Practical	**10**
Total		**100**

SEMESTER VIII

A22 – DISCIPLINE SPECIFIC MAJOR COURSE

KU8DSCSTA407: MULTIVARIATE ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
VIII	MAJOR	400 – 499	KU8DSCSTA407	4	60

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	-	-	30	70	100	2

Course Description: This course covers the theory and applications of multivariate normal distribution, including properties and inference methods, estimation of mean vectors and covariance matrices, hypothesis testing and multivariate test statistics, and classification and dimensionality reduction techniques such as principal components, canonical correlation, factor analysis, and cluster analysis.

Course Prerequisite: Higher Level Courses (Level 300 – 399)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will be able to define multivariate normal distributions, distinguish between non-singular and singular cases, and explain their properties, including marginal and conditional distributions, and variable independence.	U
2	Students will perform maximum likelihood estimation for mean vectors and dispersion matrices, determine the distribution of sample mean vectors, and conduct inferences concerning mean vectors using the Wishart distribution and properties of generalized variance.	An
3	Students will use the likelihood ratio criterion to test hypotheses on variable independence, covariance matrix proportionality, and mean vector significance, applying Hotelling's T^2 and Mahalanobis' D^2statistics and conducting sphericity tests and addressing the Fisher Behrens problem.	R
4	Students will understand the concept of classification problems in multivariate normal populations, including scenarios with known and unknown parameters. They will also learn to apply Fisher's discriminant function for accurate classification of observations.	U
5	Students will define and derive principal components and canonical correlations, and understand the basics of factor analysis and cluster analysis to reduce dimensionality and analyse relationships between variables in multivariate datasets.	A

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate I, Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1		✔		✔		✔	✔
CO 2	✔		✔		✔		✔
CO 3		✔	✔		✔	✔	
CO 4	✔			✔	✔		✔
CO 5	✔		✔	✔		✔	

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Multivariate Normal Distribution**	12
	1	Definition, non-singular and singular multivariate normal distributions	
	2	Properties of multivariate normal distribution	
	3	Marginal distributions and independence, conditional distributions, characteristic function, additive property	
	4	Independence of a linear form and quadratic form, independence of two quadratic forms, distribution of quadratic form of a multivariate vector	
2		**Estimation of Mean Vector and Covariance Matrix**	12
	1	Maximum likelihood estimation of mean vector and dispersion matrix, distribution of sample mean vector	
	2	Inference concerning the mean vector when the dispersion matrix is known for single and two populations	

	3	Wishart distribution, characteristic function of Wishart distribution, additive property	
	4	Properties generalized variance; distribution of sample generalized variance	
3	**Hypothesis Testing and Multivariate Test Statistics**		**12**
	1	Likelihood Ratio Criterion for testing independence of sets of variates, proportionality of covariance matrix, significance of a mean vector, covariance matrix	
	2	Likelihood Ratio Criterion for testing significance equality of mean vectors and covariance matrices	
	3	Hotelling's T^2 and Mahalanobis' D^2 statistics, uses of T^2 and D^2 in testing problems	
	4	Sphericity test, Fisher-Behren problem	
4	**Classification and Dimensionality Reduction Techniques**		**12**
	1	Classification of one of two multivariate normal population when the parameters are known and unknown, extension of this to several multivariate normal populations, Fisher's discriminant function	
	2	Principal components - definition and derivation	
	3	Canonical correlation - definition and derivation	
	4	Basics of factor analysis and cluster analysis	
5	**Open End (Practical)**		**12**
	Computational illustration of above concepts using R		

Essential Readings:

1. Anderson, T. W. (2009). ***An Introduction to Multivariate Statistical Analysis***, 3rd edition, Wiley.
2. Johnson, R. A. and Wichern, D. W. (1998). ***Applied Multivariate Statistical Analysis***, Prentice Hall India Learning Pvt. Ltd.

3. Rao, C. R. (2002). ***Linear Statistical Inference and its Applications***, John Wiley & Sons.

Suggested Readings:

1. Tabachnick, B. G. and Fidell, L. S. (2020). ***Using Multivariate Statistics***, 7th edition, Pearson Education.
2. Johnson, N. L. and Kotz, S. (1972). ***Distributions in Statistics: Continuous Multivariate Distributions***, Wiley-Blackwell.
3. Morrison, D. F. (1990). ***Multivariate Statistical Methods***, Mc Graw Hill Education.
4. Takeuchi, K., Yanai, H. and Mukherjee, B. N. (1982). ***The Foundations of Multivariate Analysis***, Wiley.
5. Giri, N, C. (1996). ***Multivariate Statistical Analysis***, Marcel Dekker, New York.
6. Kshirsagar, A. M. (1972**).** ***Multivariate Analysis***, Marcel Dekker, New-York.
7. Rencher, A. C. (1998). ***Multivariate Statistical Inference and Applications***, Wiley-Interscience.

Assessment Rubrics:

Evaluation Type		**Marks**
End Semester Evaluation		**70**
Continuous Evaluation		**30**
a)	Test Paper- 1	**5**
b)	Test Paper-2	**5**
c)	Assignment	**10**
d)	Seminar	**-**
e)	Book/ Article Review	-
f)	Viva-Voce	**-**
g)	Field Report/Practical	**10**
Total		**100**

SEMESTER VIII

A23 – DISCIPLINE SPECIFIC MAJOR COURSE

KU8DSCSTA408: ADVANCED REGRESSION TECHNIQUES

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
VIII	MAJOR	400 – 499	KU8DSCSTA408	4	60

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	-	-	30	70	100	2

Course Description: This course delves into least square estimation and its properties, hypothesis testing and confidence interval construction, the impact of outliers and collinearity in regression analysis, and advanced topics such as polynomial regression, generalized linear models, logistic regression, and variable selection criteria.

Course Prerequisite: Higher Level Courses (Level 300 – 399)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Apply least square estimation methods and understand their properties, including generalized least squares for design matrices of less than full rank.	A
2	Conduct hypothesis testing using likelihood ratio tests and F tests, and construct multiple correlation coefficients, confidence intervals, and prediction bands.	C
3	Diagnose and address issues such as bias, outliers, non-constant variance, and collinearity in regression models, utilizing techniques like ridge regression and principal component regression.	An
4	Implement weighted least squares for simple linear regression and extend to polynomial regression and generalized linear models, including logistic and Poisson regression.	A
5	Evaluate and select appropriate variable selection criteria to optimize regression models.	E

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate I, Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔	✔		✔		✔	
CO 2			✔	✔		✔	✔
CO 3	✔		✔		✔		✔
CO 4		✔		✔	✔	✔	✔
CO 5	✔		✔		✔		✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Linear Estimation and Generalized Least Squares**	12
	1	Least square estimation- properties of least square estimates	
	2	Unbiased estimation of σ^2	
	3	Distribution theory- maximum likelihood estimation	
	4	Estimation with linear restriction, design matrix of less than full rank- generalized least square	
2		**Hypothesis Testing and Confidence Intervals in Regression Analysis**	12
	1	Hypothesis testing; likelihood ratio test- F test	
	2	Multiple correlation coefficient	
	3	Confidence intervals and regions	

	4	Simultaneous interval estimation - confidence bands for the regression surface, prediction intervals and band for the response	
3	**Addressing Regression Model Issues and Diagnostic Techniques**		**12**
	1	Bias- incorrect variance matrix	
	2	Effect of outliers- diagnosis and remedies: residuals and hat matrix diagonals	
	3	Non-constant variance and Serial correlations - departures from normality	
	4	detecting and dealing with outliers - diagnosing collinearity, ridge regression and principal component regression	
4	**Advanced Regression Techniques and Variable Selection**		**12**
	1	The straight line - weighted least square for the straight line	
	2	Polynomial regression in one variable	
	3	Generalized linear model	
	4	Logistic regression, Poisson regression (concept only), variable selection criteria	
5	**Open End (Practical)**		**12**
	Computational illustration of above concepts using R		

Essential Readings:

1. Draper, N. R. and Smith, H. (1988). ***Applied Regression Analysis***, 3rd edition. John Wiley & Sons Inc, New York.
2. Seber, G. A. F. and Lee, A. J. (2003). ***Linear Regression Analysis***, 2nd edition, John Wiley & Sons.

Suggested Readings:

1. Abraham, B. and Ledolter, J. (2005). ***Introduction to Regression Modeling***, Cengage Learning.
2. Montgomery, D. C., Peck, E. A. and Vining, G. G. (2006). ***Introduction to Linear Regression Analysis***, 3rd edition, Wiley India Pvt. Ltd.
3. Rao, C. R. (2002). ***Linear Statistical Inference and its Applications***, John Wiley & Sons.

4. Searle, S. R. (1997). ***Linear Models***, Wiley-lnterscience.
5. Sengupta, D. and Jammalamadaka, S. R. (2003). ***Linear Models: An Integrated Approach***,
   World Scientific Publishing Co. Ltd.

Assessment Rubrics:

Evaluation Type		Marks
End Semester Evaluation		**70**
Continuous Evaluation		**30**
a)	Test Paper- 1	**5**
b)	Test Paper-2	**5**
c)	Assignment	**10**
d)	Seminar	**-**
e)	Book/ Article Review	-
f)	Viva-Voce	**-**
g)	Field Report/Practical	**10**
Total		**100**

DISCIPLINE SPECIFIC ELECTIVE COURSES

SEMESTER V

DSE 1 – DISCIPLINE SPECIFIC ELECTIVE COURSE

KU5DSESTA309: INDEX NUMBERS AND TIME SERIES

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
V	ELECTIVE	300 – 399	KU5DSESTA309	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course provides a comprehensive understanding of index numbers, including their definition, types, and tests, along with an introduction to time series analysis and stationary time series models, covering topics such as trend estimation, seasonal variation, and forecasting methods over four modules.

Course Prerequisite: Intermediate Level Courses (Level 200 – 299)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will understand the concept of index numbers, including the uses of base period, current period, and price relatives, and differentiate between different types of index numbers such as simple, weighted, Laspeyre's, Paasche's, Fisher's, and Marshall-Edgeworth index numbers, and apply factor reversal, time reversal, and circular tests.	U
2	Students will be able to perform base shifting, splicing, and deflating operations, and comprehend the concept of chain base index numbers, and calculate wholesale and consumer price index numbers.	R
3	Students will analyse time series data, identify its components, and apply different models of time series including trend estimation methods such as semi-average, moving average, and least squares method, and seasonal variation estimation methods such as simple	An

	average, ratio to moving average, link relatives, and ratio to trend method.	
4	Students will understand the concepts of stationary process and weak stationarity, auto-correlation function, and correlogram, and define special processes like MA processes of order 1 and 2, and AR processes of order 1 and 2, and apply exponential smoothing methods for forecasting.	U
5	Students will apply their knowledge of index numbers and time series analysis to analyse economic and financial data, make forecasts, and interpret trends and variations in data.	A

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1		✔		✔		✔	✔
CO 2	✔	✔			✔		✔
CO 3	✔		✔	✔		✔	
CO 4		✔			✔		✔
CO 5	✔		✔	✔	✔	✔	

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Index Numbers-I**	**12**
	1	Definition-Index number, uses base period, current period, price relatives	
	2	Types of an Index number, simple index number	

	3	Weighted index number, Laspeyre's index number, Paasche's index number, Fisher's Index number, Marshall- Edgeworth index number	
	4	Factor reversal test, time reversal test, circular test	
2	**Index Numbers-II**		**11**
	1	Base Shifting, Splicing, Deflating	
	2	Chain base index number	
	3	Whole-sale price index	
	4	Consumer price index number	
3	**Time series**		**12**
	1	Introduction and applications, Components of time series	
	2	Models of Time series	
	3	Estimation of trend- semi-average, moving average and least square method	
	4	Estimation of seasonal variation- simple average, ratio to moving average, link relatives, ratio to trend method	
4	**Stationary Time series models**		**10**
	1	Stationary process and Weak stationarity (concepts only), auto-correlation function (concept only), correlogram (definition only)	
	2	Some special processes- MA processes of order 1 and 2 (definitions only)	
	3	AR processes of order 1 and 2 (definitions only)	
	4	Forecasting by Exponential smoothing methods	
5	**Open End (Practical)**		**30**
	Computational illustration of above concepts using R		

Essential Readings:

1. Gupta S. P. (2021). ***Statistical Methods***, Sultan Chand and Sons.
2. Gupta S.C. (2018). ***Fundamentals of Statistics,*** Himalaya Publishing House.
3. Elhance D. N. and Agarwal B. M. (2018). ***Fundamentals of Statistics,*** Kitab Mahal.

Suggested Readings:

1. Agarwal B.L. (2013). ***Basic Statistics***, New Age International Pvt. Ltd.
2. Gupta, S. C., & Kapoor, V. K. (2019). ***Fundamentals of Applied Statistics***, Sulthan Chand & Sons.

Assessment Rubrics:

<table>
<tr><th colspan="2">Evaluation Type</th><th>Marks</th><th colspan="2">Evaluation Type</th><th>Marks</th><th>Total</th></tr>
<tr><td colspan="2">Lecture</td><td>75</td><td colspan="2">Practical</td><td>25</td><td rowspan="12">100</td></tr>
<tr><td colspan="2">End Semester Evaluation</td><td>50</td><td colspan="2">End Semester Evaluation</td><td>15</td></tr>
<tr><td colspan="2">Continuous Evaluation</td><td>25</td><td colspan="2">Continuous Evaluation</td><td>10</td></tr>
<tr><td>a)</td><td>Test Paper- 1</td><td>5</td><td>a)</td><td>Punctuality</td><td>3</td></tr>
<tr><td>b)</td><td>Test Paper-2</td><td>5</td><td>b)</td><td>Skill</td><td>3</td></tr>
<tr><td>c)</td><td>Assignment</td><td>10</td><td rowspan="2">c)</td><td rowspan="2">Assignment/ Field Report</td><td rowspan="2">4</td></tr>
<tr><td>d)</td><td>Seminar</td><td>-</td></tr>
<tr><td>e)</td><td>Book/ Article Review</td><td>-</td><td colspan="2"></td><td></td></tr>
<tr><td>f)</td><td>Viva-Voce</td><td>5</td><td colspan="2"></td><td></td></tr>
<tr><td>g)</td><td>Field Report</td><td>-</td><td colspan="2"></td><td></td></tr>
<tr><td colspan="2">Total</td><td>75</td><td colspan="2"></td><td>25</td></tr>
</table>

SEMESTER V

DSE 2 – DISCIPLINE SPECIFIC ELECTIVE COURSE

KU5DSESTA310: STATISTICAL DATA ANALYSIS USING R

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
V	ELECTIVE	300 – 399	KU5DSESTA310	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course provides an introduction to data analysis covering descriptive statistics, statistical tests, data visualization techniques, and advanced statistical analysis using tools like R and explores topics such as data types, statistical software, hypothesis testing, and regression analysis over four modules.

Course Prerequisite: Intermediate Level Courses (Level 200 – 299)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will be able to explain the concept of data analytics and its importance in decision-making processes across different fields.	U
2	Students will be able to distinguish between quantitative and qualitative data, identify different scales of measurement, and comprehend the steps involved in data analysis.	An
3	Students will gain proficiency in using statistical software like R, including installation, package downloading, and data reading operations.	R
4	Students will be able to summarize data, calculate cumulative frequencies, create contingency tables, and test categorical variables for independence.	A
5	Students will be able to test for normality using graphical and analytical methods, conduct t-tests for mean comparison, create bar charts, box plots, histograms, scatter plots, and line diagrams, perform correlation analysis, simple and multiple linear regression, diagnose linear regression, and conduct one-way and two-way ANOVA tests.	E

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔		✔		✔		✔
CO 2		✔		✔	✔		✔
CO 3		✔	✔		✔	✔	
CO 4	✔			✔		✔	
CO 5	✔	✔		✔		✔	✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Introduction to Data Analysis**	12
	1	Overview of Data Analytics – What is data analytics and its importance	
	2	Types of Data – Quantitative and Qualitative data; Nominal, Ordinal, Interval and Ratio data; Longitudinal, Cross-sectional and panel data. Data Analysis process – steps in data analysis.	
	3	Introduction Statistical software's – R, SPSS, SAS, Statistica, JASP etc.	
	4	Getting started with R – installation, downloading packages, reading data etc.	
2		**Exploring Descriptive Statistics and Statistical Tests**	12
	1	Descriptive Statistics – Summarizing data, calculating cumulative frequencies, creating contingency tables	
	2	Testing categorical variables for independence	

	3	Testing for normality – graphical and analytical methods	
	4	Testing mean of a sample and equality of means of two samples (t test)	
3	**Data Visualization Techniques**		**11**
	1	Creating a bar chart – adding confidence intervals and other features	
	2	Creating a box plot – multiple box plot with one box plot for each factor level	
	3	Creating a histogram – adding density estimate	
	4	Creating scatter plot and line diagrams	
4	**Advanced Statistical Analysis**		**10**
	1	Correlation – Pearson and Spearman correlation coefficients- tests of significance of correlation coefficients	
	2	Simple and Multiple linear regression models	
	3	Diagnosing a linear regression	
	4	Performing one way and two-way ANOVA	
5	**Open End (Practical)**		**30**
	Computation of integrals, Monte Carlo methods, expected values and probabilities, Importance Sampling, rare-event simulation, CLT and other approximations through simulation. Empirical computation of level of significance and power of tests.		

Essential Readings:

1. J.D. Long and Paul Teetor (2019). ***R Cookbook Proven Recipes for Data Analysis, Statistics and Graphics***, 2nd edition -, O'Reilly Media.
2. Siegmund Brandt (2014). ***Data Analysis -Statistical and Computational Methods for Scientists and Engineers***, 4th edition, Springer.
3. Joseph Schmuller (2017). ***Statistical Analysis with R for Dummies***, John Wiley and Sons.

Suggested Readings:

1. Viswa Viswanathan and Shanthi Viswanathan (2015). ***R Data Analysis Cookbook***, Packt Publishing.

Assessment Rubrics:

Evaluation Type		Marks	Evaluation Type		Marks	Total
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER V

DSE 3 – DISCIPLINE SPECIFIC ELECTIVE COURSE

KU5DSESTA311: OPERATIONS RESEARCH

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
V	ELECTIVE	300 – 399	KU5DSESTA311	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course covers linear programming, duality, integer programming, network analysis, and game theory, including theoretical foundations, methods of solution, and practical applications in decision-making processes.

