THE MAHATMA GANDHI UNIVERSITY

UNDERGRADUATE PROGRAMMES

(HONOURS) SYLLABUS

MGU-UGP (Honours)

(2024 Admission Onwards)

Faculty: Science

BoS: Statistics

Programme: Bachelor of Science (Honours) Statistics

Mahatma Gandhi University
Priyadarshini Hills
Kottayam – 686560, Kerala, India

Contents

Preface

The syllabus is designed in accordance with the guidelines of the New Education Policy to facilitate the progressive implementation of a four-year undergraduate program across colleges affiliated with Mahatma Gandhi University. It emphasises on providing comprehensive understanding of statistical principles and methodologies, equipping the students with the analytical skills necessary to navigate today's data-driven world. Throughout this programme, the stakeholders will delve into a range of major and minor courses in Statistics. Additionally, syllabi of skill development courses, multidisciplinary courses and value addition courses are provided.

From Probability Theory to Regression Analysis, Time Series Analysis to Experimental Design, the courses included lay the groundwork for a deep understanding of Statistical Inference and its applications. As by-products, the graduates will be able to conduct real-life data analysis by critically evaluating data, drawing meaningful conclusions, and communicating statistical findings effectively. By providing courses in Biostatistics, Econometrics, Machine Learning, Artificial Intelligence etc., the syllabus provides an opportunity for a tailor learning experience to suit the career aspirations of the students.

Through hands-on projects and case studies, the student will gain valuable expertise in applying statistical methods to specific domains, preparing them for diverse roles in academia, industry and beyond. The aspirants get the chance to enhance their programming abilities with courses in Spreadsheet, R, Python, Google Looker Studio, LaTex, G*Power and Gretl, equipped with the technical process required to analyse large datasets efficiently.

Major courses cover the fundamental pillars of statistical theory and practice. Emphasis is placed on both theoretical rigour and practical relevance, ensuring tackling of real-world problems across various domains. In addition to the core curriculum, minor courses offer specialised insights into niche areas of Statistics. Beyond traditional statistical training, the contents place a strong emphasis on skill development, value addition, and multidisciplinary courses.

The courses expose students to complementary fields such as Computer Science, Economics and Psychology, fostering a holistic understanding of how Statistics intersects with other disciplines to solve complex problems.

Each student, as an aspirant embarking on this educational journey, is welcomed to approach the courses with curiosity and dedication. Statistics is not merely a subject - it is a powerful tool for understanding the world around us and driving positive change. By immersing oneself in this programme's diverse offerings and seizing every opportunity for growth, the students will emerge as a skilled Statistician ready to make a meaningful impact in whichever path they choose to pursue.

Board of Studies in Statistics (UG)

Curriculum Committee

Board of Studies in Statistics (UG)		
1	Dr. Smitha S Associate Professor, Department of Statistics Kuriakose Elias College, Mannanam, Kottayam.	Chairperson
2	Dr. Naiju M Thomas Assistant Professor, Department of Statistics St. Dominic's College, Kanjirapally.	Coordinator & Member
3	Dr. Maya T Nair Assistant Professor, Department of Statistics SVR NSS College, Vazhoor, Kottayam.	Member
4	Dr. Sindhu E S Associate Professor Department of Statistics, Kuriakose Elias College Mannanam, Kottayam.	Member
5	Dr Jeevanand E S Associate Professor, Department of Statistics U.C College, Aluva.	Member
6	Dr. Jikcey Issac Associate Professor, Department of Statistics Assumption College, Changanacherry.	Member
7	Dr. Bindu Abraham Associate Professor, Department of Statistics BPC College, Piravom.	Member
8	Nisanth A Associate Professor, Department of Statistics Payyanur College, Payyanur, Kannur.	Member
9	Dr. Lishamol Tomy Associate Professor, Department of Statistics Deva Matha College, Kuravilangad.	Member
10	Dr. Priya P Menon Associate Professor, Department of Statistics Maharaja's College, Ernakulam.	Member
Expert Committee		
1	Dr. Richu Rajesh Assistant Professor, Department of Statistics Government Victoria College, Palakkad.	External Expert
2	Dr. Nidhi P. Ramesh Assistant Professor, Department of Statistics Mar Athanasius College, Kothamangalam.	Internal Expert

Academic Committee			
1	Dr.Smitha.S	Associate Professor	Kuriakose Elias College, Mannanam
2	Dr. Naiju M Thomas	Assistant Professor	St. Dominic's College, Kanjirapally
3	Mr. C Vinayachandran	Associate Professor	Govt. College, Kottayam
4	Dr. Biju Thomas	Associate Professor	Sree Sankara College, Kalady
5	Dr. Joseph Justin Rebello	Associate Professor	Aquinas College, Edakochin
6	Dr. Jikcey Isaac	Associate Professor	Assumption College, Changanassery
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8	Dr. Maya T Nair	Assistant Professor	SVR NSS College, Vazhoor
9	Dr. Sudha V	Associate Professor	MA College, Kothamangalam
10	Dr. Sindhu E.S.	Associate Professor	Kuriakose Elias College, Mannanam
11	Dr. Stephy Thomas	Assistant Professor	BCM College Kottayam
12	Dr. Dhannya P Joseph	Assistant Professor	Kuriakose Elias College, Mannanam
13	Dr. Manu Mariam Thomas	Assistant Professor	B.K. College, Amalagiri

14	Dr. Simi Sebastian	Assistant Professor	Govt. College Kattappana
15	Dr. Nidhi P. Ramesh	Assistant Professor	MA College Kothamangalam
16	Mr. Tijo Mathews	Assistant Professor	Kuriakose Elias College, Mannanam
17	Dr. Lakshmi Priya R	Assistant Professor	Sacred Heart College, Thevara
18	Sr. Dr. Jisha Varghese	Assistant Professor	St. Thomas College, Palai
19	Ms. Mary Andrews	Assistant Professor	St. Teresas College, Ernakulam
20	Ms. Shahana P A	Assistant Professor	Cochin Arts and Science College Ernakulam
21	Ms. Bindu K.A.	Assistant Professor	Indira Gandhi College of College Arts and Science, Kothamangalam
22	Ms. Rahna Babu	Assistant Professor	St. Teresas College, Ernakulam
23	Ms. Parvathy T.S.	Assistant Professor	St. Teresas College, Ernakulam
24	Ms. Krishnakumari K	Associate Professor	SAS SNDP Yogam College, Konni
25	Dr. Lishamol Tomy	Associate Professor	Deva Matha College, Kuravilangad
26	Dr. T.M. Jacob	Associate Professor	Nirmala College, Muvattupuzha
27	Dr. Deemat C. Mathew	Assistant Professor	St Thomas College, Palai

28	Dr. James Kurian	Associate Professor	Maharaja's College, Ernakulam.
29	Dr. Maya S.S.	Associate Professor	Maharaja's College, Ernakulam.
30	Dr. S H S Dharmaja	Associate Professor	Govt. College for women, Thiruvananthapuram

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Programme Outcomes (POs)

PO1	Critical Thinking and Analytical Reasoning
PO2	Scientific Reasoning and Problem Solving
PO3	Multidisciplinary /Interdisciplinary/ Transdisciplinary Approach
PO4	Communication Skills
PO5	Leadership Skills
PO6	Social Consciousness and Responsibility
PO7	Equity, Inclusiveness and Sustainability
PO8	Moral and Ethical Reasoning
PO9	Networking and Collaborating
PO10	Lifelong Learning

Evaluation Scheme

Components	**Percentage**
Continuous Comprehensive Assessment (CCA)	30
End Semester Evaluation (ESE)	70
Total	100

Syllabus Index

Name of the Major: **STATISTICS**

Semester: 1

Course Code	Title of the Course	Type of the Course DSC, MDC, SEC etc.	Credit	Hours/ week	Hour Distribution /week			
					L	T	P	O
MG1DSCSTA100	Fundamentals of Statistics and Data Visualisation	DSC A	4	5	3		2	
MG1MDCSTA100	Statistical Data Collection	MDC	3	4	2		2	
MG1MDCSTA101	Data Analysis using Libre Calc							

L — Lecture, T — Tutorial, P — Practical/Practicum , O — Others

Semester: 2

Course Code	Title of the Course	Type of the Course DSC, MDC, SEC etc.	Credit	Hours/ week	Hour Distribution /week			
					L	T	P	O
MG2DSCSTA100	Introduction to Statistical Modelling	DSC A	4	5	3		2	
MG2MDCSTA100	Time Series Methods and their Applications	MDC	3	4	2		2	
MG2MDCSTA101	Data Analysis using JAMOVI and Introduction to R							

Semester: 3

Course Code	Title of the Course	Type of the Course DSC, MDC, SEC etc.	Credit	Hours/ week	Hour Distribution /week			
					L	T	P	O
MG3DSCSTA200	Statistical Distributions	DSC A	4	4	4			
MG3DSCSTA201	Analytical Tools for Multivariate Analysis	DSC A	4	5	3		2	
MG3DSESTA200	Statistical Techniques for Data Science and Machine Learning **(Data Analytics Specialization)**	DSE	4	5	3		2	
MG3DSESTA201	Statistical Computing using R							
MG3DSESTA202	Vital Statistics and Index Numbers							
MG3DSCSTA202	Data Analysis in Inferential Statistics using R/Python	DSC B	4	5	3		2	
MG3DSCSTA203	Statistical Research Techniques using Softwares							
MG3DSCSTA204	Business Data Analytics							
MG3MDCSTA200	Statistical Analysis of Related Data	MDC	3	3	3			
MG3MDCSTA201	Data Analysis using R and Type Setting using LaTex							
MG3VACSTA200	Applied Statistical Analysis: Ethical Data Collection, Interpretation and Decision making in Society	VAC	3	3	3			

Semester: 4

Course Code	Title of the Course	Type of the Course DSC, MDC, SEC etc.	Credit	Hours/ week	Hour Distribution /week			
					L	T	P	O
MG4DSCSTA200	Basics of Multivariate Distributions	DSC A	4	5	3		2	
MG4DSCSTA201	Statistical Inference	DSC A	4	5	3		2	
MG4DSESTA200	Data Analysis Using JAMOVI **(Data Analytics Specialization)**	DSE	4	4	4			
MG4DSESTA201	Statistical Quality Control							
MG4DSESTA202	Biostatistics							
MG4DSESTA203	Econometrics							
MG4DSCSTA202	Statistical Inference using R/Python	DSC B	4	5	3		2	
MG4DSCSTA203	Statistical Research Methods using Softwares							
MG4DSCSTA204	Statistical Modelling in Data Science							
MG4SECSTA200	Introduction to Spreadsheets and Latex Typing	SEC	3	3	3			
MG4VACSTA200	Ethical Dimensions in Statistical Machine Learning through R/Python	VAC	3	3	3			
MG4INTSTA200	Internship		2					

Semester: 5

Course Code	Title of the Course	Type of the Course DSC, MDC, SEC etc.	Credit	Hours/ week	Hour Distribution /week			
					L	T	P	O
MG5DSCSTA300	Applied Regression Analysis	DSC A	4	4	4		0	
MG5DSCSTA301	Sampling Techniques	DSC A	4	4	4		0	
MG5DSCSTA302	Introduction to Multivariate Analysis	DSC A	4	4	4		0	
MG5DSCSTA303	Basic Statistical Skills for Economics- I **(For Economics Students)**	DSC A	4	4	4		0	
MG5DSESTA300	Analytical Tools for Statistics-I	DSE	4	5	3		2	
MG5DSESTA301	Statistical Reliability Analysis							
MG5DSESTA302	Statistical Computing using Python **(Data Analytics Specialization)**	DSE	4	5	3		2	
MG5DSESTA303	Lifetime Data Analysis							
MG5SECSTA300	Data Reduction using Statistical Techniques	SEC	3	3	3		0	

Semester: 6

Course Code	Title of the Course	Type of the Course DSC, MDC, SEC etc.	Credit	Hours/ week	Hour Distribution /week			
					L	T	P	O
MG6DSCSTA300	Time Series Analysis and Forecasting	DSC A	4	4	4		0	
MG6DSCSTA301	Basic Statistical Skills for Economics- II **(For Economics Students)**	DSC A	4	4	4		0	
MG6DSESTA300	Design and Analysis of Experiments	DSE	4	5	3		2	
MG6DSESTA301	Bayesian Analysis							
MG6DSESTA302	Statistical Analysis in R and Python **(Data Analytics Specialization)**	DSE	4	5	3		2	
MG6DSESTA303	Analytical Tools for Statistics-II	DSE	4	5	3		2	
MG6SECSTA300	Analysis of Actuarial Statistics using R	SEC	3	3	3		0	
MG6VACSTA300	Categorical Data Analysis using R	VAC	3	3	3		0	

Semester: 7

Course Code	Title of the Course	Type of the Course DSC, MDC, SEC etc.	Credit	Hours/ week	Hour Distribution /week			
					L	T	P	O
MG7DCCSTA400	Measure and Probability Theory	DCC	4	4	4		0	
MG7DCCSTA401	Advanced Distribution Theory	DCC	4	4	4		0	
MG7DCCSTA402	Advanced Multivariate Distributions	DCC	4	5	3		2	
MG7DCESTA400	Statistical Machine Learning	DCE	4	4	4		0	
MG7DCESTA401	Life Science Data Analysis using R Software	DCE	4	4	4		0	
MG7DCESTA402	Applied Algorithms	DCE	4	4	4		0	
MG7DCCSTA403	Statistical Techniques for Economic Analysis -1 **(For Economics Students)**	DCC	4	4	4		0	
MG7DSESTA400	Statistical Data Documentation (Those who are opting Statistics as minor)	DSE	4	4	4		0	
MG7DSESTA401	Statistical Data Visualisation (Those who are opting Statistics as minor)	DSE	4	4	4		0	
MG7DSESTA402	Population Dynamics (Those who are opting Statistics as minor)	DSE	4	4	4		0	

Semester: 8

Course Code	Title of the Course	Type of the Course DSC, MDC, SEC etc.	Credit	Hours/ week	Hour Distribution /week			
					L	T	P	O
MG8DCCSTA400	Advanced Probability Theory and Sampling Techniques	DCC	4	5	3		2	
MG8DCCSTA401	Advanced Estimation Theory	DCC	4	5	3		2	
MG8DCESTA400	Advanced Testing Statistical Hypotheses	DCE	4	5	3		2	
MG8DCESTA401	Stochastic Processes	DCE	4	5	3		2	
MG8DCESTA402	Operations Research	DCE	4	5	3		2	
MG8DCCSTA402	Statistical Techniques for Economic Analysis-II **(For Economics Students)**	DCC	4	4	4		0	
MG8PRJSTA400	Project/ Dissertation		12					

SEMESTER 1

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Programme	**BSc (Hons) Statistics**				
Course Name	**Fundamentals of Statistics and Data Visualisation**				
Type of Course	**DSC A**				
Course Code	**MG1DSCSTA100**				
Course Level	**100**				
Course Summary	This course helps to acquire basic knowledge of various types of data, probability theory, correlation, regression and their real world applications. Additionally, spreadsheet functions are used to address numerical challenges associated with the topics discussed.				
Semester	**1**	**Credits**		**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**
		3		**1**	**75**
Pre-requisites					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	Program Outcome
1	Explain and understand the concepts of different types of data, sampling and sampling techniques.	U	1
2	Summarise data using various measures of central tendency, dispersion, skewness and kurtosis.	U	1
3	Analyse relationships between variables using scatter diagrams, correlation coefficients and regression analysis.	A, An	1

4	Develop skills in solving real- world problems through the application of regression techniques, particularly in predicting outcomes and understanding the limitations of predictions.	An, A	2, 3
5	Understand basic probability concepts including random experiments, sample space and elementary ideas of probability.	U	2
6	Apply Bayes' theorem to update probabilities based on new information and evidence.	E	1
7	Understand how statistical concepts are relevant across disciplines, fostering interdisciplinary thinking.	U	2
8	Apply using spreadsheets to illustrate and analyse statistical concepts, enhancing practical skills.	A, An	2

COURSE CONTENT

Content for Classroom Transaction (Units)

Module1	**Course Description**	**Hours**	**CO NO.**
	Data and Variables, Measures of Central Tendency, Dispersion and Moments.	**15**	
1.1	Types of data and variables: Concepts of primary data and secondary data, examples of univariate and bivariate data type, Diagrams and Graphs: Bar diagrams, pie diagram and frequency graphs.	2	1
1.2	Scales of measurements: Ordinal, nominal, ratio and interval.	2	1,7
1.3	Population and sample, Types of sampling: Non-probability and Probability sampling: Simple random sampling, systematic sampling, stratified random sampling and cluster sampling with real life examples (derivations not required).	3	2
1.4	Measures of central tendency: Arithmetic Mean (AM), Geometric Mean (GM), Harmonic Mean (HM), median and mode (examples using raw data).	3	2

1.5	Measures of dispersion: Range, Quartile Deviation (QD), Mean Deviation (MD) and Standard Deviation (SD), Coefficient of Variation (CV). (examples using raw data). Box Plot.	3	2
1.6	Moments, skewness and kurtosis with examples using raw data. (derivations not required).	2	1,2
Module 2	**Correlation and Regression**	**15**	
2.1	Correlation, scatter diagram, Karl Pearson's correlation coefficient, Spearman's rank correlation coefficient. (Only the concepts, problems and properties-without proof of the above topics).	8	3
2.2	Regression: Two types of regression lines, formula and numerical problems.	7	4,7
Module 3	**Elementary Probability Theory**	**15**	
3.1	Random experiment, sample space and event with examples.	4	5
3.2	Elementary ideas of probability: Frequency, classical and axiomatic definitions with examples.	5	5
3.3	Conditional probability, independence of events, total probability law, Bayes' theorem (without proof) with examples.	6	5,6,7
Module 4	**Problem Solving using Spreadsheets** (A practical record with minimum 5 problems has to be submitted).	**30**	
4.1	Introduction to spreadsheet	**5**	1
4.2	Using spreadsheet, solve numerical problems associated with topics covered in various modules	25	7,8
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 15 marks** Quiz, Assignments **Practical: 15 marks** Lab involvement, Practical Record,Viva voce ***Summative assessment*** **Theory: 10 marks** Written tests
	B. End Semester Evaluation (ESE) **Theory : 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12). **Practical: 35 marks** Problem solving skills: 30 marks Record: 5 marks

References:

1. Gupta, S. C. and Kapoor, V. K. (2020). Fundamentals of Mathematical Statistics, 12th Edition, Sultan Chand and Sons.
2. Gupta, S.P. (2021). Statistical Methods, 46th Edition, Sultan Chand and Sons: New Delhi.
3. Beverly J. Dretzke. (2008). Statistics with Microsoft Excel, 4th Edition, Pearson.

Suggested Readings:

1. Medhi, J. (2006). Statistical Methods, 2nd Edition, New Age International Publishers.
2. Mukhopadhyay, P. (1999). Applied Statistics, New Central Book Agency Private Limited, Kolkata.

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Programme						
Course Name	**Statistical Data Collection**					
Type of Course	**MDC**					
Course Code	**MG1MDCSTA100**					
Course Level	**100**					
Course Summary	To acquire the basic knowledge of statistical data collection and basic principles of experimental design. Also students will be able to design experiments incorporating the principles of experimentation and perform basic exploratory data analysis.					
Semester	**1**	**Credits**			**3**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		2		**1**		**60**
Pre-requisites						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Understand the characteristics of scientific research.	U	1
2	Understand different sampling schemes.	U	1
3	Describe concepts of data, methods of data collection and levels of measurements.	U	1
4	Apply a proper sampling scheme for the concerned problem.	A	2
5	Develop a research problem and formulate the research hypothesis.	C	2
6	Prepare a questionnaire for a problem.	C	2
7	Design experiments and perform basic exploratory data analysis.	A, An	2

Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)

COURSE CONTENT

Content for Classroom Transaction (Units)

	Course Description	Hours	CO. No
Module 1	**Scientific Research**	**15**	
1.1	Characteristics of scientific research: Qualitative studies, quantitative studies, longitudinal studies, experimental studies and survey studies.	2	1
1.2	Stating hypothesis or research question, concepts and constructs, units of analysis and characteristics of interest, independent and dependent variables, extraneous or confounding variables.	4	1
1.3	Concepts of statistical population and sample, complete enumeration and sampling, probability and non-probability sampling, simple random sampling and stratified random sampling (Outline only).	4	2
1.4	Primary and secondary data, different types of data: quantitative and qualitative data, continuous and discrete data, time series and cross-sectional data, methods of collection of primary data, sources of secondary data.	5	3
Module 2	**Design of Experiments**	**15**	
2.1	Levels of measurement: Nominal, ordinal, interval and ratio.	2	3
2.2	Designing a questionnaire.	2	4
2.3	Planning of experiments: Basic principles of experimental design, uniformity trials.	5	7
2.4	Completely Randomised Design (CRD), Randomised Block Design (RBD), Latin Square Design (LSD), Factorial	6	6

	experiments, Split plot experiments.(**Only the concepts and outline of the designs are needed)**		
Module 3	**Practical problems from the above topics.**	**30**	
	Develop a research problem from the relevant disciplines of the students. Formulate research hypotheses. Identify the target population, determine the variables of interest and decide the proper sampling scheme.	10	4,5,6,7
	Prepare a questionnaire for the problem in (1), collect data using it and basic Exploratory Data Analysis (EDA) using any statistical software.	10	4,5,6,7
	If experimentation is needed, design experiments incorporating the principles of experimentation and perform basic EDA using the data.	10	4,5,6,7
Module 4	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Formative assessment** **Theory: 10 marks** Quiz,Assignment **Practical: 15 marks** Lab involvement, Practical book, Viva voce **Summative assessment** **Theory: 5 Marks** written test

	B. End Semester Evaluation (ESE) **Theory : 35 marks** i) MCQ : 10 questions (10*1=10). ii) Short essay type questions: Answer any 3 questions out of 5 (3*5=15). iii) Essay type questions: Answer any 1 question out of 2 (1*10=10). **Practical: 35 marks** Problem solving skills: 35 marks

References:

1. Gupta, S.C. and Kapoor, V.K. (2007). Fundamentals of Applied Statistics, Sultan Chand and Sons.
2. Gupta, S.P. (2021). Statistical Methods, 46th Edition, Sultan Chand and Sons: New Delhi.
3. Kothari, C.R. (2014). Research methodology, Second revised edition, New Age International publishers.

Suggested Readings:

1. Mukhopadhyay, P. (2009). Theory and Methods of Survey Sampling, Second Edition, PHI Learning (P) Ltd.
2. Das, M.N. and Giri, N.C. (1994). Design and analysis of experiments, Wiley Eastern Ltd.
3. Rangaswamy, R. (2010). A textbook on Agricultural Statistics, New Age International publishers.

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Programme						
Course Name	**Data Analysis using Libre Calc**					
Type of Course	**MDC**					
Course Code	**MG1MDCSTA101**					
Course Level	**100**					
Course Summary	This comprehensive course covers fundamental spreadsheet operations, including basic calculations, data entry, and manipulation using mathematical operators and built-in functions. Students will learn data visualisation techniques using Google Looker Studio, as well as how to categorise data types and perform basic statistical analysis, including mean, median, mode, and hypothesis testing. Through hands-on exercises, participants will gain proficiency in generating frequency and cross tables, conducting t-tests and chi-square tests, and analysing correlations using both parametric and non-parametric methods. By the end of the course, students will have the skills to effectively manage and analyse data, making informed decisions based on statistical insights. **Upon completion of this course student acquires NOS1,2,3,5 of Data Analysis Associate available in NQR**					
Semester	**1**	**Credits**			**3**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		2		**1**		**60**
Pre-requisites						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Apply basic Mathematical formula in Spreadsheet	A	1
2	Analyse the information in the data using visual tools	An	2
3	Analyse the data using descriptive statistics tools in spreadsheet	An	2
4	Perform basic inference tools in the data and arrive at conclusions about populations using spreadsheet	An	1
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Sub-units)

Module 1	Course Description	Hours	CO No.
	Introduction to Spreadsheets, Data Visualization and random number generation	**15**	
1.1	Entering data into cells, importing data from other formats and exporting data into other formats, Introduction to Google spreadsheets	2	**1**
1.2	Using mathematical operators (+, -, *, /), Using built-in functions (SUM, AVERAGE, MIN, MAX)	2	**1**

1.3	Understanding cell references (relative vs. Absolute), Sorting data alphabetically or numerically or in a custom order, Filtering data based on specific criteria,	2	**1**
1.4	Removing duplicates from datasets, Formatting Spreadsheets, Data validations, conditional formatting, conditional statements and vlookup and hlookup operators	2	**1**
1.5	Types of Data based on information – Ordinal, nominal, interval, ratio scale, Introduction to various charts- histogram, Bar chart, line chart, bar chart, pie chart	2	**2**
1.6	Random number generation – uniform random numbers, generation of binomial, bernoulli, other custom discrete random numbers, exponential and Erlangian random numbers	3	**3**
1.7	Generating normal and beta random numbers using Acceptance rejection sampling	2	**3**
Module 2	**Descriptive and Inferential Statistics**	**15**	
2.1	Various Measures of central tendency and measures of dispersion and contexts of their usage	3	**3**
2.2	Pivot tables and interpretations	2	**4**
2.3	T-test (one sample, paired sample t-test, independent sample t-test) – Interpreting results, one way and two way ANOVA	3	**4**
2.4	Assumptions of t-test and verifying the assumptions	2	**4**
2.5	Chi-square test for independence, Spearman and Peasron correlation in Spreadsheet directly and without using function and interpreting results	3	**4**

2.6	Non-parametric analogues of t-test, one sample ANOVA	2	**4**
Module 3	**Practicals**	**30**	
3.1	Formatting data using spreadsheets incorporating all methods in module 1	5	**1**
3.2	Generating Random numbers from exponential, binomial, normal, beta distributions using theory discussed in module 1	6	**2**
3.3	Creating a dashboard using google vlooker and apply it in 5 real data sets	6	**2**
3.4	Applying various Data visualisation in 20 real time data and 5 generated datasets	5	**2**
3.5	Analysing 10 real data sets of size minimum 30 based on the module 2 (All descriptive statistics and test procedures should be used	8	**3, 4**
Module 4	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.

Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Formative assessment** **Theory: 10 marks** Quiz, Assignment **Practical: 15 marks** Lab involvement, Practical book, Viva voce **Summative assessment** **Theory: 5 Marks** Written test
	B. End Semester Evaluation (ESE) **Theory : 35 marks** i) MCQ : 10 questions (10*1=10). ii) Short essay type questions: Answer any 3 questions out of 5 (3*5=15). iii) Essay type questions: Answer any 1 question out of 2 (1*10=10). **Practical: 35 marks** Problem solving skills: 35 marks

References

1. Sam O A(2023), Excel Mastering Data Analysis, Visualization, and Automation for Success with Microsoft 365, SA Press,
2. D Narayana, Sharad Ranjan, and Nupur Tyagi (2023), Basic Computational Techniques For Data Analysis, Routledge
3. David Ray Anderson, Dennis J. Sweeney, Thomas Arthur Williams (2011), Essentials of Statistics for Business and Economics, West Publishing Company
4. Sheldon M. Ross(2006), Simulation, Elsevier
5. Nussbaumer Knaflic, Cole(2015), Storytelling With Data: A Data Visualization Guide For Business Professionals, Wiley.