Course Prerequisite: Intermediate Level Courses (Level 200 – 299)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Understand the fundamentals of linear programming, including graphical solution methods and the concepts of feasibility, basic feasible solutions, and optimal solutions.	U
2	Demonstrate proficiency in applying the simplex method to solve linear programming problems, including its theoretical development and practical implementation.	R
3	Analyse duality in linear programming, including the interpretation of dual variables and the application of the dual simplex method.	An
4	Apply techniques of integer programming, such as cutting plane methods and branch and bound, to solve optimization problems with integer constraints.	A
5	Apply network analysis techniques, including critical path analysis, CPM, and PERT, to optimize project scheduling and resource allocation.	A

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1		✔	✔		✔		✔
CO 2	✔				✔	✔	
CO 3	✔		✔	✔		✔	✔
CO 4		✔			✔		✔
CO 5	✔	✔		✔		✔	

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1	**Algebra of Linear Programming Problems**		**12**
	1	Introduction to linear programming problem (LPP)	
	2	Graphical solution, feasible, basic feasible, and optimum basic feasible solution to an LPP	
	3	Analytical results in general LPP	
	4	Theoretical development of simplex method	
2	**Duality and Dual Simplex Method**		**12**
	1	Artificial variables, Big-M method, two-phase simplex method	
	2	Duality, duality theorems, dual simplex methods	
	3	Transportation problem	
	4	Assignment problem	
3	**Integer Programming and Network Analysis**		**11**
	1	Integer programming: Cutting plane methods, branch and bound technique	
	2	Network analysis, Critical path analysis - CPM, PERT	
	3	Distinction between CPM and PERT	
4	**Game Theory**		**10**
	1	Game theory, pure and mixed strategies	
	2	Conversion of two-person zero-sum game into a linear programming problem	

	3	Solution to game through algebraic, graphical, and linear programming method	
5	**Open End (Practical)**		**30**
	Computational illustration of above concepts using R		

Essential Readings:

1. Mital, K. V. and Mohan, C. (1996). **Optimization Methods in Operations Research and Systems Analysis, 3rd Edition,** New Age International (Pvt.) Ltd.
2. Kanti Swamp, Gupta, P.K. and John, M.M. (1985): **Operations Research**., Sultan Chand & Sons.

Suggested Readings:

1. Hadley, G. (1964). **Linear Programming**, Oxford & IBH Publishing Co, New Delhi.
2. Taha. H.A. (1982): **Operation Research**, An Instruction, Macmillan.
3. Hiller F.S. And Lieberman, G.J. (1995). I**ntroduction to Operations Research**, McGraw-Hill.

Assessment Rubrics:

Evaluation Type		**Marks**	**Evaluation Type**		**Marks**	**Total**
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER V

DSE 4 – DISCIPLINE SPECIFIC ELECTIVE COURSE

KU5DSESTA312: ACTUARIAL STATISTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
V	ELECTIVE	300 – 399	KU5DSESTA312	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course provides a comprehensive understanding of actuarial concepts including survival functions, life tables, life insurance, annuities, and premiums, covering topics such as future life time random variables, force of mortality, types of annuities, and insurance contracts.

Course Prerequisite: Intermediate Level Courses (Level 200 – 299)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will be able to explain concepts such as future lifetime random variables, survival functions, force of mortality, probability laws of mortality, curtate future lifetime, and life tables, along with assumptions for fractional ages and the uniform distribution of deaths.	U
2	Students will understand the principles of interest rates, including simple and compound interest, effective and nominal rates of interest, and the force of interest, and their relationships, and apply these principles to calculate present value and accumulated value in life insurance contexts.	U
3	Students will be able to define and differentiate types of annuities, including immediate, due certain, life annuity, continuous, discrete, m-thly annuity, and deferred annuity, and calculate their present value and accumulated value.	R

4	Students will be able to analyse and calculate continuous and discrete life annuities, including whole life, n-year temporary, n-year certain, and life annuities, both in continuous and discrete scenarios.	An
5	Students will be able to calculate premiums using the equivalence principle, analyse fully continuous and fully discrete premiums for whole life, term insurance, and endowment insurance.	A

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1			✔	✔		✔	✔
CO 2	✔	✔			✔		✔
CO 3	✔		✔	✔		✔	
CO 4		✔			✔		✔
CO 5	✔		✔	✔		✔	

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1	**Survival function & Life tables**		**12**
	1	Future life time random variable, Survival function	
	2	Force of mortality, Probability law of mortality, Curtate future life time	
	3	Life tables, assumptions for fractional ages, Uniform distribution of deaths	

	4	Constant force of mortality assumptions, select and ultimate life tables	
2	**Life insurance**		**12**
	1	Rate of interest, Simple interest, compound interest, Effective rate of interest, Nominal rate of interest, the force of interest	
	2	Relationship between these rates of interest, Present value and accumulated value, Effective and nominal rate of discount	
	3	Insurance, Elements present in an insurance contract Insurance payable at the moment of death (whole life insurance, n-year term, n-year pure endowment n-year endowment insurance, Deferred insurance) Benefit payable at the end of year of death	
3	**Annuities**		**11**
	1	Annuity; Types of annuities: Immediate, due certain, life annuity, continuous, discrete, m-th ly annuity, Deferred annuity, level annuity	
	2	Present value and accumulated value of (Immediate annuity, Annuity due, deferred immediate and due, continues annuities)	
	3	Continuous life annuities (Whole life, n-year temporary n-year certain and life annuity)	
	4	Discrete life annuities (Whole life, n- year temporary, n-year certain and life annuities)	
4	**Premiums**		**10**
	1	Loss at issue random variables, Equivalence principle	
	2	Fully continuous premiums (whole life, term insurance, endowment insurance)	
	3	Fully discrete premiums (whole life, term insurance, endowment insurance)	
5	**Open End (Practical)**		**30**
	Computational illustration of above concepts using R		

Essential Readings:

1. Deshmukh, S. R. (2009): ***Actuarial Statistics: An Introduction Using R***, Universities Press
2. Beard, R.E., Penlikainen, T. and Pesonnen, E (1984): ***Risk Theory: The Stochastic Basis of Insurance, 3rd Edition***, Chapman and Hall, London

Suggested Readings:

1. Atkinson, M. E. and Dickson, D. C. M. (2011): ***An Introduction to Actuarial Studies***, second edition, Edward Elgar Publishing limited, UK, USA
2. Newton L. Bowers, Hans U Gerber, James C Hickman & Donald A Jones (1997): ***Actuarial Mathematics***, The society of actuaries.

Assessment Rubrics:

Evaluation Type		**Marks**	**Evaluation Type**		**Marks**	**Total**
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER V

DSE 5 – DISCIPLINE SPECIFIC ELECTIVE COURSE

KU5DSESTA313: RESEARCH METHODOLOGY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
V	ELECTIVE	300 – 399	KU5DSESTA313	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course offers a comprehensive overview of research fundamentals, statistical distributions, advanced sampling techniques, and document preparation using LaTeX and R, covering topics such as research formulation, literature review, statistical distributions, Monte Carlo methods, and document formatting.

Course Prerequisite: Intermediate Level Courses (Level 200 – 299)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will be able to explain the objectives and types of research, define and select research problems, conduct literature reviews, and identify research gaps.	U
2	Students will be able to use probability and moment generating functions, understand the method of transformations, analyze distributions of statistics based on a sample from the normal distribution, and apply order statistics.	A
3	Students will be able to generate random samples using integral transformation, apply techniques such as the Accept/Reject Algorithm, Metropolis algorithm, and Gibbs sampling, understand the principles of MCMC (Markov Chain Monte Carlo), and utilize the Bootstrap method for statistical analysis.	E
4	Students will be able to create documents using LaTeX, including	C

	typing text and mathematical formulas, generating plots, tables, and figures, and managing bibliography and footnotes.	
5	Students will be able to integrate research formulation, statistical techniques, and document preparation skills to effectively communicate scientific findings through written reports and presentations.	An

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔	✔		✔	✔	✔	
CO 2		✔	✔		✔		✔
CO 3	✔		✔			✔	✔
CO 4				✔	✔		
CO 5	✔	✔		✔		✔	✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Research Fundamentals**	12
	1	Objectives and types of research	
	2	Research formulation: Defining and selecting the research problem, Its necessity	
	3	Literature review: Importance of literature review in defining a research problem	
	4	Research gap: Identifying the research gap, development of working hypothesis	

2	**Statistical Distributions and Transformations**		**12**
	1	Distribution Functions: Probability and Moment generating functions	
	2	Method of transformations	
	3	Distributions of statistics based on a sample from Normal distribution	
	4	Order Statistics	
3	**Advanced Sampling and Monte Carlo Methods**		**11**
	1	Sampling Techniques: Generating random samples using integral transformation	
	2	Accept/Reject Algorithm, Metropolis algorithm and Gibbs sampling	
	3	MCMC principle- Metropolis Hasting Algorithm, Monte Carlo simulation	
	4	Bootstrap method	
4	**Document Preparation with LaTeX and R**		**10**
	1	Latex: Basics of R and Latex	
	2	Classes of documents	
	3	Typing text and mathematical formulae, Creating plots, tables and figures	
	4	Bibliography and footnotes	
5	**Open End (Practical)**		**30**
	Preparation of a project report based on modules 1 to 4.		

Essential Readings:

1. Kothari C.R. (1990). ***Research Methodology: Methods and Techniques***, New Age Publications.

2. Johnson, N.L., Kotz, S. and Balakrishnan, N. (1994). ***Continuous Univariate Distributions***, Volume I, Second Edn, John Wiley, New York.

3. Robert C.P. and Casella G. (2004). ***Monte Carlo Statistical Methods***, Springer.

4. Gratzer, G. (2007). ***More Math into LaTeX***, 4th Edition, Springer.

5. Nicola, L. C. (2012). ***Latex for complete Novices***, Dickimaw Books.

Suggested Readings:

1. Rohatgi V.K. and Saleh, A. K. (2010). ***An Introduction to Probability and Statistics***, 2/e, John Wiley and Sons.
2. Casella G. and Berger R.L. (2002). ***Statistical Inference***, 2/e, Duxbury Advanced Press.

Assessment Rubrics:

Evaluation Type		**Marks**	**Evaluation Type**		**Marks**	**Total**
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER VI

DSE 6 – DISCIPLINE SPECIFIC ELECTIVE COURSE

KU6DSESTA314: INTRODUCTION TO BIOSTATISTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
VI	ELECTIVE	300 – 399	KU6DSESTA314	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course provides an in-depth exploration of biostatistics in biomedical research, covering topics such as the scope of biostatistics, study design principles, measures of disease occurrence, genetic concepts, clinical trial planning, and ethical considerations in research.

Course Prerequisite: Intermediate Level Courses (Level 200 – 299)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Understand the fundamental concepts of biostatistics, including the scope of its application, types of statistical problems encountered in biomedical research, and the various types of biological data and measurement scales used in analysis.	U
2	Demonstrate proficiency in designing medical studies by applying principles of biostatistics to select appropriate study designs, including observational studies, experimental studies (comparative and crossover), prospective and retrospective studies, case-control studies, and longitudinal studies.	R
3	Analyse the occurrence of disease by calculating and interpreting measures of morbidity, including prevalence and incidence rates, and understand the association between prevalence and incidence, as well as the uses and limitations of these measures in epidemiological research.	An

4	Apply basic genetic concepts such as Mendel's laws, Hardy-Weinberg equilibrium, random mating, natural selection, mutation, genetic drift, and linkage detection and estimation in the context of biomedical research and genetics.	A
5	Demonstrate an understanding of the planning and design of clinical trials, including the different phases (Phase I, II, and III) and ethical considerations involved in randomized studies with human subjects, as well as the concept of randomized dose-response studies.	E

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔		✔		✔	✔	
CO 2	✔	✔		✔		✔	✔
CO 3		✔		✔	✔		✔
CO 4	✔		✔	✔		✔	
CO 5		✔	✔		✔		✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1	**Basics of Biostatistics**		12
	1	Biostatistics – Introduction	
	2	Scope of Biostatistics	

	3	Examples of statistical problems in Biomedical Research	
	4	Types of Biological data, scales of measurements	
2	**Biomedical Research**		**12**
	1	Measuring the occurrence of disease	
	2	Measures of morbidity - prevalence and incidence rate,	
	3	Association between prevalence and incidence	
	4	Uses of prevalence and incidence, problems with incidence and prevalence measurements	
3	**Foundations of Genetics**		**11**
	1	Basic biological concepts in genetics	
	2	Mendel's law, Hardy- Weinberg equilibrium	
	3	Random mating, natural selection, mutation, genetic drift	
	4	detection and estimation of linkage in heredity	
4	**Clinical Trial Design and Ethical Considerations**		**10**
	1	Planning and design of clinical trials	
	2	Phase I, II, and III trials	
	3	Ethics behind randomized studies involving human subjects	
	4	Randomized dose-response studies (concept only)	
5	**Open End (Practical)**		**30**
	Computational illustration of above concepts using R. Various examples from medical research.		

Essential Readings:

1. Chap, T.L. (2003). ***Introductory Biostatistics***, John Wiley & Sons.
2. Altman, D G**.** (2006): ***Practical Statistics for Medical Research***, London: Chapman and Hall.
3. Daniel, W.W. (2006): ***Biostatistics: A Foundation for Analysis in the Health sciences***, JohnWiley & Sons.Inc.

Suggested Readings:

1. Dunn, G. and Everitt B. (1995): ***Clinical Biostatistics: An Introduction to Evidence-Based Medicine***, Edward Arnold.
2. Friedman, L.M., Furburg, C. and DeMets, D.L. (1998): ***Fundamentals of Clinical Trials***, Springer Verlag.
3. Li, C.C. (1976): ***First Course of Population Genetics***, Boxwood Press.
4. Fisher, L.D. and Belle, G.V. (1993): ***Biostatistics: A Methodology for the Health Science***, John Wiley & Sons Inc.
5. Lawless, J.F. (2003): ***Statistical Methods for Lifetime*** (Second Edition), John Wiley & Sons.
6. Rosner B. (2006): ***Fundamentals of Biostatistics***, Edition 6.

Assessment Rubrics:

<table>
<tr><th colspan="2">Evaluation Type</th><th>Marks</th><th colspan="2">Evaluation Type</th><th>Marks</th><th>Total</th></tr>
<tr><td colspan="2">Lecture</td><td>75</td><td colspan="2">Practical</td><td>25</td><td rowspan="12">100</td></tr>
<tr><td colspan="2">End Semester Evaluation</td><td>50</td><td colspan="2">End Semester Evaluation</td><td>15</td></tr>
<tr><td colspan="2">Continuous Evaluation</td><td>25</td><td colspan="2">Continuous Evaluation</td><td>10</td></tr>
<tr><td>a)</td><td>Test Paper- 1</td><td>5</td><td>a)</td><td>Punctuality</td><td>3</td></tr>
<tr><td>b)</td><td>Test Paper-2</td><td>5</td><td>b)</td><td>Skill</td><td>3</td></tr>
<tr><td>c)</td><td>Assignment</td><td>10</td><td rowspan="2">c)</td><td rowspan="2">Assignment/ Field Report</td><td rowspan="2">4</td></tr>
<tr><td>d)</td><td>Seminar</td><td>-</td></tr>
<tr><td>e)</td><td>Book/ Article Review</td><td>-</td><td colspan="2"></td><td></td></tr>
<tr><td>f)</td><td>Viva-Voce</td><td>5</td><td colspan="2"></td><td></td></tr>
<tr><td>g)</td><td>Field Report</td><td>-</td><td colspan="2"></td><td></td></tr>
<tr><td colspan="2">Total</td><td>75</td><td colspan="2"></td><td>25</td></tr>
</table>

SEMESTER VI

DSE 7 – DISCIPLINE SPECIFIC ELECTIVE COURSE

KU6DSESTA315: VITAL AND OFFICIAL STATISTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
VI	ELECTIVE	300 – 399	KU6DSESTA315	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course offers a comprehensive study of demography, covering foundational concepts such as population composition, fertility, mortality, and migration, advanced measurement techniques including life table analysis, population dynamics, estimation techniques, and an overview of India's official statistical system and economic indicators.

Course Prerequisite: Intermediate Level Courses (Level 200 – 299)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will be able to define key concepts in demography, understand the sources of demographic data, and recognize the interface between statistics and demography.	U
2	Students will be able to analyse population composition based on age, sex, religion, education, income, and dependency, and understand population structure using population pyramids.	An
3	Students will understand the concepts of fertility, mortality, morbidity, migration, and urbanization, along with their determinants and consequences on population change and distribution.	E
4	Students will be able to measure mortality and morbidity rates, fertility rates (TFR, GRR, NRR), and understand standardization techniques, life table construction, and birth interval analysis.	A

5	Students will understand Lotka's stable population theory, population estimation, projection methods (exponential, logistic), and various techniques used for population growth estimation, including mathematical and component methods.	R

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1		✔		✔		✔	✔
CO 2	✔		✔		✔		✔
CO 3	✔	✔		✔		✔	
CO 4		✔		✔		✔	✔
CO 5	✔			✔	✔		✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Foundations of Demography**	12
	1	Definitions and concepts used in Demography- Interface between Statistics and Demography- Sources of Demographic data: Census, Vital Registration System, Sample surveys	
	2	Population Composition and Structure- Age, Sex, Religion, Education, Income, Dependency etc., Population pyramid	
	3	Concepts of Fertility, Nuptiality, Mortality, Morbidity, Migration and Urbanisation.	
	4	Determinants and consequences of population change, population distribution	

2	**Advanced Demographic Measurement and Life Table Analysis**		**12**
	1	Measurement of mortality and morbidity, Force of mortality	
	2	Measurement of fertility- TFR, GRR, NRR	
	3	Standardisation of rates- Concept of life tables- Various types of life tables- Multiple decrement and multi-state life tables- Working life table- mortality models- model life tables- U.N., Coale & Demeny, Leaderman's system, Brass' Logit system, U.N.	
	4	Tables for developing countries- Stable population models - database and application- Uses of life table approach in Demography- Birth Interval Analysis	
3	**Population Dynamics and Estimation Techniques**		**11**
	1	Structure of population- Lotka's stable population theory: concepts, assumptions and properties	
	2	Stationery and quasi-stable population, population momentum, population waves	
	3	Population estimation and projection. Population growth- exponential, logistic	
	4	Different methods of population estimation and projection- Mathematical and component methods	
4	**Official Statistical System and Economic Indicators in India**		**10**
	1	An outline of present official statistical system in India, Methods of collection of official statistics, their reliability and limitations. Role of Ministry of Statistics & Program Implementation (MoSPI), Central Statistical Office (CSO), National Sample Survey Office (NSSO), Registered General Office and National Statistical Commission	
	2	Government of India's Principal publications containing data on the topics such as Agriculture, price, population, industry, finance and employment	
	3	Consumer price Index, Wholesale price index number and index of industrial production	
	4	National Income: Basic idea and a brief description of income, expenditure and production approaches	
5	**Open End (Practical/Tutorial)**		**30**

	History of Indian Statistical system, Indian Statistical Heritage, Indian Statistical Institute, International Statistical Institute, National Statistics Day, International Statistics Day, Indian Statistical Service, Computation of Demographic measures and Vital statistics using R	

Essential Readings:

1. Goon A.M., Gupta M.K. and Dasgupta B. (2008): ***Fundamentals of Statistics***, Vol-II, World Press.
2. ***Guide to current Indian Official Statistics***, Central Statistical Office, GOI, New Delhi. http://mospi.nic.in/
3. Mukhopadhyay, P. (1998): ***Applied Statistics***, Books and Allied(P) Company Ltd, Kolkata
4. Gupta, S. P. (2011): ***Statistical Methods***, Sultan Chand and Sons, New Delhi

Suggested Readings:

1. Saluja M.P. (2006). ***Indian Official Statistical Systems***, Statistics Publishing Society, Kolkata.
2. Gupta, S. C., Kapoor, V. K. (2007). ***Fundamentals of Applied Statistics.*** India: Sultan Chand & Sons.