SEMESTER 2

Mahatma Gandhi University

Kottayam

Programme	**BSc (Hons) Statistics**					
Course Name	**Introduction to Statistical Modelling**					
Type of Course	**DSC A**					
Course Code	**MG2DSCSTA100**					
Course Level	**100**					
Course Summary	To acquire the basic knowledge of theory of random variables, various probability functions and their applications. Also spreadsheet functions are used to solve numerical problems associated with the topics discussed.					
Semester	**2**	**Credits**			**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		3		**1**		**75**
Pre-requisites						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Examine major components of random variable theory and distribution theory.	U	1
2	Develop skills required to effectively understand various distributions.	S	2
3	Analyse several applications and advantages of distributions.	An	2

4	Evaluate fitting procedure of distribution and its simulation using spreadsheet.	A,E & S	2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module1	**Random Variable Theory**	**15**	
1.1	Describe univariate random variables in discrete and continuous cases.	2	1
1.2	Demonstrate probability mass function, probability density function and their properties, distribution function of a random variable: Definition and properties.	3	1
1.3	Demonstrate functions of random variable, transformations of random variable (univariate).	2	1
1.4	Describe bivariate random variable, demonstrate joint probability mass function, joint probability density function and their properties, describe joint distribution function and its properties.	4	1
1.5	Demonstrate marginal and conditional distributions (bivariate case), demonstrate independence of random variables (bivariate case).	4	1
Module 2	**Mathematical Expectation**	**15**	
2.1	Demonstrate mathematical expectation, its properties and simple problems.	4	1

2.2	Describe Arithmetic Mean (AM), Geometric Mean (GM), Harmonic Mean (HM), Mean Deviation and Variance in terms of expectation and evaluate simple problems.	5	1
2.3	Describe generating functions: Moment generating function, characteristic function, their properties and simple problems.	6	1
Module 3	**Discrete and Continuous Distributions**	**15**	
3.1	Discrete uniform distribution and Bernoulli distribution, explain binomial distribution and its properties, simple problems.	3	2
3.2	Explain Poisson distribution and its properties, simple problems. Explain geometric distribution, its characteristics and lack of memory property.	4	2
3.3	Explain continuous uniform distribution and its properties.	2	2
3.4	Explain exponential distribution, gamma distribution and their characteristics. Lack of memory property of exponential distribution.	3	2
3.5	Explain normal distribution and its properties. Discuss standard normal distribution and use of standard normal tables, problems.	3	3
Module 4	**Spreadsheet for Statistical Computing** (A practical record with minimum 10 problems has to be submitted).	**30**	
4.1	Use spreadsheet functions to solve numerical problems associated with topics covered in various modules.	30	4
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 15 marks** Quiz, Assignments **Practical: 15 marks** Lab involvement, Practical Record,Viva voce ***Summative assessment*** **Theory: 10 marks** Written tests
	B. End Semester Evaluation (ESE) **Theory : 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12). **Practical: 35 marks** Problem solving skills: 30 marks Record: 5 marks

References:

1. Mukhopadhaya, P. (1996). Mathematical Statistics. New Central Book Agency (P) Ltd., Calcutta.
2. Beverly J. Dretzke. (2008). Statistics with Microsoft Excel, Fourth Edition, Pearson.
3. Gupta, S.C. and Kapoor, V.K. (2002). Fundamentals of Mathematical Statistics. Sulthan Chand, New Delhi.

Suggested Readings:

1. Bhat, B.R., Venkata Ramana, T. and Rao Madhava, K.S. (1977). Statistics: A Beginners Text Vol-2, New Age International (P) Ltd., New Delhi.
2. Goon, A. M., Gupta, N.K., and Das Gupta, B. (1999). Fundamentals of Statistics-Vol.2. World Press, Kolkatha.
3. Rohatgi, V.K. and Saleh, A.M.E. (2001). An Introduction to Probability and Statistics. 2nd Edition. John Wiley & Sons, Inc, New York.
4. Wilks, S.S. (1964). Mathematical Statistics, John Wiley, New York.

Mahatma Gandhi University

Kottayam

Programme						
Course Name	**Time Series Methods and Their Applications**					
Type of Course	**MDC**					
Course Code	**MG2MDCSTA100**					
Course Level	**100**					
Course Summary	Introductory R programming, time series analysis and forecasting methods using statistical packages.					
Semester	**2**	**Credits**			**3**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		2		**1**		**60**
Pre-requisites						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	To critically analyse and summarise time series data.	An	1
2	To familiarise the basic concepts of time series model building and its applications.	S	2
3	Illustrate the time series models with different live data.	I	2
4	Apply R built in functions to solve numerical problems.	A	2

**Remember (K), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

Module 1	Course Description	Hours	CO No.
	Exploratory Time Series Data Analysis and Forecasting	**15**	
1.1	Introduction to time series , real world examples and applications of time series for social science in GDP, inflation etc.	3	1
1.2	Time series plots, interpretations using different tools, sampling frequency, basic assumption of time series, components of time series.	4	1
1.3	Trend spotting: Linear, rapid growth, periodic, examples of increasing variance trends over time, sample transformations.	3	1,2
1.4	White noise model, simulations of white noise models in R and examples.	3	2
1.5	Random walk model (simple examples of non-stationary model), stationary processes.	2	2
Module 2	**Correlation Analysis**	**15**	
2.1	Scatter plots, covariance and correlations.	3	3
2.2	Covariance and correlation: Log returns, autocorrelation.	3	1,3
2.3	Auto regressive model estimation and forecasting.	5	1,2,3
2.4	Introduce simulation and live data explanations with AR model.	4	2,3
Module 3	**Illustrate the concepts in Module 1 and 2 Using R.**	**30**	3

	(A practical record with minimum 5 problems has to be submitted)		
Module 4	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Formative assessment** **Theory: 10 marks** Quiz, Assignment **Practical: 15 marks** Lab involvement, Practical record, Viva voce **Summative assessment** **Theory: 5 Marks** Written test
	B. End Semester Evaluation (ESE) **Theory : 35 marks** i) MCQ : 10 questions (10*1=10). ii) Short essay type questions: Answer any 3 questions out of 5 (3*5=15). iii) Essay type questions: Answer any 1 question out of 2 (1*10=10).

	Practical: 35 marks Problem solving skills: 35 marks

References:

1. Cowpertwait, Paul, S.P., and Andrew V. Metcalfe. (2009). Introductory time series with R. Springer Science & Business Media.
2. Box, George EP, et al. (2015). Time series analysis: Forecasting and Control. John Wiley & Sons.

Suggested Readings:

1. Chatfield, Christopher. (2013). The analysis of time series: Theory and Practice. Springer.
2. Chan, Kung-Sik, and Jonathan D. Cryer. (2008). Time series analysis with applications in R. springer publication.
3. Chatfield, Chris, and Haipeng Xing. (2019).The analysis of time series: An introduction with R. CRC press.

Mahatma Gandhi University

Kottayam

Programme						
Course Name	**Data Analysis Using JAMOVI and Introduction to R**					
Type of Course	**MDC**					
Course Code	**MG2MDCSTA101**					
Course Level	**100**					
Course Summary	This course provides comprehensive training in statistical analysis using JAMOVI and Introduces R programming. Students will learn to analyse real data sets, conduct various statistical tests, and apply regression analysis using JAMOVI, enhancing their proficiency in statistical analysis for research and data-driven decision-making. **Upon completion of this course student acquires NOS1,2,3,5 of Data Analysis Associate available in NQR**					
Semester	**2**	**Credits**			**3**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		2		**1**		**60**
Pre-requisites						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No

1	Analyse the information in the data using visual tools from JAMOVI	An	1
2	Analyse the data using descriptive statistics tools in JAMOVI	An	1
3	Perform basic inference tools in the data and arrive at conclusions about populations using JAMOVI	An	1
4	Apply loops and conditional statements in R	A	2

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)**

COURSE CONTENT

Content for Classroom transaction (Sub-units)

Module 1	**Course Description**	**Hours**	**CO No.**
	Data Visualization and *Inferential Statistics* using JAMOVI	**15**	
1.1	Types of Data-Ordinal Interval, ratio, measures of central tendency – mean, median, mode, measures of dispersion – Quartile Deviation, variance, standard deviation.	3	3
1.2	Introduction to correlation and regression- simple and multiple.	3	3
1.3	Verifying the assumptions of Linear Regressions.	2	3
1.4	Logistic Regression and interpreting results.	3	3
1.5	Non-parametric analogues of t-test, one sample ANOVA	4	4

Module 2	**Introduction to R Programing**	**20**	
2.1	Introduction to R and arithmetic operations in R	4	4
2.2	IF THEN statements and FOR, WHILE loops in R and basic Programs in R	6	4
2.3	Data Frames, subsetting, filtering and other data manipulations	6	4
2.4	R Markdown	4	4
Module 3	**Practicals using JAMOVI and Basic Operations in R**	**30**	
3.1	Entering data into JAMOVI, importing data from other formats to JAMOVI	2	4
3.2	Introduction to various charts- histogram, Bar chart, line chart, bar chart, pie chart	2	3
3.3	Generating various charts using real time data	2	4
3.4	Generating frequency table and cross tables and summary measures using JAMOVI	2	4
3.5	Scatter diagram and correlation – Pearson and Spearman's Correlation in JAMOVI	2	4
3.6	Regression Analysis in Jamovi and Spreadsheet.	2	4
3.8	t-test (one sample, paired sample t-test, independent sample t-test) – Interpreting results, one way and two way ANOVA	3	4

3.9	Assumptions of t-test and verifying the assumptions	2	3
3.10	Chi-square test for independence	2	4
3.11	Non-parametric analogues of t-test, one sample ANOVA	2	4
3.12	Logistic Regression in JAMOVI	2	3
3.13	Analyse atleast 10 data sets using all the methods in 3.1- 3.12	2	1,2,3
3.14	Practicals of R	3	4
Module 4	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Formative assessment** **Theory: 10 marks** Quiz, Assignment **Practical: 15 marks** Lab involvement, Practical Record, Viva voce. **Summative assessment** **Theory: 5 Marks** Written test

	B. End Semester Evaluation (ESE) **Theory : 35 marks** i) MCQ : 10 questions (10*1=10). ii) Short essay type questions: Answer any 3 questions out of 5 (3*5=15). iii) Essay type questions: Answer any 1 question out of 2 (1*10=10). **Practical: 35 marks** Problem solving skills: 35 marks

References

1. D Narayana, Sharad Ranjan, and Nupur Tyagi (2023), Basic Computational Techniques For Data Analysis, Routledge
2. Navarro DJ and Foxcroft DR (2022). learning statistics with jamovi: a tutorial for psychology students and other beginners. (Version 0.75). DOI: 10.24384/hgc3-7p15r
3. Nussbaumer Knaflic, Cole(2015), Storytelling With Data: A Data Visualization Guide For Business Professionals, Wiley
4. Andy Field, Jeremy Miles, Zoe Field (2012) DISCOVERING STATISTICS USING R, Sage Publications

SEMESTER 3

Mahatma Gandhi University

Kottayam

Programme	**BSc (Hons) Statistics**					
Course Name	**Statistical Distributions**					
Type of Course	**DSC A**					
Course Code	**MG3DSCSTA200**					
Course Level	**200**					
Course Summary	Gain foundational knowledge in random variables, explore discrete distributions like Binomial, Poisson, Uniform and Geometric, understand continuous distributions such as Uniform, Exponential, Gamma, Beta (two types), Normal, Lognormal, Cauchy and Laplace distributions and their basic properties. Students will get an idea about sampling distributions and their inter relationships. Spreadsheet is applied for practical applications.					
Semester	**3**	**Credits**			**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		4				**60**
Pre-requisites	Level 100 knowledge of Statistics					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Understand various concepts such as probability density functions and cumulative distribution functions etc. of random variables.	U	1
2	Derive various generating functions of random variables such as moment generating functions, characteristic functions etc.	C	2

3	Find out characteristics of random variables like moments from either probability density (mass) functions or the generating functions.	E	1
4	Fitting of Binomial, Poisson and Normal distributions.	A, E & S	2
5	Derivation of the sampling distribution of sample mean and variance for a normal population.	C & S	2
6	Establish relationships between t, F and $\chi 2$ distributions.	A	1
Remember (K), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	**Hours**	**CO No.**
Module 1	**Discrete Distributions**	**15**	
1.1	Random variables: Discrete random variables, probability mass function, distribution function, change of variables.	3	1
1.2	Definition of mathematical expectation, properties, mean and variance using expectation.	2	1
1.3	Moment generating function (mgf), characteristic function, important properties.	4	2
1.4	Binomial, Poisson, uniform, geometric distributions: Mean, variance, mgf and characteristic functions, lack of memory property of geometric distribution.	3	2
1.5	Fitting of Binomial and Poisson distributions.	3	4
Module 2	**Continuous Distributions**	**15**	
2.1	Continuous random variables, probability density function, distribution function and change of variable.	2	1
2.2	Definition of mathematical expectation, properties, mean and variance using expectation. mgf, characteristic function, properties.	4	1,2

2.3	Uniform, exponential, gamma, beta (two types), Laplace distributions: Mean, variance, mgf and characteristic functions, Cauchy distribution, lack of memory property of exponential distribution.	4	2
2.4	Normal distribution, standard normal distribution, use of standard normal tables for various probability computation, properties of normal distribution, normal distribution as a limiting case of binomial and Poisson under suitable assumptions. Fitting of normal distribution. Lindeberg-Levy central limit theorem (without proof).	4	3, 4
2.5	Lognormal distribution: Definition and properties only (Derivation not required).	1	1
Module 3	**Sampling Distributions**	**15**	
3.1	Derivation of the sampling distribution of sample mean and variance for a normal population, standard errors of sample mean and sample variance.	3	5
3.2	Definition and derivation of pdf of $\chi^2$with n degrees of freedom, nature of pdf curve for different degrees of freedom, mean, variance, mgf, additive property of χ^2 distribution.	4	5
3.3	Student's t-distribution, derivation of its pdf, nature of probability curve with different degrees of freedom, mean, variance.	3	5
3.4	Snedecor's F-distribution: Derivation of pdf, nature of pdf curve with different degrees of freedom, mean, variance. Distribution of 1/F .	3	5
3.5	Relationship between t, F and χ^2 distributions.	2	6
Module 4	**Statistical Analysis Using Spreadsheet** (A record with minimum 10 problems has to be submitted).	**15**	
	1. Fitting of binomial distribution for given n and p. 2. Fitting of binomial distribution after computing mean and variance. 3. Fitting of Poisson distribution for given value of λ. 4. Fitting of Poisson distribution after computing mean. 5. Problems based on binomial distribution.	15	4

	6. Problems based on Poisson distribution 7. Fitting of normal distribution when parameters are given and not given. 8. Problems based on Normal distribution. 9. Random number generation from Binomial distribution, Poisson distribution and their histograms. 10. Random number generation from Normal distribution and its histogram.		
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 20 Marks** Quiz, Assignments, Seminar ***Summative assessment*** **Theory: 10 marks** Two written tests: 10 marks (5 marks each)
	B. Semester End Examination: (Theory based examination) **Total:70 marks** i) Short answer type questions: Answer any 10 questions out of 12 (10*3=30). ii) Short essay type questions: Answer any 4 questions out of 6 (4*7=28). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12).

References:

1. Gupta, S.C. and Kapoor, V.K. (2020). Fundamentals of Mathematical Statistics, 12th Edition. Sultan Chand & Sons, New Delhi.
2. Mood, A.M., Graybill, F.A. and Boes, D.C. (2007). Introduction to the Theory of Statistics, 3rd Edition. (Reprint). Tata McGraw-Hill Pub. Co. Ltd.
3. Beverly J. Dretzke. (2008). Statistics with Microsoft Excel, 4th Edition, Pearson.

Suggested Readings:

1. Hogg, R.V., McKean, J.W. and Craig, A.T. (2014). Introduction to Mathematical Statistics, 7th Edition, Pearson Education Publication.
2. Rohatgi, V.K. and Saleh, A.K.MD.E. (2015).An Introduction to Probability and Statistics, 3rd Edition, John Wiley & Sons Inc.
3. Johnson, N.L., Kotz, S. and Balakrishnan, N (1994).Continuous Univariate Distributions, Vol.I, 2nd Edition. John Wiley, New York.
4. Johnson, N.L., Kemp, A.W. and Kotz, S. (2005).Univariate Discrete Distributions, 3rd Edition , John Wiley, New York.

Mahatma Gandhi University

Kottayam

Programme	**BSc (Hons) Statistics**					
Course Name	**Analytical Tools for Multivariate Analysis.**					
Type of Course	**DSC A**					
Course Code	**MG3DSCSTA201**					
Course Level	**200**					
Course Summary	Students will comprehend real vectors, orthogonality and Gram-Schmidt orthogonalization process. They will also grasp the concepts of matrices, determinants, G-inverse, quadratic forms and characteristic roots. Additionally, students will gain the ability to apply this knowledge practically using R/Python software.					
Semester	**3**	**Credits**			**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		3		**1**		**75**
Pre-requisites	Level 100 knowledge of Statistics.					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Interpret vector space, linear dependence and independence of vectors, spanning vector space, projection of vectors.	U	1
2	Evaluate matrices, trace, determinant, adjoint and inverse of a matrix, product of determinants, related results.	An	1
3	Solve theory of equations, generalised inverse of matrix, quadratic forms, linear transformations.	A	2

4	Obtain the characteristic roots, characteristic vectors, and different related methods.	E	2
5	Find inner product and norm.	An	2
6	Applications of linear algebra in Statistics as the foundation to the courses like Multivariate Analysis and Linear Models.	C	3
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	**Hours**	**CO No.**
Module 1	**Real vectors**	**15**	
1.1	Real vectors (generalisation of coordinates), angle and norm of vectors, orthogonality and Gram-Schmidt orthogonalization process, Axiomatic approach and examples.	6	1
1.2	Subspaces, intersection and sum of subspaces, span of a set, linear dependence and independence, dimension and basis, dimension theorem.	5	1
1.3	Direct sum and complement subspace, orthogonal projection of a vector.	4	1
Module 2	**Matrices and Determinants**	**15**	
2.1	Algebra of matrices, theorems related to triangular, symmetric and skew symmetric matrices, idempotent matrices, orthogonal matrices and their properties.	3	2
2.2	Trace of a matrix, determinant, singular and non-singular matrices, adjoint and inverse of a matrix and related properties.	3	2
2.3	Product of determinants, rank of a matrix, row-rank, column-rank, standard theorems on ranks, rank of the sum and the product of two matrices. Rank factorization and Sylvester's Inequality.	5	2

2.4	Partitioning of matrices, determinant and inverse of partitioned matrices, elementary transformations, Echelon form and Normal form.	4	2
Module 3	**G-inverse , Quadratic forms and Characteristic roots**	**15**	
3.1	System of homogeneous and non-homogeneous linear equations, Cramer's rule, projection matrix and its applications to least square method.	3	3
3.2	Generalised inverse, Moore-Penrose inverse, quadratic forms: Classification and canonical reduction, linear transformations.	3	3
3.3	Characteristic roots and characteristic vectors, properties of characteristic roots (symmetric and general matrices).	3	4
3.4	Diagonalization of matrices, spectral decomposition, and singular value decomposition, power method, Cayley- Hamilton theorem, extrema of quadratic forms.	3	4
3.5	General concepts of inner product and norm. Applications of Linear Algebra in Statistics.	**3**	5,6
Module 4	**Practicals Using R/Python** (A practical record with minimum 10 problems has to be submitted).	**30**	
	1. Linear independence and dependence. 2. Orthogonality and Gram-Schmidt orthogonalization process. 3. Basis and Dimension 4. Basis of sum intersection and complement of subspaces. 5. Projection of vectors on a subspace 6. Determinant of a matrix. 7. Inverse of a matrix. 8. Rank and rank factorization of matrices. 9. Elementary transformations. 10. Solutions of system of linear equations. 11. Finding G-inverse of a matrix 12. Problems on quadratic forms 13. Problems related to characteristic roots and vectors. 14. Power method of finding characteristic roots.	30	3

	15. Problems related to linear transformations.		
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 15 marks** Quiz, Assignments **Practical: 15 marks** Lab involvement, Practical Record,Viva voce ***Summative assessment*** **Theory: 10 marks** Written tests
	B. End Semester Evaluation (ESE) **Theory : 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12). **Practical: 35 marks** Problem solving skills: 30 marks

	Record: 5 marks

References:

1. Shanti Narayan and Mittal, P.K. (2007). A Textbook of Matrices, S Chand & Co Ltd.
2. Mathai, A.M. (1997). Jacobians of Matrix Transformation and Functions of Matrix Arguments, World Scientific Publishing Company.
3. Lipschutz, S. and Lipson, M. (2017). Schaum's Outline of Linear Algebra , 3rd Edition, McGraw Hill Education.
4. Nick Fieller. (2021). Basics of Matrix Algebra for Statistics with R, 1st Edition, Chapman & Hall.
5. Archana Jadhav and Nandani Sakhare. (2018). Linear Algebra Using Python, Himalaya Publishing House.

Suggested Readings:

1. Hadley G.(2020). Linear Algebra, Narosa Publishing House.
2. Rao A.R. and Bhimasankaram P. (2000): Linear Algebra, 2nd Edition, Hindustan Book Agency.
3. Searle S.R. and Khuri, A.I. (2017). Matrix Algebra Useful for Statistics 2nd Edition, Wiley.
4. Rao, C.R.(2009). Linear Statistical Inference & its Applications 2nd Edition , Wiley.
5. Strang G.(2023). Introduction to Linear Algebra 6th Edition, Wellesley-Cambridge Press, U.S.

Mahatma Gandhi University

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Programme	**BSc (Hons) Statistics**				
Course Name	**Statistical Techniques for Data Science and Machine Learning (Data Analytics Specialization)**				
Type of Course	**DSE**				
Course Code	**MG3DSESTA200**				
Course Level	**200**				
Course Summary	Students will be able to navigate the realms of inferential statistics, non-parametric tests, ANOVA, machine learning and data science.				
Semester	**3**	**Credits**		**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**
		3		**1**	**75**
Pre-requisites	Level 100 knowledge of Statistics				

EXPECTED COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	Program Outcome
1	Operate parametric tests.	A	2
2	Relate non parametric tests.	An	2
3	Apply Machine learning tools in Statistics.	A	2
4	Understand the basics of Data science.	U	1
5	Conduct data analysis using R/Python.	E	2

Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module1	**Inferential Statistics, Non-Parametric Tests and ANOVA**	**15**	1
1.1	Introduction, sampling distribution: Normal and t.	3	1
1.2	Hypothesis testing: z test(One sample), t test(One sample).	3	1
1.3	Introduction, Chi-square test for goodness of fit.	3	2
1.4	Chi -square test for independence.	3	2
1.5	F test, ANOVA (one way classification)	3	2
Module 2	**Introduction to Machine Learning and its Applications**	**15**	
2.1	Introduction: Techniques of Machine Learning: Supervised learning, unsupervised learning, reinforcement learning.	4	3
2.2	Applications of machine learning, statistical tools for machine learning.	3	3
2.3	Simple linear regression (concepts and simple applications).	2	3
2.4	Multiple linear regression (concepts and simple applications).	3	3
2.5	Logistic regression (concepts and simple applications).	3	3
Module 3	**Introduction to Data Science**	**15**	
3.1	Introduction, definition.	1	4
3.2	Data Science in various fields, Examples.	2	4
3.3	Impact of data science.	2	4
3.4	Understating data: Introduction, types of data, numeric, categorical, graphical, high dimensional data.	3	4
3.5	Classification of digital data: Structured, Semi-structured, Unstructured, Example, Applications.	3	4
3.6	Sources of data: Time series data, transactional data, biological data, spatial data, social network data.	2	4
3.7	Data evolution, introduction to big data.	2	4
Module 4	**Data analysis Using R /Python** (A practical record with minimum 5 problems has to be submitted).	**30**	
4.1	Categorical data analysis.	8	5
4.2	Correlation and Regression.	12	5
4.3	Testing, ANOVA (one-way classification).	10	5
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 15 marks** Quiz, Assignments **Practical: 15 marks** Lab involvement, Practical Record,Viva voce ***Summative assessment*** **Theory: 10 marks** Written tests
	B. End Semester Evaluation (ESE) **Theory : 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12). **Practical: 35 marks** Problem solving skills: 30 marks Record: 5 marks

References:

1. Gupta, S.P. (2021). Statistical Methods. Sultan Chandand Sons: NewDelhi.
2. Gupta, S.C. and Kapoor, V.K. (2020). Fundamentals of Mathematical Statistics, Sultan Chand and Sons.
3. Sudha G. Purohit, Sharad D. Gore and Shailaja R. Deshmukh. (2019). Statistics Using R, 2nd Edition, Narosa Publishing House.

Suggested Readings:

1. Tilman M. Davies. (2016).The Book of R, A First Course in R Programming and Statistics, NoStarch Press.

2. Dirk P. Kroese, Zdravko Botev, Thomas Taimre and Radislav Vaisman ·(2019). Data Science and Machine Learning, Mathematical and Statistical Methods, CRC Press.

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Kottayam

Programme	**BSc (Hons) Statistics**				
Course Name	**Statistical Computing Using R**				
Type of Course	**DSE**				
Course Code	**MG3DSESTA201**				
Course Level	**200**				
Course Summary	Through this course, students will comprehend R software, adept at conducting descriptive statistics, handling probability distributions and gaining insights into correlation and regression.				
Semester	**3**	**Credits**		**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**
		3		**1**	**75**
Pre-requisites	Level 100 knowledge of Statistics				

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Understand various methods of data input and commands in R software.	U	1
2	Manipulate data using various commands and functions in R.	A	1
3	Analyse data using R software.	An	2
4	Apply various R graphics.	A	2
5	Evaluate various measures of central tendency, dispersion, skewness and kurtosis.	E	1

6	Fitting probability distributions using R software.	C	2
7	Generate random numbers from important probability distributions.	C	2
8	Develop correlation and regression analysis using R software.	A	3
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Introduction to Statistical Software R and Descriptive Statistics.**	**15**	
1.1	Introduction to statistical software R, data objects in R.	2	1
1.2	Manipulating vectors, matrices, lists, importing of files, data frame, Controlling Loops : For, repeat, while, if, if else etc., functions in R.	3	2
1.3	Diagrammatic and graphical representation of data: Bar diagram, histogram, pie diagram, box plot, Q-Q plot, the plot function and curve function, stem and leaf plot, scatter plot, Plot options: The plot function and curve function, multiple plots in a single graphic window.	4	4
1.4	Frequency table, measures of central tendency and dispersion.	2	5
1.5	Measures of skewness and kurtosis.	2	5
1.6	Selection of representative samples.	2	5
Module 2	**Probability Distributions Using R**	**15**	
2.1	Probability distributions, some discrete distributions: Bernoulli, binomial, Poisson, geometric and uniform, plotting of these distributions, fitting of discrete distributions.	4	6
2.2	Continuous probability distributions, some continuous distributions (Normal, exponential, rectangular), plotting of these distributions, fitting of normal distribution.	4	6

2.3	Methods for generating random numbers: Introduction, random number generation-discrete and continuous distributions in R.	4	7
2.4	Quantiles, inverse transform method, and transformation methods.	3	7
Module 3	**Correlation and Regression Analysis**	**15**	
3.1	Correlation, inference procedures for correlation coefficient, linear regression, coefficient of determination.	7	8
3.2	Simple regression, logistic regression, inference procedures for simple linear model.	8	8
Module 4	**Practical Using R** (A practical record with minimum 10 problems has to be submitted)	**30**	8
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Formative assessment** **Theory: 15 Marks** Quiz, Assignments **Practical: 15 Marks** Lab involvement, Practical Record, Viva voce **Summative assessment** **Theory: 10 Marks** Two written tests.

	B. End Semester Evaluation (ESE) **Theory : 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12). **Practical: 35 marks** Problem solving skills: 30 marks Record: 5 marks

References:

1. Purohit, S.G, Gore, S.D and Deshmukh, S.R. (2015).Statistics Using R, 2nd Edition, Narosa Publishing House.
2. W. N. Venables, D. M. Smith and the R Development Core Team (2009). An Introduction to R, 2nd Edition, Network Theory Limited.

Suggested Readings:

1. Zuur, A.F, Leno, E.N. and Meesters, E.H.W.G. (2009): Use R, Springer.
2. Rizzo, M.L. (2007). Statistical Computing with R, Chapman and Hall/CRC.
3. Dalgaard, P. (2008). Introductory Statistics with R, Springer.

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Programme	**BSc (Hons) Statistics**					
Course Name	**Vital Statistics and Index Numbers**					
Type of Course	**DSE**					
Course Code	**MG3DSESTA202**					
Course Level	**200**					
Course Summary	By combining theoretical knowledge of vital statistics, mortality and fertility measurement, population growth and index numbers with practical applications using spreadsheets. This course equips students with the skills and understanding necessary for proficient demographic analysis and decision-making in various fields.					
Semester	**3**	**Credits**			**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		3		**1**		**75**
Pre-requisites	Level 100 knowledge of Statistics.					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Understand the sources of vital statistics including census, registration, adhoc survey and hospital records.	U	1
2	Determine the measurement of mortality including Crude Death Rate, Specific Death Rate, Infant Mortality Rate and Standardised Death Rate.	U,E	2
3	Understand complete life tables and its characteristics.	U,A	1
4	Understand abridged life tables and its characteristics.	U,A	1

5	Determine the measurement of fertility including Crude Birth Rate, General Fertility Rate, Age Specific Fertility Rate, Total Fertility Rate, Gross Reproduction Rate and Net Reproduction Rate.	U,E	2
6	Obtain the measurement of population growth including Crude rates of natural increase, Pearl's vital index, Gross Reproduction Rate and Net Reproduction Rate.	An, E	2 & 3
7	Understand the concepts of index numbers including price, quantity and value indices.	U	1
8	Explain the tests for index numbers, various formulae and their comparisons.	U,A & E	2
**** Understand (U), Apply (A), Analyse (An), Evaluate (E)***			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Sources of Vital Statistics**	**15**	
1.1	Introduction and sources of collecting data on vital statistics.	6	1
1.2	Census, registration, adhoc surveys, hospital records.	9	1
Module 2	**Measurement of Mortality, Fertility and Population Growth.**	**15**	
2.1	Crude Death Rate (CDR) and Specific Death Rate (SDR), Standardised Death Rates and Infant Mortality Rate (IMR).	3	2
2.2	Complete life tables and its characteristics, Abridged life tables and its characteristics.	4	3
2.3	Crude Birth Rate, General Fertility Rate, Age-Specific Fertility Rate, Total Fertility Rate.	4	5
2.4	Crude rates of natural increase and Pearl's Vital Index,Gross Reproduction Rate (GRR) and Net Reproduction Rate (NRR).	4	6
Module 3	**Index Numbers**	**15**	

3.1	Price, Quantity and Value indices.	1	7
3.2	Construction, uses and limitations of index number.	3	7
3.3	Tests for index numbers, various formulae, and their comparisons.	4	8
3.4	Chain-index numbers.	3	7
3.5	Formulae and uses of some important indices: Consumer Price Index, wholesale price index and index of industrial production.	4	7
Module 4	**Practical Using Spreadsheet** (A practical record with minimum 10 problems has to be submitted.)	**30**	
	1. Calculate CDR and ASDR. 2. Calculate STDR by direct method. 3. Calculate STDR by indirect method.	8	2
	4. Find the missing values in the Life Table.	4	3
	5. Calculate CBR and GFR. 6. Calculate age-specific fertility rate and Total Fertility rate. 7. Calculate Gross Reproduction Rate and Net Reproduction Rate.	12	5
	8. Calculate various types of weighted index numbers. 9. Check whether the index numbers satisfy the factor reversal test and time reversal test. 10. Calculate the consumer price index.	6	7
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.

Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 15 marks** Quiz, Assignments **Practical: 15 marks** Lab involvement, Practical Record,Viva voce ***Summative assessment*** **Theory: 10 marks** Written tests
	B. End Semester Evaluation (ESE) **Theory : 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12). **Practical: 35 marks** Problem solving skills: 30 marks Record: 5 marks

References:

1. Gupta, S.C. and. Kapoor, V.K. (2018). Fundamentals of Applied Statistics, Sultan Chand & Co. New Delhi.
2. Srivastava, O.S. (1983). A Text Book of Demography, Vikas Publishing House, New Delhi.
3. Parimal Mukhopadhyay. (2005). Applied Statistics. Books & Allied (p) Ltd.

Suggested Readings:

1. Goon, A.M. Gupta, M.K. and Das Gupta, B. (2016): Fundamentals of Statistics, Vol. II, World press, Calcutta.
2. Newsholme, A. (2021). The Elements of Vital Statistics, Routledge, Taylor & Francis Group.
3. Keyfitz,N, and Beekman, J.A.(2010), Demography through Problems, 1st Edition, Springer- Verlag.
4. Jhingan, M.L., Bhatt, B.K. and Desai, J.N.(2016). Demography, 3rdEdition, Vrinda Publications (P) Ltd, Delhi.
5. Benjamin B (1960).Elements of Vital Statistics, Quadrangle Books.
6. Whipple, G.C.(2022).Vital Statistics: An Introduction to the Science of Demography, Legare Street Press.

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Programme	**BSc (Hons) Statistics**				
Course Name	**Data Analysis in Inferential Statistics Using R/Python**				
Type of Course	**DSC B**				
Course Code	**MG3DSCSTA202**				
Course Level	**200**				
Course Summary	This course covers key concepts in Statistics including sampling distribution, estimation of parameters, testing of hypothesis and non-parametric tests. Emphasis is placed on practical applications using R or Python.				
Semester	**3**	**Credits**		**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**
		3		**1**	**75**
Pre-requisites	Level 100 knowledge of Statistics.				

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	Program Outcome
1	Understand different Sampling Distributions.	U	1
2	Describe estimation and methods.	U	1
3	Relate different parametric tests in testing the hypothesis.	An	1
4	Organise different non-parametric tests in testing the hypothesis.	An	1
5	Conduct data analysis using R/Python.	E	2

Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Sampling Distributions**	**15**	
1.1	Statistic, parameter.	2	1
1.2	Distribution of sample mean and variance.	2	1
1.3	Normal distribution, Student's t-distribution.	5	1
1.4	Chi- square distribution, F distribution.	4	1
1.5	Inter-relationship between Normal, t, Chi-square and F distributions.	2	1
Module 2	**Statistical Inference**	**15**	
2.1	Estimation, point estimation and interval estimation.	2	2
2.2	Desirable properties of a good point estimator.	2	2
2.3	Methods of estimation – MLE, Method of moments.	4	2
2.4	Testing of hypothesis: Statistical test, null and alternative hypothesis, types of errors, significance level, power, critical region, p value.	3	3
2.5	Parametric test: Testing of population mean (One sample and two sample) (z test, t-test), testing of population proportion (One sample and two sample), paired t test. ANOVA(one way only).	4	3
Module 3	**Non- Parametric Tests**	**15**	
3.1	Goodness of fit, Chi-Square test(independence of attributes).	4	4
3.2	Sign test, median test.	5	4
3.3	Kruskal Wallis H test, Wilcoxon test.	6	4
Module 4	**Data Analysis using R /Python**	**30**	
4.1	Introduction to R/Python.	6	5
4.2	Categorical data analysis.	6	5
4.3	Correlation and Regression.	8	5
4.4	Testing, ANOVA (one-way classification). (A practical record with minimum 5 problems has to be submitted).	10	5
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Formative assessment** **Theory: 15 Marks** Quiz,Two Assignments (5 marks each) **Practical: 15 Marks** Lab involvement, Practical Record, Viva voce(5 marks each) **Summative assessment** **Theory: 10 Marks** Two written tests: (5 marks each)
	B. End Semester Evaluation (ESE) **Theory : 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12). **Practical: 35 marks** Problem solving skills: 30 marks Record: 5 marks

References:

1. Rohatgi V.K. and Saleh, A.K. Md.E. (2009): An Introduction to Probability andStatistics.2nd Edition. (Reprint)John Wiley andSons.
2. Gupta,S.P. (2021) Statistical Methods. Sultan Chandand Sons: NewDelhi.
3. Gupta,S.C.and Kapoor, V.K.(2020) Fundamentals of Mathematical Statistics, Sultan Chand and Sons.
4. Sudha G Purohit, Sharad D. Gore, Shailaja Deshmukh (2019) Statistics using R, 2nd Edition, Narosa Publishing House.
5. Python for Everybody: Exploring Data Using Python3, ADS 2016.

Suggested Readings:

1. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007) Introduction to the Theory of Statistics,3rd Edition., (Reprint), Tata Mc Graw-Hill Pub. Co.Ltd.
2. John E Freund, Mathematical Statistics, Pearson Edn, NewDelhi
3. Tilman M. Davies. (2016) The Book of R, A First Course in Programming and Statistics, No Starch Press.
4. Python for Data Analysis (2012)WesMc Kinney, O'REILLY.

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Programme	**BSc (Hons) Statistics**				
Course Name	**Statistical Research Techniques using Softwares**				
Type of Course	**DSC B**				
Course Code	**MG3DSCSTA203**				
Course Level	**200**				
Course Summary	This course aims to equip students with a solid foundation in Research Methodology, Statistical Testing and Data Analysis.				
Semester	**3**	**Credits**		**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**
		3		**1**	**75**
Pre-requisites	Level 100 knowledge of Statistics				

EXPECTED COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	Program Outcome
1	Understand different research methods in social science.	U	1
2	Understand the statistical testing procedures.	A	2
3	Illustrate the parametric tests.	An	2
4	Describe the non-parametric tests.	An	2
5	Conduct a Social survey and data analysis using R/Python/Spreadsheet.	E	2

**Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Introduction to Research Methodology**	**15**	
1.1	Research design, qualitative and quantitative research.	3	1
1.2	Data collection methods and sampling techniques.	3	1
1.3	Research reporting and communication: Writing Research proposal.	4	1
1.4	Apply research methods to real-world social issues.	5	1
Module 2	**Testing of hypothesis**	**10**	
2.1	Parameter, Statistic.	2	1
2.2	Statistical hypothesis: Simple and composite hypothesis, null and alternative hypothesis.	4	1
2.3	Types of Errors, significance level.	3	1
2.4	p-value, power, testing procedure.	4	1
2.5	Critical region.	2	1
Module 3	**Parametric and Non-parametric Tests**	**20**	
3.1	Large sample test: z test for single mean and equality of two means.	3	2
3.2	Small sample test: t test for single mean and equality of two means, paired t test.	5	3
3.3	ANOVA (one way only).	2	3
3.4	Non- parametric tests: Testing association of attributes using Chi square test.	2	4
3.5	Sign test, Median test, Wilcoxon ranked test-simple problems only.	6	4
3.6	Applications of statistical tests in various fields.	2	4
Module 4	**Data Analysis using R/Spreadsheet/Python** (A practical record with minimum 5 problems has to be submitted).	**30**	

4.1	Conduct a social survey and prepare a project report (Questionnaire, geographical and diagrammatic representation, analysis - Descriptive Statistics).	15	5
4.2	Statistical analysis and interpretation of a social problem by using Spreadsheet/ Python/ R programming.	15	5
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 15 marks** Quiz, Assignments **Practical: 15 marks** Lab involvement, Practical Record,Viva voce ***Summative assessment*** **Theory: 10 marks** Written tests
	B. End Semester Evaluation (ESE) **Theory : 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12).

	Practical: 35 marks Problem solving skills: 30 marks Record: 5 marks

References:

1. Rohatgi V.K. and Saleh, A.K. Md.E. (2009): An Introduction to Probability andStatistics.2nd Edn. (Reprint)John Wiley andSons.
2. Gupta,S.P. (2021) Statistical Methods. Sultan Chandand Sons: NewDelhi.
3. Gupta,S.C.and Kapoor, V.K.(2020) Fundamentals of Mathematical Statistics, Sultan Chand and Sons.
4. Sudha G Purohit, Sharad D. Gore, Shailaja Deshmukh (2019) Statistics using R, 2nd Edition, Narosa Publishing House.
5. Python for Everybody: Exploring Data Using Python3, ADS 2016.
6. Kothari, C. R. (2014)-Research-methodology-2nd-revised Edition, New age International publications.

Suggested Readings:

1. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007) Introduction to the Theory of Statistics,3rd Edition, (Reprint), Tata Mc Graw-Hill Pub. Co.Ltd.
2. John E Freund, Mathematical Statistics, Pearson Edition, NewDelhi
3. Tilman M. Davies. (2016) The Book of R, A First Course in Programming and Statistics, No Starch Press.
4. Python for Data Analysis (2012)WesMc Kinney, O'REILLY.

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Programme	**BSc (Hons) Statistics**					
Course Name	**Business Data Analytics**					
Type of Course	**DSC B**					
Course Code	**MG3DSCSTA204**					
Course Level	**200**					
Course Summary	Students will be equipped with a comprehensive set of skills ranging from handling different types of data to apply time series analysis, statistical quality control, optimization techniques and statistical software for effective data analysis.					
Semester	**3**	**Credits**			**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		3		**1**		**75**
Pre-requisites	Level 100 knowledge of Statistics					

EXPECTED COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains*	Program Outcome
1	Understand different types of data and data sources.	U	1
2	Analyze trends in time series.	A	2
3	Implement Statistical quality assurance in business.	An	2
4	Apply optimization techniques in decision-making problems.	An	2
5	Conduct a market survey and data analysis using R/Python/Spreadsheet.	E	2

Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Introduction to Different types of Data and Time series Analysis**	**15**	
1.1	Data in various fields, example.	2	1
1.2	Understating of data, types of data: numeric, categorical, graphical, high dimensional data. Classification of digital data: Structured, semi-structured, unstructured, example, applications.	3	1
1.3	Sources of data: Time series data, financial data, actuarial data, transactional data, biological data, spatial data, social and network data. Big data. Data Evolution.	3	1
1.4	Components of Time Series. Different Models.	2	2
1.5	Methods of finding components (Only Trend and Seasonal Variation- Simple average method).	3	2
1.6	Forecasting Sales and Profits (Trend Analysis).	2	2
Module 2	**Statistical Quality Assurance**	**15**	
2.1	Quality and Quality Assurance.	1	3
2.2	Methods of Quality Assurance.	1	3
2.3	Introduction to TQM and ISO 9000 standards.	1	3
2.4	Statistical Quality Control.	1	3
2.5	Acceptance Sampling for Attributes.	3	3
2.6	Single Sampling.	1	3
2.7	Double Sampling.	1	3
2.8	Multiple and Sequential Sampling Plans.	2	3
2.9	Control charts : Mean and Range charts.	4	3
Module 3	**Optimization Techniques**	**15**	
3.1	Decision Theory.	3	4
3.2	Decision making under uncertainty.	4	4
3.3	Decision making under risks.	4	4
3.4	Decision trees.	4	4
Module 4	**Data Analysis Using R/Python/Spreadsheet** (A practical record with minimum 5 problems has to be submitted).	**30**	
4.1	Conduct a market survey and prepare a project report (Questionnaire, geographical and diagrammatic representation, analysis - Descriptive Statistics) by using Spreadsheet/ Python/ R programming.	15	5

4.2	Statistical analysis and interpretation of a social problem by using Spreadsheet/ Python/ R programming.	15	5
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 15 marks** Quiz, Assignments **Practical: 15 marks** Lab involvement, Practical Record,Viva voce ***Summative assessment*** **Theory: 10 marks** Written tests

	B. End Semester Evaluation (ESE) **Theory : 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12). **Practical: 35 marks** Problem solving skills: 30 marks Record: 5 marks

References:

1. Gupta, S.P. (2021). Statistical Methods. Sultan Chandand Sons: NewDelhi.
2. Gupta, S.C. and Kapoor, V.K. (2020). Fundamentals of Mathematical Statistics, Sultan Chand and Sons.
3. Sudha G. Purohit, Sharad D. Gore and Shailaja R. Deshmukh. (2019). Statistics Using R, 2nd Edition, Narosa Publishing House.

Suggested Readings:

1. Tilman M. Davies. (2016). The Book of R, A First Course in R Programming and Statistics, No Starch Press.
2. Python for Data Analysis. (2012). Wes McKinney, O'REILLY.
3. Jason R Brigs: Python for kids- A playful introduction to programming, No Starch Press.
4. Amit Saha. (2015). Doing Math with Python, No Starch Press.

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Programme						
Course Name	**Statistical Analysis of Related Data**					
Type of Course	**MDC**					
Course Code	**MG3MDCSTA200**					
Course Level	**200**					
Course Summary	This course focuses on a fundamental aspect of data analysis and machine learning-identifying and understanding the relationships or associations between variables. The curriculum covers the exploration of relationships among variables, considering various types of data scales such as nominal, ordinal, interval and ratio. Practical applications involve leveraging the Google Looker Studio and gretl for the computation and analysis of these relationships, providing students with a comprehensive skill set to navigate and interpret data across different scales.					
Semester	**3**	**Credits**		**3**		**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		3				**45**
Pre-requisites						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No

1	Understand the basic concepts of Google Looker Studio and gretl.	U	1
2	Apply Google Looker Studio for visualising the relationship between related variables.	A	2
3	Analyze and interpret measures of associations and dependencies.	An	2
4	Utilise gretl for practical demonstration and problem-solving in association between related variables.	A	2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

Module 1	**Course Description**	**Hours**	**CO No.**
	Exploratory Time Series Data Analysis	**15**	
1.1	Google Looker Studio - Understanding the user interface, navigating through dashboards and reports, connecting to various data sources, creating charts, graphs, and tables, customising visualisations for effective communication.	8	1
1.2	Implementing filters and drill-downs in Google looker Studio and analysing real-world datasets using Google Looker Studio.	5	1
1.3	Gretl: Introduction, data entry and import, descriptive statistics and data exploration.	2	1,3
Module 2	**Correlation and Regression Analysis**	**15**	
2.1	Correlation: Definition, properties and range of correlation coefficient, invariance under linear transformation - Demonstration using gretl.	2	2,3
2.2	Importance of scatter diagram and construction of scatter diagram using Google Looker Studio.	2	1, 2
2.3	Rank correlation: Definition and examples, solving problems using gretl, illustrating the situations where Pearson	3	1,2,3

	correlation coefficient and rank correlation is used using Google Looker Studio.		
2.4	Principle of least squares: Introduction and basic problems, demonstration using Google Looker Studio.	2	1,2
2.5	Fitting of straight line and parabola using gretl with visual representation using google looker studio.	2	1,2, 3
2.6	Regression coefficients and regression lines: Basics and illustrations using gretl.	2	1,2,3
2.7	Relationship between correlation coefficient and regression coefficients and validating the relationships using data, analysis of real data for regression.	2	1,2,3
Module 3	**Statistical Analysis Using gretl**	**15**	
3.1	Categorical data: Definition, examples, frequency distributions, contingency table.	3	2,3
3.2	Visual representation of categorical data using different charts.	2	1
3.3	Chi-square test for association between variables.	2	2,3
3.4	Ordinal and logistic regression, Mantel- Haenszel test.	3	2,3
3.5	Measures of associations and dependencies - Odds Ratio, Kendall's Tau.	5	2,3
Module 4	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.

Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 15 marks** Quiz, Two Assignments(5 marks each) ***Summative assessment*** **Theory: 10 marks** Two written tests
	B. End Semester Evaluation (ESE): (Theory based examination.) **Total: 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12).

References:

1. Hurst, L. (2020). Hands On With Google Data Studio: A Data Citizen's Survival Guide. John Wiley & Sons.
2. Arnold, J. (2023). Learning Microsoft Power Bi: Transforming Data Into Insights. O'Reilly Media.

Suggested Readings:

1. Pulipati,S. and Kelly,N. (2022). Data Storytelling with Google Looker Studio: A hands-on guide to using Looker Studio for building compelling and effective dashboards
2. Lucchetti, R. and Cottrell, A. .Gretl - Gnu Regression, Econometrics and Time-series Library by Gnu Regression, Econometrics and Time-series Library, Allin Cottrell.
3. Agresti, A. (2013). Categorical Data Analysis. 3rd Edition, John Wiley & Sons Inc.

Mahatma Gandhi University

Kottayam

Programme						
Course Name	**Data Analysis Using R and Type Setting Using LaTex**					
Type of Course	**MDC**					
Course Code	**MG3MDCSTA201**					
Course Level	**200**					
Course Summary	This comprehensive course covers fundamental statistical analysis techniques, including generating frequency tables, conducting t-tests, chi-square tests, ANOVA tests, and correlation analysis. Students will also learn advanced data visualisation skills using ggplot2, delve into principles of curve fitting and linear regression models, and gain proficiency in LaTeX typesetting for creating professional documents with tables, equations, images, and bibliographies. By the end of the course, students will be equipped with essential statistical analysis tools and LaTeX formatting skills to conduct data analysis and produce high-quality research documents.					
Semester	**3**	**Credits**			**3**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		3				**45**
Pre-requisites	Basic Knowledge in R programming					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Analyse the information in the data using visual tools from R	An	1
2	Analyse the data using descriptive statistics tools in R	An	1
3	Perform basic inference tools in the data and arrive at conclusions about populations using R	A n	2
4	Understand the Basic Typesetting using Latex	U	2

Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)

COURSE CONTENT

Content for Classroom transaction (Sub-units)

Module 1	Course Description	Hours	CO No.
	Data Visualization using R	**8**	
1.1	Introduction to R and importing data into R from Other formats	3	1
1.2	Introduction to various charts and Data Visualization using ggplot2 - histogram, Bar chart, line chart, bar chart, pie chart	2	1
1.3	Generating various charts using real time data	2	1
1.4	Generating frequency table and cross tables and summary measures using R	1	1

Module 2	**Inferential Statistics and Regression Analysis using R**	**16**	
2.1	T-test (one sample, paired sample t-test, independent sample t-test) – Interpreting results, one way and two way ANOVA	4	2
2.2	Assumptions of t-test and verifying the assumptions	1	2
2.3	Non-parametric analogues of t-test, one sample ANOVA, Chi-square test for independence	4	2
2.4	Scatter diagram and correlation – Pearson and Spearman's Correlation in R	2	3
2.5	Regression Analysis in R – Linear and Multiple, Verifying the assumptions of Linear Regressions and Box Cox Transformations	3	3
2.6	Logistic Regression in R and interpreting results	2	3
Module 3	**Type Setting using Latex**	**21**	
3.1	Introduction to LaTeX and typesetting: Understand the basics of LaTeX and its role in document preparation and Learn how to customise fonts and adjust the size of text in LaTeX documents.	4	4
3.2	Explore different document classes and page styles available in LaTeX for various types of documents	3	4
3.3	Learn how to create a table of contents, index, and glossary in LaTeX for better document navigation.and Bibliography	6	4
3.4	Create lists with bullets and numbering, and format them	2	4

	effectively in LaTeX.		
3.5	Gain proficiency in creating tables, writing equations, and inserting images into LaTeX documents for comprehensive document preparation.	6	4
Module 4	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 15 marks** Quiz, Assignments ***Summative assessment*** **Theory: 10 marks** Written tests
	B. End Semester Evaluation (ESE): (Theory based examination.) **Total: 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12).

References

1. D Narayana, Sharad Ranjan, and Nupur Tyagi (2023), Basic Computational Techniques For Data Analysis, Routledge
2. Nussbaumer Knaflic, Cole(2015), Storytelling With Data: A Data Visualization Guide For Business Professionals, Wiley
3. Andy Field, Jeremy Miles, Zoe Field (2012) DISCOVERING STATISTICS USING R, Sage Publications
4. LATEX Tutorials : A PREMIER by Indian TEX Users Group, Edited by E. Krishnan, 2003. A free PDF document from the URL https://www.tug.org/twg/mactex/tutorials/ltxprimer-1.0.pdf
5. LATEX , a Document Preparation System by Leslie Lamport (second edition, Addison Wesley, 1994)
6. Hadley Wickham and Garrett Grolemund , R for Data Science

Mahatma Gandhi University

Kottayam

Programme	**STATISTICS**				
Course Name	**Applied Statistical Analysis: Ethical Data Collection, Interpretation and Decision making in Society.**				
Type of Course	**VAC**				
Course Code	**MG3VACSTA200**				
Course Level	**200**				
Course Summary	Students will critically assess ethical implications in statistical analysis, communicate findings responsibly and synthesise information to make ethical decisions based on statistical outcomes. They will assess the reliability of statistical inferences in societal scenarios considering both the statistical significance and ethical implications of their findings.				
Semester	**3**	**Credits**		**3**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**
		3			**45**
Pre-requisites	Level 100 knowledge of Statistics.				