Assessment Rubrics:

Evaluation Type		**Marks**	**Evaluation Type**		**Marks**	**Total**
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER VI

DSE 8 – DISCIPLINE SPECIFIC ELECTIVE COURSE

KU6DSESTA316: POPULATION STATISTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
VI	ELECTIVE	300 – 399	KU6DSESTA316	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course provides a comprehensive understanding of population data and mortality measurements, covering sources of population data, vital event rates, mortality measurements including maternal and infant mortality rates, life table analysis, fertility measurements, population growth, and estimation and forecasting techniques.

Course Prerequisite: Intermediate Level Courses (Level 200 – 299)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will be able to identify and describe the sources of population data, including census data and registration data, and understand the errors associated with such data.	U
2	Students will be able to calculate and interpret rates and ratios of vital events, such as birth rates, death rates, and specific mortality rates.	An
3	Students will be able to calculate and interpret various mortality measures, including crude death rate, specific death rate, standardized death rate, maternal mortality rate, infant mortality rate, neonatal mortality rate, and perinatal mortality rate.	A
4	Students will be able to describe complete and abridged life tables, understand the difference between cohort and generation life tables, and construct complete life tables from population and death statistics.	R

5	Students will be able to calculate and interpret fertility measures, such as crude birth rate, general fertility rate, age-specific fertility rate, and total fertility rate, as well as measures of population growth, including crude rate of natural increase, vital index, gross reproduction rate, and net reproduction rate.	E

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔		✔		✔		✔
CO 2		✔		✔		✔	✔
CO 3		✔		✔		✔	
CO 4	✔		✔		✔		✔
CO 5		✔	✔		✔	✔	

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1	**Foundations of Population Data and Mortality Measurements**		12
	1	Introduction: Sources of Population Data – Census data, Registration data and the errors in such data	
	2	Rates and ratios of vital events	
	3	Measurements of Mortality: Crude Death rate, Specific Death Rate, Standardized death Rate, Cause of death rate	
	4	Maternal Mortality Rate, Infant Mortality Rate, Neonatal and Perinatal Mortality Rates	

2	**Life Tables and Population Dynamics**		**12**
	1	Life tables: Descriptions of Complete and Abridged Life Tables and their uses	
	2	Cohort (or Current) vs. Generation Life Tables	
	3	Stable population and Stationary population	
	4	Construction of complete life table from population and death statistics	
3	**Fertility and Population Growth Measurement**		**11**
	1	Measurements of Fertility: Crude Birth Rate, General Fertility Rate	
	2	Age Specific Fertility Rate, Total Fertility Rate	
	3	Measurement of Population Growth: Crude Rate of Natural Increase and Vital Index	
	4	Gross and Net Reproduction Rates	
4	**Population Estimation and Forecasting Techniques**		**10**
	1	Population Estimation	
	2	Projection and Forecasting: Use of A.P. and G.P. methods for population estimates	
	3	Derivation of the equation to the Logistic curve, its properties	
	4	Fitting to observed data for population forecasting using Rhode's method	
5	**Open End (Practical)**		**30**
	Computational illustration of above concepts using R.		

Essential Readings:

1. Goon, A.M., Gupta, M. K. and Dasgupta, B. (2001): ***Fundamentals of Statistics***, Vol. II, World Press.
2. Spiegelman, M. (1980): ***Introduction to Demography***, Harvard University Press.
3. Cox P.R. (1976): ***Demography***, Cambridge University Press, New York.

Suggested Readings:

1. Biswas, S. and Sriwastav, G. L. (2011): ***Stochastic Processes in Demography and Applications***, New Central Book Agency.
2. Mishra B.D. (1980): ***An Introduction to the Study of Population***, South Asian Publishers.
3. Keyfitz. N and Caswell. H (2005): ***Applied Mathematical Demography*** (3rd edition), Springer

Assessment Rubrics:

Evaluation Type		**Marks**	**Evaluation Type**		**Marks**	**Total**
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER VI

DSE 9 – DISCIPLINE SPECIFIC ELECTIVE COURSE

KU6DSESTA317: FINANCIAL STATISTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
VI	ELECTIVE	300 – 399	KU6DSESTA317	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course offers a comprehensive study of probability theory and stochastic processes, covering real-valued random variables, discrete stochastic processes, option pricing tools, derivatives introduction, pricing derivatives, and advanced stochastic models in finance including geometric Brownian motion and the Black-Scholes formula.

Course Prerequisite: Intermediate Level Courses (Level 200 – 299)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will be able to review real-valued random variables, calculate expectations and variances, analyse skewness and kurtosis, and understand conditional probabilities and expectations.	An
2	Students will understand binomial processes, general random walks, and geometric random walks, and apply binomial models with state-dependent increments.	U
3	Students will be able to apply Wiener process, stochastic integration, and stochastic differential equations for option pricing, and understand the concepts of forward contracts, spot price, forward price, future price, call and put options, zero-coupon bonds, and discount bonds.	A
4	Students will be able to price derivatives using arbitrage relations and perfect financial markets, understand pricing futures, put-call parity for European options, and the relationship between strike price and option price, and analyze stochastic models such as the binomial model with period one.	E

5	Students will understand continuous-time processes like geometric Brownian motion, Ito's lemma, the Black-Scholes differential equation, and the Black-Scholes formula for European options, as well as hedging portfolios through Delta, Gamma, and Theta hedging. They will also learn about the Cox-Ross-Rubinstein approach to option pricing and discrete dividends in the binomial model for European options.	R

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔		✔		✔	✔	
CO 2	✔		✔		✔		✔
CO 3		✔		✔		✔	
CO 4	✔		✔		✔		✔
CO 5		✔		✔		✔	✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Fundamentals of Probability and Stochastic Processes**	**12**
	1	Probability review: Real valued random variables, expectation and variance, skewness and kurtosis, conditional probabilities and expectations	
	2	Discrete Stochastic Processes, Binomial processes	
	3	General random walks, Geometric random walks	

	4	Binomial models with state dependent increments	
2	**Introduction to Option Pricing and Derivatives**		**12**
	1	Tools Needed for Option Pricing: Wiener process, stochastic integration, and stochastic differential equations	
	2	Introduction to derivatives: Forward contracts, spot price, forward price, future price	
	3	Call and put options	
	4	Zero-coupon bonds and discount bonds	
3	**Derivative Pricing and Stochastic Models in Finance**		**11**
	1	Pricing Derivatives: Arbitrage relations and perfect financial markets	
	2	Pricing futures, put-call parity for European options	
	3	Relationship between strike price and option price	
	4	Stochastic Models in Finance: Discrete time process- binomial model with period one	
4	**Advanced Stochastic Models and Option Pricing**		**10**
	1	Stochastic Models in Finance: Continuous time process- geometric Brownian motion	
	2	Ito's lemma, Black-Scholes differential equation, Black-Scholes formula for European options	
	3	Hedging portfolios: Delta, Gamma and Theta hedging	
	4	Binomial Model for European options: Cox-Ross-Rubinstein approach to option pricing. Discrete dividends	
5	**Open End (Practical)**		**30**
	Computational illustration of above concepts using R.		

Essential Readings:

1. Franke, J., Hardle, W.K., and Hafner, C.M. (2011): ***Statistics of Financial Markets: An Introduction***, 3rd Edition, Springer Publications.
2. Stanley, L. S. (2012): ***A Course on Statistics for Finance***, Chapman and Hall/CRC.
3. Ruppert, D. (2006): ***Statistics and Finance: An Introduction***, Springer-Verlag, New York, Inc.

Suggested Readings:

1. Severini, T. A. (2018): ***Introduction to Statistical Methods for Financial Models***, CRC Press.

Assessment Rubrics:

Evaluation Type		**Marks**	**Evaluation Type**		**Marks**	**Total**
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER VI

DSE 10 – DISCIPLINE SPECIFIC ELECTIVE COURSE

KU6DSESTA318: ECONOMETRICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
VI	ELECTIVE	300 – 399	KU6DSESTA318	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course provides a comprehensive study of econometrics, covering the purpose and scope of econometrics, general linear models, estimation techniques, econometric problems such as heteroscedasticity and autocorrelation, and advanced topics including multiple regression analysis and multicollinearity.

Course Prerequisite: Intermediate Level Courses (Level 200 – 299)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will be able to explain the purpose and scope of econometrics, understand the concept of econometric models, and recognize the role of econometrics in model building and economic analysis.	U
2	Students will be able to understand and apply the general linear model, including estimation under linear restrictions and the properties of estimators within this framework.	A
3	Students will be able to recognize the presence of heteroscedasticity and autocorrelation in econometric models, understand their consequences, and apply appropriate tests to detect and address these issues.	E
4	Students will be able to understand the concept of distributed lag models, their consequences, and apply estimation techniques for parameters in these models.	R

5	Students will be able to identify multicollinearity in multiple regression models, understand its consequences and sources, apply tests for multicollinearity detection, and use appropriate estimation techniques to address multicollinearity.	An

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1		✔		✔		✔	
CO 2	✔		✔		✔	✔	
CO 3	✔	✔		✔			✔
CO 4			✔		✔		✔
CO 5	✔	✔		✔		✔	

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Introduction to Econometrics**	12
	1	Introduction: Purpose and scope of econometrics	
	2	Econometric model, model building and role of econometrics.	
	3	General linear model (GLM)	
	4	Estimation under linear restrictions and properties of estimators	

2	**Heteroscedasticity**		**12**
	1	Econometric problems – Heteroscedasticity	
	2	Tests for heteroscedasticity	
	3	Consequences of heteroscedasticity	
	4	Remedial measures	
3	**Autocorrelation**		**11**
	1	Autocorrelation: concept	
	2	Consequences of autocorrelated disturbances	
	3	Detection and tests of autocorrelation	
	4	Distributed lag models and estimation of parameters	
4	**Multicollinearity**		**10**
	1	Multiple regression analysis	
	2	Multicollinearity: Introduction and concepts	
	3	Detection of multicollinearity, consequences, sources	
	4	Tests and estimation of multicollinearity	
5	**Open End (Practical)**		**30**
	Computational illustration of testing of parameters of general linear model using R.		

Essential Readings:

1. Gujarati, D. and Sangeetha, N. (2007). ***Basic Econometrics***, Tata Mc Graw-Hill, New Delhi.
2. Johnston, J. (2009). ***Econometric Methods***, 4th edition, Mc Graw Hill
3. Judge, G. G., Griffiths, W. E., Hill, R. C., Lutkepohl, H. and Lee, T. C. (1985). ***The Theory and Practice of Econometrics***, 2nd edition, John Wiley
4. Wooldridge, J. M. (2012). ***Introductory Econometrics - A Modern Approach***, 5th edition, South-Western College Publishing.

Suggested Readings:

1. Maddala, G.S. and Lahiri, K. (2009): ***Introduction to Econometrics***, 4th Wiley & Sons.

Assessment Rubrics:

Evaluation Type		**Marks**	**Evaluation Type**		**Marks**	**Total**
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER VI

DSE 11 – DISCIPLINE SPECIFIC ELECTIVE COURSE

KU6DSESTA319: STATISTICAL DECISION THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
VI	ELECTIVE	300 – 399	KU6DSESTA319	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course provides a comprehensive study of statistical decision theory, Bayesian inference, game theory, and decision analysis, covering topics such as decision rules, utility functions, prior specification, Bayesian inference, hierarchical Bayes analysis, admissibility of Bayes rules, and game theory techniques.

Course Prerequisite: Intermediate Level Courses (Level 200 – 299)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will be able to explain statistical decision problems, decision rules, loss functions, randomized decision rules, and principles such as sufficient statistic and convexity.	U
2	Students will be able to determine subjective prior densities, use maximum entropy priors, select priors based on marginal distributions, and understand the concept of conjugate priors.	A
3	Students will be able to compute posterior distributions, apply Bayesian decision theory including empirical Bayes analysis, hierarchical Bayes analysis, and understand Bayesian robustness.	E
4	Students will be able to explain basic concepts of game theory, techniques for solving games, understand games with finite states of nature, the supporting and separating hyperplane theorems, and the minimax theorem.	R
5	Students will be able to analyse statistical games and the admissibility of Bayes rules in decision-making contexts.	An

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1		✔		✔		✔	✔
CO 2	✔		✔		✔		✔
CO 3		✔		✔		✔	
CO 4	✔		✔		✔	✔	
CO 5	✔		✔		✔		✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Foundations of Statistical Decision Theory**	12
	1	Statistical decision Problem – Decision rule and loss-randomized decision rule	
	2	Decision Principle – sufficient statistic and convexity	
	3	Utility and loss-loss functions-standard loss functions	
	4	Vector valued loss functions	
2		**Bayesian Prior Specification and Selection**	12
	1	Prior information-subjective determination of prior density	
	2	Non-informative priors-maximum entropy priors	
	3	The marginal distribution to determine the prior-the ML-II approach to prior selection	
	4	Conjugate priors	
3		**Advanced Bayesian Inference and Decision Theory**	11
	1	The posterior distribution-Bayesian inference	
	2	Bayesian decision theory-empirical Bayes analysis	
	3	Hierarchical Bayes analysis-Bayesian robustness	
	4	Admissibility of Bayes rules	
4		**Game Theory and Decision Analysis**	10
	1	Game theory – basic concepts – general techniques for solving games	

	2	Games with finite state of nature-the supporting and separating hyper plane theorems	
	3	The minimax theorem	
	4	Statistical games	
5	**Open End (Practical)**		**30**
	Computational illustration of the above concepts using R.		

Essential Readings:

1. Berger, O, J. (1985). ***Statistical decision Theory and Bayesian Analysis***, Second Edition Springer-Verlag**.**
2. Ferguson, T.S. (1967). ***Mathematical Statistics; A Decision-Theoretic Approach***, Academic Press, New-York.

Suggested Readings:

1. George E. P. Box and George C. Tiao (1973). ***Bayesian Inference in Statistical Analysis***, Addison-Wesley Publishing Company

Assessment Rubrics:

Evaluation Type		**Marks**	**Evaluation Type**		**Marks**	**Total**
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER VIII

DSE 12 – DISCIPLINE SPECIFIC ELECTIVE COURSE

KU8DSESTA421: OPTIMIZATION TECHNIQUES

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
VIII	ELECTIVE	400 – 499	KU8DSESTA421	4	60

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	-	-	30	70	100	2

Course Description: This course covers the principles and methods of operations research, including linear programming problems and their solutions, simplex method, duality, transportation and assignment problems, network analysis, queuing models, and game theory.

Course Prerequisite: Higher Level Courses (Level 300 – 399)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will be able to define, formulate, and solve linear programming problems using both graphical and simplex methods.	An
2	Students will learn to implement artificial variable techniques such as the Big-M method and two-phase method to handle constraints in linear programming.	A
3	Students will understand the concepts of degeneracy and duality in linear programming, and how to solve dual problems.	U
4	Students will be able to mathematically formulate and find optimal solutions for transportation and assignment problems, including dealing with unbalanced and degenerate cases.	R
5	Students will be able to draw network diagrams, perform critical path analysis (CPM and PERT), and understand basic queuing models and game theory applications.	E

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1		✔	✔			✔	✔
CO 2	✔			✔	✔		
CO 3		✔		✔			
CO 4		✔	✔		✔		
CO 5	✔				✔		✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Linear Programming Problems**	12
	1	Operations research – definition, scope and objectives	
	2	Linear programming Problem (LPP): Mathematical formulation of LPP	
	3	Graphical method for solving LPP	
	4	Canonical and standard form of LPP	
2		**Simplex Method and Duality in Linear Programming**	12
	1	Simplex method	
	2	Artificial variable techniques	
	3	Big-M method, two-phase method	

	4	Degeneracy, duality	
3	**Transportation and Assignment Problems**		**12**
	1	Transportation problem: Mathematical formulation	
	2	Method of finding initial basic feasible solution, method of finding optimal solution	
	3	Unbalanced transportation problem and degeneracy	
	4	Assignment problem: mathematical formulation, Hungarian method	
4	**Network Analysis, Queuing Models and Game Theory**		**12**
	1	Network analysis and drawing network diagram	
	2	Critical path analysis – CPM, PERT: distinction between CPM and PERT, expected completion time and its variance	
	3	Queuing Models – Introduction, M/M/C or M/M/C: ∞/FCFS Queuing models	
	4	Game Theory – Basic Definitions, Two-Person Zero-Sum Game	
5	**Open End (Practical)**		**12**
	Numerical computation of the above concepts.		

Essential Readings:

1. Kanti Swarup, Gupta P. K., Man Mohan (2010). ***Operations Research,*** Sultan Chand and Sons, New Delhi.
2. Taha, H. A. (2014). ***Operations Research,*** Pearson Education Publication.
3. Gupta, R. K. (2010). ***Operations Research,*** Krishna Prakashan Media (P) Ltd., Meerut.

Suggested Readings:

1. Goel, B. S., Mittal, S. K. and Pundir, S. K. (2023). ***Operations Research,*** Pragati Prakashan, Meerut.
2. Sharma, J. K. (2017). ***Operation Research: Theory and Applications***, Laxmi Publications.

Assessment Rubrics:

Evaluation Type		Marks
End Semester Evaluation		**70**
Continuous Evaluation		**30**
a)	Test Paper- 1	**5**
b)	Test Paper-2	**5**
c)	Assignment	**10**
d)	Seminar	**-**
e)	Book/ Article Review	-
f)	Viva-Voce	**-**
g)	Field Report/Practical	**10**
Total		**100**

SEMESTER VIII

DSE 13 – DISCIPLINE SPECIFIC ELECTIVE COURSE

KU8DSESTA422: RELIABILITY THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
VIII	ELECTIVE	400 – 499	KU8DSESTA422	4	60

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	-	-	30	70	100	2

Course Description: This course provides a comprehensive study of reliability concepts, including system structures, failure rates, ageing properties, life time models, dependent component systems, and reliability estimation methods using MLE, UMVUE, and Bayesian approaches.