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No

1	Demonstrate various data collection methods, sampling strategies, and statistical tools used for organising, summarising, and visualising data in societal contexts.	A	1
2	Apply statistical techniques such as hypothesis testing, correlation and regression analysis to real-world data.	A	2
3	Evaluate ethical considerations in data collection, statistical analysis and interpretation of results in societal contexts using statistical software packages.	E	8
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Sampling, Data Collection, Organizing and Summarizing Data: Case study based on a relevant topic taken from society**	**15**	
1.1	Nature of data, sampling strategies, questionnaire designing, data collection (primary/secondary) interview- designing, conduct and ethics.	3	1,3
1.2	Classification of data, tabulation of data and scaling of data.	2	1
1.3	Measures of central tendency (mean, median, mode), Measure of dispersion (Standard deviation).	3	1
1.4	Visualisation of data: Histogram, frequency polygon and ogives.	2	1
1.5	Concepts of correlation and regression.	2	1
1.6	Theory of attributes: Introduction, independence of attributes, criterion of independence, association of attributes, Yule's coefficient of association, coefficient of colligation.	3	1

Module 2	**Tests of Significance**	**15**	
2.1	Parameter, statistic, statistical inference, null and alternative hypotheses, level of significance, p-value, large sample tests for single mean, difference of means and test for proportion (one sample and two samples).	6	2
2.2	Small sample tests-t test of significance for single mean, difference in means, paired t - test for related samples.	5	2
2.3	Chi square test for independence of attributes.	4	2
Module 3	**Analysis using Statistical Software.**	**15**	
3.1	Working with real life data using statistical software packages, Introduction to R and R commander and its application. : Defining variables: Numeric and String Variables Assigning names and labels to variables and values - Entering Data.	5	1,2,3
3.2	Summary Statistics: Frequencies, Descriptive Statistics: Means, Crosstab, Graphs, Histograms and Bar charts, Scatter diagram, Pie diagram, Bivariate correlation - Linear regression.	3	1
3.3	Inferential Statistics: Statistical Tests: Testing a mean, t-test for a mean, two sample Z test for Means- Two sample t-test for means, Paired t- test, Chi-square test for independence of attributes.	4	2,3
3.4	Ethical theories and principles in data science, Group discussions on ethical frameworks and their application in data analysis.	3	3
Module 4	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.

Assessment Types	MODE OF ASSESSMENT
	A. Continuous Comprehensive Assessment (CCA) ***Formative assessment*** **Theory: 15 marks** Quiz, Assignments ***Summative assessment*** **Theory: 10 marks** Two written tests.
	B. End Semester Examination(ESE) **Total: 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12).

References:

1. Powers, Daniel, and Yu Xie. (2008) Statistical methods for categorical data analysis. Emerald Group Publishing.
2. Kapoor, V.K. and Gupta, S.C. (2020): Fundamentals of Mathematical Statistics,Sultan Chand & Sons, New Delhi.
3. Fox, J. (2005). The R Commander: A basic-statistics graphical user interface to R. Journal of Statistical Software,19(9):1–42.

Suggested Readings:

1. Davis, K.(2012) Ethics of Big Data: Balancing risk and innovation. " O'Reilly Media, Inc."
2. Chiang, Chin Long.(2003) Statistical methods of analysis. World Scientific.
3. Fox, J. (2007).Extending the R Commander by “plug-in” packages. R News,7(3):46–52.

SEMESTER 4

Mahatma Gandhi University

Kottayam

Programme	**BSc (Hons) Statistics**				
Course Name	**Basics of Multivariate Distributions**				
Type of Course	**DSC A**				
Course Code	**MG4DSCSTA200**				
Course Level	**200**				
Course Summary	Students will be proficient in conducting correlation and regression analysis, understanding bivariate and multivariate distributions, interpreting results from the distribution of quadratic forms and applying these skills in practical scenarios using R/Python software.				
Semester	**4**	**Credits**		**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**
		3		**1**	**75**
Pre-requisites					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Illustrate bivariate and multivariate data and analyze them.	U & A	1
2	Analyze the bivariate data using a scatter diagram.	A	2
3	Elucidate various types of correlation measures.	Ap	2

4	Construct regression models and estimate values of dependent variables.	An & C	3
5	Describe bivariate distributions and obtain marginal and conditional distributions and examine the independence of random variables.	U ,An & E	1
6	Obtain mathematical expectations and correlation.	A	2
7	Apply multivariate normal distribution in real-life situations.	U & A	2
8	Build characterizations of multivariate distribution.	C	3
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Correlation and Regression**	**15**	
1.1	Bivariate data, multivariate data, scatter diagram, types of correlation: Karl Pearson, Spearman's rho and Kendall's tau.	6	1,2,3
1.2	Curve fitting and regression analysis.	4	4
1.3	Multiple linear regression, multiple correlation and partial correlation : Their properties and related results.	5	4
Module 2	**Bivariate and Multivariate Distributions**	**15**	
2.1	Bivariate random vector, joint pmf, joint pdf, and bivariate cdf, marginal and conditional distributions and independence of random variables.	4	5
2.2	Mathematical expectation, conditional expectation, covariance and correlation.	2	6
2.3	Random vectors, mean vector and dispersion matrix.	2	8

2.4	Bivariate normal distribution: pdf, marginal distributions, conditional distributions and independence.	2	5
2.5	Multivariate normal distribution: mgf, characteristic function, marginal distributions and conditional distributions, properties, characterizations and orthogonal transformation.	3	7,8
2.6	Multinomial distribution and its basic properties.	2	7
Module 3	**Distribution of Quadratic Forms**	**15**	
3.1	Quadratic forms: Types, independence, Scalar quadratic forms: properties.	8	9
3.2	Distribution of quadratic forms, Cochran's theorem.	7	9
Module 4	**Practical Using R/Python** (A practical record with minimum 10 problems has to be submitted).	**30**	
4.1	1. Multiple correlation and regression. 2. Partial correlation. 3. Curve fitting. 4. Karl Pearson's correlation coefficient. 5. Spearman's rho. 6. Kendall's tau. 7. Multivariate normal distribution (variance-covariance matrix). 8. Quadratic forms (positive definite). 9. Multinomial distribution.		1, 2, 3, 4, 7, 8
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.

Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Formative assessment** **Theory: 15 Marks** Quiz,Two Assignments **Practical: 15 Marks** Lab involvement, Practical Record, Viva voce **Summative assessment** **Theory: 10 Marks** Two written tests.
	B. End Semester Evaluation (ESE) **Theory : 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12). **Practical: 35 marks** Problem solving skills: 30 marks Record: 5 marks

References:

1. Gupta, S.C. and Kapoor, V.K. (2020).Fundamentals of Mathematical Statistics,12th Edition, Sultan Chand & Sons, New Delhi.
2. Anderson, T.W. (2009).An Introduction to Multivariate Statistical Analysis,3rd Edition, John Wiley.
3. Rencher, A.C. (1998).Multivariate Statistical Inference and Applications, 1st Edition, Wiley-Interscience.
4. Sudha G. Purohit, Sharad D. Gore and Shailaja R. Deshmukh. (2019). Statistics Using R, 2nd Edition, Narosa Publishing House.
5. F. Mary Harin Fernandez. (2022) R Programming Language, Booknetz.
6. Mathai, A.M. ,Serge B. Provost , Hans J. Haubold (2022). Multivariate Statistical Analysis in the Real and Complex Domains, Springer.
7. Mathai, A.M. (1997). Jacobians of Matrix Transformation and Functions of Matrix Arguments, World Scientific Publishing Company.

Suggested Readings:

1. Rohatgi, V.K. and Saleh, A.K.MD.E.(2015).An Introduction to Probability and Statistics, 3rd Edition, John Wiley & Sons Inc.
2. Johnson , R.A. and Wichern, D.W.(2013).Applied Multivariate Statistical Analysis, 6th Edition, Pearson Education.
3. Hogg, R.V., McKean, J.W. and Craig, A.T. (2014).Introduction to Mathematical Statistics,7th Edition, Pearson Education Publication.
4. Mood, A.M., Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edition (Reprint), Tata McGraw-Hill Pub. Co. Ltd.

Mahatma Gandhi University

Kottayam

Programme	**BSc (Hons) Statistics**					
Course Name	**Statistical Inference**					
Type of Course	**DSC A**					
Course Code	**MG4DSCSTA201**					
Course Level	**200**					
Course Summary	Students will be well-equipped to apply statistical hypothesis testing, parametric and non - parametric tests, and conduct data analysis using R / Python programming.					
Semester	**4**	**Credits**			**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		3		**1**		**75**
Pre-requisites						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Understand Chebychev's inequality, Analyse basic concepts of stochastic convergence.	U, An	1
2	Apply Law of large numbers and CLT to sequences of random variables.	A	2
3	Examine properties of a good estimator, apply Cramer-Rao inequality.	A	1,2
4	Obtain minimum variance bound estimator, estimate parameters using various methods.	E	2, 3
5	Construct confidence intervals for parameters.	C	2

6	Understand basic concepts of statistical hypotheses and their applications.	U & A	1
7	Explain various parametric test procedures and perform various parametric tests.	U,A & An	1
8	Understand the importance of normality assumption in data analysis and construct tests for normality.	U, A & C	1
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Point and Interval Estimation**	**15**	
1.1	Chebychev's inequality, sequence of random variables, convergence of sequence of random variables, Law of large numbers (statement only).	6	1
1.2	Properties of a good estimator, Cramer-Rao inequality (without proof) and its applications.	4	2
1.3	Confidence interval, confidence coefficient, construction of confidence intervals for the mean, difference of means, variance, ratio of variances, proportion, difference of proportions and Odds ratio.	5	3
Module 2	**Methods of Estimation**	**15**	
2.1	Method of moments.	4	7
2.2	Method of maximum likelihood, properties of maximum likelihood estimation (statement only).	6	7
2.3	Method of minimum variance.	5	7
Module 3	**Statistical Hypothesis**	**15**	
3.1	Introduction to statistical hypothesis testing, Neyman-Pearson test procedure, Neyman-Pearson lemma (without proof),	**3**	4

3.2	**Parametric Tests:** Tests concerning mean, equality of means, proportion and equality of proportions, paired-t test, tests for variance and equality of variance: Chi- square test, F test, Bartlett's test and Levene's test, One way ANOVA, tests for sphericity. (Problem oriented approach)	5	4
3.3	**Non - parametric tests:** Chi-square tests: Goodness of fit, independence and homogeneity, Tests for normality- Anderson- Darling test, Shapiro-Wilk test, one sample and paired sample: Sign test, Wilcoxon signed rank test, Mann-Whitney U test and Kruskal-Wallis test. (Problem oriented approach).	7	4
Module 4	**Practical Using R/Python**	**30**	
4.1	A practical record with minimum 10 problems has to be submitted.		1
Module 5	**Teacher Specific content.** This can be classroom teaching, practical session, field visit etc. as specified by the teacher concerned. This content will be evaluated internally.		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Formative assessment** **Theory: 15 Marks** Quiz,Two Assignments(5 marks each) **Practical: 15 Marks** Lab involvement, Practical record, Viva voce(5 marks each) **Summative assessment** **Theory: 10 Marks** Two written tests.

	B. End Semester Evaluation (ESE) **Theory : 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12). **Practical: 35 marks** Problem solving skills: 30 marks Record: 5 marks

References:

1. Gupta, S.C. and Kapoor, V.K. (2014). Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi.
2. Mood, A.M., Graybill, F.A. and Boes, D.C. (2001). Introduction to the Theory of Statistics, 3rd Edition, McGraw Hill Education (India) Private Limited.
3. Sudha G. Purohit, Sharad D. Gore and Shailaja R. Deshmukh. (2019).Statistics Using R, 2nd Edition, Narosa Publishing House.
4. Srivastava, M., Hamid Khan, A., Srivastava, N. (2014). Statistical Inference : Theory of Estimation. PHI Learning.
5. Srivastava, M., Srivastava, N. (2019) Statistical Inference : Testing of Hypotheses. PHI Learning.

Suggested Readings:

1. Hogg, R.V., McKean, J.W. and Craig, A.T. (2014).Introduction to Mathematical Statistics, 7th Edition , Pearson Education Publication.
2. Spiegel, M.R. and Stephens L.J. (2014). Statistics,5th Edition, Schaum's outlines, McGraw-Hill Education.
3. Lehmann, E.L. and Casella, G.(2003).Theory of Point Estimation, 2nd Edition, Springer.
4. Rohatgi, V.K. and Saleh, A.K.MD.E.(2015).An Introduction to Probability and Statistics, 3rd Edition, John Wiley & Sons Inc.

Mahatma Gandhi University

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Programme	**BSc (Hons) Statistics**					
Course Name	**Data Analysis Using JAMOVI (Data Analytics Specialization)**					
Type of Course	**DSE**					
Course Code	**MG4DSESTA200**					
Course Level	**200**					
Course Summary	**To make the students proficient in the open source statistical data analysis software JAMOVI**					
Semester	**4**	**Credits**			**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		4				**60**
Pre-requisites						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Understand basics of JAMOVI	U	1, 2
2	Apply EDA procedures to real life datasets in JAMOVI	A, Ap, S	1, 2
3	Apply Regression modelling techniques in JAMOVI	A, Ap, S	1, 2
4	Apply Factor analysis for identification of latent variables in JAMOVI	A, Ap, S	2
5	Test statistical hypothesis in JAMOVI	A, Ap, S	2

6	Apply PCA for dimension reduction in JAMOVI	A, Ap, S	2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Sub-units)

Module 1	**Course Description**	**Hours**	**CO No.**
	Title- Introduction to JAMOVI	**15**	
1.1	Introduction to JAMOVI, Downloading and installing JAMOVI, Exploring-Variable Types in JAMOVI	4	1, 2
1.2	Sample datasets in JAMOVI, Menus in JAMOVI, Syntax mode, Adding modules to JAMOVI, Rj Editor	11	1,2
Module 2	**Intermediate JAMOVI**	**15**	
2.1	Computing columns, Data& Label Editing, Filtering columns, Descriptive statistics and basic plots, Distributions module-random number generation, estimation of parameters	8	3,4, 6
2.2	Scatter plots, Correlation coefficients, Linear regression, Log-linear regression	7	5
Module 3	**More with JAMOVI**	**15**	
3.1	Testing of Hypothesis- Binomial test, One Sample t-test, two sample t-test, paired t-test, ANOVA, tests for association	15	5
Module 4	**Advanced JAMOVI**	**15**	

4.1	Factor Analysis-EFA, Logistic regression, Principal Component Analysis, Reliability analysis.	15	6
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 20 marks** Quiz, Assignments ,Seminar(5 marks each). ***Summative assessment*** **Theory: 10 marks** Written tests.
	B. End Semester Evaluation (ESE) **Total:70 marks** i) Short answer type questions: Answer any 10 questions out of 12 (10*3=30). ii) Short essay type questions: Answer any 4 questions out of 6 (4*7=28). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12).

References:

1. Navarro, Danielle, and David Foxcroft. "Learning statistics with jamovi: A tutorial for psychology students and other beginners (Version 0.70)." Tillgänglig online: http://learnstatswithjamovi. com [Hämtad 14 december] (2019).

2. Heo, I., Veen, D., & Van de Schoot, R. (2020, July). Tutorial: JASP for beginners. Zenodo. https://doi.org/10.5281/zenodo.4008280

3. Anderson T. W. (2010) An Introduction to Multivariate Statistical Analysis (3rd ed.) John Wiley.

4. Johnson R.A. and Wichern DAV. (2008) Applied Multivariate Statistical Analysis, (fi^edn) Pearson education.

Mahatma Gandhi University

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Programme	**BSc (Hons) Statistics**				
Course Name	**Statistical Quality Control**				
Type of Course	**DSE**				
Course Code	**MG4DSESTA201**				
Course Level	**200**				
Course Summary	To acquire the basic knowledge of process and product control techniques. Also, built in functions in R programming are used to solve numerical problems associated with the topics discussed.				
Semester	**4**	**Credits**		**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**
		4			**60**
Pre-requisites					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Understand quality and dimensions.	U	1
2	Describe statistical process control and causes of variations.	U, A	2
3	Learn statistical control charts and its construction.	K. A	2
4	Understand Control charts for variables and attributes.	A	2
5	Analyse the patterns on the control chart.	An	2

6	Learn process capability analysis and process capability indices	K,A	2
7	Understand the concept of Acceptance sampling plans.	A, An	2
8	Use R built in functions to solve numerical problems associated with topics covered in various modules	A, S	2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Control Charts**	**15**	
1.1	Quality: Definition, dimensions of quality, Quality system and standards: Introduction to ISO quality standards, Quality registration.	2	1
1.2	Statistical Process Control: Seven tools of SPC, chance and assignable causes of quality variation.	2	2
1.3	Statistical Control Charts: Construction and Statistical basis of 3-σ Control charts, Rational Sub-grouping.	3	3
1.4	Control charts for variables: X-bar and R-chart, X-bar and s-chart. Control charts for attributes: np-chart, p-chart, c-chart and u-chart.	4	4
1.5	Comparison between control charts for variables and control charts for attributes.	2	4
1.6	Analysis of patterns on control charts.	2	5
Module 2	**Process Capability Analysis**	**15**	
2.1	Process capability analysis, process capability indices – Cp Cpk, Cpm., estimation of process capability.	8	6
2.2	Introduction to Six-Sigma: Overview of Six Sigma, Lean Manufacturing and Total Quality Management (TQM).	7	6

Module 3	**Acceptance Sampling Plans**	**15**	
3.1	Principle of acceptance sampling plans. Single and Double sampling plan.	4	7
3.2	OC, AQL, LTPD, AOQ, AOQL, ASN, ATI functions with graphical interpretation of SSP and DSP.	6	7
3.3	Use and interpretation of Dodge and Romig sampling inspection plan tables.	5	7
Module 4	**Statistical Analysis Using R programming** (Record with minimum 5 problems has to be submitted.)	**15**	
4.1	Introduction to R	4	8
4.2	Use R built in functions to solve numerical problems associated with topics covered in various modules.	11	8
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 20 marks** Quiz, Assignments, Seminar (5 marks each). ***Summative assessment*** **Theory: 10 marks** Two written tests

	B. End Semester Evaluation (ESE) **Total: 70 marks** i) Short answer type questions: Answer any 10 questions out of 12 (10*3=30). ii) Short essay type questions: Answer any 4 questions out of 6 (4*7=28). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12).

References:

1. Montgomery, D. C. (2009): Introduction to Statistical Quality Control, 6th Edition, Wiley India Pvt. Ltd.
2. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edition. The World Press, Kolkata.
3. Mukhopadhyay, P (2011). Applied Statistics, 2nd edition revised reprint, Books and Allied(P) Ltd.

Suggested Readings:

1. Montgomery, D. C. and Runger, G.C. (2008): Applied Statistics and Probability for Engineers, 3rd Edition reprint, Wiley India Pvt. Ltd.
2. Ehrlich, B. Harris. (2002): Transactional Six Sigma and Lean Servicing, 2nd Edition, St. Lucie Press.
3. Hoyle, David. (1995): ISO Quality Systems Handbook, 2nd Edition, Butterworth Heinemann Publication.
4. Purohit,S.G.,Deshmukh,S.R.,& Gore,S.D.(2008).Statistics using R.Alpha Science International, United Kingdom
5. Wilks S.S. (1964). Mathematical Statistics, John Wiley, New York.

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Programme	**BSc (Hons) Statistics**					
Course Name	**Biostatistics**					
Type of Course	**DSE**					
Course Code	**MG4DSESTA202**					
Course Level	**200**					
Course Summary	This course equips students to understand the problems in Biomedical Research with the Principles of Biostatistical designs and application of different distributions.					
Semester	**4**	**Credits**			**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		4				**60**
Pre-requisites						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Understand the problems in Biomedical Research.	U	1
2	Understand the Principles of Biostatistical designs and application of different distributions.	U, A	2
3	Describe Type 1, Type 2 ,progressive censoring and random censoring.	K	2
4	Evaluate mean survival time.	E	2
5	Explain categorical data analysis.	K	2
6	Evaluate probabilities of death under competing risks models.	E	2

7	Planning and design of clinical trials.	K,An	2
8	Describe different types of clinical trials and apply in different situations.	K,A, S	2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Introduction to Biostatistics**	**15**	
1.1	Biostatistics: Example on statistical problems in Biomedical Research-Types of Biological data.	3	1
1.2	Principles of Biostatistical design of medical studies, functions of survival time, survival distributions and their applications viz. exponential, gamma, Weibull, Rayleigh, lognormal, distribution having bath-tub shape hazard function.	7	2
1.3	Parametric methods for comparing two survival distributions (L.R test and Cox's F- test).	5	2
Module 2	**Types of Censoring**	**15**	
2.1	Type I, Type II and progressive or random censoring with biological examples.	4	3
2.2	Estimation of mean survival time and variance of the estimator for type I and type II censored data with numerical examples.	4	4
2.3	Non-parametric methods for estimating survival function and variance of the estimator viz. Actuarial and Kaplan –Meier methods.	7	4
Module 3	**Categorical Data Analysis**	**15**	
3.1	Categorical data analysis (logistic regression) : competing risk theory, indices for measurement of probability of death under competing risks and their inter-relations.	6	5

3.2	Estimation of probabilities of death under competing risks by ML method.	4	6
3.3	Stochastic epidemic models: Simple and general epidemic models.	5	6
Module 4	**Basic Biological concepts in Genetics**	**15**	
4.1	Basic biological concepts in genetics, Mendel's law, Hardy-Weinberg equilibrium, random mating, natural selection, mutation, genetic drift, detection and estimation of linkage in heredity.	4	7
4.2	Planning and design of clinical trials, Phase I, II, and III trials. Sample size determination in fixed sample designs.	5	7
4.3	Planning of sequential, randomised clinical trials, designs for comparative trials; randomization techniques and associated distribution theory and permutation tests (basic ideas only); ethics behind randomised studies involving human subjects; randomised dose-response studies(concept only).	6	8
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.

Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 20 marks** Quiz, Assignments ,Seminar(5 marks each). ***Summative assessment*** **Theory: 10 marks** Written tests.
	B. End Semester Evaluation (ESE) **Total:70 marks** i) Short answer type questions: Answer any 10 questions out of 12 (10*3=30). ii) Short essay type questions: Answer any 4 questions out of 6 (4*7=28). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12).

References:

1. Biswas, S. (1995). Applied Stochastic Processes. A Biostatistical and Population Oriented Approach. Wiley Eastern Ltd., New Delhi.
2. Cox, D.R. and Oakes, D. (1984). Analysis of Survival Data. Chapman & Hall, New York.

Suggested Readings:

1. Elandt, R.C. and Johnson (1975). Probability Models and Statistical Methods in Genetics. John Wiley & Sons, New York.
2. Lawless, J.F.(2003). Statistical Methods for Lifetime - Second Edition. John Wiley & Sons, New York.

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Programme	**BSc (Hons) Statistics**					
Course Name	**Econometrics**					
Type of Course	**DSE**					
Course Code	**MG4DSESTA203**					
Course Level	**400**					
Course Summary	To acquire the basic knowledge of econometric models and its applications. Also learn tests and solutions of multicollinearity and heteroscedasticity concepts.					
Semester	**4**	**Credits**			**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		4				**60**
Pre-requisites						

EXPECTED COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains*	Program Outcome
1	Apply the challenges of empirical modelling in economics and business.	A	2
2	Analyze economic data by using regression analysis.	An	2

3	Explain theoretical background for the standard methods used in empirical analyses, like properties of least squares estimators and the statistical testing of hypotheses.	A	2
4	Describe the concept of structural econometric models and their applications in econometric modelling.	U	1

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Homogeneous functions**	**15**	
1.1	Demand and supply functions, elasticity of demand, equilibrium of market.	6	1
1.2	Production functions: Homogeneous functions, elasticity of production.	5	1
1.3	Input- output analysis, Leontief's open and closed models.	4	1
Module 2	**Linear Regression Models**	**15**	
2.1	Simple linear regression models, multiple linear regression models.	3	2
2.2	Estimation of the model parameters, tests concerning the parameters, confidence intervals,	4	2
2.3	Prediction, heteroscedasticity, tests, consequences,	4	2
2.4	Multicollinearity- consequences, Farrar-Glauber test, remedial measures. Residual Analysis.	4	
Module 3	**Generalised Least Square Methods**	**15**	

3.1	Aitken's generalised least square method, tests for autocorrelation, consequences and estimation procedures.	5	3
3.2	stochastic regressors, errors in variables, use of Dummy variables in regression.	4	3
3.3	polynomial regression models in one variable, basic ideas of logistic regression and stepwise regression.	6	3
Module 4	**Simultaneous Equation Models and its Identification**	**15**	
4.1	Simultaneous equation models, Identification problems, rank and order condition.	5	4
4.2	Methods of estimation- indirect least squares, least variance ratio(LVR) or LIML.	6	4
4.3	Two-stage least squares, FIML- methods.	4	4
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 20 marks** Quiz, Assignments, Seminar ***Summative assessment*** **Theory:10 marks** Written tests

	B. End Semester Evaluation(ESE) **Total:70 marks** i) Short answer type questions: Answer any 10 questions out of 12 (10*3=30). ii) Short essay type questions: Answer any 4 questions out of 6 (4*7=28). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12).

References:

1. Johnston J. (1984). Econometric Methods (Third edition), McGraw Hill, New York.
2. Montgomery D.C., Peck E.A. and Vining G.G. (2007). Introduction to Linear Regression Analysis, John Wiley, India.
3. Gujarati D. (2009). Basic Econometrics, Fifth edn McGraw Hill.
4. Apte P.G. (1990). Text book of Econometrics, Tata McGraw Hill.
5. Theil H. (1982). Introduction to the Theory and Practice of Econometrics, John Wiley.

Suggested Readings:

1. Gujarati, D. and Sangeetha, S. (2007). Basic Econometrics, 4th Edition, McGraw Hill Companies.
2. Johnston, J. (1972). Econometric Methods, 2nd Edition, McGraw Hill International.
3. Maddala, G.S. and Lahiri, K. (2009). Introduction to Econometrics, 4th Edition, John Wiley & Sons.
4. Koutsoyiannis, A. (2004). Theory of Econometrics, 2nd Edition, Palgrave Macmillan Limited.