Course Prerequisite: Higher Level Courses (Level 300 – 399)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will be able to describe and analyse the structure functions and coherent systems used in reliability engineering.	U
2	Students will gain the ability to calculate and interpret failure rates, mean residual life, and other key reliability metrics, and understand their interrelationships.	A
3	Students will develop an understanding of various notions of ageing (IFR, IFRA, NBU, NBUE, DMRL, HNBUE, NBUC) and their implications, as well as the use of TTT transforms for characterizing ageing classes.	An
4	Students will be able to study and evaluate different life time models (exponential, Weibull, lognormal, generalized Pareto, gamma) and understand their basic concepts and ageing characteristics, including non-monotonic failure rates.	E
5	Students will acquire skills to perform reliability estimation using methods like MLE, UMVUE, and Bayesian approaches for exponential, Weibull, and gamma distributions, based on both censored and non-censored samples.	R

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔		✔		✔		✔
CO 2		✔			✔		✔
CO 3		✔		✔		✔	
CO 4			✔		✔		✔
CO 5	✔			✔			✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Reliability Theory and Ageing Analysis**	12
	1	Structure functions, Coherent Systems	
	2	Basic concepts in reliability: Failure rate, mean, variance and percentile residual life, identities connecting them	
	3	Notions of ageing - IFR, IFRA, NBU, NBUE, DMRL, HNBUE, NBUC etc. and their mutual implications	
	4	TTT transforms and characterization of ageing classes	
2		**Life Time Models and Non-Monotonic Failure Rates**	12
	1	Non-monotonic failure rates and mean residual life functions	
	2	Study of life time models viz. exponential, Weibull, lognormal, generalized Pareto, gamma with reference to basic concepts and ageing characteristics	
	3	Bath tub and upside-down bath tub failure rate distributions	
3		**Reliability Systems and Dependence Measures**	12
	1	Reliability systems with dependent components: -Parallel and series systems, k out of n systems	
	2	Ageing properties with dependent and independents components	
	3	Concepts and measures of dependence in reliability - RCSI, LCSD, PF 2, WPQD	
4		**Reliability Estimation Methods**	12
	1	Reliability estimation using MLE - exponential, Weibull and gamma	

		distributions based on censored and non-censored samples	
	2	UMVUE estimation of reliability function	
	3	Bayesian reliability estimation of exponential and Weibull models	
5	**Open End (Practical)**		**12**
	Computational illustration of the above concepts using R.		

Essential Readings:

1. Lai, C. D. and Xie, M. (2006): ***Stochastic Ageing and Dependence for Reliability***, Springer.
2. Sinha, S. K. (1987). ***Reliability and Life Testing***, Wiley – Blackwell.
3. Barlow, R. E. and Proschan, F. (1975). ***Statistical Theory of Reliability and Life Testing***, Holt, Reinhart and Winston of Canada Ltd.

Suggested Readings:

1. Marshall, A.W. and Olkin, I. (2007). ***Life Distributions: Structure of Nonparametric, Semiparametric and Parametric Families***, Springer.
2. Galambos, J., and Kotz, S. (1978). ***Characterizations of Probability Distributions: A Unified Approach with an Emphasis on Exponential and Related Models***. Lecture Notes in Mathematics, 675, Springer, Berlin.
3. Lawless, J. F. (2003). ***Statistical Models and Methods for Life Data***, Wiley – Interscience.

Assessment Rubrics:

Evaluation Type		Marks
End Semester Evaluation		**70**
Continuous Evaluation		**30**
a)	Test Paper- 1	**5**
b)	Test Paper-2	**5**
c)	Assignment	**10**
d)	Seminar	**-**
e)	Book/ Article Review	-
f)	Viva-Voce	**-**
g)	Field Report/Practical	**10**
Total		**100**

SEMESTER VIII

DSE 14 – DISCIPLINE SPECIFIC ELECTIVE COURSE
KU8DSESTA423: SURVIVAL ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
VIII	ELECTIVE	400 – 499	KU8DSESTA423	4	60

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	-	-	30	70	100	2

Course Description: This course provides a comprehensive introduction to survival analysis, covering foundational concepts, survival distributions, censoring and truncation techniques, non-parametric methods, and regression models, with practical applications and problem-solving exercises.

Course Prerequisite: Higher Level Courses (Level 300 – 399)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will demonstrate a clear understanding of survival analysis concepts, definitions, and basic principles.	U
2	Students will be able to analyse survival data by applying appropriate survival distributions such as exponential, gamma, Weibull, Rayleigh, and lognormal distributions.	An
3	Students will calculate and interpret survival functions, probability density functions, and hazard functions, and understand their interrelationships.	R
4	Students will compute and interpret mean residual time for survival data sets, providing insights into the overall survival experience.	A
5	Students will engage with suggested readings to deepen their understanding of survival analysis concepts and reinforce their learning from the module.	U

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔			✔	✔		✔
CO 2			✔		✔		✔
CO 3	✔			✔			
CO 4		✔			✔		✔
CO 5	✔		✔	✔		✔	

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Fundamentals of Survival Analysis**	12
	1	Introduction to survival analysis, concepts and definitions	
	2	Survival function, probability density function, hazard function; inter relationships	
	3	Survival distributions- exponential distribution, gamma distribution, Weibull, Rayleigh, lognormal distribution	
	4	Mean Residual time	
2		**Censoring, Truncation, and Estimation in Survival Analysis**	12
	1	Concepts of censoring and truncation, Type I, Type II and progressive or random censoring with biological examples	
	2	Estimation of mean survival time and variance of the estimator for type I and type II censored data	
	3	Numerical examples	
3		**Non-parametric Estimation and Log-rank Testing in Survival Analysis**	12
	1	Non-parametric methods: Actuarial and Kaplan–Meier methods for estimating survival function	
	2	Variance of the estimator	
	3	Log-rank test	
4		**Advanced Survival Analysis Models and Applications**	12
	1	Exponential regression models	

	2	The Cox proportional hazards model and its characteristics	
	3	Evaluating the proportional hazards assumptions	
	4	Practice problems	
5	**Open End (Practical)**		**12**
	Computational illustration of the above concepts using R.		

Essential Readings:

1. Altman, D. G**.** (2006). ***Practical Statistics for Medical Research***, Chapman and Hall/CRC.
2. Cox, D. R. and Oakes, D. (1984). ***Analysis of Survival Data***, Chapman and Hall/CRC.
3. Lawless, J. F. (2003). ***Statistical Models and Methods for Lifetime Data***, Second Edition, John Wiley & Sons.

Suggested Readings:

1. Kleinbaum, D. G. and Klein, M. (2012). ***Survival Analysis: A Self Learning Text***, Third Edition, Springer.
2. Gross, A. J. and Clark, V. A. (1975). ***Survival Distributions: Reliability Applications in the Biomedical Sciences***, John Wiley & Sons.
3. Lee, E. T. (1992). ***Statistical Methods for Survival Data Analysis***, Wiley – Blackwell.

Assessment Rubrics:

Evaluation Type		Marks
End Semester Evaluation		**70**
Continuous Evaluation		**30**
a)	Test Paper- 1	**5**
b)	Test Paper-2	**5**
c)	Assignment	**10**
d)	Seminar	**-**
e)	Book/ Article Review	-
f)	Viva-Voce	**-**
g)	Field Report/Practical	**10**
Total		**100**

SEMESTER VIII

DSE 15 – DISCIPLINE SPECIFIC ELECTIVE COURSE

KU8DSESTA424: ADVANCED RESEARCH METHODOLOGY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
VIII	ELECTIVE	400 – 499	KU8DSESTA424	4	60

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	-	-	30	70	100	2

Course Description: This course covers the fundamentals of statistical research methodology, including literature review, scientific word processing, statistical programming with R, simulation techniques, Monte Carlo integration, MCMC methods, and computer-oriented numerical methods, emphasizing practical applications and computer-based tools.

Course Prerequisite: Higher Level Courses (Level 300 – 399)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will understand the importance of research ethics and be able to select appropriate topics for statistical research, develop research schedules, and recognize the historical context of Statistics.	U
2	Learners will be proficient in conducting literature reviews, utilizing various sources such as books, journals, and electronic databases, and applying computer applications for thesis writing and scientific research.	An
3	Participants will acquire skills in scientific word processing using LaTeX and MS-Word, including article and thesis report preparation, and slide creation using Power Point features.	R
4	Students will demonstrate proficiency in statistical programming using R, including manipulation of numbers and vectors, handling arrays and matrices, creating lists and data frames, and defining user-defined functions.	A
5	Learners will gain knowledge and practical experience in simulation techniques, random variable generation, Monte Carlo integration, MCMC algorithms, bootstrap methods, and computer-oriented numerical methods such as solving algebraic equations, numerical integration, and matrix operations.	U

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔		✔		✔		✔
CO 2		✔		✔			✔
CO 3	✔		✔			✔	
CO 4		✔		✔			✔
CO 5	✔		✔		✔	✔	

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Introduction to Statistical Research and Literature Review**	12
	1	Concept of research in Statistics - importance and need for research ethics, selection of topic for research-research schedules	
	2	Review of literature and its use in designing a research work - mode of literature survey - books and monographs, journals, conference proceedings, abstracting and indexing journals	
	3	E-Journals/Books and CD-ROMS - reports etc. Thesis writing – computer application in scientific research – www - searching scientific articles - statistical data base	
	4	History of Statistics, statistical heritage of India	
2		**Advanced Techniques in Scientific Writing and Statistical Programming**	12
	1	Scientific word processing with LaTeX and MS-Word: article, thesis report and slides making - power point features, slide preparation	
	2	Statistical programming with R: simple manipulations using numbers and vectors objects and their attributes	
	3	Arrays and matrices - lists and data frames, grouping, loops and conditions - user defined functions	
	4	Probability distributions and statistical models in R	
3		**Simulation Techniques and Monte Carlo Methods in Statistical Analysis**	12
	1	Simulation: concepts and advantages of simulation - event	
	2	Type simulation random variable generation - U (0,1), exponential, gamma and normal random variables	
	3	Monte Carlo integration	

	4	The MCMC principle, algorithms and its variants, bootstrap methods	
4	**Computational Methods for Numerical Analysis and Matrix Operations**		**12**
	1	Computer oriented numerical methods - algorithms for solving algebraic and transcendental equations	
	2	Numerical integration	
	3	Matrix operations	
5	**Open End (Practical)**		**12**
	Computational illustration of the above concepts using R.		

Essential Readings:

1. Anderson, J. and Poole, M. (2019). ***Assignment and Thesis Writing***, Wiley India Exclusive (CBS).
2. Beveridge, W. I. (2004). ***The Art of Scientific Investigation***, The Blackburn Press.
3. Braun, W. J. and Murdoch, D. J. (2007). ***A First Course in Statistical Programming with R***, Cambridge University Press.
4. Chambers, J. M. (2009). ***Software for Data Analysis: Programming with R***, Springer - Verlag New York Inc.
5. Crawley, M. J. (2012). ***The R Book***, John Wiley & Sons Inc.
6. Dalgaard, P. (2008). ***Introductory Statistics with R***, Springer.
7. Ghosh, J. K., Mitra, S. K. and Parthasarathy, K. R. (1993). ***Glimpses of India's Statistical Heritage***, Wiley – Blackwell.
8. Hald, A. (1998). ***A History of Mathematical Statistics from 1750 to 1930***, Wiley – Blackwell.

Suggested Readings:

1. Kanti Swarup, Gupta, P. K. and Man Mohan (2014). ***Operations Research***, Sultan Chand & Sons.
2. Kothari, C. R. and Garg, G. (2019). ***Research Methodology***, New Age International Publishers.
3. Lamport, L. (1994). ***LATEX: A Document Preparation System***, Addison-Wesley.
4. Panneerselvam, R. (2014). ***Research Methodology***, Prentice-Hall of India Learning.
5. Robert, C. P. and Casella, G. (2004). ***Monte Carlo Statistical Methods***, Springer.
6. Venkataraman, M. K. (1999). ***Numerical Methods in Science and Engineering***, The National Publishing Company – Madras.

Assessment Rubrics:

Evaluation Type		Marks
End Semester Evaluation		**70**
Continuous Evaluation		**30**
a)	Test Paper- 1	**5**
b)	Test Paper-2	**5**
c)	Assignment	**10**
d)	Seminar	**-**
e)	Book/ Article Review	-
f)	Viva-Voce	**-**
g)	Field Report/Practical	**10**
Total		**100**

SEMESTER VIII

DSE 16 – DISCIPLINE SPECIFIC ELECTIVE COURSE

KU8DSESTA425: STATISTICAL ANALYSIS AND BUSINESS INTELLIGENCE

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
VIII	ELECTIVE	400 – 499	KU8DSESTA425	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course covers essential data analysis techniques including data cleansing and validation, data handling and import, descriptive statistics, data mining and its business applications, business intelligence, data-driven decision-making, statistical testing (normality, t-tests, chi-square, ANOVA), correlation and regression analyses (linear and logistic).

Course Prerequisite: Higher Level Courses (Level 300 – 399)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Apply techniques for data preparation, including data cleansing, validation, and handling missing values, ensuring data integrity and reliability for analysis.	A
2	Employ various data handling methods such as sub setting, integrating, appending, and concatenating to manipulate datasets effectively.	An
3	Demonstrate proficiency in reading and importing data into software tools commonly used in data analysis.	R
4	Utilize descriptive statistics to summarize data effectively, calculate cumulative frequencies, and create contingency tables for comprehensive data exploration.	E
5	Understand the concepts and applications of data mining, business intelligence, and decision support systems, enabling informed decision-making in a business context.	U

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1		✔	✔		✔		✔
CO 2		✔		✔		✔	✔
CO 3	✔			✔			
CO 4		✔		✔		✔	✔
CO 5	✔		✔		✔		✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1	**Fundamentals of Data Preparation and Descriptive Statistics**		12
	1	Data cleansing and data validation, missing value treatment	
	2	Data handling – sub setting, integrating, appending and concatenating	
	3	Reading or importing data into software	
	4	Descriptive Statistics – summarizing data, calculating cumulative frequencies, creating contingency tables	
2	**Data Mining, Business Intelligence, and Decision Support Systems**		12
	1	Understanding data mining and its applications in business	
	2	Overview of business intelligence and decision support systems	
	3	Data-driven decision-making in business	
	4	Data reduction and feature selection	
3	**Hypothesis Testing**		11
	1	Testing for normality – graphical and analytical methods	
	2	Testing mean of a sample and equality of means of two samples (t test)	
	3	Chi square test for independence of attributes	
	4	One-way and Two-way ANOVA	
4	**Regression Analysis and Predictive Modelling**		10
	1	Correlation analysis and scatter plots	

	2	Linear Regression models- checking the assumptions	
	3	Simple and multiple linear regression model fitting	
	4	Logistic Regression model fitting	
5	**Open End (Practical)**		**30**
	Computational illustration of the above concepts using R.		

Essential Readings:

1. Long, J. D. and Teetor, P. (2019). ***R Cookbook: Proven Recipes for Data Analysis, Statistics, and Graphics***, 2nd edition, O'Reilly Media.
2. Brandt, S. (2014). ***Data Analysis: Statistical and Computational Methods for Scientists and Engineers***, 4th edition, Springer.
3. Schmuller, J. (2017). ***Statistical Analysis with R for Dummies***, John Wiley & Sons.

Suggested Readings:

1. Viswanathan, V. and Viswanathan, S. (2015). ***R Data Analysis Cookbook***, Packt Publishing Ltd.

Assessment Rubrics:

Evaluation Type		**Marks**	**Evaluation Type**		**Marks**	**Total**
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

DISCIPLINE SPECIFIC MINOR COURSES

SEMESTER I

B1 – DISCIPLINE SPECIFIC MINOR COURSE
KU1DSCSTA121: INTRODUCTORY STATISTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
I	MINOR	100 – 199	KU1DSCSTA121	4	60

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	-	-	30	70	100	2

Course Description: This course covers statistical methods including data classification, sources of data, sampling techniques, measures of central tendency and dispersion, moments, skewness, and kurtosis, providing a comprehensive understanding of data analysis and interpretation.

Course Prerequisite: HSE level Mathematics/Statistics Courses

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will be able to identify and classify data based on nominal, ordinal, interval, and ratio scales of measurement.	R
2	Students will understand the concepts of primary and secondary data and their respective sources.	U
3	Students will be able to compare census and sample survey methods, and understand the principal steps involved in a sample survey.	An
4	Students will understand and be able to apply simple random sampling, stratified random sampling, and systematic random sampling for data collection.	A
5	Students will be able to compute measures of central tendency (mean, median, mode, etc.), dispersion (range, quartiles, standard	E

	deviation, etc.), moments, skewness, and kurtosis, and interpret their properties and significance in data analysis.	

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1		✔	✔		✔		✔
CO 2	✔		✔	✔		✔	
CO 3	✔	✔			✔		✔
CO 4			✔	✔		✔	✔
CO 5	✔	✔		✔	✔		✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Statistical Methods**	12
	1	Different types of data: Scales of measurement - Nominal, ordinal, interval and ratio, Classification of data	
	2	Source of data: Primary and Secondary data, their sources	
	3	Census and Sampling method: Definitions, Comparison of census method and sample survey method, Principal steps in a sample survey	
	4	Probability sampling – simple random sampling, stratified and systematic random sampling, non-probability sampling (concepts only)	
2		**Measures of Central Tendency**	12
	1	Definition and properties of various measures of central tendency –	

		Arithmetic Mean, Median, Mode	
	2	Geometric Mean, Harmonic Mean and weighted averages	
	3	Partition values - Quartiles, Deciles, Percentiles	
3	**Measures of Dispersion**		**12**
	1	Definition and properties of various measures of dispersion - Range, Quartile Deviation, Mean Deviation, Standard Deviation	
	2	Properties and relative measures of dispersion (Coefficient of range, Coefficient of quartile deviation, Coefficient of variation, Coefficient of mean deviation)	
4	**Moments**		**12**
	1	Definitions of raw and central moments, calculation of moments	
	2	Relationship between raw and central moments	
	3	Skewness: Definition and various measures of skewness	
	4	Kurtosis - Definition and various measures of kurtosis	
5	**Open End**		**12**
	Practical using MS Excel		
	History of Statistics, Data entry using MS Excel, Understanding the usage of various statistical and mathematical functions in Excel, Preparation of diagrams and analysis of data using methods explained in Module 2 to 4 by Excel, Preparation and submission of a report.		