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Programme	**BSc (Hons) Statistics**					
Course Name	**Statistical Inference Using R/Python**					
Type of Course	**DSC B**					
Course Code	**MG4DSCSTA202**					
Course Level	**200**					
Course Summary	This course equips students with a comprehensive understanding of different sampling distributions, estimation methods, parameter testing, and non - parametric testing for hypothesis evaluation. The practical aspect of the course involves hands-on experience in conducting data analysis using R or Python.					
Semester	**4**	**Credits**			**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		3		**1**		**75**
Pre-requisites	Level 100 knowledge of Statistics					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	Program Outcome
1	Understand different sampling distributions.	U	1
2	Describe estimation and methods.	U	1
3	Relate different parametric tests in testing the hypothesis.	An	1
4	Organise different non-parametric tests in testing the hypothesis.	An	1
5	Conduct data analysis using R/Python.	E	2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Sampling Distributions**	**15**	
1.1	Statistic, parameter.	1	1
1.2	Distribution of sample mean and variance.	2	1
1.3	Normal distribution.	3	1
1.4	Student's t-distribution.	2	1
1.5	Chi- square distribution.	2	1
1.6	F distribution.	2	1
1.7	Inter-relationship between normal, t, Chi-square and F distributions.	3	1
Module 2	**Estimation of Parameters and methods of Estimation**	**15**	
2.1	Estimation, point estimation and interval estimation.	2	2
2.2	Desirable properties of a good point estimator.	6	2
2.3	Methods of estimation – MLE, method of moments.	7	2
Module 3	**Testing of Hypothesis**	**15**	
3.1	Testing of hypothesis, Statistical test, null and alternative hypothesis, types of errors, significance level, power, critical region and p- value.	2	3
3.2	Parametric test: Testing of population mean (One sample and two samples) (z test, t-test), paired t test.	6	3
3.3	Testing of population proportion (One sample and two samples).	3	3
3.4	ANOVA(one way only).	1	3
3.5	Non-parametric tests: Chi-square test, sign test, median test. Kruskal Wallis H test and Wilcoxon test.	3	3
Module 4	**Data analysis using R /Python.**	**30**	
4.1	Introduction to Python/R.	4	5
4.2	Categorical data analysis.	4	5
4.3	Random number Generation.	2	5
4.4	Descriptive and inferential statistical analysis using R/Python, Data visualisation, Descriptive measures, Correlation and Regression, Statistical Tests, ANOVA.	20	5
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** ***Theory:* 15 marks** Quiz, Assignments ***Practical:* 15 marks** Lab involvement, Practical record,Viva voce. ***Summative assessment*** **Theory: 10 marks** Written tests.
	B. End Semester Evaluation (ESE) **Theory : 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12). **Practical: 35 marks** Problem solving skills: 30 marks Record: 5 marks

References:

1. Rohatgi V.K. and Saleh, A.K. Md.E. (2009): An Introduction to Probability andStatistics.2nd Edn. (Reprint)John Wiley andSons.
2. Gupta, S.P. (2021) Statistical Methods. Sultan Chandand Sons: NewDelhi.
3. Gupta, S.C. and Kapoor, V.K.(2020) Fundamentals of Mathematical Statistics, Sultan Chand and Sons.
4. Sudha G Purohit, Sharad D. Gore, Shailaja Deshmukh (2019) Statistics using R, 2nd edition, Narosa Publishing House.
5. Python for Everybody: Exploring Data Using Python3, ADS 2016.

Suggested Readings:

1. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007) Introduction to the Theory of Statistics, 3rd Edition., (Reprint), Tata Mc Graw-Hill Pub. Co.Ltd.
2. John E Freund, Mathematical Statistics, Pearson Edn, NewDelhi
3. Tilman M. Davies. (2016) The Book of R, A First Course in Programming and Statistics, No Starch Press.
4. Python for Data Analysis (2012).WesMc Kinney, O'REILLY.

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Programme	**BSc (Hons) Statistics**					
Course Name	**Statistical Research Methods using Softwares.**					
Type of Course	**DSC B**					
Course Code	**MG4DSCSTA203**					
Course Level	**200**					
Course Summary & Justification	This course aims to equip students with a solid foundation in Research Methodology, Statistical Testing and Data Analysis.					
Semester	**4**	**Credits**			**4**	**Total Hours**
Total Student Learning Time (SLT)	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		3		**1**		**75**
Pre-requisites	Level 100 knowledge of Statistics					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	Program Outcome
1	Understand different research methods in social science	U	1
2	Understand the statistical testing procedure in sociology	U	1
3	Illustrate the large sample tests	A	2
4	Describe the small sample tests	A	2
5	Conduct a social survey and data analysis using R/Python/Spreadsheet.	E	2

Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Introduction to Research Methodology**	**15**	
1.1	Research design, Qualitative and quantitative research.	3	1
1.2	Data collection methods & sampling techniques.	5	1
1.3	Research reporting and Communication-Writing Research proposal.	4	1
1.4	Apply research methods to real-world social issues.	3	
Module 2	**Testing of Hypothesis**	**10**	
2.1	Parameter, statistic.	1	2
2.2	Statistical hypothesis, Simple and composite hypothesis.	1	2
2.3	Null and alternative hypotheses, type I and type II Errors.	2	2
2.4	Critical region, size of the test, p value, power.	2	2
2.5	Sociological research problems in Statistical perspective.	4	2
Module 3	**Parametric and Non-parametric Tests**	**20**	
3.1	Large sample test: z test for single mean and equality of two means.	5	2
3.2	Small sample test: t test for single mean and equality of two means, paired t test.	5	3
3.3	ANOVA (one way only).	1	3
3.4	Non- parametric tests: Testing association of attributes using Chi square test.	2	4
3.5	Sign test, median test, Wilcoxon Ranked test-simple problems only.	6	4
3.6	Applications of statistical tests in various fields.	1	4
Module 4	**Data analysis using R/spreadsheet/Python**	**30**	
4.1	Conduct a social survey and prepare a project report (Questionnaire, geographical and diagrammatic representation, analysis - Descriptive Statistics).	12	5
4.2	Statistical analysis and interpretation of a social problem by using Spreadsheet/ Python/ R programming.	18	5
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** ***Theory:* 15 marks** Quiz, Assignments ***Practical:* 15 marks** Lab involvement, Practical Record, Viva voce. ***Summative assessment*** **Theory: 10 marks** Written tests
	B. End Semester Evaluation (ESE) **Theory : 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12). **Practical: 35 marks** Problem solving skills: 30 marks Record: 5 marks

References:

1. Rohatgi V.K. and Saleh, A.K. Md.E. (2009): An Introduction to Probability andStatistics.2nd Edition (Reprint)John Wiley andSons.
2. Gupta, S.P. (2021) Statistical Methods. Sultan Chandand Sons: NewDelhi.
3. Gupta, S.C. and Kapoor, V.K.(2020) Fundamentals of Mathematical Statistics, Sultan Chand and Sons.
4. Sudha G Purohit, Sharad D. Gore, Shailaja Deshmukh (2019) Statistics using R, 2nd Edition, Narosa Publishing House.
5. Python for Everybody: Exploring Data Using Python3, ADS 2016.

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1. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007) Introduction to the Theory of Statistics, 3rd Edition., (Reprint), Tata Mc Graw-Hill Pub. Co.Ltd.
2. John E Freund, Mathematical Statistics, Pearson Edn, New Delhi
3. Tilman M. Davies. (2016). The Book of R, A First Course in Programming and Statistics, No Starch Press.
4. Python for Data Analysis (2012).WesMc Kinney, O'REILLY.

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Programme	**BSc (Hons) Statistics**					
Course Name	**Statistical Modelling in Data Science**					
Type of Course	**DSC B**					
Course Code	**MG4DSCSTA204**					
Course Level	**200**					
Course Summary	This course provides a comprehensive introduction to Data Sciences, covering Inferential Statistics, Non-parametric Tests, ANOVA and Analysis of AI models in Statistics. The focus is on developing practical skills for data analysis and interpretation in real-world scenarios.					
Semester	**4**	**Credits**			**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		3		**1**		**75**
Pre-requisites	Level 100 knowledge of Statistics					

EXPECTED COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	Program Outcome
1	Understand the basics of Data science	U	1
2	Operate Parametric tests	A	2
3	Relate Non parametric tests	An	1
4	Compare AI models in statistics	An	1
5	Conduct statistical data analysis using R/Python	E	2
****Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Introduction to Data Science**	**15**	
1.1	Introduction, definition.	1	1
1.2	Data Science in various fields, examples.	1	1
1.3	Impact of data science.	1	1
1.4	Understating data: Introduction, types of data, numeric, categorical, graphical, high dimensional data.	3	1
1.5	Classification of digital data: structured, semi-structured, unstructured, example, applications.	3	1
1.6	Sources of data: Time series data, transactional data, biological data, spatial data, social network data.	3	1
1.7	Data evolution.	1	1
1.8	Introduction of big data.	2	1
Module 2	**Inferential Statistics, Non parametric test and ANOVA**	**18**	
2.1	Introduction, sampling distribution: z distribution, t distribution.	5	2
2.2	Hypothesis testing: z test, t test (one sample), problems.	5	2
2.3	Introduction, chi square test for goodness of fit and independence.	4	3
2.4	F test. ANOVA (one way classification).	4	3
Module 3	**AI models in Statistics**	**12**	
3.1	Linear and Multiple Regression.	4	4
3.2	Logistic Regression.	4	4
3.3	Decision Trees.	4	4
Module 4	**Exploratory Data Analysis using R/Python**	**30**	
4.1	Random number generation.	6	5
4.2	Descriptive and inferential statistical analysis using R/Python Data visualisation, Descriptive measures, Correlation and Regression, Statistical Tests, ANOVA.	24	5
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** ***Theory:* 15 marks** Quiz, Assignments ***Practical:* 15 marks** Lab involvement, Practical Record,Viva voce ***Summative assessment*** **Theory: 10 marks** Written tests
	B. End Semester Evaluation (ESE) **Theory : 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12). **Practical: 35 marks** Problem solving skills: 30 marks Record: 5 marks

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1. Rohatgi V.K. and Saleh, A.K. Md.E. (2009). An Introduction to Probability andStatistics.2nd Edition. (Reprint)John Wiley andSons.
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3. Gupta, S.C. and Kapoor, V.K.(2020). Fundamentals of Mathematical Statistics, Sultan Chand and Sons.
4. Sudha G Purohit, Sharad D. Gore, Shailaja Deshmukh (2019) Statistics using R, 2nd Edition, Narosa Publishing House.
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4. Python for Data Analysis (2012).WesMc Kinney, O'REILLY.

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Programme					
Course Name	**Introduction to Spreadsheets and LaTex typing**				
Type of Course	**SEC**				
Course Code	**MG4SECSTA200**				
Course Level	**200**				
Course Summary	To get basic knowledge and skills of data analysis using spreadsheets and be able to create printed materials with professional quality using LaTex.				
Semester	**4**	**Credits**		**3**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**
		3			**45**
Pre-requisites	Level 100 knowledge in Statistics /Computer				

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	Program Outcome
1	Illustrate how to present data in a presentable format using pictures, tables and create well-presented documents.	U	1
2	Analyze the data and compare the distributions with statistical believes.	A	2
3	Elucidate new conclusions, if any, shown by the data based on the thorough analysis.	Ap	2
4	Critically examine and compare the results of the data analysis.	A	2
5	Describe the data based on the analysis using the spreadsheet.	U	1

6	Explain how to create documents and powerpoints.	U	1
7	Build documents using LaTex.	C	1
8	Appraise the need for presenting data and documents suitable for different situations.	E	2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Spreadsheet and Data**	**15**	
1.1	Basics of spreadsheet and data types, creation of worksheets, editing, formatting and saving.	3	1
1.2	Introduction to functions in a spreadsheet, if function, freeze panes, vlookup, hlookup, sorting, filtering.	5	1,2
1.3	Pivot tables, Statistics in spreadsheets, conditional formatting,data validation.	4	2,3,4
1.4	Data visualisation, Statistical analysis using spreadsheets.	3	4,5
Module 2	**Basics of LaTex**	**15**	
2.1	Introduction to LaTex interfaces, understanding Latex compilation, basic syntax.	3	7
2.2	Writing equations, matrices, tables. Page Layout: Titles,abstract,chapters,sections,references,equatio references, citation.List Making Environments.	4	7
2.3	Table of contents, generating commands, figure handling numbering, list of figures,list of tables, generating index.	3	7
2.4	Classes: Article, book, report, beamer, slides. Applicationsto: Writing articles / Projects.	3	7,8
2.5	Presentation using beamer.	2	6,8

Module 3	**Statistical Computing using spreadsheet and LaTex.** (Exercises based on the above concepts. Both spreadsheet & LaTex).	**15**	2,6,7,8
Module 4	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 15 marks** Quiz, Assignments. ***Summative assessment*** **Theory: 10 marks** Written tests
	B. End Semester Evaluation(ESE) **Total: 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12).

References:

1. Excel 2022: From Basic to Advanced. (2022). George Wahlberg.
2. Stefan Kottwitz: LATEX Cookbook. (2015). Packt Publishing.
3. David F. Griffths and Desmond J. Higham. (2016). Learning LATEX (2nd edition) Siam.

Suggested Readings:

1. Excel Formulas and Functions. (2020). Basics: Step-by-Step Guide with Examples for Beginners (Excel Academy Book 2) Adam Ramirez .
2. Excel 2022 : Three books-in-one: a to z mastery guide on excel basic operations, excel formulas, functions, pivot tables & dashboards (2022). Joe Webinar.
3. M.R.C. van Dongen:LATEX and Friends (2012). Springer-Verlag Berlin Heidelberg.

Mahatma Gandhi University

Kottayam

Programme	**STATISTICS**					
Course Name	**Ethical Dimensions in Statistical Machine Learning through R/Python**					
Type of Course	**VAC**					
Course Code	**MG4VACSTA200**					
Course Level	**200**					
Course Summary	The course delves into the crucial intersection of ethics and data analysis tools. Students examine real-world ethical dilemmas and learn strategies to mitigate biases and ensure responsible data handling within software-driven analyses. The course also gives an introduction to statistical machine learning and enables the student to up-skill his technical presentation skills.					
Semester	**4**	**Credits**			**3**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		3				**45**
Pre-requisites						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	Program Outcome
1	To critically analyze summarising data and testing a hypothesis.	An	1
2	To familiarise the basic concepts of model building and Statistical Machine Learning.	S	2

3	To articulate and present, both orally and in written form, the ethical implications of real life data using R/Python.	Ap	8
Remember (K), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Foundation of Data Analysis and Ethical Framework**	**15**	
1.1	Basic on data collection, questionnaire preparation, interview methods for collecting data, organising and cleaning data.	2	1
1.2	Descriptive statistics, correlation and scatter plot. Visualisation of data: Histogram, frequency polygon and ogives.	3	1
1.3	Theory of attributes: Introduction, independence of attributes, criterion of independence, association of attributes, Yule's coefficient of association and coefficient of colligation.	4	1
1.4	Small sample tests: t test and F test-t test of significance for single mean, difference in means, paired t - test for related samples, F test of significance for equality of population variances, chi- square test.	6	1
Module 2	**Introduction to Model Building and Statistical Machine Learning**	**15**	
2.1	Regression, simple linear regression, multiple linear regression and logistic regression.	4	1, 2
2.2	Bayesian inference: Prior, posterior, map, regularisation in Bayesian setup, introduction to mcmc (markov chain monte carlo).	5	2
2.3	Classification, introduction, example of supervised learning, classification model, classification learning steps, common classification algorithms- KNN, decision tree, random forest models, support vector machine.	6	2

Module 3	**Ethical Decision Making and Communication in Data Analysis**	**15**	
3.1	Ethical theories and principles in data science, group discussions on ethical frameworks and their applications in data analysis.	6	3
3.2	Introduction to R/ Python.	4	1,3
3.3	Presentation on the implemented data analysis using real life data using R/Python.	5	1,2,3
Module 4	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 15 marks** Quiz, Assignments ***Summative assessment*** **Theory: 10 marks** Written tests.

	B. End Semester Evaluation: (Theory based examination.) **Total: 50 marks** i) MCQ: Answer 10 questions (10*1=10). ii) Short essay type questions: Answer any 5 questions out of 7 (5*6=30). iii) Essay type questions: Answer any 1 question out of 2 (1*10=10).

References:

1. Wickham, Hadley, Mine Çetinkaya-Rundel, and Garrett Grolemund.(2023). R for data science. " O'Reilly Media, Inc.".
2. V.K.Kapoor and S.C.Gupta (2010). Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi.
3. Chiang, Chin Long.(2003). Statistical methods of analysis. World Scientific.

Suggested Readings:

1. Davis, Kord. (2012). Ethics of Big Data: Balancing risk and innovation." O'Reilly Media, Inc.".
2. Powers, Daniel, and Yu Xie.(2008). Statistical methods for categorical data analysis. Emerald Group Publishing.
3. Sugiyama, Masashi.(2015). Introduction to statistical machine learning. Morgan Kaufmann.

SEMESTER 5

Mahatma Gandhi University

Kottayam

Programme	**BSc (Hons) Statistics**				
Course Name	**Applied Regression Analysis**				
Type of Course	**DSC A**				
Course Code	**MG5DSCSTA300**				
Course Level	**300**				
Course Summary	The students have studied simple linear regression, multiple regression, residual analysis for fitting a suitable model to a given data and to check the suitability. They have studied necessary transformations and modifications to be made when model assumptions are violated. They are capable of fitting logistic and Poisson models, orthogonal and polynomial models. They have understood ridge regression, kernel regression, nonparametric regression etc.				
Semester	**5**	**Credits**		**4**	**Total Hours**
Course Details	Learning Approach	Lecture	Tutorial	Practical	Others	
		4			**60**
Pre-requisites					

EXPECTED COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	Program Outcome
1	Describe various aspects of regression analysis.	U,K	1
2	Explain multiple linear regression models and evaluate regression coefficient.	U, K, E	1
3	Analyze polynomial regression model.	An, C,S	2

4	Describe non linear regression.	U	1
5	Prediction of residual analysis.	S, I	2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Introduction to Regression Analysis**	**15**	
1.1	Introduction to regression analysis: Overview and applications of regression analysis, major steps in regression analysis.	3	1
1.2	Simple linear regression (Two variables): Assumptions, estimation and properties of regression coefficients, significance and confidence intervals of regression coefficients, measuring the quality of the fit.	5	1
1.3	Residual analysis, various types of residuals.	3	1
1.4	Departures from underlying assumptions, departures from normality, diagnostics and remedies.	4	1
Module 2	**Multiple Linear Regression Model**	**15**	
2.1	Multiple linear regression model: Assumptions, ordinary least square estimation of regression coefficients, interpretation and properties of regression coefficient, significance and confidence intervals of regression coefficients.	5	2
2.2	Mean Square error criteria, coefficient of determination, criteria for model selection: Need for transformation of variables; power transformation.	5	2
2.3	Box-Cox transformation, removal of heteroscedasticity and serial correlation, Leverage and influence. Effect of outliers.	5	2
Module 3	**Polynomial Regression Models**	**15**	
3.1	Generalised least squares and weighted least squares.	3	3

3.2	Polynomial regression models: Forward, backward and stepwise procedures.	3	3
3.3	Nonparametric regression, Kernel regression, Loess, ridge regression,	4	3
3.4	Orthogonal polynomials, indicator variables, subset regression, stepwise regression, variable selection, robust regression.	5	3
Module 4	**Introduction to Nonlinear Regression**	**15**	
4.1	Introduction to nonlinear regression, linearity transformations, logarithmic transformation, Least squares in the nonlinear case and estimation of parameters.	4	4
4.2	Models for binary response variables, generalised linear models, estimation and diagnosis methods for Logistic and Poisson regressions.	5	4
4.3	Prediction and residual analysis, multinomial logistic regression.	4	5
4.4	Random and mixed effect models, multicollinearity, sources, effects, tests.	2	5
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.

Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 20 marks** Quiz, Assignments, Seminar. ***Summative assessment*** **Theory:10 marks** Written tests
	B. End semester Evaluation: **Total: 70 marks** i) Short answer type questions: Answer any 10 questions out of 12 (10*3=30). ii) Short essay type questions: Answer any 4 questions out of 6 (4*7=28). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12).

References

1. Montgomery, D. C . , Peck, E.A. and Vining, G.G. (2003). Introduction to Linear Regression Analysis, John Wiley and Sons, Inc.NY.
2. Chatterjee,S. and Hadi, A. (2013). Regression Analysis by Example, 5th Edition., John Wiley and Sons.
3. Seber, A.F. and Lee, A.J. (2003). Linear Regression Analysis, John Wiley, Relevant sections from 4. Pardoe, L. (2012). Applied Regression Modelling, John Wiley and Sons, Inc,.

Suggested Readings:

1. McCullagh. P, Nelder,J.A.(1989). Generalised Linear Models, Chapman & Hall,. John O. Rawlings
2. Sastry G. Pantula, David A. Dickey (1998). Applied Regression Analysis, Second Edition, Springer.
3. Draper, N. and Smith, H. (2012). Applied Regression Analysis – John Wiley & Sons.

Mahatma Gandhi University

Kottayam

Programme	**BSc (Hons) Statistics**				
Course Name	**Sampling Techniques**				
Type of Course	**DSC A**				
Course Code	**MG5DSCSTA301**				
Course Level	**300**				
Course Summary	The course explores in detail the basic concepts of sampling techniques and their implementations using R/Python/G* Power.				
Semester	**5**	**Credits**		**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**
		4			**60**
Pre-requisites					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	Program Outcome
1	Summarise probability and non-probability sampling.	U & An	1
2	Carry out a large scale sample survey.	A	2
3	Illustrate various sampling techniques.	U	1
4	Obtain unbiased estimators of population mean and their variance and interpretation.	A &E	2
5	Construct confidence intervals for population mean.	C	2
6	Determine sample size based on desired accuracy.	E	2

7	Perform different types of allocations in stratified random sampling.	A & An	2
8	Design an appropriate sampling scheme for a particular survey.	A & C	1
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Basic Concepts and Simple Random Sampling.**	**15**	
1.1	Census and sampling, types of sampling: probability and non-probability sampling, advantages and disadvantages.	3	1
1.2	Principal steps in a sample survey, sampling and non-sampling errors, organisational aspects of sample survey.	4	2
1.3	Simple random sampling with and without replacement (SRSWR and SRSWOR), procedures of selecting a sample, unbiased estimates of the population mean and population total-their variances and estimates of the variances, confidence interval for population mean and total, simple random sampling for attributes.	6	3, 4 , 5
1.4	Determination of the sample size	2	6
Module 2	**Stratified and Systematic Random Sampling.**	**15**	
2.1	Stratified random sampling, estimation of the population mean and population total: Their variances and estimates of the variances.	4	4
2.2	Proportional allocation and Neyman allocation of sample sizes, cost function, optimum allocation, comparison with simple random sampling.	5	7
2.3	Linear and circular systematic sampling, estimates of the population mean and population total.	3	3 ,4 ,8
2.4	Comparison of systematic sampling, SRS and stratified random sampling for a population with a linear trend.	3	3

Module 3	**Cluster Sampling and Multistage Sampling.**	**15**	
3.1	Cluster sampling, clusters with equal sizes, estimation of population mean and total: Their variances and estimates of the variances.	8	3 ,4, 8
3.2	Multistage sampling, estimation of the population mean and its standard error.	7	3 ,4, 8
Module 4	**Statistical Analysis using R/Python/G*Power** A record with minimum 5 problems has to be submitted.	**15**	
4.1	Simulate sampling scenarios mentioned in the above modules using R/ Python packages and perform Statistical inferences on the sample data. Determine sample size using G*Power software for different scenarios.	15	3 ,4,8
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory:20 marks** Quiz, Assignments, Seminar. ***Summative assessment*** **Theory: 10 marks** Written tests

	B. End Semester Evaluation: **Total: 70 marks** i) Short answer type questions: Answer any 10 questions out of 12 (10*3=30). ii) Short essay type questions: Answer any 4 questions out of 6 (4*7=28). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12).

References:

1. Cochran, W.G. (2007).Sampling Techniques, 3rd Edition., John Wiley and Sons.
2. Mukhopadhyay, P. (2013). Theory and Methods of Survey Sampling, 2nd Edition., Prentice Hall of India.

Suggested Readings:

1. Gupta, S.C. and. Kapoor, V.K. 2018.Fundamentals of Applied Statistics, Sultan Chand & Co. New Delhi.
2. Singh, D. and Choudhary,F.S .2020. Theory and Analysis of Sample Survey Designs, 2nd Edition. ,New Age International Publishers. Prentice- Hall of India.
3. Sampath.(2005).Sampling Theory and Methods, 2nd Edition., Alpha Science International Limited.
4. Sukhatme,P.V., Sukhatme,B.V., Sukhatme, S. and Asok, C. (1954).Theory of Sample surveys with applications , IASRI, Delhi.

Mahatma Gandhi University

Kottayam

Programme	**BSc (Hons) Statistics**					
Course Name	**Introduction to Multivariate Analysis**					
Type of Course	**DSC A**					
Course Code	**MG5DSCSTA302**					
Course Level	**300**					
Course Summary	To provide the students with knowledge of the statistical concepts of multivariate data analysis and their basic methodology.					
Semester	**5**	**Credits**			**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		4				**60**
Pre-requisites						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	Program Outcome
1	Understand basics of multivariate techniques.	U	1, 2
2	Apply multivariate testing procedures to real life datasets.	A, Ap, S	1, 2
3	Apply MDS and PCA for dimension reduction.	A, Ap, S	1, 2
4	Apply Factor analysis for identification of latent variables.	A, Ap, S	2
5	Classify the multivariate observations into groups using classification methods.	A, Ap, S	2
6	Identify patterns in data using cluster and correspondence analyses.	A, Ap, S	2

Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	**Hours**	**CO No.**
Module 1	**Dimension Reduction Techniques**	**15**	
1.1	Hotelling's and Mahalanobis statistics, their properties, inter-relationships and uses. Canonical variates and canonical correlation, use, estimation, and computation.	6	1, 2
1.2	Profile Analysis and the associated tests.	3	2
1.3	Multidimensional Scaling, Principal Component Analysis(PCA)-Method of extraction-properties, the associated tests.	6	2, 3
Module 2	**Latent Variable Identification**	**15**	
2.1	Factor Analysis-Types- Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). EFA-Orthogonal Model.	9	4
2.2	Estimation of factor loadings, factor rotations.	6	4
Module 3	**Statistical Machine Learning**	**15**	
3.1	Bayes' Classifier, Fisher's linear discriminant function.	3	5
3.2	Support Vector Machine, PCA approach.	3	5
3.3	Classification trees and K-Nearest Neighbors (KNN) algorithm.	3	5
3.4	Cluster Analysis: proximity measures.	**2**	6
3.5	Hierarchical and non-hierarchical methods.	2	6
3.6	Correspondence Analysis.	2	6

Module 4	**Statistical Analysis**	**15**	
4.1	A record with minimum 5 problems has to be submitted.		4,5
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 20 marks** Quiz, Assignments, Seminar ***Summative assessment*** **Theory: 10 marks** Written tests
	B. Semester End Examination: (Theory based examination) **Total: 70 marks** i) Short answer type questions: Answer any 10 questions out of 12 (10*3=30). ii) Short essay type questions: Answer any 4 questions out of 6 (4*7=28). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12).

References:

1. Johnson, R.A. and Wichern, D.W.(2013). Applied Multivariate Statistical Analysis, 6th Edition.Pearson Education.
2. Vander Plas, J. (2022). Python Data Science Handbook: Essential Tools for Working with Data.2nd Edition. Shroff Publishers & Distributors Pvt. Ltd
3. Brian Everitt , Torsten Hothorn (2011). An Introduction to Applied Multivariate Analysis with R, Springer New York, NY.

Suggested Readings:

1. Anderson, T.W.(2009).An Introduction to Multivariate Statistical Analysis, 3rd Edition, John Wiley.
2. VanderPlas, J. (2022). Python Data Science Handbook: Essential Tools for Working with Data. 2nd Edition.,Shroff Publishers & Distributors Pvt. Ltd.
3. Rencher, A.C.(1998). Multivariate Statistical Inference and Applications,1st Edition, Wiley-Interscience.
4. Seber G. F. (2004). Multivariate Observations. 1st Edition, John Wiley & Sons.