Essential Readings:

1. Gupta, S. C. & Kapoor, V. K. (1980). ***Fundamentals of Mathematical Statistics***, Sultan Chand & Sons, New Delhi.
2. Gupta, S. C. & Kapoor, V. K. (1994). ***Fundamentals of Applied Statistics***, Sultan Chand & Sons, New Delhi.
3. Gupta, S. P. (2004). ***Statistical Methods***, Sultan Chand & Sons, New-Delhi.

Suggested Readings:

1. Mukhopadhyay, P. (1996). ***Mathematical Statistics***, New Central Book Agency (P) Ltd., Kolkata.

2. Agarwal, B. L. (2006). ***Basic Statistics***, 4th Edition, New Age International (P) Ltd., New Delhi.

Assessment Rubrics:

Evaluation Type		Marks
End Semester Evaluation		**70**
Continuous Evaluation		**30**
a)	Test Paper- 1	**5**
b)	Test Paper-2	**5**
c)	Assignment	**10**
d)	Seminar	**-**
e)	Book/ Article Review	-
f)	Viva-Voce	**-**
g)	Field Report/Practical	**10**
Total		**100**

SEMESTER I

B2 – DISCIPLINE SPECIFIC MINOR COURSE
KU1DSCSTA122: STATISTICAL METHODS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
I	MINOR	100 – 199	KU1DSCSTA122	4	60

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	-	-	30	70	100	2

Course Description: This course provides an introductory understanding of statistics, covering topics such as the definition and nature of statistics, variables, data tabulation, graphical representation, measures of central tendency and dispersion, skewness, and kurtosis.

Course Prerequisite: HSE level Mathematics/Statistics Courses

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will be able to define statistics, understand its nature, uses, and its relation to other disciplines, as well as recognize the potential for misuse of statistics.	R
2	Students will understand the concepts of variables, attributes, primary data, secondary data, population, and sample, as well as the difference between census and sample survey methods.	U
3	Students will be able to create frequency distributions (ungrouped and grouped) and cumulative frequency distributions and understand the principles of data tabulation.	E
4	Students will understand and be able to create various charts and diagrams (e.g., bar diagrams, pie charts, histograms, frequency polygons, frequency curves, ogives) and recognize the advantages of graphical representation in data analysis.	An
5	Students will be able to calculate measures of central tendency (mean, median, mode, geometric mean, harmonic mean) and measures of dispersion (range, quartile deviation, mean deviation, standard deviation, variance) from raw data and understand their advantages, disadvantages, as well as measures of skewness and kurtosis.	A

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔		✔		✔		✔
CO 2		✔		✔		✔	
CO 3	✔		✔		✔		✔
CO 4		✔		✔		✔	
CO 5	✔		✔		✔		✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Introduction to Statistics**	12
	1	Introduction- definition of Statistics, Nature of Statistics, uses of Statistics, Statistics in relation to other disciplines, abuse of Statistics	
	2	Variables, Attributes. Primary data and secondary data. Population and sample. Census and sample survey	
	3	Tabulation of data- basic principles	
	4	Frequency distribution-ungrouped and grouped, cumulative frequency distribution	
2		**Diagrammatic and Graphical Representation of Data**	12
	1	Charts and diagrams- bar diagram, pie chart	
	2	Histogram, frequency polygon, frequency curve	
	3	Ogives	

	4	Advantages of diagram and graphical representation of data	
3	**Measures of Central tendency**		**12**
	1	Definition and properties of Various measures of central tendency- AM, median, mode, GM, HM	
	2	Calculation of various measure of Central tendency (from raw data only)	
	3	Advantages and disadvantages of various measures of central tendency	
4	**Measures of Dispersion**		**12**
	1	Definitions – Range, QD, MD, SD, Variance	
	2	Calculation of various measures of dispersion (from raw data only)	
	3	Skewness: Definition and various measures of skewness	
	4	Kurtosis - Definition and various measures of kurtosis	
5	**Open End**		**12**
	Practical using MS Excel		
	History of Statistics, Data entry using MS Excel, Understanding the usage of various statistical and mathematical functions in Excel, Preparation of diagrams and analysis of data using methods explained in Module 2 to 4 by Excel, Preparation and submission of a report.		

Essential Readings:

1. Gupta, S. C. & Kapoor, V. K. (1980). ***Fundamentals of Mathematical Statistics***, Sultan Chand & Sons, New Delhi.
2. Gupta, S. C. & Kapoor, V. K. (1994). ***Fundamentals of Applied Statistics***, Sultan Chand & Sons, New Delhi.
3. Gupta, S. P. (2004). ***Statistical Methods***, Sultan Chand & Sons, New-Delhi.

Suggested Readings:

1. Mukhopadhyay, P. (1996). ***Mathematical Statistics***, New Central Book Agency (P) Ltd., Kolkata.
2. Agarwal, B. L. (2006). ***Basic Statistics***, 4th Edition, New Age International (P) Ltd., New Delhi.

Assessment Rubrics:

Evaluation Type		Marks
End Semester Evaluation		**70**
Continuous Evaluation		**30**
a)	Test Paper- 1	**5**
b)	Test Paper-2	**5**
c)	Assignment	**10**
d)	Seminar	**-**
e)	Book/ Article Review	-
f)	Viva-Voce	**-**
g)	Field Report/Practical	**10**
Total		**100**

SEMESTER I

B3 – DISCIPLINE SPECIFIC MINOR COURSE

KU1DSCSTA123: INTRODUCTION TO OPERATIONS RESEARCH

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
I	MINOR	100 – 199	KU1DSCSTA123	4	60

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	-	-	30	70	100	2

Course Description: This course offers a comprehensive study of linear programming, transportation, and assignment problems, covering topics such as mathematical formulation, solution methods including graphical, simplex, and Hungarian methods, as well as duality and special cases.

Course Prerequisite: HSE level Mathematics/Statistics Courses

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will be able to understand the basics of linear programming and its applications in various real-world problems.	U
2	Students will be able to formulate mathematical models for linear programming problems (LPP) and solve them using graphical methods, simplex method, and understand canonical and standard forms of LPP.	An
3	Students will understand the transportation problem and its mathematical formulation, and will be able to solve it using various methods such as the North-West corner rule, matrix minima method, Vogel's approximation method, and modified distribution method.	A
4	Students will understand the assignment problem and its mathematical formulation, and will be able to solve it using the Hungarian method. They will also be able to handle special cases such as maximization case and prohibited assignments.	E
5	Students will grasp the concept of duality in linear programming, including its basic concepts and applications. They will understand how primal and dual problems are related and the significance of duality in optimization problems.	R

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔			✔	✔		✔
CO 2		✔		✔			✔
CO 3	✔			✔	✔		
CO 4		✔		✔		✔	✔
CO 5	✔		✔		✔		✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Linear Programming Problem**	12
	1	Introduction	
	2	Mathematical formulation of a linear programming problem	
2		**Solution of a Linear Programming Problem**	12
	1	Solution of a linear programming problem by graphical method	
	2	General Linear programming problem, canonical and standard forms of LPP	
	3	Solution of a linear programming problem by simplex method (Simplex algorithm and simple problems only)	
	4	Duality in LPP (Basic concepts only)	

3	**Transportation Problem**		**12**
	1	Mathematical formulation	
	2	Solution of a Transportation Problem by North-West corner rule and Matrix minima method	
	3	Vogel's Approximation method	
	4	Modified distribution method	
4	**Assignment Problem**		**12**
	1	Mathematical formulation	
	2	Solution of an Assignment problem by Hungarian method	
	3	Special cases in assignment problem: Maximization case, prohibited assignments	
5	**Open End (Practical)**		**12**
	Numerical computation using methods explained in Module 1 to 4.		

Essential Readings:

1. Kantiswarup, Gupta P. K. and Manmohan. (2022): ***Operations Research***, Sultan Chand and Sons.
2. Hira, D. S. (1992): ***Operations Research***, S. Chand Publishing.

Suggested Readings:

1. Taha, H. A. (2019): ***Operations Research – An Introduction***, Pearson Education.

Assessment Rubrics:

Evaluation Type		Marks
End Semester Evaluation		**70**
Continuous Evaluation		**30**
a)	Test Paper- 1	**5**
b)	Test Paper-2	**5**
c)	Assignment	**10**
d)	Seminar	**-**
e)	Book/ Article Review	-
f)	Viva-Voce	**-**
g)	Field Report/Practical	**10**
Total		**100**

SEMESTER I

B4 – DISCIPLINE SPECIFIC MINOR COURSE

KU1DSCSTA124: BASIC STATISTICS AND NUMERICAL SKILLS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
I	MINOR	100 – 199	KU1DSCSTA124	4	60

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	-	-	30	70	100	2

Course Description: This course provides a comprehensive understanding of statistical methods, covering different types of data, sources of data, sampling methods, measures of central tendency, measures of dispersion, and basic concepts of matrix algebra, including mathematical operations, determinants, and solutions of simultaneous equations using Crammer's rule.

Course Prerequisite: HSE level Mathematics/Statistics Courses

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will be able to classify different types of data according to their scales of measurement and understand the properties of nominal, ordinal, interval, and ratio data.	R
2	Students will acquire the knowledge to distinguish between primary and secondary data sources and understand the importance of each in statistical analysis.	An
3	Upon completion of the course, students will demonstrate proficiency in designing and executing sampling methods, including census and various types of probability sampling techniques.	E
4	Students will be able to calculate and interpret various measures of central tendency, such as arithmetic mean, median, and mode, along with partition values like quartiles, deciles, and percentiles.	A
5	By the end of the course, students will have a solid understanding of measures of dispersion, including range, quartile deviation, mean deviation, and standard deviation, and be able to apply relative measures of dispersion effectively.	U

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1		✔		✔	✔		✔
CO 2	✔			✔	✔		✔
CO 3	✔			✔		✔	
CO 4		✔		✔		✔	✔
CO 5	✔		✔		✔		✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Statistical Methods**	12
	1	Different types of data: Scales of measurement - Nominal, ordinal, interval and ratio, Classification of data	
	2	Source of data: Primary and Secondary data, their sources	
	3	Census and Sampling method: Definitions, Comparison of census method and sample survey method, Principal steps in a sample survey	
	4	Probability sampling – simple random sampling, stratified and systematic random sampling, non-probability sampling (concepts only)	
2		**Measures of Central Tendency**	12
	1	Definition and properties of various measures of central tendency – Arithmetic mean, median, mode	
	2	Geometric mean, harmonic mean and weighted averages	
	3	Partition values - Quartiles, Deciles, Percentiles	

3	**Measures of Dispersion**		**12**
	1	Definition and properties of various measures of dispersion - Range, quartile deviation, mean deviation, standard deviation	
	2	Properties and relative measures of dispersion (Coefficient of range, Coefficient of quartile deviation, Coefficient of variation, Coefficient of mean deviation)	
4	**Matrix Algebra**		**12**
	1	Definition and types of matrices, transpose of a matrix	
	2	Mathematical operations on matrices – Addition, scalar multiplication and product of two matrices	
	3	Determinant of a matrix (of order 2 and 3), rank of a matrix	
	4	Solution of simultaneous equations using Crammer's rule (3 variables)	
5	**Open End (Practical)**		**12**
	Set theory, Types of sets, set operations, Representation of sets using Venn diagram, Numerical computation of concepts explained in Module 2 and 3 using MS Excel.		

Essential Readings:

1. Gupta, S. C. & Kapoor, V. K. (1980). ***Fundamentals of Mathematical Statistics***, Sultan Chand & Sons, New Delhi.
2. Gupta, S. C. & Kapoor, V. K. (1994). ***Fundamentals of Applied Statistics***, Sultan Chand & Sons, New Delhi.
3. Gupta, S. P. (2004). ***Statistical Methods***, Sultan Chand & Sons, New-Delhi.
4. Shanthi Narayan, & Mittal P.K. (2010). ***A Text book of matrices***. S. Chand and company Pvt. Ltd.
5. Mittal P. K. (2007). ***Matrices***, Vrinda Publications Pvt. Ltd.

Suggested Readings:

1. Mukhopadhyay, P. (1996). ***Mathematical Statistics***, New Central Book Agency (P) Ltd., Kolkata.
2. K.B. Datta. (2007). ***Matrix and Linear Algebra***. Prentice Hall of India Pvt. Ltd.

Assessment Rubrics:

Evaluation Type		Marks
End Semester Evaluation		**70**
Continuous Evaluation		**30**
a)	Test Paper- 1	**5**
b)	Test Paper-2	**5**
c)	Assignment	**10**
d)	Seminar	**-**
e)	Book/ Article Review	-
f)	Viva-Voce	**-**
g)	Field Report/Practical	**10**
Total		**100**

SEMESTER II

B5 – DISCIPLINE SPECIFIC MINOR COURSE

KU2DSCSTA131: PROBABILITY AND RANDOM VARIABLES

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
II	MINOR	100 – 199	KU2DSCSTA131	4	60

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	-	-	30	70	100	2

Course Description: This course delves into probability theory, random variables, bivariate random variables, and correlation and regression analysis, covering topics such as definitions of probability, conditional probability, probability distributions, random variable transformations, joint and marginal probability distributions, correlation analysis, and regression analysis techniques.

Course Prerequisite: HSE level Mathematics/Statistics Courses

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will grasp the concepts of random experiments and probability, including frequency, classical, and axiomatic definitions.	U
2	Students will comprehend the definitions of discrete and continuous random variables and their probability mass and density functions.	R
3	Students will understand the concept of bivariate random variables and they will be able to compute conditional distributions and determine the independence of random variables.	A
4	Students will understand the concepts of correlation and its different types, and able to perform simple linear regression, including fitting regression lines and understanding regression coefficients.	An
5	Students will be able to apply correlation and regression analysis, probability theory, random variables, and bivariate random variables to analyse and solve real-world problems in various fields such as business, economics, and social sciences.	E

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1		✔		✔		✔	✔
CO 2			✔			✔	
CO 3	✔	✔		✔			✔
CO 4	✔			✔	✔		✔
CO 5		✔		✔		✔	

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Probability Theory**	12
	1	Random experiment, definitions of probability (frequency, classical and axiomatic) addition theorem (2 and 3 events), numerical examples	
	2	Conditional probability, multiplication theorem	
	3	Independence of events: pair wise and mutual independence	
	4	Baye's theorem and its applications	
2		**Random Variables**	12
	1	Definition - discrete and continuous random variables	
	2	Probability mass function and probability density function	
	3	Distribution function - definition and properties	
	4	Transformation of random variables - discrete and continuous	
3		**Bivariate Random Variables**	12
	1	Definition of bivariate random variable	
	2	Joint and marginal probability distributions	
	3	Conditional distributions. Independence of random variables	
4		**Correlation and Regression Analysis**	12
	1	Method of least squares - Fitting of linear and quadratic equations	
	2	Correlation analysis – Definition and different types of correlation	
	3	Methods of studying correlation: Scatter diagram, Karl Pearson	

		correlation coefficient and its properties	
	4	Simple linear regression: Fitting of regression lines, regression coefficients and their properties	
5	**Open End (Practical)**		**12**
	Numerical computation of concepts explained in Module 4 using MS Excel.		

Essential Readings:

1. Gupta, S. C. & Kapoor, V. K. (1980). ***Fundamentals of Mathematical Statistics***, Sultan Chand & Sons, New Delhi.
2. Gupta, S. C. & Kapoor, V. K. (1994). ***Fundamentals of Applied Statistics***, Sultan Chand & Sons, New Delhi.
3. Gupta, S. P. (2004). ***Statistical Methods***, Sultan Chand & Sons, New-Delhi.

Suggested Readings:

1. Mukhopadhyay, P. (1996). ***Mathematical Statistics***, New Central Book Agency (P) Ltd., Kolkata.
2. Agarwal, B. L. (2006). ***Basic Statistics***, 4th Edition, New Age International (P) Ltd., New Delhi.

Assessment Rubrics:

Evaluation Type		**Marks**
End Semester Evaluation		**70**
Continuous Evaluation		**30**
a)	Test Paper- 1	**5**
b)	Test Paper-2	**5**
c)	Assignment	**10**
d)	Seminar	**-**
e)	Book/ Article Review	-
f)	Viva-Voce	**-**
g)	Field Report/Practical	**10**
Total		**100**

SEMESTER II

B6 – DISCIPLINE SPECIFIC MINOR COURSE

KU2DSCSTA132: PROBABILITY THEORY AND BIVARIATE DATA ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
II	MINOR	100 – 199	KU2DSCSTA132	4	60

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	-	-	30	70	100	2

Course Description: This course provides a comprehensive study of probability theory, random variables, standard probability distributions, and bivariate data analysis, covering topics such as classical definition of probability, addition and multiplication laws, conditional probability, standard probability distributions including binomial, Poisson, and normal distributions, and simple correlation and regression analysis.

Course Prerequisite: HSE level Mathematics/Statistics Courses

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will gain a solid understanding of random experiments, events, and sample space, including the classical definition of probability.	U
2	Students will understand the definitions of discrete and continuous random variables and be able to compute probability mass and density functions.	R
3	Students will comprehend the properties of the binomial, Poisson, and normal distributions and they will apply these distributions to model and solve real-world problems in various fields.	An
4	Students will be able to calculate and interpret the simple correlation coefficient regression coefficients for bivariate data.	E
5	Students will apply probability theory, random variables, standard probability distributions, and bivariate data analysis techniques to	A

	analyse and solve real-world problems in various domains, such as business, economics, and social sciences.	

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔	✔		✔		✔	✔
CO 2			✔		✔		✔
CO 3		✔	✔			✔	
CO 4	✔			✔		✔	✔
CO 5	✔		✔		✔		✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Probability Theory**	**12**
	1	Random experiment, Events, sample space- classical definition of probability	
	2	Addition and multiplication laws of probability (for two events)	
	3	Conditional probability and statistical independence	
	4	Baye's theorem and its applications	
2		**Random Variables**	**12**
	1	Definition - discrete and continuous random variables	
	2	Probability mass function and probability density function	

	3	Expectation and variance (definition and simple problems only)	
3	**Standard Probability Distributions**		**12**
	1	Binomial distribution-definition, properties (statement and problems only)	
	2	Poisson distribution- definition, properties (statement and problems only)	
	3	Normal and standard normal distribution-definition, properties (statement and problems only)	
4	**Bivariate Data Analysis**		**12**
	1	Simple Correlation coefficient and properties	
	2	Spearman rank correlation coefficient (in the case of no tie)	
	3	Simple linear regression lines-equations and application	
	4	Regression coefficients and their properties	
5	**Open End (Practical)**		**12**
	Numerical computation of concepts explained in Module 4 using MS Excel.		

Essential Readings:

1. Gupta, S. C. & Kapoor, V. K. (1980). ***Fundamentals of Mathematical Statistics***, Sultan Chand & Sons, New Delhi.
2. Elhance, D.N., Veena E. and Aggarwal, B. M. (2010). ***Fundamentals of Statistics***, Kitab Mahal, Allahabad.
3. Lipschutz, S. and Schiller, J. J. (1998). ***Schaum's Outline of Theory and Problems of Introduction to Probability and Statistics***, The McGraw-Hill Companies, Inc.

Suggested Readings:

1. Biswas, D. (2012). ***Probability and Statistics***, Vol. 1, New Central Book Agency Pvt. Ltd., Kolkata.
2. Pitman, J. (1993). ***Probability***, Narosa Publishing House, New Delhi.
3. Rohatgi, V. K. (1993). ***An Introduction to Probability Theory and Mathematical Statistics***, Wiley Eastern, New Delhi.

Assessment Rubrics:

Evaluation Type		Marks
End Semester Evaluation		**70**
Continuous Evaluation		**30**
a)	Test Paper- 1	**5**
b)	Test Paper-2	**5**
c)	Assignment	**10**
d)	Seminar	**-**
e)	Book/ Article Review	-
f)	Viva-Voce	**-**
g)	Field Report/Practical	**10**
Total		**100**

SEMESTER II

B7 – DISCIPLINE SPECIFIC MINOR COURSE

KU2DSCSTA133: TIME SERIES AND INDEX NUMBERS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
II	MINOR	100 – 199	KU2DSCSTA133	4	60

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	-	-	30	70	100	2

Course Description: This course explores time series analysis, measurement of trend, index numbers, and methods of constructing index numbers, covering topics such as time series data, trend analysis techniques, index number construction, and tests of index number adequacy.

Course Prerequisite: HSE level Mathematics/Statistics Courses

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will be able to identify and explain the different components of a time series, such as trend, seasonality, cyclical variations, and irregular fluctuations.	An
2	Students will learn various methods to measure trend in time series data, including graphic methods, semi-average method, moving average method, and method of least squares in both linear and quadratic forms.	U
3	Students will understand the definition and uses of index numbers in economic and statistical analysis.	R
4	Students will learn the methods of constructing unweighted and weighted index numbers, including Laspeyres, Paasche, Dorbish and Bowley, and Fisher's methods.	A
5	Students will be able to evaluate the adequacy of index number formulas using various tests, such as unit test, time reversal test, and factor reversal test.	E

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1			✔	✔		✔	
CO 2	✔		✔		✔		✔
CO 3	✔			✔	✔		✔
CO 4		✔	✔			✔	✔
CO 5	✔		✔		✔	✔	

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Time Series Analysis**	12
	1	Time series data	
	2	Utility of time series analysis	
	3	Different components of time series	
2		**Measurement of Trend**	12
	1	Graphic method	
	2	Semi-average method	
	3	Moving average method	
	4	Method of least squares (Linear and quadratic form)	
3		**Index Numbers**	12
	1	Definition and uses of index numbers	
	2	Problems in the construction of index numbers	
	3	Limitations of index numbers	
4		**Methods of Constructing Index Numbers**	12
	1	Unweighted index numbers	
	2	Weighted index numbers: Laspeyres, Paasche, Dorbish, Bowley and Fisher's method	
	3	Test of adequacy of index numbers formulae: Unit test, time reversal test and factor reversal test	

	4	Base shifting	
5	**Open End (Practical)**		**12**
	Numerical computation of the above concepts using MS Excel.		

Essential Readings:

1. Gupta, S. P. (2021). ***Statistical Methods***, Sultan Chand & Sons, New Delhi.
2. Gupta, S. C. & Kapoor, V. K. (1994). ***Fundamentals of Applied Statistics***, Sultan Chand & Sons, New Delhi.
3. Elhance, D.N., Veena E. and Aggarwal, B. M. (2010). ***Fundamentals of Statistics***, Kitab Mahal, Allahabad.

Suggested Readings:

1. John E. Freund (1980). ***Mathematical Statistics***, Prentice Hall of India, New Delhi.
2. Gupta, S. C. &Kapoor, V. K. (1980). ***Fundamentals of Mathematical Statistics***, Sultan Chand & Sons, New Delhi.

Assessment Rubrics:

Evaluation Type		**Marks**
End Semester Evaluation		**70**
Continuous Evaluation		**30**
a)	Test Paper- 1	**5**
b)	Test Paper-2	**5**
c)	Assignment	**10**
d)	Seminar	**-**
e)	Book/ Article Review	-
f)	Viva-Voce	**-**
g)	Field Report/Practical	**10**
Total		**100**

SEMESTER II

B8 – DISCIPLINE SPECIFIC MINOR COURSE

KU2DSCSTA134: QUANTITATIVE TECHNIQUES IN DATA ANALYSIS – I

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
II	MINOR	100 – 199	KU2DSCSTA134	4	60

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	-	-	30	70	100	2

Course Description: This course offers a comprehensive study of correlation, regression analysis, time series analysis, and index numbers, covering topics such as different types of correlation, methods for studying correlation, regression types, trend measurement methods, index number construction, and tests of index number adequacy.

Course Prerequisite: HSE level Mathematics/Statistics Courses

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will understand the concept and various types of correlation and be able to apply methods such as scatter diagrams, Karl Pearson's correlation coefficient, and Spearman's rank correlation coefficient to analyse relationships between variables.	An
2	Upon completion of the course, students will be able to define regression analysis, distinguish between different types of regressions, and demonstrate proficiency in constructing regression lines and equations.	U
3	Students will acquire the skills to identify and analyze time series data, including understanding the components of time series and applying methods such as graphical, semi-average, moving average, and method of least squares for trend measurement.	R

4	By the end of the course, students will be familiar with index numbers, including their definitions, uses, construction methods, and tests of adequacy such as unit test, time reversal test, and factor reversal test.	A
5	Students will develop the ability to interpret and analyse statistical data using correlation, regression analysis, time series analysis, and index numbers to make informed decisions in various fields.	E

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔		✔		✔		✔
CO 2		✔			✔	✔	
CO 3			✔	✔		✔	✔
CO 4			✔		✔		✔
CO 5	✔	✔		✔			✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	**UNIT**	**DESCRIPTION**	**HOURS**
1	**Correlation**		**12**
	1	Meaning and various types of correlation	
	2	Methods for studying correlation – Scatter diagram, Karl Pearson's correlation coefficient	
	3	Spearman's rank correlation coefficient.	

2	**Regression Analysis**		**12**
	1	Meaning and definition	
	2	Types of regressions	
	3	Regression lines and regression equations	
	4	Properties of regression coefficients	
3	**Time Series Analysis**		**12**
	1	Definitions and components of time series	
	2	Methods for measuring trend – Graphical method and semi-average method	
	3	Moving average method and method of least squares	
4	**Index Numbers**		**12**
	1	Definition and uses of index numbers	
	2	Unweighted index numbers	
	3	Weighted index numbers: Laspeyres, Paasche, Dorbish, Bowley and Fisher's method	
	4	Test of adequacy of index numbers formulae: Unit test, time reversal test and factor reversal test	
5	**Open End (Practical)**		**12**
	Numerical computation of the above concepts using MS Excel.		

Essential Readings:

1. Gupta, S. P. (2021). ***Statistical Methods***, Sultan Chand & Sons, New Delhi.
2. Gupta, S. C. & Kapoor, V. K. (1994). ***Fundamentals of Applied Statistics***, Sultan Chand & Sons, New Delhi.
3. Elhance, D.N., Veena E. and Aggarwal, B. M. (2010). ***Fundamentals of Statistics***, Kitab Mahal, Allahabad.

Suggested Readings:

1. John E. Freund (1980). ***Mathematical Statistics***, Prentice Hall of India, New Delhi.
2. Gupta, S. C. &Kapoor, V. K. (1980). ***Fundamentals of Mathematical Statistics***, Sultan Chand & Sons, New Delhi.

Assessment Rubrics:

Evaluation Type		Marks
End Semester Evaluation		**70**
Continuous Evaluation		**30**
a)	Test Paper- 1	**5**
b)	Test Paper-2	**5**
c)	Assignment	**10**
d)	Seminar	**-**
e)	Book/ Article Review	-
f)	Viva-Voce	**-**
g)	Field Report/Practical	**10**
Total		**100**

SEMESTER III

B9 – DISCIPLINE SPECIFIC MINOR COURSE
KU3DSCSTA221: PROBABILITY DISTRIBUTIONS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
III	MINOR	200 – 299	KU3DSCSTA221	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course provides a comprehensive study of mathematical expectation, including properties, addition and multiplication theorems, moments, and extends to bivariate random variables, discrete distributions such as uniform, binomial, Poisson, and geometric, and continuous distributions like rectangular, exponential, and normal distributions.

Course Prerequisite: Foundation Courses (Level 100 – 199)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will understand the definition and properties of mathematical expectation, including linearity and additivity.	U
2	Students will be able to calculate conditional means and variances for bivariate random variables.	A
3	Students will understand various discrete probability distributions, including uniform, binomial, Poisson, and geometric distributions.	R
4	Students will learn about common continuous probability distributions, such as rectangular, exponential, and normal distributions.	R
5	Students will gain practical skills in using spreadsheets to perform calculations related to diagrams, graphs, measures of central tendency, dispersion, moments, correlation, regression, and probability.	E

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔		✔		✔	✔	
CO 2	✔		✔		✔		✔
CO 3		✔		✔		✔	
CO 4	✔		✔		✔		✔
CO 5		✔	✔		✔		✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Mathematical Expectation**	11
	1	Definition and properties of mathematical expectation	
	2	Addition and multiplication theorem on expectation	
	3	Expectation of functions of random variables	
	4	Moments - Definition of raw and central moments, relation between raw and central moments	
2		**Expectation of Bivariate Random Variables**	10
	1	Conditional mean and variance	
	2	Coefficient of correlation between random variable	
	3	Moment generating function - Definition and properties	
	4	Characteristic function -Definition and properties	
3		**Discrete Distributions**	12
	1	Uniform Distribution: Definition, mean variance and mgf, simple problems	
	2	Binomial: Definition, mean variance and mgf, simple problems	
	3	Poisson: Definition, mean variance and mgf, simple problems	
	4	Geometric: Definition, mean, variance and mgf, lack of memory property	
4		**Continuous Distributions**	12
	1	Rectangular distribution: Definition, mean variance and mgf, simple	

		problems	
	2	Exponential distribution: Definition, mean variance and mgf, simple problems	
	3	Normal distribution: Definition, mean variance and mgf, simple problems	
	4	Standard normal distribution: Definition, mean variance and mgf, simple problems	
5	**Open End (Practical)**		**30**
	Numerical computation of the above concepts.		

Essential Readings:

1. Gupta, S. C. &Kapoor, V. K. (1980). ***Fundamentals of Mathematical Statistics***, Sultan Chand & Sons, New Delhi.
2. Goon, A. M., Gupta, M. K. & Dasgupta, B. (2003). ***An Outline of Statistical Theory,*** Volume I, 4thEdn, The World Press Pvt. Ltd., Kolkata.

Suggested Readings:

1. John E. Freund (1980). ***Mathematical Statistics***, Prentice Hall of India, New Delhi.
2. Rohatgi, V. K. (1993). ***An Introduction to Probability Theory and Mathematical Statistics***, Wiley Eastern, New Delhi.
3. Mood, A. M., Graybill, F. A. & Bose, D. C. (2007). ***Introduction to the Theory of Statistics***, 3rd Edn (Reprint). Tata McGraw-Hill Publishing Company Ltd., New Delhi.

Assessment Rubrics:

Evaluation Type		Marks	Evaluation Type		Marks	Total
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER III

B10 – DISCIPLINE SPECIFIC MINOR COURSE

KU3DSCSTA222: STATISTICAL INFERENCE

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
III	MINOR	200 – 299	KU3DSCSTA222	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course covers sampling theory, sampling distributions, and statistical inference, including the types of sampling, sampling error, nonprobability and probability sampling methods, sampling distributions such as t, F, and chi-square, and statistical inference techniques like point estimation, confidence intervals, hypothesis testing, and various tests including t-tests and chi-square test.

Course Prerequisite: Foundation Courses (Level 100 – 199)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will differentiate between nonprobability sampling methods (convenient, quota, purposive) and probability sampling methods (simple random, stratified, systematic, multistage), and be able to apply these methods with examples.	An
2	Students will understand the concept of sampling distribution and its importance in statistical inference.	U
3	Students will be able to make point estimates and understand the criteria for good estimators.	R
4	Students will be able to perform hypothesis tests, including single-group t-tests, independent groups t-tests, paired t-tests, and chi-square tests for association of two attributes.	A
5	Students will develop analytical and problem-solving skills by solving various problems related to sampling theory, sampling distributions, statistical inference, and hypothesis testing.	C

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1		✔	✔		✔	✔	
CO 2		✔		✔			✔
CO 3	✔		✔		✔		✔
CO 4		✔		✔		✔	
CO 5	✔		✔		✔		✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Sampling Theory**	11
	1	Meaning and objects of sampling	
	2	Sampling Error and Bias	
	3	Types of nonprobability sampling-Convenient sampling, quota sampling, purposive sampling (methods of drawing samples with example)	
	4	Types of probability sampling- Simple random sampling, stratified random sampling, systematic sampling, multistage sampling (methods of drawing random samples with example only)	
2		**Sampling Distributions**	10
	1	Sampling distribution-meaning and definition	
	2	Important sampling distribution-t, F, chi square distributions (definition and Properties	
	3	Standard error (SE)	
3		**Statistical Inference-1**	12
	1	Point estimation, criteria of good estimators (Definition only)	
	2	Interval estimation- confidence interval for population mean using large sample (definition and problems only)	
	3	Testing of hypothesis: Null and Alternative hypothesis, simple and composite hypothesis, one tail test and two tail tests	
	4	Type I error and type II error, Level of significance, Power of the test. (definition only)	

4	**Statistical Inference-2**		**12**
	1	Single group t-test (Problems only)	
	2	Independent groups t-test (problems only)	
	3	Paired t- test (problems only)	
	4	Chi- square test for association of two attributes (problems only (2 x 2 table without Yates corrections)	
5	**Open End (Practical)**		**30**
	Numerical computation of the above concepts using MS Excel.		

Essential Readings:

1. Gupta, S. C. &Kapoor, V. K. (1980). ***Fundamentals of Mathematical Statistics***, Sultan Chand & Sons, New Delhi.
2. Goon, A. M., Gupta, M. K. & Dasgupta, B. (2003). *An Outline of Statistical Theory,* Volume I, 4thEdn, The World Press Pvt. Ltd., Kolkata.

Suggested Readings:

1. John E. Freund (1980). *Mathematical Statistics*, Prentice Hall of India, New Delhi.
2. Rohatgi, V. K. (1993). *An Introduction to Probability Theory and Mathematical Statistics*, Wiley Eastern, New Delhi.
3. Mood, A. M., Graybill, F. A. &Boes, D. C. (2007). *Introduction to the Theory of Statistics*, 3rdEdn (Reprint). Tata McGraw-Hill Publishing Company Ltd., New Delhi.

Assessment Rubrics:

Evaluation Type		Marks	Evaluation Type		Marks	Total
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER III

B11 – DISCIPLINE SPECIFIC MINOR COURSE

KU3DSCSTA223: INFERENCIAL STATISTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
III	MINOR	200 – 299	KU3DSCSTA223	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course provides a comprehensive overview of statistical estimation and hypothesis testing, covering methods such as maximum likelihood estimation and method of moments, confidence interval estimation for various parameters, hypothesis testing techniques including one and two tail tests, and tests for mean, variance, dependent samples, and chi-square tests for goodness of fit and independence of attributes.

Course Prerequisite: Foundation Courses (Level 100 – 199)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Students will understand the concept of statistical inference and the importance of point estimation, along with the desirable properties of a good estimator such as unbiasedness, consistency, efficiency, and sufficiency.	U
2	Students will be able to apply the method of maximum likelihood estimation (MLE) and the method of moments to estimate parameters in statistical models.	A
3	Students will comprehend the concept of confidence interval and be able to calculate confidence intervals for the mean, difference of means, proportion, and variance of a population using both large and small samples.	R
4	Students will learn the fundamental principles of hypothesis testing, including the formulation of null and alternative hypotheses, types of errors, significance level, power of the test, and the general steps involved in hypothesis testing.	U
5	Students will be able to conduct hypothesis tests for the mean of a population (both large and small samples), test for dependent samples (paired t-test), and chi-square tests for goodness of fit and independence of attributes, and interpret the results.	An

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔		✔	✔			✔
CO 2		✔		✔		✔	
CO 3	✔				✔		✔
CO 4		✔		✔		✔	
CO 5	✔		✔		✔		✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Statistical Estimation – I**	12
	1	Statistical inference, Point estimation, desirable properties of a good estimator (unbiasedness, consistency, efficiency and sufficiency – simple problems)	
	2	Methods of estimation – method of MLE (definition and simple problems only)	
	3	Method of estimation – method of moments	
2		**Statistical Estimation – II**	10
	1	Definition of confidence interval	
	2	Confidence interval for mean and difference of means using large and small samples (Numerical problems only)	
	3	Confidence interval for proportion of a population (Numerical problems only)	

	4	Confidence interval for the variance of a population. (Numerical problems only)	
3	**Testing of Hypothesis – I**		**11**
	1	Statistical hypothesis, Null and Alternative hypothesis, simple and composite Hypothesis, one tail test and two tail tests	
	2	Test statistic, Critical region, type I error and type II error, general steps of testing a hypothesis	
	3	Level of significance and Power of the test. Most powerful test and Neyman Pearson Lemma (Definition only)	
4	**Testing of Hypothesis – II**		**12**
	1	Test for mean of a population (Large and small samples - Numerical problems only)	
	2	Test for dependent samples (paired t-test) (Numerical problems only)	
	3	Chi-square test for goodness of fit. (Definition and Numerical problems)	
	4	Chi-square test for independence of attributes. (Definition and Numerical problems)	
5	**Open End (Practical)**		**30**
	Numerical computation of the above concepts using MS Excel.		

Essential Readings:

1. Gupta, S. C. &Kapoor, V. K. (1980). ***Fundamentals of Mathematical Statistics***, Sultan Chand & Sons, New Delhi.
2. Goon, A. M., Gupta, M. K. & Dasgupta, B. (2003). ***An Outline of Statistical Theory,*** Volume I, 4th Edn, The World Press Pvt. Ltd., Kolkata.

Suggested Readings:

1. John E. Freund (1980). ***Mathematical Statistics***, Prentice Hall of India, New Delhi.
2. Rohatgi, V. K. (1993). ***An Introduction to Probability Theory and Mathematical Statistics***, Wiley Eastern, New Delhi.
3. Mood, A. M., Graybill, F. A. &Boes, D. C. (2007). ***Introduction to the Theory of Statistics***, 3rdEdn (Reprint). Tata McGraw-Hill Publishing Company Ltd., New Delhi.