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Programme						
Course Name	**Basic Statistical Skills for Economics- I** **(For Economics Students)**					
Type of Course	**DSC A**					
Course Code	**MG5DSCSTA303**					
Course Level	**300**					
Course Summary	This course explores a strong foundation in mathematical modelling and its applications in economic analysis and they can also understand how economic theory can be zipped using mathematical tools in differential calculus.					
Semester	**5**	**Credits**			**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		4				**60**
Pre-requisites						

EXPECTED COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	Program Outcome
1	Provide students with a strong foundation in mathematical modelling and its applications in economic analysis.	U	1

2	Develop a quantitative way approach in solving economic situations using matrix algebra.	A	2
3	Develop mathematical models for future predictions using differentiation.	A	2
4	Understand how the economic theory can be zipped using mathematical tools in differential calculus.	U	1
5	Solve the problems using R.	E	2

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	**Hours**	**CO No.**
Module 1	**Basic Mathematics for Economic Analysis**	**15**	
1.1	Constants, parameters and Variables.	1	1
1.2	Sets and functions,Types of functions: Linear and Non-linear (Quadratic, Logarithmic and Exponential) Solution of linear, quadratic and simultaneous equations.	7	1
1.3	Graphical Representation of Economic models- Economic functions: Demand function, Supply function, Utility function, Consumption function, Production function, Cost function, Revenue function.	7	1
Module 2	**Theory of Matrices**	**15**	
2.1	Concept and types of Matrices, Matrix Operation- Addition, Subtraction, Multiplication (up to 3x3)- Determinants (up to order 3x 3), properties of determinants.	6	2
2.2	Adjoint and inverse of Matrix, Matrix formulation of a problem, Matrix formulation of a system of equations.	5	2

2.3	Solution to linear equations, Cramer's rule and its applications, Uses of matrices in Economics.	4	2
Module 3	**Differential Calculus**	**15**	
3.1	Meaning and definition of differentiation, Rules of Differentiation, Derivative of Logarithmic and Exponential Functions.	5	3
3.2	Differentiation of an implicit function, Partial Derivatives and Rules of Partial Differentiation, Higher-order Partial Derivatives.	5	3
3.3	Uses of Derivatives in Economics- Increasing and decreasing functions, Maxima and Minima of Functions.	5	3
Module 4	**Applications of Differential Calculus**	**15**	
4.1	Marginal utility, Marginal propensity to consume, Marginal propensity to save, Marginal Product, Marginal Cost, Marginal Revenue.	5	4
4.2	Relationship between Average Revenue and Marginal Revenue-Relationship between Average Cost and Marginal Cost – Elasticity: Price elasticity, Income elasticity.	5	4
4.3	Maxima and Minima of functions. Economic applications: Utility maximisation, cost minimisation, profit maximisation. Production function: Homogeneous and non-homogeneous, Cobb-Douglas production function.	5	4
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.

Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 20 marks** Quiz, Assignments, Seminar. ***Summative assessment*** **Theory: 10 marks** Written tests
	B. Semester End Examination: (Theory based examination) **Total: 70 marks** i) Short answer type questions: Answer any 10 questions out of 12 (10*3=30). ii) Short essay type questions: Answer any 4 questions out of 6 (4*7=28). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12).

References:

1. Allen R.G.D: Mathematical Analysis for Economists. Palgrave Mac Millan
2. Bradley Teresa. Essential Mathematics for Economics and Business. Wiley: New Delhi.
3. Alpha C, Chiang and Kevin Wainwright:Fundamental Methods of Mathematical Economics, Fourth Edition, McGraw-Hill.
4. Geoff Renshaw: Maths for Economics, Second edition, Oxford University press.

Suggested Readings:

1. Mike Rosser and Piotr Lis: Basic Mathematics for Economists, third Edition, Rutledge.

2. Dowling E.T, Introduction to Mathematical Economics, 2nd Edition, Schaums Outline Series, McGraw-Hill, New York.
3. James Bradfield , Jeffrey Baldani, An Introduction to Mathematical Economics, Cengage Learning India Pvt Ltd .
4. Knut Sydsaeter, Peter Hammond and Arne Strom :Essential Mathematics for Economic Analysis, Fourth Edition, Pearson.
5. Larry J. Goldstein, David C. Lay, David I. Schneider and Nakhle H. Asmar : Calculus and its Applications, 14th edition, Pearson.

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Programme	**BSc (Hons) Statistics**					
Course Name	**Analytical Tools for Statistics-I**					
Type of Course	**DSE**					
Course Code	**MG5DSESTA300**					
Course Level	**300**					
Course Summary	In essence, this course provides a comprehensive foundation in mathematical concepts that are not only essential for understanding higher-level mathematics but also have wide-ranging applications in various scientific disciplines. The inclusion of sets, sequences, series, functions, and uniform convergence ensures a well-rounded understanding of mathematical structures and their significance.					
Semester	**5**	**Credits**			**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		3		1		**75**
Pre-requisites						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	Program Outcome
1	Summarise and classify different concepts related to sets and sequences.	U	2
2	Apply algebra of sequences to test the convergence of sequences.	A , An & E	1

3	Perform various tests for convergence of the series by critically analysing the series.	A, An & E	2
4	Distinguish between positive term series and alternating series and perform appropriate tests for convergence.	A, An, & E	1
5	To check the continuity of different types of functions and judge whether a function is continuous or not.	A ,An & E	2
6	Synthesise uniform continuity and absolute continuity and check these for functions .	U & An	1
7	Understand Rolle's theorem and mean value theorems and their interpretation.	U &An	1
8	Apply mathematical techniques like convergence of series , continuity and differentiability etc. in various statistical concepts and build new models.	A, E & C	2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	**Hours**	**CO No.**
Module1	**Sets and Sequences**	**15**	
1.1	Sets-Bounded and unbounded sets, supremum and infimum.	3	1
1.2	Neighbourhood of a point, limit point of a set, derived set, Bolzano-Weierstrass theorem (without proof), open and closed sets.	4	1
1.3	Sequences-Convergence and divergence of sequences, Bolzano-Weierstrass theorem(without proof), limit inferior and limit superior (Definitions and examples only), Cauchy's general	5	1

	principle of convergence, Cauchy sequences. Limits of some special sequences such as $r^n, (1+\frac{r}{n})^n$ and $n^{\frac{1}{n}}$.		
1.4	Algebra of sequences, Sandwich theorem, Cauchy's first and second theorems on limits, Monotonic sequences, Monotone convergence theorem.	3	2
Module 2	**Infinite Series**	**13**	
2.1	Definition, positive term series, tests for convergence: comparison test, Cauchy's root test, D'Alembert's ratio test, Raabe's test, logarithmic test.	6	3
2.2	Alternating series, Leibnitz test for the convergence of alternating series.	4	4
2.3	Absolute convergence and conditional convergence.	3	4
Module 3	**Functions of a Single Variable, Uniform Convergence of Sequences and Series of Functions.**	**17**	
3.1	Limits of a function, continuous functions, continuity at a point and continuity in an interval, discontinuous functions, types of discontinuity, functions continuous on closed interval.	5	5
3.2	Uniform continuity and absolute continuity, derivatives, derivability at a point, derivability in an interval.	3	6
3.3	Darboux's theorem (without proof), intermediate value theorem for derivatives, Rolle's Theorem, Lagrange's Mean Value Theorem, Cauchy's Mean value theorem.	4	6
3.4	Sequence of functions, point wise convergence, uniform convergence, M_n test for uniform convergence (Without proof).	3	7
3.5	Series of functions, Point wise convergence, uniform convergence, Weierstrass's M-Test (Without proof).	2	7
Module 4	**Practical Using Statistical Softwares** (Submit practical sheet with minimum 10 problems)	**30**	7
Module 5	**Teacher Specific content.** This can be classroom teaching, practical session, field visit etc. as specified by the teacher concerned. This content will be evaluated internally.		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** ***Theory:* 15 marks** Quiz, Assignments ***Practical:* 15 marks** Lab involvement, Practical Record,Viva voce ***Summative assessment*** **Theory: 10 marks** Written tests
	B. End Semester Evaluation (ESE) **Theory : 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12). **Practical: 35 marks** Problem solving skills: 30 marks Record: 5 marks

References:

1. Malik, S.C. and Arora, S. (2017*)*. Mathematical Analysis, 5th Edition, New Age International limited, New Delhi.

2. Bali, N.P (2023). Real Analysis, 2nd Edition. New Age International limited, New Delhi.

Suggested Readings:

1. Shanti Narayan and Raisinghania, M.D. (2021).Elements of Real Analysis, S.Chand & Company, New Delhi
2. Rudin,W.(2023). Principles of Mathematical Analysis, 3rd Edition, McGraw Hill.
3. Apostal, T.M.(2002).Mathematical Analysis, 2nd Edition, Narosa Publishing House, New Delhi.

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Programme	**BSc (Hons) Statistics**				
Course Name	**Statistical Reliability Analysis**				
Type of Course	**DSE**				
Course Code	**MG5DSESTA301**				
Course Level	**300**				
Course Summary	Students will gain a solid comprehension of life distribution, various ageing types, and reliability estimation, enabling them to adeptly navigate hands-on sessions using software tools.				
Semester	**5**	**Credits**		**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**
		3		**1**	**75**
Pre-requisites					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	Program Outcome
1	Describe the basic concepts of reliability .	U,K	1
2	Explain coherent systems and can represent such systems by paths and cuts.	K	1
3	Calculate the reliability of components in complicated systems.	A	2
4	Explain different reliability measures.	U	1

Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Introduction to Reliability**	**15**	
1.1	Basic concepts in reliability, series and parallel systems, k out of n systems and its reliability.	8	1
1.2	Coherent systems, reliability of coherent systems, cuts and paths, bounds on system reliability.	7	2
Module 2	**Life Distributions**	**15**	
2.1	Life distributions, reliability function, hazard rate and mean residual life function, one-one correspondence of these functions.	6	1
2.2	Study of life time models viz, exponential, Weibull, Lognormal, Pareto, Gamma, Makeham, Reliegh distributions.	6	1
2.3	Proportional hazard models and their characteristics.	3	1
Module 3	**Different types of Ageing and Reliability Estimation**	**15**	
3.1	Notions of ageing, increasing failure rate (IFR), increasing failure rate average (IFRA).	3	3
3.2	New Better than Used (NBU), Decreasing Mean Residual Life (DMRL) and New Better than Used in Expectation (NBUE).	3	3
3.3	Classes and their duals, loss of memory property of the exponential distribution, closures of these classes under formation of coherent systems, convolutions and mixtures.	3	3
3.4	Reliability estimation using MLE - Exponential, Weibull and Gamma distributions based on censored and uncensored samples.	3	4
3.5	Kaplan-Meier estimates of the distribution function, stress-strength reliability and its estimation.	3	4
Module 4	**Practical using R/Python**	**30**	

4.1	A record with minimum 10 problems has to be submitted.		4
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** ***Theory:* 15 marks** Quiz, Assignments ***Practical:* 15 marks** Lab involvement, Practical Record,Viva voce ***Summative assessment*** **Theory: 10 marks** Written tests
	B. End Semester Evaluation (ESE) **Theory : 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12). **Practical: 35 marks**

	Problem solving skills: 30 marks Record: 5 marks

References:

1. Barlow R.E. and Proschan F. (1965) Mathematical Theory of Reliability, Wiley, New York.
2. Sinha S. K. (1986) Reliability and Life Testing, Wiley Eastern.
3. Barlow R.E. and Proschan F. (1985) Statistical Theory of Reliability and Life Testing, Holt Rinehart and Winston, New York.

Suggested Readings:

1. Rao S.S. (1992). Reliability-based design, McGraw Hill, New York.
2. Lai C.D and Xie M. (2006). Stochastic ageing and dependence in reliability, Springer.

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Programme	**BSc (Hons) Statistics**					
Course Name	**Statistical Computing using Python (Data Analytics Specialization)**					
Type of Course	**DSE**					
Course Code	**MG5DSESTA302**					
Course Level	**300**					
Course Summary	To equip the students to use Python programming language in statistical data investigations.					
Semester	**5**	**Credits**			**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		3		**1**		**75**
Pre-requisites						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	Program Outcome
1	Identify the role of Python programming and packages in statistical data analysis.	U, Ap	2
2	Understand the features and syntax of Python Programming.	U	1
3	Use Python programming for data manipulation and for getting descriptive measures of datasets.	A, S	1
4	Implement Python in creating graphical representations of data.	A, An, E	1
5	Create statistical models for studying the relationship between variables, using Python.	A, An, E	2

6	Construct artificial data using random number generators for simulating real life phenomena.	A, C	1
7	Formulate statistical hypothesis for research problems and check the validity of the hypothesis from sample data using statistical hypothesis testing procedures in Python.	A, An, E, C	2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	**Hours**	**CO No.**
Module 1	**Introduction to Python**	**15**	
1.1	Different Python interfaces: Python Idle, Conda, Spyder, Jupyter Notebook.	5	1
1.2	Python Data types: Python numbers, string, list, tuple, dictionary and set.	4	1, 2
1.3	Basic syntax-Importance of indentation in Python.	3	2
1.4	Control flow structures: if else statements, while, for loops, defining functions in python.	3	2
Module 2	**Introduction to Data Science Packages**	**15**	
2.1	Introduction to NumPy. Creating NumPy arrays from lists. Pattern and random number generation using Numpy-range(), linspace(), random() etc. Useful functions in NumPy.	5	3
2.2	Introduction to Pandas, Creating Panda series and Data frame from various inputs like lists, dictionary, csv files, etc. Indexing elements in Pandas objects.	3	3
2.3	Data Manipulation with functions and methods in Pandas. Dealing with missing values-dropna(), fillna(). Reshaping data-stack(), melt(), pivot_table() functions.	5	3
2.4	Joining datasets row wise and column wise. Joining tables based on key columns-inner join, outer join.	2	3

Module 3	**Introduction to Plotting in Python**	**15**	
3.1	Matplotlib- Scatter plots, histogram, bar plots, line diagram, box plots, pie charts.	4	4
3.2	Introduction to seaborn package. Low level plots and the corresponding high-level plots-countplot vs catplot, scatterplot vs relplot, regplot vs lmplot, etc.	6	4
3.3	Advanced Plotting using seaborn-lmplot, stripplot, swarmplot, violinplot, boxenplot , etc.: Faceting and hue.	5	4
Module 4	**Data Science using Python** (A practical record with minimum 10 problems has to be submitted.)	**30**	
4.1	Introduction to stat module from sciPy. Random Number Generation- Uniform, Bernoulli, Binomial, Normal, etc. p-p plots, qq plots, illustrating limit theorems using random number generation and various relationships. Computing probabilities and quantiles using pdf(), ppf(), isf(), etc.	8	5
4.2	Defining new distributions. Testing of Hypotheses- t-tests, ANOVA, Tests for sphericity, Tests for proportion, etc. Introduction to machine learning using Scikit Learn-Principal Component Analysis, Multidimensional Scaling, Factor Analysis	8	5, 6
4.3	Supervised learning- Linear and logistic regression, Classification-Fisher's Discriminant, Support vector machine, KNN, Decision Tree-Classification Tree and Regression Tree.	8	6, 7
4.4	Unsupervised Learning- Clustering-K Means and Hierarchical, Correspondence analysis.	6	6, 7
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.

Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** ***Theory:* 15 marks** Quiz, Assignments ***Practical:* 15 marks** Lab involvement, Practical Record,Viva voce ***Summative assessment*** **Theory: 10 marks** Written tests
	B. End Semester Evaluation (ESE) **Theory : 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12). **Practical: 35 marks** Problem solving skills: 30 marks Record: 5 marks

References:

1. Vander Plas, J. (2022). Python Data Science Handbook: Essential Tools for Working with Data. 2nd Edition., Shroff Publishers & Distributors Pvt. Ltd.
2. Gaddis, T.(2018). Starting out with Python. 4th Edition Pearson Education

Suggested Readings:

1. Langtangen, H. P. (2018*).* A primer on scientific programming with Python (Vol.6). 5th Edition, Springer.
2. Downey, A., Elkner, J. and Meyers, C. (2015).Learning With Python. 1st Edition Dreamtech Press.
3. Salaria R.S.(2019).Programming in Python, Khanna Book Publishing Co.(P) Ltd., New Delhi.
4. Grus, J. (2019). Data Science From Scratch: First Principles with Python. 2nd Edition, Shroff Publishers & Distributors Pvt. Ltd

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Programme	**BSc (Hons) Statistics**					
Course Name	**Lifetime Data Analysis**					
Type of Course	**DSE**					
Course Code	**MG5DSESTA303**					
Course Level	**300**					
Course Summary	Students will master the fundamental principles of survival analysis and develop a comprehensive understanding of censoring.					
Semester	**5**	**Credits**			**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		3		**1**		**75**
Pre-requisites						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains*	Program Outcome
1	Understand the basic concepts of survival	U	1
2	Evaluate nonparametric Estimation of Basic Quantities for Right Censored and Left Censored Data	E	1
3	Explain different types of semiparametric models	U,K	1
4	Apply model building using the Proportional Hazards Model	A,S	2
5	Analyse likelihood Function Formulation, Nonparametric Methods.	An	2
6	Describe multiple mode of Failures and evaluate basic Characteristics and Model Specification,	U,E	1

**Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Introduction to Survival Analysis**	**15**	
1.1	Basic Quantities and Models - Survival function, Hazard function, Mean residual life function, Common Parametric Models for Survival Data.	7	1
1.2	Censoring and Truncation - Right Censoring, Left or Interval Censoring, Truncation, Likelihood Construction for Censored and Truncated Data, Counting Processes.	8	1
Module 2	**Nonparametric Estimation**	**15**	
2.1	Nonparametric Estimation of Basic Quantities for Right Censored and Left Censored Data.	2	2
2.2	Estimators of the Survival and Cumulative Hazard Functions for Right Censored Data, Pointwise Confidence Intervals for the Survival Function (without derivation).	5	2
2.3	Estimators of the Survival Function for Left-Truncated and Right-Truncated Data; Estimation of the Survival Function for Left, Estimating the Hazard Function.	5	2
2.4	Hypothesis Testing - One-Sample Tests, Tests for Two or More Samples.	3	2
Module 3	**Semiparametric Models**	**15**	
3.1	Semiparametric Proportional Hazards Regression with Fixed Covariates: Coding Covariates, Partial Likelihoods for Distinct-Event Time Data, Partial Likelihoods when Ties are present,	4	3
3.2	Model building using the Proportional Hazards model, Estimation for the survival function, Regression diagnostics, Cox-Snell	5	4

	residuals for assessing the fit of a Cox Model, Graphical checks of the Proportional Hazards assumption.		
3.3	Deviance residuals, inference for parametric regression models - Exponential, Weibull and Log Logistics;	2	4
3.4	Multiple modes of failure: Basic characteristics and model specification,	2	6
3.5	Likelihood function formulation, nonparametric methods.	2	5
Module 4	**Practical using R/Python**	**30**	
4.1	A record with minimum 10 problems has to be submitted.		4,5
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** ***Theory:* 15 marks** Quiz, Assignments ***Practical:* 15 marks** Lab involvement, Practical Record,Viva voce ***Summative assessment*** **Theory: 10 marks** Written tests

	B. End Semester Evaluation (ESE) **Theory : 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12). **Practical: 35 marks** Problem solving skills: 30 marks Record: 5 marks

References:

1. Klein J.P. and Moeschberger M.L. (2003). Survival Analysis - Techniques for censored and truncated data, Second Edition, Springer-Verlag , New York,
2. Lawless J.F. (2003). Statistical Models and Methods for Lifetime Data, Second Edition, John Wiley & Sons, Relevant Sections of the Chapters 9.

Suggested Readings:

1. Kalbfleisch J.D. and Prentice, R.L. (2002). The Statistical Analysis of Failure Time Data, Second Edition, John Wiley & Sons Inc.
2. Hosmer Jr. D.W and Lemeshow S. (1999). Applied Survival Analysis - Regression Modelling of Time to event Data, John Wiley & Sons. Inc.
3. Nelson. W. (2003). Applied Life Data Analysis.
4. Miller, R.G. (1981). Survival Analysis, John Wiley.

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Programme	**STATISTICS**					
Course Name	**Data Reduction Using Statistical Techniques**					
Type of Course	**SEC**					
Course Code	**MG5SECSTA300**					
Course Level	**300**					
Course Summary	Discussion of various Statistical data reduction techniques and their implementation using the programming language R.					
Semester	**5**	**Credits**			**3**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		3				**45**
Pre-requisites						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	Program Outcome
1	Analyse the Data and decide upon the appropriate Data reduction Technique.	A	2
2	Practise various Data reduction Techniques using R.	A	2
3	Conclude from Various Data Reduction Techniques.	An	8

**Remember (K), Understand (U), Apply (A), Analyze (An), Evaluate I, Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Proximity Measures**	**15**	
1.1	Introduction and need of distance. Similarity measures.	3	1
1.2	Similarity measures: Euclidean distance, Manhattan distance (L1 norm),Cosine similarity, Jaccard similarity, Pearson correlation coefficient.	6	1
1.3	Dissimilarity measures: Hamming distance, Manhattan dissimilarity, Mahalanobis distance, Minkowski distance.	6	1
Module 2	**Dimension Reduction in Machine learning**	**15**	
2.1	Introduction about Chernoff face	3	1
2.2	Chernoff faces in R by using the package aplpack .	3	2
2.3	Introduction to Multidimensional scaling	3	2
2.4	Introduction to feature selection, feature extraction, Principal Component Analysis (PCA), Exploratory Factor Analysis (EFA). Implementation of PCA and FA in R. Reducing the Data using PCA and FA.	6	2
Module 3	**Cluster Analysis**	**15**	
3.1	Discrimination and Classification / (Supervised vs unsupervised learning).	5	1

3.2	Linear Discriminant function analysis (LDA)	5	1
3.3	Illustrate the concepts mentioned in all modules using R	5	1
Module 4	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 15 marks** Quiz, Assignments ***Summative assessment*** **Theory: 10 marks** Written tests
	B. End Semester Evaluation(ESE) **Total: 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14).

	ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12).

References:

1. Johnson, Richard A;Wichern, Dean W. (2013). Applied Multivariate Statistical Analysis. Pearson Education Limited.
2. Charu C. Aggarwal (2022). Machine Learning for Text, Springer.

Suggested Readings:

1. Antony Unwin. (2015). Graphical Data Analysis with R. Chapman & Hall/CRC the R Series, CRC Press.
2. Klaus Backhaus, Bernd Erichson, Sonja Gensler, Rolf Weiber, Thomas Weiber. (2023). Multivariate Analysis: An Application- Oriented Introduction, Springer Gabler.
3. Joseph F. Hair, William C. Black, Barry J. Babin, Rolph E Anderson. (2019). Multivariate Data Analysis. Cengage Learning.
4. Paul Fieguth. (2022). An Introduction to Pattern Recognition and Machine Learning, Springer.

SEMESTER 6

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Programme	**BSc (Hons) Statistics**				
Course Name	**Time Series Analysis and Forecasting**				
Type of Course	**DSC A**				
Course Code	**MG6DSCSTA300**				
Course Level	**300**				
Course Summary	This course aims to introduce the concept of time series and its statistical analysis.				
Semester	**6**	**Credits**		**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**
		4			**60**
Pre-requisites					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	Program Outcome
1	Understand the importance of time series analysis in real life problems.	U, Ap	1, 2
2	Apply the concept of additive and multiplicative models in decomposing the components of a time series data.	U, A, Ap	1, 2
3	Estimate the trend component, present in a time series.	A, An, E	1, 2
4	Estimate the seasonal and cyclical variations.	A, An, E	2
5	Perform statistical modelling of a time series using the concepts of autoregression and moving average.	C, A	2

6	Forecast future values of a time series based on past data.	A	2
Remember (K), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Introduction to Time Series Data**	**15**	
1.1	Time series, components of time series, additive and multiplicative models.		1, 2
1.2	Determination of trend, analysis of seasonal fluctuations, test for trend and seasonality.		2, 3, 4
1.3	Exponential and moving average smoothing, holt-winter smoothing, forecasting based on smoothing.		6
Module 2	**Study of Stationarity**	**15**	
2.1	Time series as a discrete parameter stochastic process, auto covariance and autocorrelation functions and their properties, stationary processes.		5
2.2	Test for stationarity. Unit root test, stationary processes in the frequency domain, spectral analysis of lime series.		5
2.3	Detailed study of the stationary processes: Moving Average (MA) and autoregressive (AR).		5, 6
2.4	Introduction to Autoregressive moving average (ARMA) and autoregressive integrated moving average (ARIMA) models.		5, 6
Module 3	**Estimation of ARMA models**	**15**	
3.1	Estimation of ARMA models, maximum likelihood method (the likelihood function for a Gaussian AR(1) and a Gaussian MA(1)) and Least squares.	8	5, 6

3.2	Yule-Walker estimation for AR Processes, choice of AR and MA periods, forecasting, residual analysis and diagnostic checking.	7	5, 6
Module 4	**Statistical Analysis Using R /Python**	**30**	5, 6
4.1	1. Plotting a real life time series, and detecting various features (trend, periodic behaviours etc.). Suggested data sets: Sun spot data, Dollar-Rupee exchange rates, Stock market data, etc. 2. Fitting and plotting of mathematical curves: modified exponential curve, Gompertz curve. 3. Fitting of trend by Moving Average Method. 4. Plotting de- trended series. 5. Measurement of Seasonal indices Ratio-to-Moving Average method. 6. Plotting ACF and PACF of a given time series using Yule-Walker equation to fit AR (1) and AR (2) models to real life data. 7. Forecasting by short term forecasting methods. 8. Forecasting by exponential smoothing.		
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, Explicit teaching, E-learning, Interactive Instruction, Active Cooperative learning, Seminar, Library work and Group discussion, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 20 marks** Quiz, Assignments, Seminar ***Summative assessment*** **Theory:10 marks** Written tests

	B. End Semester Evaluation(ESE) **Total:70 marks** i) Short answer type questions: Answer any 10 questions out of 12 (10*3=30). ii) Short essay type questions: Answer any 4 questions out of 6 (4*7=28). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12).

References:

1. Box, G.E.P and Jenkins, G.M., Reinsel, G.C. and Ljung, G.M. (2015) Time Series Analysis, Forecasting and Control. 5th Edition. Wiley.
2. Chatfield, C. (2003). The Analysis of Time Series - An Introduction. 6th Edition. Chapman and Hall.

Suggested Readings:

1. Abraham, B. and Ledoltcr, J.C. (2005).Statistical Methods for Forecasting, 1st Edition. Wiley.
2. Brockwell, P.J and Davis, R.A. (2016).Introduction to Time Series and Forecasting 3rd Edition.Springer-Verlag.
3. Kendall, M.G. (1978) Time Series, 2nd Edition.,Charles Griffin and Co Ltd.