Assessment Rubrics:

Evaluation Type		Marks	Evaluation Type		Marks	Total
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

SEMESTER III

B12 – DISCIPLINE SPECIFIC MINOR COURSE

KU3DSCSTA224: QUANTITATIVE TECHNIQUES IN DATA ANALYSIS – II

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
III	MINOR	200 – 299	KU3DSCSTA224	4	75

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	-	35	65	100	2

Course Description: This course provides a comprehensive introduction to probability theory, standard probability distributions, statistical inference including interval estimation and hypothesis testing, and various statistical tests such as t-tests, chi-square tests, and non-parametric tests.

Course Prerequisite: Foundation Courses (Level 100 – 199)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Demonstrate a solid understanding of the fundamental concepts of probability, including random experiments, sample spaces, events, and the classical definition of probability.	U
2	Apply various probability theorems and methods, such as the addition theorem, conditional probability, and Bayes' theorem, to solve simple probability problems and analyse real-world scenarios.	A
3	Understand the concept and characteristics of standard probability distributions, including the binomial, Poisson, normal, and standard normal distributions, and their application in solving practical problems.	R
4	Apply statistical inference techniques, including interval estimation and hypothesis testing, to estimate population parameters, make inferences about population means and proportions, and test hypotheses using appropriate tests such as t-tests and chi-square tests.	A
5	Analyse and interpret statistical data using advanced inference methods, including the chi-square test for goodness of fit and independence of attributes, analysis of variance, and non-parametric tests, to draw meaningful conclusions from data sets with different characteristics.	An

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1		✔	✔		✔		✔
CO 2	✔		✔		✔		✔
CO 3		✔		✔		✔	
CO 4	✔		✔		✔		✔
CO 5		✔	✔		✔	✔	

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Introduction to Probability**	12
	1	Random experiment, sample space, events, classical definition of probability, permutations and combinations, numerical examples	
	2	Addition theorem of probability (for 2 events), conditional probability, multiplication theorem of probability (statement and examples only)	
	3	Baye's theorem, simple applications	
	4	Random variable, probability distribution of a random variable	
2		**Standard Probability Distributions**	12
	1	Binomial distribution – definition and examples only	
	2	Poisson distribution – definition and examples only	
	3	Normal and standard normal distribution – definition, properties and examples only	

	4	Sampling distributions – chi square, t and F distributions (definition only) and standard error	
3	**Statistical Inference – I**		**11**
	1	Interval estimation – Confidence interval for mean and proportion	
	2	Testing of hypothesis – Null and Alternative hypothesis, two types of errors, critical region, level of significance, power of a test, one-tailed and two-tailed tests, procedure for testing a given hypothesis.	
	3	Test for population mean and population proportion	
	4	Test for equality of means (t -test) and paired t-test	
4	**Statistical Inference – II**		**10**
	1	Chi-square test for goodness of fit and independence of attributes	
	2	Analysis of variance (one-way only)	
	3	Non-parametric test – Sign test, Wilcoxon signed rank test, Mann-Whitney U test (simple applications only)	
5	**Open End (Practical)**		**30**
	Numerical computation of the above concepts using MS Excel.		

Essential Readings:

1. Gupta, S. C. &Kapoor, V. K. (1980). ***Fundamentals of Mathematical Statistics***, Sultan Chand & Sons, New Delhi.
2. Goon, A. M., Gupta, M. K. & Dasgupta, B. (2003). ***An Outline of Statistical Theory,*** Volume I, 4thEdn, The World Press Pvt. Ltd., Kolkata.

Suggested Readings:

1. John E. Freund (1980). ***Mathematical Statistics***, Prentice Hall of India, New Delhi.
2. Rohatgi, V. K. (1993). ***An Introduction to Probability Theory and Mathematical Statistics***, Wiley Eastern, New Delhi.
3. Mood, A. M., Graybill, F. A. &Boes, D. C. (2007). ***Introduction to the Theory of Statistics***, 3rdEdn (Reprint). Tata McGraw-Hill Publishing Company Ltd., New Delhi.

Assessment Rubrics:

Evaluation Type		**Marks**	**Evaluation Type**		**Marks**	**Total**
Lecture		**75**	**Practical**		**25**	**100**
End Semester Evaluation		**50**	End Semester Evaluation		**15**	
Continuous Evaluation		**25**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**3**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment	**10**	c)	Assignment/ Field Report	**4**	
d)	Seminar	**-**				
e)	Book/ Article Review	-				
f)	Viva-Voce	**5**				
g)	Field Report	-				
Total		**75**			**25**	

MULTI-DISCIPLINARY COURSES

SEMESTER I

MDC1 – MULTI-DISCIPLINARY COURSE

KU1MDCSTA141: BASICS OF STATISTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
I	**MULTI-DISCIPLINARY**	100 – 199	KU1MDCSTA141	3	45

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	-	-	25	50	75	1½

Course Description: This course covers fundamental mathematical concepts such as number systems, equations, and progressions, along with an introduction to statistics including data types, measurement scales, and methods of data collection and presentation.

Course Prerequisite: HSE level Mathematics/Statistics Courses

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Understand the concepts and properties of numbers including integers, rational and irrational numbers.	U
2	Apply ratio and proportion concepts in solving real-world problems.	A
3	Demonstrate proficiency in using laws of indices and logarithms in mathematical calculations.	R
4	Solve linear and quadratic equations and apply arithmetic and geometric progressions to practical situations.	E
5	Analyse and interpret statistical data, including differentiating between quantitative and qualitative data types and understanding various measurement scales.	An

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔		✔		✔		✔
CO 2		✔	✔		✔		✔
CO 3		✔		✔			✔
CO 4	✔			✔		✔	
CO 5		✔	✔		✔	✔	

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Elementary Mathematics – I**	8
	1	Number system – Integers, rational and irrational numbers	
	2	Ratio and proportion	
	3	Laws of indices	
	4	Logarithm	
2		**Elementary Mathematics – II**	7
	1	Equations – Solution of linear and quadratic equations	
	2	Arithmetic and geometric progression	
	3	Simple and compound growth rate	
	4	Profit and loss, Market equilibrium	

3	**Introduction to Statistics**		**8**
	1	Statistics: Definition, nature and scope of statistics in various streams	
	2	Different types of data: quantitative, qualitative, geographical and chronological	
	3	Scales of measurement of data: nominal, ordinal, interval and ratio scale	
	4	Time series, cross sectional and longitudinal data	
4	**Statistical Methods**		**7**
	1	Collection of data: Primary and Secondary and their sources	
	2	Presentation of data: classification and tabulation of data	
	3	Diagrammatic Representation: Line diagram, bar diagrams and pie diagrams	
	4	Graphical presentation: Histogram, frequency polygon, frequency curve and ogives	
5	**Open End**		**15**
	Practical using MS Excel		
	History of Statistics, Data entry using MS Excel, Understanding the usage of various statistical and mathematical functions in Excel, Preparation of diagrams explained in Module 4 by Excel, Preparation and submission of a report.		

Essential Readings:

1. Gupta S. C. and Kapoor, V. K. (2002): ***Fundamentals of Mathematical Statistics***, Sultan Chand & Co.
2. Gupta S. C. (2018): ***Fundamentals of Statistics***, Himalaya Publishing House.
3. B L Agrawal (2013): ***Basic Statistics***, New Age International Publishers.
4. Yule and Kendall (1984): ***An Introduction to the Theory of Statistics***, Charles Gtiffin & Co, London.
5. Spiegel, M.R (2000): ***Theory and Problem of Statistics***, McGraw Hill, London.

Suggested Readings:

1. Mood A. M., Gray bill F. A., Bose D. C. (2007): ***Introduction to the theory of statistics*** - Tata Magraw Hill.

2. Goon A. M., Gupta M. K., Das Gupta. B. (1999): ***Fundamentals of Statistics***, Vol. I, World Press, Calcutta.
3. Croxton. F. E and Cowden. D. J (1973): ***Applied General Statistics***, Printice Hall of India.

Assessment Rubrics:

Evaluation Type		Marks
End Semester Evaluation		**50**
Continuous Evaluation		**25**
a)	Test Paper- 1	**5**
b)	Test Paper-2	**5**
c)	Assignment	**5**
d)	Seminar	**-**
e)	Book/ Article Review	-
f)	Viva-Voce	**-**
g)	Field Report/Practical	**10**
Total		**75**

SEMESTER II

MDC2 – MULTI-DISCIPLINARY COURSE

KU2MDCSTA151: INTRODUCTION TO DATA ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
II	**MULTI-DISCIPLINARY**	100 – 199	KU2MDCSTA151	3	45

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	-	-	25	50	75	1½

Course Description: This course provides a comprehensive understanding of statistical measures including central tendency, dispersion, correlation analysis, and regression analysis with practical applications and examples.

Course Prerequisite: HSE level Mathematics/Statistics Courses

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Understand and calculate various measures of central tendency including the arithmetic mean, median, mode, and quartiles, deciles, and percentiles.	U
2	Calculate and interpret measures of dispersion such as range, quartile deviation, mean deviation, standard deviation, and coefficient of variation to assess the spread of data.	R
3	Analyse relationships between variables using correlation techniques including scatter diagrams, Karl Pearson's correlation coefficient, and Spearman's rank correlation coefficient.	An
4	Apply regression analysis techniques to model relationships between variables, including understanding regression types, fitting regression lines, and interpreting regression coefficients.	A
5	Evaluate and interpret statistical summaries obtained from measures of central tendency, dispersion, correlation, and regression analysis to draw meaningful conclusions from data.	E

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔		✔			✔	✔
CO 2		✔			✔		
CO 3	✔		✔		✔		✔
CO 4		✔		✔			✔
CO 5	✔		✔		✔		✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1	**Measures of Central Tendency**		8
	1	Arithmetic mean	
	2	Median	
	3	Mode	
	4	Quartiles, Deciles and Percentiles	
2	**Measures of Dispersion**		8
	1	Range	
	2	Quartile deviation	
	3	Mean deviation	
	4	Standard deviation and coefficient of variation	
3	**Correlation Analysis**		7
	1	Definition and types of correlation	
	2	Scatter Diagram	
	3	Karl Pearson's correlation coefficient	
	4	Spearman's rank correlation coefficient (without tie)	
4	**Regression Analysis**		7
	1	Definition and types of regression	
	2	Regression lines	

	3	Fitting of regression equations, examples	
	4	Properties of regression coefficients	
5	**Open End**		**15**
	Practical using MS Excel		
	Analysis of data using concepts explained in Module 1 to 4 by Ms Excel, Preparation and submission of a report.		

Essential Readings:

1. Gupta S. C. and Kapoor, V. K. (2002): ***Fundamentals of Mathematical Statistics***, Sultan Chand & Co.
2. Gupta S. C. (2018): ***Fundamentals of Statistics***, Himalaya Publishing House.
3. B L Agrawal (2013): ***Basic Statistics***, New Age International Publishers.

Suggested Readings:

1. Mood A. M., Gray bill F. A., Bose D. C. (2007): ***Introduction to the theory of statistics*** - Tata Magraw Hill.
2. Goon A. M., Gupta M. K., Das Gupta. B. (1999): ***Fundamentals of Statistics***, Vol. I, World Press, Calcutta.

Assessment Rubrics:

Evaluation Type		**Marks**
End Semester Evaluation		**50**
Continuous Evaluation		**25**
a)	Test Paper- 1	**5**
b)	Test Paper-2	**5**
c)	Assignment	**5**
d)	Seminar	**-**
e)	Book/ Article Review	-
f)	Viva-Voce	**-**
g)	Field Report/Practical	**10**
Total		**75**

SEMESTER III

MDC3 – MULTI-DISCIPLINARY COURSE

KU3MDCSTA241: INTRODUCTION TO STATISTICAL INFERENCE

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
III	**MULTI-DISCIPLINARY**	200 – 299	KU3MDCSTA251	3	45

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	-	-	25	50	75	1½

Course Description: This course covers the foundational concepts of probability theory, including random experiments, sample spaces, permutations, combinations, and classical probability, as well as random variables, probability distributions such as binomial, Poisson, and normal distributions, and basic statistical inference techniques including estimation, hypothesis testing, and chi-square, t, and F distributions.

Course Prerequisite: Foundation Courses (Level 100 – 199)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Understand the fundamental concepts of probability theory, including random experiments, sample spaces, permutations, combinations, and classical definitions of probability.	U
2	Identify and differentiate between discrete and continuous random variables and describe their probability distributions, including properties and basic examples.	An
3	Apply probability distribution functions, including binomial, Poisson, normal, and standard normal distributions, to solve simple problems.	A
4	Demonstrate knowledge of statistical inference techniques, such as sampling distribution, point estimation, interval estimation, and hypothesis testing, including understanding the concepts of null and alternative hypotheses, critical regions, and type I and type II errors.	R

5	Utilize various statistical tests, including tests for population mean and proportion, equality of means, paired t-test, chi-square test for goodness of fit and independence, and one-way analysis of variance (ANOVA), to analyze data and draw meaningful conclusions.	E

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔			✔	✔		
CO 2	✔		✔		✔		✔
CO 3				✔	✔		✔
CO 4	✔			✔		✔	✔
CO 5		✔		✔		✔	

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Foundations of Probability**	**8**
	1	Random experiment, sample space, events, permutations and combinations	
	2	Classical definition of probability, numerical examples.	
	3	Addition theorem for two events, conditional probability, multiplication theorem of probability, simple examples	
	4	Baye's theorem and its applications	

2	**Random Variables and Probability Distributions**		**7**
	1	Definition, types of random variables – discrete and continuous	
	2	Probability mass function and probability density function, properties, simple examples	
	3	Binomial distribution and Poisson distribution (definition, properties and simple examples only)	
	4	Normal and standard normal distribution (definition, properties and simple examples only),	
3	**Statistical Inference – I**		**7**
	1	Sampling distribution and standard error, introduction to chi-square, t and F distributions	
	2	Point estimation and interval estimation (concepts only), Confidence interval for mean and proportion (one sample only)	
	3	Testing of hypothesis – Null and Alternative hypothesis, two types of errors, critical region, level of significance, power of a test	
	4	One-tailed and two-tailed tests, procedure for testing a given hypothesis	
4	**Statistical Inference – II**		**8**
	1	Test for population mean and population proportion	
	2	Test for equality of means (t -test) and paired t-test	
	3	Chi-square test for goodness of fit and independence of attributes	
	4	Analysis of variance (one-way only)	
5	**Open End**		**15**
	Practical using MS Excel		
	Analysis of data using concepts explained above by Ms Excel, Preparation and submission of a report.		

Essential Readings:

1. Gupta S. C. and Kapoor, V. K. (2002): ***Fundamentals of Mathematical Statistics***, Sultan Chand & Co.
2. Gupta S. C. (2018): ***Fundamentals of Statistics***, Himalaya Publishing House.
3. B L Agrawal (2013): ***Basic Statistics***, New Age International Publishers.

Suggested Readings:

1. Mood A. M., Gray bill F. A., Bose D. C. (2007): ***Introduction to the theory of statistics*** - Tata Magraw Hill.
2. Goon A. M., Gupta M. K., Das Gupta. B. (1999): ***Fundamentals of Statistics***, Vol. I, World Press, Calcutta.

Assessment Rubrics:

Evaluation Type		**Marks**
End Semester Evaluation		**50**
Continuous Evaluation		**25**
a)	Test Paper- 1	**5**
b)	Test Paper-2	**5**
c)	Assignment	**5**
d)	Seminar	**-**
e)	Book/ Article Review	-
f)	Viva-Voce	**-**
g)	Field Report/Practical	**10**
Total		**75**

SKILL ENHANCEMENT COURSES

SEMESTER IV

SEC1 – SKILL ENHANCEMENT COURSE

KU4SECSTA251: STATISTICAL COMPUTING AND DATA VISUALIZATION BY MS EXCEL

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
IV	**SKILL ENHANCEMENT**	200 – 299	KU4SECSTA251	3	60

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	-	25	50	75	1½

Course Description: The course provides an introduction to statistics, covering definitions, data types, collection, presentation methods, Excel operations, data representation through various charts and graphs, and summary statistics including measures of central tendency, dispersion, correlation, and regression analysis.

Course Prerequisite: Foundation Courses (Level 100 – 199)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Understand the fundamental definition and significance of statistics in various fields.	U
2	Demonstrate proficiency in differentiating and categorizing various types of data.	R
3	Acquire skills in employing data collection techniques and presenting data effectively using Excel.	U
4	Apply different methods for summarizing data, including measures of central tendency and dispersion.	A
5	Analyse and interpret data representations such as histograms, scatter plots, and pie charts, and perform basic statistical analyses like correlation and regression.	An

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔		✔	✔			✔
CO 2	✔			✔			✔
CO 3			✔		✔		
CO 4	✔		✔		✔		✔
CO 5	✔	✔		✔		✔	

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Introduction to Statistics**	7
	1	Definition of Statistics and its importance	
	2	Types of data	
	3	Data collection and presentation methods	
	4	Data summarization methods	
2		**Introduction to Excel**	7
	1	File Operations	
	2	Data operations, creating forms to enter data – concatenation of text, numbers	
	3	Splitting of data into columns, sort and reverse sort	

	4	Grouping and ungrouping of data	
3	**Data Representation**		**8**
	1	Histogram, line diagram	
	2	Box plots, scatter plots	
	3	Bar charts – stack, subdivided	
	4	Pie charts, radar graphs	
4	**Summary Statistics**		**8**
	1	Arithmetic Mean, Median, Mode	
	2	Range, Standard Deviation, Coefficient of Variation	
	3	Simple Correlation, correlation graph, rank correlation	
	4	Simple Regression	
5	**Open End**		**30**
	Practical using MS Excel		
	History of Statistics, Data entry using MS Excel, Understanding the usage of various statistical and mathematical functions in Excel, Preparation of diagrams explained in Module 4 by Excel, Preparation and submission of a report.		

Essential Readings:

1. Sarma, K. V. S. (2010). ***Statistics Made Simple: Do it Yourself on PC***, Prentice Hall India Learning Pvt. Ltd.
2. Wayne, W. L. (2019). ***Microsoft Excel: Data Analysis & Business Model***, Microsoft Press.