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Programme						
Course Name	**Basic Statistical Skills for Economics- II** **(For Economics Students)**					
Type of Course	**DSC A**					
Course Code	**MG6DSCSTA301**					
Course Level	**300**					
Course Summary	The course explores in detail the basics of compiling economic data and evaluating its basic parameters using descriptive statistics. Stakeholders will get an idea about correlation, regression, index numbers and time series that are needed for understanding the economic structure of a nation.					
Semester	**6**	**Credits**			**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		4				**60**
Pre-requisites						

Co No.	Expected Course Outcome	Learning Domains*	Program Outcome
1	Understand the basics of compiling economic data and evaluating its basic parameters using descriptive statistics	U	1

2	Compute and interpret measures of central tendency and dispersion, enabling them to analyse and communicate key characteristics of datasets in diverse practical contexts.	U	1
3	Familiarise the basic quantitative and statistical concepts for economic applications in correlation and regression.	U	1
4	Get an idea about the index numbers and time series that are needed for understanding the economic structure of a nation.	U	1

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

Module 1	**Course Description**	**Hours**	**CO No.**
	Descriptive Statistics	**15**	1
1.1	Statistics, Meaning, collection and presentation of data.	2	1
1.2	Concept of primary and secondary data, quantitative and qualitative data, nominal, ordinal and time series data, discrete and continuous data.	3	1
1.3	Designing a questionnaire.	2	1
1.4	Concepts of statistical population and sample from a population, different sampling and non sampling methods.	4	1
1.5	Presentation of data by table and by diagrams, frequency distributions by histogram and frequency polygon, cumulative frequency distributions (inclusive and exclusive methods) and ogives.	4	1
Module 2	**Measures of Central Tendency and Dispersion**	**15**	
2.1	Overview of measures of Central tendency- Mean, Median, Mode, Geometric Mean and Harmonic Mean	6	2

2.2	Measures of dispersion. Range, QD, MD, SD, CV	5	2
2.3	Skewness and Kurtosis, Lorenz curve and Gini coefficient.	4	2
Module 3	**Correlation and Regression Analysis**	**15**	
3.1	Correlation, meaning, types.	2	3
3.2	Methods of measuring correlation, scatter diagram, Karl Pearson's coefficient of correlation, rank correlation.	5	3
3.3	Regression, simple linear regression model.	4	3
3.4	Method of ordinary least squares,regression lines, Methods for estimation.	4	3
Module 4	**Index numbers and Time Series Analysis**	**15**	
4.1	Index numbers-uses, weighted and unweighted index numbers, types of index numbers, tests of index numbers.	5	4
4.2	Consumer price index number, wholesale and retail price index number.	4	4
4.3	Time series analysis: Introduction and examples of time series from various fields, components of times series, additive and multiplicative models.	4	4
4.4	Trend: Estimation of trend by free hand curve method, method of semi averages, method of moving averages and OLS method	2	4
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.

Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory:20 marks** Quiz,Assignments, Seminar ***Summative assessment*** **Theory: 10 marks** Written tests
	B. End Semester Examination(ESE) **Total:70 marks** i) Short answer type questions: Answer any 10 questions out of 12 (10*3=30). ii) Short essay type questions: Answer any 4 questions out of 6 (4*7=28). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12).

References:

1. Murray R Spiegel, Larry J Stephens – Statistics, 4th Edition, Schaum's outline series
2. Vohra, N. D. Business Statistics , MC Graw hill
3. Gupta, S. P. Statistical Methods, sultan Chand and Sons.
4. Neil A. Weiss – Introductory statistics, 10th edition, Pearson
5. Amir D Aczel, Jayavel Sounderpandian, Palanisamy Saravanan and Rohit Joshi Complete Business Statistics, 7th Edition, Tata McGrawhill.

Suggested Readings:

1. David R Anderson, Dennis J Sweeney and Thomas A Williams Statistics for business and Economics , 110th edition Cengage.
2. Douglas A Lind, William G Marchal and Samuel W Wathen Statistical techniques in Business and Economics, 13th edition, Tata McGrawhill.

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Programme	**BSc (Hons) Statistics**					
Course Name	**Design and Analysis of Experiments**					
Type of Course	**DSE**					
Course Code	**MG6DSESTA300**					
Course Level	**300**					
Course Summary	This course provides a thorough exploration of statistical modelling and analysis, focusing on the Gauss-Markov Model and Linear Estimation, ANOVA (Analysis of Variance) and ANCOVA (Analysis of Covariance), Experimental Design, Factorial Experiments, with practical implementations using the Python programming language.					
Semester	**6**	**Credits**			**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		3		**1**		**75**
Pre-requisites						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	Program Outcome
1	Understand Gauss Markov set up and determine least square estimates of the parameters.	U & A	1
2	Test the estimability of linear parametric function with reference to a Gauss-Markov model.	An	2
3	Carry out ANOVA, draw conclusions and interpret them	A, An & E	2
4	Compare and contrast ANOVA and ANCOVA.	E	1
5	Synthesise the concepts of designed experiments and develop models for real life situations.	U & C	3
6	Understand various designs like CRD, RBD, LSD and factorial experiments.	U	1
7	Distinguish between simple experiments and factorial experiments.	An	1
8	Apply confounding and analyse confounded designs.	A & An	2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Gauss-Markov model, Linear Estimation, ANOVA and ANCOVA**	**15**	
1.1	Gauss Markov set up, Method of least squares.	2	1
1.2	Linear parametric function, estimability, necessary and sufficient condition for estimability of a linear parametric function. Fixed effects model, random effects model, mixed effects model and analysis of variance model (definitions only).	4	2

1.3	BLUE, Gauss-Markov Theorem (without proof) and simple problems.	3	2
1.4	Testing of linear hypotheses.ANOVA-Definition, models and assumptions used in analysis of variance. Contrasts and analysis of variance, orthogonal contrasts. Analysis of variance of one way classified data. Analysis of variance of two-way classified data (with single observation per cell).	4	3
1.5	Analysis of covariance in one-way classified data with one covariate (Concepts and problems only). Analysis of covariance in two-way classified data with one covariate (Concepts and problems only).	2	4
Module 2	**Experimental Designs**	**15**	
2.1	Absolute and comparative experiments, terminology, experimental error, uniformity trials. Basic principles of designs of experiments-Randomization, Replication and Local control.	3	5
2.2	Completely Randomised Design (CRD).	2	6
2.3	Randomised Block Design (RBD) - Layout. Model and statistical analysis. Relative efficiency of RBD with respect to CRD, Missing plot technique-estimation and analysis of missing observations.	5	6
2.4	Latin Square Design (LSD)-Layout. Model and statistical analysis. Relative efficiency of LSD with respect to CRD and RBD, Missing plot technique -estimation and analysis of missing observations.	5	6
Module 3	**Factorial Experiments**	**15**	
3.1	Definition and use of factorial experiments, definitions of symmetrical and asymmetrical factorial experiments, illustrations. Main effects and interaction effects.	4	7
3.2	Analysis in $2^2, 2^3$ and 2^n experiments in the set-up of RBD, Yates' method for computing factorial effects total.	3	7
3.3	Basic concepts of Confounding (with reference to 2^n experiments).	3	8

3.4	Elementary concepts of BIBD, Split plot design and response surface design (basic concepts only).	5	3
Module 4	**Practical using R/Python** (A practical record with minimum 10 problems has to be submitted.)	**30**	
4.1	1. Estimability when A is a full rank matrix and not a full rank matrix. 2. BLUE 3. Analysis of variance of one way classified data. 4. Analysis of variance of two-way classified data (with single observation per cell). 5. Analysis of covariance in one-way classified data with one covariate. 6. Analysis of covariance in two-way classified data with one covariate. 7. Analysis of CRD. 8. Analysis of RBD. 9. Analysis of LSD. 10. Analysis of RBD with one missing observation. 11. Analysis of LSD with one missing observation. 12. Analysis of 2^2 factorial experiment in RBD. 13. Analysis of 2^3 factorial experiment in RBD.		1, 2, 3,4
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, Explicit teaching, E-learning, Interactive Instruction, Active Cooperative learning, Seminar, Library work and Group discussion, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment***

	Theory: **15 marks** Quiz, Assignments ***Practical:*** **15 marks** Lab involvement, Practical Record,Viva voce ***Summative assessment*** **Theory: 10 marks** Written tests
	B. End Semester Evaluation (ESE) **Theory : 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12). **Practical: 35 marks** Problem solving skills: 30 marks Record: 5 marks

References:

1. Gupta,S.C. and. Kapoor,V.K .(2018).Fundamentals of Applied Statistics, Sultan Chand & Co. New Delhi.
2. Das, M.N. and Giri, N.C. (2017).Design and Analysis of Experiments, 3rd Edition, New Age International (P) Limited Publishers.
3. Montgomery, D.C. (2013).Design and Analysis of Experiments: International Student Version, 8th Edition,Wiley India Pvt. Ltd.

Suggested Readings:

1. Joshi,D.D. (2020).Linear Estimation and Design of Experiments, 2nd Edition, New Age International (P) Limited Publishers.
2. Cochran, W.G. and Cox, G.M. (1992). Experimental Designs, 2nd Edition, Wiley Classics Library.

3. Hinkelmann, K. and Kempthrone, O. (2014).Design and Analysis of Experiments, Vol.I, John Wiley and Sons

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Programme	**BSc (Hons) Statistics**				
Course Name	**Bayesian Analysis**				
Type of Course	**DSE**				
Course Code	**MG6DSESTA301**				
Course Level	**300**				
Course Summary	Students can understand the role of Bayesian inference in probability and Statistics.				
Semester	**6**	**Credits**		**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**
		3		**1**	**75**
Pre-requisites					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	Program Outcome
1	Understand subjective and frequentist probability, Bayesian inference, prior distributions, posterior distributions and loss function.	U & An	1
2	Explain Bayesian improper priors, common problems of Bayesian inference and Bayesian confidence intervals.	A	1
3	Apply Bayes' Theorem for distributions with Discrete Prior.	Ap	2
4	Understand Bayesian estimation and hypothesis testing.	U	1

5	Obtain Bayesian inference for normal mean.	E	2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Introduction to Bayesian Thinking**	**15**	
1.1	Subjective and frequentist probability, Bayesian inference, prior distributions, posterior distributions.	4	1
1.2	Loss function , the principle of minimum expected posterior loss, quadratic and other common loss functions.	4	1
1.3	Advantages of being Bayesian , improper priors, common problems of Bayesian inference .	4	2
1.4	Point estimators , Bayesian confidence intervals.	3	2
Module 2	**Bayesian Inference for Discrete Random Variables**	**15**	
2.1	Two Equivalent Ways of Using Bayes' Theorem , Bayes' theorem for binomial with discrete prior, important consequences of Bayes' theorem and Bayes' theorem for Poisson with discrete prior.	2	3
2.2	Bayesian inference for binomial: Using a uniform prior - using a beta prior - Choosing your prior.	3	3
2.3	Estimating the proportion, Bayesian credible interval comparing Bayesian and frequentist inferences for proportion: Point estimation.	4	4

2.4	Comparing estimators for proportion, interval estimation.	2	4
2.5	Hypothesis testing. Bayesian inference for Poisson: Some prior distributions for Poisson , Inference for Poisson parameter.	4	4
Module 3	**Bayesian Inference for Normal Mean and Bayesian Computations**	**15**	
3.1	Bayes' theorem for normal mean with a discrete prior, normal mean with a continuous prior , normal prior.	5	5
3.2	Bayesian credible interval for normal mean, predictive density for next observation.	3	5
3.3	Analytic approximation : E-M Algorithm , Monte Carlo sampling , Markov chain Monte Carlo methods.	3	5
3.4	Metropolis-Hastings Algorithm , Gibbs sampling: Examples and convergence issues.	4	5
Module 4	**Practical** (Record with minimum 10 problems should be submitted)	**30**	
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, Explicit teaching, E-learning, Interactive Instruction, Active Cooperative learning, Seminar, Library work and Group discussion, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** ***Theory:* 15 marks** Quiz, Assignments

	Practical: **15 marks** Lab involvement, Practical Record,Viva voce ***Summative assessment*** **Theory: 10 marks** Written tests
	B. End Semester Evaluation (ESE) **Theory : 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12). **Practical: 35 marks** Problem solving skills: 30 marks Record: 5 marks

References:

1. Bolstad W. M. and Curran, J.M. (2016) Introduction to Bayesian Statistics 3rd Edition. Wiley, New York
2. Jim, A. (2009). Bayesian Computation with R, 2nd Edition, Springer

Suggested Readings:

1. Berger, J.O. (1985a). Statistical Decision Theory and Bayesian Analysis, 2nd Edition Springer-Verlag, New York.
2. Ghosh, J. K., Delampady M. and T. Samantha (2006). An Introduction to Bayesian Analysis: Theory & Methods, Springer.

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Programme	**BSc (Hons) Statistics**					
Course Name	**Statistical Analysis in R and Python** **(Data Analytics Specialization)**					
Type of Course	**DSE**					
Course Code	**MG6DSESTA302**					
Course Level	**300**					
Course Summary	The course explores in detail the advanced concepts R and Python packages to analyse and evaluate univariate and multivariate distributions. This course provides a basis for advanced data analysis					
Semester	**6**	**Credits**			**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		3		**2**		**75**
Pre-requisites						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Analyse discrete univariate discrete distributions in R and Python.	U & An	1
2	Analyse discrete univariate continuous distributions in R and Python.	An & E	2

3	Apply R and Python to evaluate sampling distributions.	A & E	3
4	Analyse Multivariate distributions in R and Python.	C	2
5	Evaluate the distributions of quadratic forms in R and Python.	An & E	1
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

Module 1	Course Description	Hours	CO No.
	Discrete Distributions in R/Python	**15**	
1.1	Bernoulli distribution in R programming : dbern(), pbern(), qbern() and r bern() functions, and their plots. Binomial distribution in R programming-dbinom(), pbinom(), qbiono() and rbinom() functions in R and their plots. Bernoulli and binomial distributions in Python	5	1
1.2	Geometric distribution in R programming-dgeom(), pgeom(), qgeom() and rgeom() functions and their plots, Poisson Distribution in R- dpois(x, lambda), ppois(q, lambda), rpois(n, lambda), and their plots. Implementing Poisson Distribution in R. Geometric and Poisson distributions in Python	5	2
1.3	Negative Binomial Density in R Programming: pnbinom(), dnbinom(), qnbinom(), pnbinom() Function, and their plots. Hypergeometric Distribution in R Programming- dhyper(), phyper(),qhyper(),rhyper()and their plots. Negative binomial and hypergeometric distributions in Python.	5	2

Module 2	**Continuous Distributions in R/Python**	**15**	
2.1	Continuous Uniform Distribution in R- runif(), qunif(),dunif() and punif() functions and their plots.Exponential Distribution in R Programming – dexp(), pexp(), qexp(), and rexp() Functions and their plots . Weibull Distributionin R Programming – dweibull(),curve(dweibull(), qweibull(),pweibull(),rweibull()and their plots. Beta Distribution in R Programmin-dbeta(), pbeta(),qbeta(),rbeta() and their plots. Gamma Distribution in R Programming – dgamma(), pgamma(), qgamma(), and rgamma() Functions and their plots. Uniform, exponential, Weibull, beta and gamma distributions in Python.	7	3
2.2	Pareto Distribution in R Programming- dpareto() ppareto(), qpareto(), rpareto(1) and their plots. Normal Distribution in R- dnorm(), pnorm(),qnorm(),rnorm()) and their plots. lognormal Distribution in R: dlnorm(),plnorm(),qlnorm(),rlnorm() functions and their plots. Cauchy Density in R Programming: dcauchy(),pcauchy(),qcauchy(),rcauchy() fumctions and their plots. Laplace Distribution in R- dlaplace ().plaplace(), qlaplace(), rlaplace() and their plots. Logistic distribution in R- dlogis(),plogis(),qlogis(), rlogis() and their plots. Inverse Gaussian Distribution in R- dinvgauss(), pinvgauss(),qinvgauss(),rinvgauss() and their plots. Pareto, normal, lognormal, Cauchy, inverse Gaussian and Laplace distributions in Python.	8	3
Module 3	**Sampling Distributions in R/Python**	**15**	
3.1	Chi-square distribution in R, t-distribution in R, F-distribution in R and Python.	5	4
3.2	Order Statistics in R and Python .	5	4
3.3	Pearson family of distributions in R and Python.	5	4
Module 4	**Practicals using R/Python**	**30**	

4.1	Gumbel's bivariate exponential distribution in R and Python, Bivariate normal distribution in R and Python, Understanding Multinomial Distribution using R and Python.	8	5
4.2	Multivariate normal distribution in R and Python Estimation of ,Mean vector and Variance-Covariance matrix, Visualisation of Variance-Covariance matrix in R and Python , matrix variate gamma and beta distributions in R and Python, Wishart distribution in R and Python.	12	5
4.3	Quadratic forms and their distributions in R and Python, Simple, partial, and multiple correlation between variables in R and Python.	10	5
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** ***Theory:* 15 marks** Quiz, Assignments ***Practical:* 15 marks** Lab involvement, Practical Record,Viva voce ***Summative assessment*** **Theory: 10 marks** Written tests

	B. End Semester Evaluation (ESE) **Theory : 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12). **Practical: 35 marks** Problem solving skills: 30 marks Record: 5 marks

References:

1. Schneider, David I. (2016). An Introduction to Programming Using Python,Pearson Education Limited

2. Haslwanter, Thomas. (2016), An Introduction to Statistics with Python: With Applications in the Life Sciences, Springer.

3. Asmussen, Søren, Glynn, Peter W(2007). Stochastic Simulation: Algorithms and Analysis, Springer.

4. An Introduction to R by W. N. Venables, D. M. Smith and the R Core Team
5. Dalgard, Peter, Introductory statistics with R.Springer.
6. Schumacker, Randall E.(2016). Using R with multivariate statistics,.Sage Publications.
7. Michael J. Crawley. (2007). The R Book. John Wiley and Sons, Ltd.

Suggestions for Reading:

1. Ceder, Vernon L, The Quick Python Book, Manning Publications Co.,Greenwich

2. Saha, Amit Doing math with Python: use programming to explorealgebra, statistics, calculus, and more!, No Starch Press, 2015

3. https://machinelearningmastery.com/how-to-generate-randomnumbers-in-python/

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Programme	**BSc (Hons) Statistics**					
Course Name	**Analytical Tools for Statistics-II**					
Type of Course	**DSE**					
Course Code	**MG6DSESTA303**					
Course Level	**300**					
Course Summary	Calculus of finite differences, Interpolation and numerical integration, Complex Analysis, Functions of several variables, and Riemann Integral collectively form a foundation for advanced mathematical understanding and applications in various fields.					
Semester	**6**	**Credits**			**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		3		**1**		**75**
Pre-requisites						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	Program Outcome
1	Understand the basic operators in calculus of finite differences including Delta, E, Nabla and divided differences and their properties.	U	1
2	Solve interpolation problems using Newton's forward and backward formula, Lagrange's formula, Newton's divided difference formula, Stirling's formula, Bessel's formula and Everett's formula.	An,E	2

3	Compute numerical integration using Trapezoidal rule, Simpson's one-third and three-eighth and Weddle's rule.	An,E	2
4	Understand the concepts and theorems of analytical function including Cauchy-Riemann equations, Cauchy's integral formula, and fundamental theorem of algebra, poles, and singularities.	U,A	1
5	Understand the concepts of maxima and minima and method of Lagrangian multipliers.	U,A	1
6	Understand Fourier transform and Laplace transform and its application to Differential equations.	U,A	1
7	Understand the concept of Riemann integral and its Properties, Integration and differentiation.	U,A	1
8	Explain Fundamental Theorem of Integral Calculus, First Mean Value Theorem of Integral Calculus.	U	4
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	**Hours**	**CO No.**
Module 1	**Calculus of Finite Differences , Interpolation and Numerical Integration**	**15**	
1.1	Operators E, Delta, backward difference operator, central difference operator and their basic properties.	3	1
1.2	Separation of symbols, Divided differences.	2	1
1.3	Newton's forward and backward interpolation formula	2	2
1.4	Lagrange's formula, Newton's divided difference formula.	3	2
1.5	Central difference formulae- Stirling's, Bessel's and Everett's formulae.	3	2

1.6	Numerical quadrature: Trapezoidal rule, Simpson's 1/3rd and 3/8th rules and Weddle's rule.	2	3
Module 2	**Complex Analysis**	**15**	
2.1	Analytic functions , Cauchy Riemann equations.	4	4
2.2	Complex Integration :Cauchy' theorem, Cauchy's integral formula, Morera's theorem, Liouville's theorem.	6	4
2.3	Poles and singularities Cauchy' residue theorem (Statement only of all the theorems).	5	4
Module 3	**Functions of Several Variables and Riemann Integral**	**15**	
3.1	Maxima and minima, method of Lagrangian multipliers.	4	5
3.2	Laplace transform and its application to differential equations, Fourier transforms.	4	6
3.3	Definition and examples of Riemann integral, properties of Riemann integral, integral as a limit of sums, integrability of continuous and monotonic functions, integration and differentiation.	5	7
3.4	Fundamental theorem of integral calculus (without proof), First mean value theorem of integral calculus (without proof).	2	8
Module 4	**Practical using Statistical Softwares** (Record with minimum 10 problems should be submitted)	**30**	
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, Explicit teaching, E-learning, Interactive Instruction, Active Cooperative learning, Seminar, Library work and Group discussion, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)**

	Formative assessment ***Theory:* 15 marks** Quiz, Assignments ***Practical:* 15 marks** Lab involvement, Practical Record,Viva voce ***Summative assessment*** **Theory: 10 marks** Written tests
	B. End Semester Evaluation (ESE) **Theory : 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12). **Practical: 35 marks** Problem solving skills: 30 marks Record: 5 marks

References:

1. Saxena, H.C. (2010).Finite Differences and Numerical Analysis, S.Chand.
2. Shanti Narayan and Raisinghania, M.D. (2021).Elements of Real Analysis, S.Chand & Company, New Delhi.

Suggested Readings:

1. Tyagi, B.S. (2020).Functions of a Complex Variable, Kedar Nath Ram Nath Educational Publishers.
2. Malik, S.C. and Arora, S. (2017). Mathematical Analysis, 5th Edition, New Age International limited, New Delhi.
3. Apostal, T.M.(2002). Mathematical Analysis, 2nd Edition, Narosa Publishing House, New Delhi.

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Programme	**BSc (Hons) Statistics**					
Course Name	**Analysis of Actuarial Statistics using R**					
Type of Course	**SEC**					
Course Code	**MG6SECSTA300**					
Course Level	**300**					
Course Summary	To Understand the concept of computation of interest and its variants. To get an idea on the concept of annuities and to explore the various related features of annuities. To get knowledge of stochastic interest rates, enhance the ideas of the computation of mortality.					
Semester	**6**	**Credits**			**3**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		3				**45**
Pre-requisites	Level 200 knowledge of Statistics and computer					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	Program Outcome
1	To compute the effective rate of interest and effective rate of discount.	U & A	2
2	To get an idea about the increasing and decreasing annuities.	U	1

3	Calculate the purchase prices of an annuity net of tax.	A & An	2
4	Computation of stochastic interest rates.	An & E	2
5	Computation of mortality.	An & E	2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Effective Rate of Interest and Effective Rate of Discount**	**15**	
1.1	Effective Rate of Interest *I*Nominal Rate of Interest $i^{(m)}$- Force of Interest a –Relationship Between different rates of interest – Expression for a by use of calculus-	6	**1**
1.2	Present values –Effective Rate of discount d – Nominalizate discount $d^{(m)}$.	3	**1**
1.3	Annuities –ImmediateAnnuity – Annuity – due – perpetuity – accumulation and Present Values of Annuities – Increasing and Decreasing annuities – Annuities and interest rates with different frequencies –Continuous Annuities.	6	**2**
Module 2	**Annuity Payments, Stochastic interest rates and Probabilities of living and dying.**	**15**	
2.1	Analysis of Annuity payments- Capital and Interest elements included in Annuity payments - loan outstanding after payments-purchase price of Annuities - Annuities Involving Income Tax-Purchase prices of an annuity net of tax.	5	**3**

2.2	Stochastic interest rates - Independent annual interest annual interest rates - The definition of S_n - Mean and variance of Sn- Definition of A_n - Mean and variance of A_n- Simple problems.	5	**4**
2.3	Probabilities of living and dying - The force of mortality i_x - Estimation of i_x - UniformDistributionofdeaths - Select and Ultimate rates.	5	**5**
Module 3	**Statistical Analysis Using R**	**15**	**2,3,4,5**
Module 4	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 15 marks** Quiz, Assignments ***Summative assessment*** **Theory: 10 marks** Written tests

	B. End Semester Examination(ESE) **Total: 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12).

References:

1. Bedford, T and Cooke, R. (2001). Probabilistic risk analysis, Cambridge.

2. Medina,P.K and Merino, S (2003). A discrete introduction: Mathematical finance and Probability, Birkhauser.

3. Philip,M et. al.(1999). Modern Actuarial Theory and Practice, Chapman and Hall..

Suggested Readings:

1. Dickson, David C.M., Cambridge (2009). Actuarial Mathematics for Life Contingent Risks, First Edition, Cambridge University Press.

2. R. Cunningham, T. Herzog, R. London (2008). Models for Quantifying Risk, 3rd Edition, Actex.

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Programme	**BSc (Hons) Statistics**					
Course Name	**Categorical Data Analysis Using R**					
Type of Course	**VAC**					
Course Code	**MG6VACSTA300**					
Course Level	**300**					
Course Summary	Categorical data analysis deals with the study of information captured through expressions or verbal forms. This course helps to make the students proficient in categorical statistical data analysis using R software.					
Semester	**6**	**Credits**			**3**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		3				**45**
Pre-requisites						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	Program Outcome
1	Understand the concept of categorical data.	U	1, 2
2	Describe the categorical response.	A, Ap	1, 2
3	Apply regression models for categorical response variables.	A, Ap, S	1, 2

4	Analyse the above concepts using R software.	A, An	2

Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Introduction to Categorical Data**	**15**	
1.1	Introduction to categorical response data, distributions for categorical data (Bernoulli distribution, Multinomial distribution).	5	1, 2
1.2	Statistical inference for categorical data. Statistical inference for a proportion. Contingency Tables. Table structure. Comparing proportions. Odds ratio.	5	2
1.3	Chi-squared tests. Exact tests for small samples. Correlation for categorical data.	5	2, 3
Module 2	**Generalised Linear Models**	**15**	
2.1	Components of generalised linear model. GLMs for binary data, fitting generalised linear models.	5	3
2.2	Logistic Regression. Probit. Odds and Odds ratios. Logistic regression for classification.	5	2
2.3	Inference for logistic regression. Categorical predictors. Summarising effects. Strategies in model selection. Model checking. Wald Test.	5	2
Module 3	**Statistical Analysis using R**	**15**	
3.1	Apply using R to illustrate and analyse the above statistical concepts.	15	4

Module 4	**Teacher Specific content.**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 15 marks** Quiz, Assignments ***Summative assessment*** **Theory: 10 marks** Written tests
	B. End Semester Examination(ESE) **Total:50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12).