Suggested Readings:

1. Nelson, S. L. and Nelson, E. C. (2018). ***Microsoft data analysis for dummies***, Wiley.

2. Berk, K. N. and Carey, P. (2000), ***Data Analysis with Microsoft Excel***, S. Chand (G/L) & Company Ltd, 3/e.

Assessment Rubrics:

Evaluation Type		**Marks**	**Evaluation Type**		**Marks**	**Total**
Lecture		**50**	**Practical**		**25**	**75**
End Semester Evaluation		**35**	End Semester Evaluation		**15**	
Continuous Evaluation		**15**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**2**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment/ Viva-Voce	**5**	c)	Assignment/ Field Report	**5**	
Total		**50**			**25**	

SEMESTER V

SEC2 – SKILL ENHANCEMENT COURSE

KU5SECSTA341: INTRODUCTION TO DATA ANALYSIS USING R

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
V	**SKILL ENHANCEMENT**	300 – 399	KU5SECSTA341	3	60

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	-	25	50	75	1½

Course Description: This course provides an introduction to R as a statistical software and programming language, covering data inputting methods, descriptive statistics, probability distributions, and statistical inference techniques including hypothesis testing and interval estimation.

Course Prerequisite: Intermediate Level Courses (Level 200 – 299)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Apply R as a versatile tool for statistical analysis, programming, and graphical visualization.	A
2	Utilize various data inputting methods and data accessing techniques in R for effective data management.	R
3	Demonstrate proficiency in generating descriptive statistics, including measures of central tendency and dispersion, and interpreting them in context.	U
4	Employ R to analyse probability distributions, including understanding cumulative distribution functions and probability density functions.	An
5	Apply statistical inference techniques in R to perform hypothesis testing, conduct interval estimation, and assess the goodness of fit of data.	C

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔		✔			✔	
CO 2		✔		✔	✔		✔
CO 3	✔		✔		✔		✔
CO 4		✔		✔		✔	
CO 5	✔		✔		✔		✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Introduction to R**	7
	1	R as a calculator, statistical software and a programming language	
	2	R preliminaries, getting help, data inputting methods	
	3	Data accessing, and indexing	
	4	Graphics in R, built in functions, saving, storing and retrieving work	
2		**Descriptive Statistics**	8
	1	Diagrammatic representation of univariate and bivariate data	
	2	Measures of central tendency, partition values	
	3	measures of dispersion	
	4	Skewness and kurtosis, random sampling with and without replacement	
3		**Probability Distributions**	7
	1	R as a set of statistical tables, cumulative distribution	
	2	Probability density function	
	3	Quantile function and simulate from the distribution	
	4	Plotting probability curves for standard distributions	
4		**Statistical Inference**	8
	1	One- and two-sample tests, z-test, t-test, F-test	
	2	Chi-square test of independence and goodness of fit	

	3	Interval estimation for mean, difference of mean and variance	
	4	Tests for normality	
5	**Open End (Practical)**		**30**
	Numerical computation of the above concepts using R		

Essential Readings:

1. Gardener, D. M. (2013). ***Beginning R: The Statistical Programming Language***, John Wiley & Sons.
2. Purohit, S. G., Gore, S. D. and Deshmukh, S. R. (2008). ***Statistics Using R***, Narosa Publishing House, India.

Suggested Readings:

1. Crawley, M. J. (2012). ***The R Book***, John Wiley & Sons.

Assessment Rubrics:

Evaluation Type		**Marks**	**Evaluation Type**		**Marks**	**Total**
Lecture		**50**	**Practical**		**25**	**75**
End Semester Evaluation		**35**	End Semester Evaluation		**15**	
Continuous Evaluation		**15**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**2**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment/ Viva-Voce	**5**	c)	Assignment/ Field Report	**5**	
Total		**50**			**25**	

SEMESTER VI

SEC3 – SKILL ENHANCEMENT COURSE

KU6SECSTA351: STATISTICAL TECHNIQUES IN RESEARCH METHODOLOGY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
VI	**SKILL ENHANCEMENT**	300 – 399	KU6SECSTA351	3	60

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	-	25	50	75	1½

Course Description: This course provides a comprehensive introduction to research methodology, descriptive and inferential statistics, and regression analysis using R, equipping students with essential skills for data collection, analysis, and interpretation in various research contexts.

Course Prerequisite: Intermediate Level Courses (Level 200 – 299)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Understand the fundamental concepts and principles of research methodology, including the definition, scope, and significance of research in various fields.	U
2	Identify and select appropriate research designs based on the objectives and nature of the study, distinguishing between experimental, observational, and survey designs.	An
3	Demonstrate proficiency in data collection methods, including primary and secondary data collection techniques, and apply various sampling techniques effectively.	R
4	Apply descriptive statistical methods to analyze and interpret data, including measures of central tendency, dispersion, and graphical representations.	A
5	Apply inferential statistical techniques such as probability distributions, estimation, hypothesis testing, and non-parametric	A

	methods to make meaningful inferences from data and draw conclusions.	

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1		✔	✔		✔		
CO 2	✔			✔		✔	✔
CO 3		✔	✔		✔		✔
CO 4		✔		✔		✔	
CO 5	✔		✔		✔		✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Basics of Research Methodology**	7
	1	Introduction to Research Methodology - definition and scope of research, importance of statistical techniques in research	
	2	Research design - concept and types of research designs	
	3	Data Collection Methods – collection of primary and secondary data, sampling techniques	
	4	Data Processing and Management	
2		**Introduction to Descriptive Statistics**	8
	1	Measures of central tendency and dispersion	

	2	Data Visualization – Graphical methods and summary tables	
	3	Exploratory Data Analysis (EDA) - EDA tools and software packages	
	4	Introduction to R for Descriptive Statistics	
3	**Inferential Statistics**		**8**
	1	Probability and Probability Distributions – binomial, Poisson and normal distributions and their applications	
	2	Estimation – point estimation and interval estimation	
	3	Hypothesis Testing	
	4	Non-parametric Methods - Mann-Whitney U test, Wilcoxon signed-rank test, and Kruskal-Wallis's test	
4	**Regression Analysis and Multivariate Techniques**		**7**
	1	Simple and Multiple Linear Regression	
	2	Logistic Regression	
	3	Factor Analysis	
	4	Cluster Analysis	
5	**Open End (Internship)**		**30**
	Prepare the students to design a research project proposal by selecting an appropriate research design (experimental, observational, or survey), outlining the data collection methods (both primary and secondary), and justifying the choice of sampling technique for any research topic.		

Essential Readings:

1. Kothari, C. R. and Garg, G. (2019). ***Research Methodology – Methods and Techniques***, New Age International Publishers.
2. Keller, G. (2013). ***Statistics for Management and Economics***, South-Western College Publishing.
3. Field, A., Miles, J. and Field, Z. (2012). ***Discovering Statistics Using R***, Sage Publications Ltd.

Suggested Readings:

1. Kleinbaum, D. G., Kupper, L., Nizam, A. and Muller, K. E. (2007). ***Applied Regression Analysis and Other Multivariable Methods***, Wadsworth Publishing Co. Inc.
2. Hollander, M. and Wolfe, D. A. (1999). ***Nonparametric Statistical Methods***, Wiley-Blackwell.

Assessment Rubrics:

Evaluation Type	**Marks**	**Evaluation Type**	**Marks**	**Total**
Lecture	**50**	**Practical**	**25**	**75**
End Semester Evaluation	**35**	End Semester Evaluation	**15**	
Continuous Evaluation	**15**	Continuous Evaluation	**10**	
a) Test Paper- 1	**5**	a) Punctuality	**2**	
b) Test Paper-2	**5**	b) Skill	**3**	
c) Assignment/ Viva-Voce	**5**	c) Assignment/ Field Report	**5**	
Total	**50**		**25**	

VALUE ADDED COURSES

SEMESTER III

VAC1 – VALUE ADDED COURSE

KU3VACSTA261: DATA VISUALIZATION AND INTERPRETATION

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
III	VALUE ADDED	200 – 299	KU3VACSTA261	3	60

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	-	25	50	75	1½

Course Description: This course introduces students to fundamental concepts in data analysis including data types, scaling techniques, census and sampling methodologies, measures of central tendency and dispersion, and bivariate data analysis, emphasizing practical applications through various statistical tools and techniques.

Course Prerequisite: Foundation Courses (Level 100 – 199)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Understand and distinguish between different data types (quantitative, qualitative, time-series, and cross-sectional) and their appropriate scaling techniques.	U
2	Apply census and sampling methodologies effectively, including the collection of primary and secondary data, and utilize various graphical representations for data presentation.	A
3	Calculate and interpret measures of central tendency (mean, median, and mode) and dispersion (range, mean deviation, standard deviation) along with the coefficient of variation.	R
4	Analyse bivariate data through correlation techniques, including the	An

	understanding of different types of correlation and the application of scatter diagrams and Karl Pearson's correlation coefficient.	
5	Perform simple linear regression analysis, interpret regression coefficients, and understand the properties of regression models for predictive modelling.	E

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1	✔	✔		✔			✔
CO 2	✔		✔		✔		✔
CO 3		✔		✔		✔	
CO 4		✔		✔	✔		✔
CO 5	✔	✔				✔	

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1		**Data types and Scaling techniques**	7
	1	Concepts of population and sample	
	2	Quantitative, qualitative, time-series and cross-sectional data	
	3	Discrete and continuous data	
	4	Different types of scales: Nominal, ordinal, interval and ratio	

2	**Census and Sampling**		**8**
	1	Census and Sampling – meaning and comparison	
	2	Primary data. Secondary data – its major sources	
	3	Diagrammatic presentation- line diagram, bar diagrams and pie diagrams, pictograms, cartograms and box-plot	
	4	Frequency tables, frequency polygon, frequency curve, ogives and histogram	
3	**Measures of Central Tendency and Dispersion**		**8**
	1	Central tendency- Mean, median and mode (concept and application only)	
	2	Range, mean deviation, standard deviation (concept and application only)	
	3	Coefficient of variation	
4	**Bivariate Data Analysis**		**7**
	1	Correlation (concept and application only), types of correlation	
	2	Scatter diagram, Karl Pearson's correlation coefficient (simple examples)	
	3	Simple linear regression	
	4	Regression coefficients and its properties	
5	**Practical using MS Excel**		**30**
	Practical based on Module 2 to 4 using MS Excel. Data analysis: presentation of data – Charts and Diagrams, Frequency table, Histogram, calculation of descriptive statistics and bivariate data analysis		

Essential Readings:

1. Gupta, S. C. and Kapoor, V. K. (2014). ***Fundamentals of Mathematical Statistics***, Sultan Chand & Sons.
2. Agarwal, B. L. (2006). ***Basic Statistics***. 4th Edition, New Age international (P) Ltd., New Delhi.

3. Salkind, N. J. (2010). ***Excel Statistics: A Quick Guide***, SAGE Publication Inc. New Delhi.
4. Gupta, V. (2002). ***Statistical Analysis with Excel***, VJ Books Inc. Canada.

Suggested Readings:

1. Gupta, S. P. (2004). ***Statistical Methods***, Sultan Chand & Sons, New Delhi.
2. Remenyi, D., Onofrei, G. and English, J. (2010). ***An Introduction to Statistics Using Microsoft Excel***, Academic Publishing Ltd., UK.

Assessment Rubrics:

Evaluation Type		Marks	Evaluation Type		Marks	Total
Lecture		**50**	**Practical**		**25**	**75**
End Semester Evaluation		**35**	End Semester Evaluation		**15**	
Continuous Evaluation		**15**	Continuous Evaluation		**10**	
a)	Test Paper- 1	**5**	a)	Punctuality	**2**	
b)	Test Paper-2	**5**	b)	Skill	**3**	
c)	Assignment/ Viva-Voce	**5**	c)	Assignment/ Field Report	**5**	
Total		**50**			**25**	

SEMESTER IV

VAC2 – VALUE ADDED COURSE

KU4VACSTA361: BIG DATA ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
IV	VALUE ADDED	200 – 299	KU4VACSTA361	3	45

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	-	-	25	50	75	1½

Course Description: This course provides a comprehensive introduction to big data, covering its sources, characteristics, analytics techniques, important software tools such as Apache Hadoop and Spark, and the integration of artificial intelligence, offering insights into its historical development, industry applications, and future prospects.

Course Prerequisite: Foundation Courses (Level 100 – 199)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Demonstrate a comprehensive understanding of big data, including its definition, sources, historical development, and the characteristics that define it (volume, velocity, variety, veracity, and value).	U
2	Analyse and differentiate between various types of big data analytics, including descriptive, diagnostic, predictive, and prescriptive analytics, and understand the advantages and applications of each.	An
3	Utilize important software tools for big data analysis such as Apache Hadoop, Apache Spark, and cloud-based platforms like AWS EMR, Google Cloud Dataproc, Microsoft Azure HDInsight, Databricks, and Tableau, to process and analyse large datasets effectively.	R
4	Evaluate the role of artificial intelligence in the modern world, including its scope, historical context, and diverse applications across different industries.	E
5	Apply knowledge of big data analytics and artificial intelligence to real-life scenarios, identifying specific areas where these technologies can be effectively utilized for problem-solving and decision-making.	A

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1		✔			✔		✔
CO 2	✔		✔			✔	✔
CO 3	✔		✔		✔		
CO 4		✔	✔			✔	
CO 5	✔			✔	✔		✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1	**Introduction to Big Data**		10
	1	Introduction to big data, meaning of big data	
	2	Sources and historical development of big data	
	3	Structured and unstructured data, semi structured data	
	4	Elements of big data- volume, velocity, variety, veracity and value	
2	**Basic Concepts of Big Data Analytics**		15
	1	Main types of business analytics: descriptive, diagnostic, predictive and prescriptive	
	2	Machine learning, natural language processing, graph analytics, distributed computing, data mining	
	3	Advantage of big data analytics	

	4	Fields of application of big data analytics and their uses	
3	**Important Software Tools for Big Data Analysis**		**15**
	1	Apache Hadoop, Apache Spark	
	2	Hortonworks Data Platform (HDP) / Cloudera Data Platform (CDP)	
	3	AWS EMR, Google cloud Dataproc, Microsoft Azure HDInsight, Databricks, Tableau	
	4	Uses of big data analysis in industry	
4	**Artificial Intelligence**		**5**
	1	Artificial intelligence – meaning and scope	
	2	Importance of AI in modern world	
	3	History of artificial intelligence	
	4	Areas of application in real life	

Essential Readings:

1. Alex, B. and Smith, S. J. (1997). ***Data Warehousing, Data Mining, and OLAP***, McGraw-Hill Education, Inc.
2. Han, J. and Micheline, K. (2006). ***Data mining: concepts and techniques***, Morgan Kaufmann.
3. Cielen, D., Meysman, A., and Ali, M. (2016). ***Introducing Data Science: Big data, machine learning, and more, using Python tools***, Dreamtech Press.

Suggested Readings:

1. Berthold, M. and Hand, D. J. (2007). ***Intelligent Data Analysis***, Springer.
2. Liebowitz, J. (2013). ***Big Data and Business Analytics***, Auerbach Publications, CRC Press.

Assessment Rubrics:

Evaluation Type		Marks
End Semester Evaluation		**50**
Continuous Evaluation		**25**
a)	Test Paper- 1	**5**
b)	Test Paper-2	**5**
c)	Assignment	**10**
d)	Seminar	**-**
e)	Book/ Article Review	-
f)	Viva-Voce	**5**
g)	Field Report	-
Total		**75**

SEMESTER IV

VAC3 – VALUE ADDED COURSE

KU4VACSTA362: STUDY DESIGN IN RESEARCH

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
IV	VALUE ADDED	200 – 299	KU4VACSTA362	3	45

Learning Approach (Hours/Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	-	-	25	50	75	1½

Course Description: This course provides a comprehensive understanding of study design fundamentals, including observational and intervention studies, cohort studies, cross-sectional studies, case-control studies, basic inferential techniques for both quantitative and categorical variables, and parametric and non-parametric data analysis methods.

Course Prerequisite: Foundation Courses (Level 100 – 199)

Course Outcomes:

CO No.	Expected Outcome	Learning Domains
1	Understand the fundamentals of study design, including the distinction between observational and intervention studies, and the characteristics of cohort studies, cross-sectional studies, and case-control studies.	U
2	Apply knowledge of tables, charts, and data analysis techniques to effectively communicate and interpret research findings, identifying study types and drawing appropriate conclusions.	A
3	Recognize and develop scenarios for various case studies, demonstrating an understanding of when different study designs are appropriate.	C
4	Apply descriptive techniques for quantitative variables, such as the five-number summary, quantiles, and measures of spread, to summarize and analyse data effectively.	A
5	Utilize inferential techniques for both categorical and non-categorical variables, including hypothesis testing for means, proportions, and medians, as well as parametric and non-parametric methods for data analysis.	R

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)

Mapping of Course Outcomes to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO 1		✔	✔		✔		✔
CO 2		✔		✔		✔	
CO 3	✔		✔		✔		✔
CO 4		✔		✔		✔	
CO 5	✔		✔		✔		✔

COURSE CONTENTS

Contents for Classroom Transaction:

MODULE	UNIT	DESCRIPTION	HOURS
1	**Fundamentals of study design – I**		12
	1	Introduction to study design	
	2	Main classes: observational studies and intervention studies	
	3	Cohort studies, cross-sectional studies and case control studies	
	4	Types of variables (qualitative, quantitative and hierarchy type)	
2	**Fundamentals of study design – II**		13
	1	Tables and charts (tables in charts, diagrams in reports)	
	2	Data Analysis (includes basic problems on identification of study type and conclusion)	
	3	Develop situations where each case study arises	

3	**Basic Inferential Techniques**		**10**
	1	Descriptive techniques for quantitative variables (The five number summary, Quantiles, the two number summary, summary statistics of spread, assessing symmetry, investigating shape)	
	2	Inferential technique for categorical variables (contingency tables, binary variables: proportion and percentages, comparing two proportions or percentages)	
4	**Inferential techniques of parametric and non- parametric data**		**10**
	1	Inference about mean (checking normality, inference for a single mean, comparing two means, paired data)	
	2	Basic Inferential techniques for non-normal data (Transformations, nonparametric tests, confidence interval for medians)	

Essential Readings:

1. Aggarwal, N. (2010). ***Essentials of Biostatistics***, Peepee Publishers and Distributors (P) Ltd, Delhi.
2. Kothari, C. R. and Garg, G. (2019). ***Research Methodology: Methods and Techniques***, New Age International Publishers.
3. Woodward, M. (2014). ***Epidemiology: Study Design and Data Analysis***, Chapman & Hall/CRC.

Suggested Readings:

1. Mahajan, B. K. (1997). ***Methods in Bio Statistics: For Medical Students and Research Workers***, Jaypee Brothers Medical Publishers (P) Ltd.

Assessment Rubrics:

Evaluation Type		Marks
End Semester Evaluation		**50**
Continuous Evaluation		**25**
a)	Test Paper- 1	**5**
b)	Test Paper-2	**5**
c)	Assignment	**10**
d)	Seminar	**-**
e)	Book/ Article Review	-
f)	Viva-Voce	**5**
g)	Field Report	-
Total		**75**