References:

1. Agresti, A. (2010). Analysis of ordinal categorical. John Wiley and Sons.

2. Bilder, C R and Loughin, T M. (2014) . Analysis of categorical data with R. Chapman and Hall/CRC

Suggested Reading:

1. Le, C T. (2009) Applied categorical data analysis and translational research, second edition, John Wiley and Sons.

SEMESTER 7

Mahatma Gandhi University

Kottayam

Programme	**BSc (Hons) Statistics**				
Course Name	**Measure and Probability Theory**				
Type of Course	**DCC**				
Course Code	**MG7DCCSTA400**				
Course Level	**400**				
Course Summary	The course explores in detail the fundamental concepts of Measure Theory and Probability , random variables, distribution functions and their properties, This course provides a basis to introduce higher statistical theory and applications.				
Semester	**7**	**Credits**		**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**
		4			**60**
Pre-requisites					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	Program Outcome
1	Synthesise limit of a sequence of sets and obtain them for sequence of sets.	U , An	1
2	Construct sigma fields and Borel fields.	An , E	2
3	Understand measure theory and identify probability as a measure.	Ap , C	4
4	Compare Lebesgue, Lebesgue-Stieltjes Integral and Riemann Integrals.	U,C	1, 3

5	Evaluate properties of probability.	An , E	2
6	Obtain empirical distribution function.	E	1
7	Identify mathematical expectations as Lebesgue integral	E	2
8	Explain Measurable functions and identify random variables as q measurable functions.	A	1
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Measure Theory**	**15**	
1.1	Finite and countable operations on sets	2	1
1.2	Sequences of sets, monotone sequence and limit of a sequence of sets.	2	2
1.3	Field and sigma field, monotone class, generated sigma field, minimal sigma field, Borel field of R and of R^n	3	3 , 4
1.4	Measurable space, measure, measure space, finite and sigma finite measures, monotone and continuity properties of measures, Counting measure, Lebesgue measure and Probability measure.	5	3 , 4
1.5	Caratheodory Extension theorem (statement only) Lebesgue Stieltjes measures and distribution functions.	3	3, 4
Module 2	**Measurable Functions and Integration**	**15**	
2.1	Measurable functions and their properties, indicator functions, simple functions, measurable functions as limit of simple functions.	4	4
2.2	Integrals of indicator function, simple function and measurable functions	3	4

2.3	Basic integration theorems. Monotone convergence theorem, Fatou's Lemma, Bounded convergence theorem and Lebesgue dominated convergence theorem,	4	4
2.4	Lebesgue and Lebesgue-Stieltjes Integral, comparison of Lebesgue and Riemann Integral.	4	4
Module 3	**Probability Theory**	**15**	
3.1	Discrete and Continuous probability spaces and their properties, monotone, continuity and other properties.	4	5
3.2	Conditional probability, multiplication theorem, total probability and Bayes' theorem. Independence of events.	3	5
3.3	Borel 0-1 criterion. Random variable, vector and sequence of random variables, properties of random variables and vectors, distribution of random variables. Distribution function and its properties.	3	5
3.4	Jordan decomposition theorem, Correspondence theorem (statement only), Independence of random variables.	3	5
3.5	Mathematical expectation, moments and its properties	2	5
Module 4	**Inequalities and Stochastic Convergence**	**15**	
4.1	Basic, Chebychev's, Markov's, Liaponov's, Jensen's, Cr, Cauchy-Swartz's, Holder's, Minkowski's and Chebychev's inequalities.	4	8
4.2	The four modes of convergence-convergence almost surely, convergence in probability, convergence in distribution and convergence in r^{th} mean of a sequence of random variables, properties, counter examples and their inter-relationships.	6	6
4.3	Weak and complete convergence of distribution functions .Helly-Bray Lemma and Helly- Bray Theorem (statements only).	5	7
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 20 marks** Quiz, Assignments, Seminar ***Summative assessment*** **Theory: 10 marks** Written tests.
	B. Semester End Examination: (Theory based examination) **Total: 70 marks** i) Short answer type questions: Answer any 10 questions out of 12 (10*3=30). ii) Short essay type questions: Answer any 4 questions out of 6 (4*7=28). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12).

References:

1. Ash R.B. and Doléans-Dade C.A. (2000). Probability and measure theory, Academic Press.
2. Bhat B.R. (1999). Modern Probability theory, Third Edition, WileyEastern Ltd, New Delhi.
3. Laha R.G. and Rohatgi V.K. (1979). Probability theory, John Wiley.

Suggested Readings:

1. Basu A.K. (2012). Measure Theory and Probability, Second Edition,PHI Learning Pvt. Ltd, New Delhi.
2. Billingsley P. (2012) Probability and Measure, Anniversary edition,Wiley Eastern ltd.
3. Loeve M. (1977) Probability Theory, Fourth edition, Springer-Verlag.
4. Rohatgi V.K. and SalehM. (2015) An introduction to probability and statistics, Third edition, Wiley.
5. Robert G. Bartle (2001), A Modern Theory of Integration, American Mathematical Society (RI).

Mahatma Gandhi University

Kottayam

Programme	**BSc (Hons) Statistics**				
Course Name	**Advanced Distribution Theory**				
Type of Course	**DCC**				
Course Code	**MG7DCCSTA401**				
Course Level	**400**				
Course Summary	The course explores in detail the advanced concepts of probability distributions , and their properties. This course provides a basis to introduce higher statistical theory and applications.				
Semester	**7**	**Credits**		**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**
		4			**60**
Pre-requisites					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	Program Outcome
1	Synthesise various modes of probability distributions.	U, An	1
2	Explore various properties of discrete distributions.	An, E	2
3	Investigate various continuous distributions and their relevance in statistics.	A ,An	4
4	Understand order statistics and derive their distributions.	A ,An	3

Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Probability Distributions**	**15**	
1.1	Probability generating functions, moment generating functions and their properties:,	2	1
1.2	Discrete distributions : Bernoulli, Binomial, geometric, Poisson, negative binomial and hypergeometric, power series.	3	2
1.3	Odd family of distributions: Definition, identification of members.	2	1
1.4	Rectangular, exponential, Weibull, beta, gamma, pareto	2	2
1.5	Normal, lognormal, Cauchy, Laplace, logistic, Inverse Gaussian.	3	4
1.6	Pearson family and exponential family of distributions: Definition and identification of members.	3	2
Module 2	**Functions of Random Variables**	**15**	
2.1	Functions of random variables and their distributions. probability integral transform, distributions of sums, products and ratios of independent random variables		3
2.2	Truncated distributions, compound distributions.		1
Module 3	**Sampling Distributions**	**15**	
3.1	Sampling distributions: Chi-square, t and F distributions (central and non-central forms),	7	4

3.2	Order statistics and their distributions: Joint and marginal distributions, distributions of sample median, range and mid–range (Exponential and Uniform), Quantiles and QQ plot.	8	3
Module 4	**Statistical computing using R/Python** A record with minimum 10 problems has to be submitted.	**15**	2,3,4
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 20 marks** Quiz, Assignments, Seminar ***Summative assessment*** **Theory: 10 marks** Written tests
	B. End Semester Examination(ESE) **Total:70 marks** i) Short answer type questions: Answer any 10 questions out of 12 (10*3=30). ii) Short essay type questions: Answer any 4 questions out of 6 (4*7=28). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12).

References:

1. Gupta S.C. and Kapoor V.K. (2000) Fundamentals of Mathematical Statistics, S. Chand & Co, New Delhi.
2. Hogg R.V and Craig A.T. (2013) Introduction to Mathematical Statistics, Mac Millian publishing company.

Suggested Reading:

1. Arnold B.C, Balakrishnan N. and Nagaraja H.N. (1992). A first Course in Order Statistics.
2. Biswas S. and Srivastava G.L. (2008). Mathematical Statistics: A textbook, Alpha Science International Ltd.
3. Johnson N.L, Kotz S. and Balakrishnan N. (1991) Continuous Univariate distributions I & II, Wiley.
4. Johnson N.L, Kotz S. and Kemp A.W. (1992) Univariate discrete distributions, Wiley.
5. Kotz S, Balakrishnan N. and Johnson N.L. (2000) Continuous Multivariate distributions, Wiley.
6. Rohatgi V.K. and Saleh M. (2015) An introduction to probability and Statistics, Third edition, Wiley.

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Kottayam

Programme	**BSc (Hons) Statistics**					
Course Name	**Advanced Multivariate Distributions**					
Type of Course	**DCC**					
Course Code	**MG7DCCSTA402**					
Course Level	**400**					
Course Summary	The course explores in detail the advanced concepts Multivariate Distributions , and their properties, This course provides a basis to introduce higher statistical theory and applications					
Semester	**7**	**Credits**			**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		3		**1**		**75**
Pre-requisites						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	Program Outcome
1	Synthesise various concepts bivariate distributions and apply.	U , An	1
2	Explore various properties of multivariate normal distributions.	An , E	2
3	Analyse Wishart distribution.	A , E	3
4	Analyse quadratic forms.	C	2
5	Analyse distribution theory of simple and partial correlations.	An , E	1

Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module1	**Bivariate Distributions**	**10**	
1.1	Notions of bivariate distributions, Gumbel's bivariate exponentials and basic properties.	4	1
1.2	Bivariate normal distribution: Marginals and conditionals, independence of random vectors.	4	2
1.3	Multinomial distribution and its basic properties.	2	2
Module 2	**Multivariate Normal Distribution and Wishart Distribution**	**20**	
2.1	Multivariate normal (singular and non-singular), characteristic function, marginals, and conditionals.	4	3
2.2	Properties, characterizations of multivariate normal distribution.	2	3
2.3	Estimation of mean vector and dispersion matrix, independence of sample mean vector and sample dispersion matrix.	4	3
2.4	Jacobian of matrix transformations of Y= AXB; Y= AXA'; X=TT'.	3	4
2.5	Matrix variate gamma and beta distributions.	3	4
2.6	Wishart distribution and its basic properties, characteristic function.	2	4
2.7	Generalised variance and its distribution.	2	4
Module 3	**Quadratic Forms**	**15**	
3.1	Quadratic forms and their distributions (both scalar and vector forms).	4	5

3.2	Independence of quadratic forms, Cochran's theorem.	3	5
3.3	Simple, partial, and multiple correlation distributions, properties and their interrelationships, tests.	4	5
3.4	Null and non-null distribution of simple and partial correlations, null distribution of multiple correlation.	4	5
Module 4	**Practical using R/Python** (A record with minimum 10 problems has to be submitted.)	**30**	**2,3,4**
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, Explicit teaching, E-learning, Interactive Instruction, Active Cooperative learning, Seminar, Library work and Group discussion, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 15 marks** Quiz, Assignments **Practical: 15 marks** Lab involvement, Practical Record,Viva voce ***Summative assessment*** **Theory: 10 marks** Written tests
	B. End Semester Evaluation (ESE) **Theory : 50 marks**

	i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12). **Practical: 35 marks** Problem solving skills: 30 marks Record: 5 marks

References:

1. Anderson T.W. (1984). An introduction to multivariate statistical analysis, Second Edition, John Wiley.
2. Dean W. Wichern, Richard A. Johnson, Applied Multivariate Statistical Analysis, Sixth Edition, Pearson.

Suggested Readings:

1. Feller W. (1968) Introduction to Probability Theory and its Applications, Vols. I & II, John
2 . Seber G.A.F. (1983). Multivariate Observations, John Wiley.
3. Giri, N.(1984). Multivariate Statistical Inference, Academic publishers.
4. Kollo T and Rosen D.V. (2005). Advanced Multivariate Statistics with Matrices, Springer.
5. Kotz S, Balakrishnan N, and Johnson N.L (2000). Continuous Multivariate Distributions, Models and Applications,Volume 1,Second Edition, John Wiley.
6. Mathai A.M. (1996). Jacobians of Matrix Transformations and functions of Matrix Argument, World Scientific Pub CoPvt.Ltd
7. Rao.C.R(2009). Linear statistical inference and its applications,Second Edition, Wiley Eastern.

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Programme	**BSc (Hons) Statistics**					
Course Name	**Statistical Machine Learning**					
Type of Course	**DCE**					
Course Code	**MG7DCESTA400**					
Course Level	**300**					
Course Summary	The course explores in detail the advanced concepts Machine learning, Artificial Neural Networks, Bayesian Learning and Ensemble Learning. This course provides a basis to introduce higher statistical theory and applications					
Semester	**7**	**Credits**			**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		4				**60**
Pre-requisites						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Apply Machine learning	U & An	1
2	Create Artificial Neural Networks	An & E	2
3	Apply Bayesian Learning	A & E	3

4	Analyse Naive Bayes Classifier	C	2
5	Analyse Ensemble Learning	An & E	1
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Introduction to Machine learning**	**15**	
1.1	Introduction to Machine learning, difference between machine learning and Statistics, Decision Tree Learning, Appropriate Problems for Decision tree learning, Basic decision tree algorithm	7	1
1.2	Hypothesis space in decision tree learning, inductive bias in decision tree learning, issues in decision tree learning, Supervised and Unsupervised learning.	8	2
Module 2	**Artificial Neural Networks**	**15**	
2.1	Artificial Neural Networks: Neural network representation, Appropriate problems for neural network learning	8	3
2.2	Perceptron, multilayer networking, and Backpropagation algorithm	7	3
Module 3	**Bayesian Learning and Ensemble Learning**	**15**	
3.1	Bayesian Learning: Bayes theorem and concept of learning, ML and least squared error hypothesis	3	4

3.2	ML hypothesis for predicting probabilities, minimum length description principle	4	4
3.3	Bayes' optimal classifier, Gibbs Algorithm, Naive Bayes Classifier, Bayesian Belief Networks	4	4
3.4	Ensemble Learning: Boosting Procedures, The AdaBoost Algorithm	**2**	5
3.5	Initial analysis, margin explanation, Statistical view, Multiclass Extension, Noise Tolerance, Two Ensemble Paradigms, The Bagging Algorithm, Random Tree Ensembles- Random Forest.	2	5
Module 4	**Statistical Analysis using R and Python** (Record should be submitted with minimum 5 problems)	**15**	
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.

Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 20 marks** Quiz, Assignments, Seminar ***Summative assessment*** **Theory: 10 marks** Written tests
	B. End Semester Evaluation(ESE) **Total:70 marks** i) Short answer type questions: Answer any 10 questions out of 12 (10*3=30). ii) Short essay type questions: Answer any 4 questions out of 6 (4*7=28). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12).

References :

1. Tom Mitchell. (1997). Machine Learning, McGraw Hill. (For Modules 1to 3)
2. Zhi-Hua Zhou (2012). Ensemble Methods Foundations and Algorithms, Chapman & Hall/CRC (For third Module)
3. Pratap Dangeti. (2017). Statistics for Machine Learning Techniques for exploring supervised, unsupervised, and reinforcement learning models with Python and R, Packt Publishing; 1st Edition.

Suggested Readings:

1. Trevor Hastie, Robert Tibshirani, Jerome Friedman The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Springer, Second Edition.
2. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, An Introduction to Statistical Learning with Applications in R, Springer

Mahatma Gandhi University

Kottayam

Programme	**BSc (Hons) Statistics**					
Course Name	**Life Science Data Analysis using R Software**					
Type of Course	**DCE**					
Course Code	**MG7DCESTA401**					
Course Level	**300**					
Course Summary	This course on Lifetime Data Analysis provides a comprehensive exploration of statistical methods crucial for understanding the dynamics of time-to-event data, offering invaluable insights across various disciplines. As we delve into life tables, survival analysis, and regression models, participants will acquire essential skills to analyse and interpret lifetime data. Understanding the nuances of these techniques is paramount, as it equips individuals to uncover patterns, make predictions, and derive meaningful conclusions from diverse datasets, enhancing their ability to make informed decisions in real-world scenarios.					
Semester	**7**	**Credits**			**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		4				**60**
Pre-requisites						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Utilise R for the practical preparation of life tables, demonstrating proficiency in data manipulation and statistical programming.	A	1
2	Assess the significance and practical implications of survival analysis, including the computation and interpretation of survival functions.	A	1
3	Demonstrate the ability to fit and assess regression models for lifetime data, applying statistical techniques to evaluate model performance.	A	2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

Module 1	Course Description	Hours	CO No.
	Life tables, Censoring and Truncation	**15**	
1.1	Life tables: Description of different columns of the life table. Preparation of life tables using R.	3	1
1.2	Definition of survival analysis, survival function, hazard function and cumulative hazard function.	4	2
1.3	Censoring and truncation: Definition and various types.	4	2

1.4	Generating censored and truncated data using R.	4	2
Module 2	**Statistical Methods in Lifetime Data**	**15**	
2.1	Introduction to Kaplan-Meier estimator for survival curves, Implementation of the Kaplan-Meier estimator in real-life datasets.,Log-rank test for comparing survival curves. Practical application of the Log-rank test for group comparison.	5	2
2.2	Introduction to Exponential and Weibull distributions as parametric models.	3	2,3
2.3	Understanding the concept of Maximum Likelihood Estimation (MLE) in the context of parametric survival models.	4	1, 2
2.4	Introduction to alternative parametric models such as Gompertz and Log-Normal distributions.	3	2,3
Module 3	**Cox Proportional Hazards Model**	**15**	
3.1	Cox Proportional Hazards Model: Interpretation and assumptions.	2	3
3.2	Cox Proportional Hazards Model: Model fitting and assessment.	2	3
3.3	Handling Categorical Variables: Handling categorical variables in the context of Cox Proportional Hazards Model-dummy coding or stratification for incorporating categorical predictors.	3	3
3.4	Introduce the concept of time-dependent covariates and how they can be accommodated in the Cox model.	2	3

3.5	Elaborate on the assumption of proportional hazards and how to test and assess it, provide guidance on what to do if the assumption is violated.	3	3
3.6	Compare models using statistical metrics such as Akaike Information Criterion (AIC) or likelihood ratio tests.	3	3
Module 4	**Diagnostic Plots**	**15**	
4.1	Introduce diagnostic plots, such as Schoenfeld residuals, to assess the goodness-of-fit of the Cox model, discuss interpretation and implications of diagnostic plots.	6	3
4.2	Implementing the Cox model using popular statistical software like R.	4	1,3
4.3	Examples of real-world applications of the Cox Proportional Hazards Model in various fields	5	1,3
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.

Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 20 marks** Quiz, Assignments, Seminar ***Summative assessment*** **Theory: 10 marks** Written tests
	B. End Semester Evaluation(ESE) **Total:70 marks** i) Short answer type questions: Answer any 10 questions out of 12 (10*3=30). ii) Short essay type questions: Answer any 4 questions out of 6 (4*7=28). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12).

References

1. Field, A., Miles, J., & Field, Z. (2012). *Discovering statistics using R*. SAGE Publications.

2. David G. Kleinbaum, Mitchel Klein (2012).Survival Analysis: A Self-Learning Text, Third Edition. Springer-Verlag New York

3. Moore, D.F. (2016) Applied Survival Analysis Using R. Use R. Springer, Berli.

Suggested Readings

1. Elisa T. Lee, John Wenyu Wang (2003) Statistical Methods for Survival Data Analysis, Third Edition (Wiley Series in Probability and Statistics).

2. Manual of R Package Lifetable https://cran .r-project.org /web/packages/ LifeTables /LifeTables.pdf.

Mahatma Gandhi University

Kottayam

Programme	**BSc (Hons) Statistics**				
Course Name	**Applied Algorithms**				
Type of Course	**DCE**				
Course Code	**MG7DCESTA402**				
Course Level	**300**				
Course Summary	The course explores in detail the advanced concepts of EM algorithm, Support Vector Machines, Multidimensional scaling and Structural Equation Modelling. This course provides a basis to introduce higher statistical theory and applications				
Semester	**7**	**Credits**		**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**
		4			**60**
Pre-requisites					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Apply EM algorithm.	U & An	1
2	Create Support Vector Machines (SVM).	An & E	2

3	Apply Multidimensional scaling.	A & E	3
4	Analyse quadratic forms.	C	2
5	Analyse Structural Equation Modelling.	An & E	1

Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**EM Algorithm**	**15**	
1.1	EM Algorithm: Two-Component Mixture Model, Gaussian Models. The EM Algorithm in General.	8	1
1.2	EM as a Maximization–Maximization Procedure.	7	2
Module 2	**Support Vector Machines**	**15**	
2.1	Maximal Margin Classifier, Support Vector Classifiers, Support Vector Machines.	7	3
2.2	SVMs with More than Two Class: One- Versus-One Classification and One-Versus-All Classification.	8	3
Module 3	**Multidimensional Scaling**	**15**	
3.1	Multidimensional scaling, Definition, Perceptual Map, Interpreting the axes, decision framework for perceptual mapping.	5	4

3.2	Decision framework for perceptual mapping, Aggregate and disaggregate analysis.	6	4
3.3	Decompositional and Compositional approaches, Interpreting the MDS results.	4	4
Module 4	**Structural Equation Modelling**	**15**	
4.1	Structural Equation Modelling, importance of SEM, variable and constant.	8	5
4.2	Various stages in SEM, Performing SEM and Interpreting them.	7	5
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 20 marks** Quiz, Assignments, Seminar ***Summative assessment*** **Theory: 10 marks** Written tests

	B. End Semester Evaluation(ESE) **Total:70 marks** i) Short answer type questions: Answer any 10 questions out of 12 (10*3=30). ii) Short essay type questions: Answer any 4 questions out of 6 (4*7=28). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12).

References

1. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, An Introduction to Statistical Learning with Applications in R, Springer.
2. Trevor Hastie, Robert Tibshirani, Jerome Friedman The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Springer,
3. Glenn Fung, Olvi L. Mangasarian, Proximal support vector machine classifiers, Proceedings of the seventh ACM SIGKDD international conference on Knowledge discovery and data mining August 2001 Pages 77–86https://doi.org/10.1145/502512.502527 Second Edition.
4. Brian Everitt, Torsten Hothorn (2011) . An Introduction to Applied Multivariate Analysis with R-Springer-Verlag New York.
5. Joseph F. Hair, William C. Black, Barry J. Babin, Rolph E. Anderson. (2009). Multivariate Data Analysis (7th Edition)-Prentice Hall.

Suggestions for Reading:

1. Rex B. Kline (2010). Principles and Practice of Structural Equation Modelling (Methodology in the Social Sciences)-Guilford Press.
2. Randall E. Schumacker. (2015). Using R With Multivariate Statistics-SAGE Publications .

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Programme						
Course Name	**Statistical Techniques for Economic Analysis-I** **(For Economics Students)**					
Type of Course	**DCC**					
Course Code	**MG7DCCSTA403**					
Course Level	**400**					
Course Summary	The course explores in detail the basic concepts of probability, integration and some basic distributions.					
Semester	**7**	**Credits**			**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		4				**60**
Pre-requisites						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains*	Program Outcome
1	Understand the concept of probability	U	1

2	Understand the concept of Integration	U	1
3	Describe Random Variable	U	1
4	Understand BasicDistributions	A	2

Module 1	**Course Description**	**Hours**	**CO No.**
	Probability	**15**	
1.1	Basic probability concepts, meaning of probability.	2	1
1.2	Mutually exclusive and exhaustive events. Independent events.	2	1
1.3	Approaches to assigning probabilities, classical probability, empirical probability, subjective probability.	5	1
1.4	Rules for computing probabilities, additive rule, multiplicative rule.	3	1
1.5	Bayes' theorem, problems.	3	1
Module 2	**Integration**	**15**	
2.1	Indefinite Integral-rules of integration.	2	2
2.2	Integration by substitution, integration by parts.	3	2
2.3	Definite integrals, Area under a curve.	3	2
2.4	Difference equations and differential equations(basic concepts only).	2	2
2.5	Improper integrals-Beta and Gamma integrals.	3	2
2.6	Applications in Economics.	2	2
Module 3	**Random Variables**	**15**	
3.1	Meaning and definition. Discrete and continuous random variables (only concepts).	5	3
3.2	Probability mass function, cumulative distribution function.	4	3

3.3	Expectation of a random variable, Mean and variance using expectation(discrete and continuous random variable).	6	3
Module 4	**Basic Distributions**	**15**	
4.1	Binomial distribution: Definition, pdf, problems.	3	4
4.2	Poisson distribution: Definition, pdf, problems.	3	4
4.3	Normal distribution, standard normal distribution, properties and calculation of probabilities using standard normal table.	9	4
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 20 marks** Quiz, Assignments, Seminar ***Summative assessment*** **Theory: 10 marks** Written tests
	B. End Semester Evaluation(ESE) **Total:70 marks** i) Short answer type questions: Answer any 10 questions out of 12 (10*3=30).

	ii) Short essay type questions: Answer any 4 questions out of 6 (4*7=28). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12).

References

1. Rohatgi V.K. and Saleh, A.K. Md.E. (2009): An Introduction to Probability and Statistics.2nd Edition. (Reprint)John Wiley andSons.
2. Gupta,S.P.StatisticalMethods.SultanChandandSons:NewDelhi.
3. S.C.GuptaandV.K.Kapoor,FundamentalsofMathematicalStatistics,SultanChandand Sons.
4. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory ofStatistics,3rdEdn.,(Reprint),Tata McGraw-Hill Pub.Co.Ltd.John Freund, Mathematical Statistics, Pearson Edn, NewDelhi.

Suggested Readings:

1. McClave, Benson and Sincich (2012): A First Course in Business Statistics,8th Ed, Prentice Hall.
2. Moore, McCabe, Alwan, Craig and Duckworth (20111a): The Practice of Statistics for Business and Economics H Freeman and Company.
3. Lind A. Douglas, Marchal G. William and Wathen A. Samuel (2016)- Basic Statistics for Business and Economics, 7th Ed, McGraw Hill International Edition.
4. Mendenhall William, Beaver J. Robert and Beaver M. Barbara (2014) - Introduction to Probability and Statistics – 12th Ed, Thomson Books/Cole publishers.

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Programme	**BSc (Hons) Statistics**					
Course Name	**Statistical Data Documentation** **(Those who are opting Statistics as minor)**					
Type of Course	**DSE**					
Course Code	**MG7DSESTA400**					
Course Level	**400**					
Course Summary	**Students will be able to prepare documents using LaTex and R markdown.**					
Semester	**7**	**Credits**			**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		4				**60**
Pre-requisites						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	Program Outcome
1	Create basic types of LaTeX documents (article, report, letter, book).	C	1
2	Able to write the index of a document very easily.	S	2
3	Create or import graphics into a LaTeX document.	C	1

4	Create professional presentations using LaTeX; using beamer package.	C	1
5	Create reports in R Markdown, consisting of R codes as well as their output in R	C	1
**Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Introduction to LATEX**	**15**	
1.1	Introduction to LaTex, What is Latex, Merits of LaTex over Word processors, Demerits of LaTex.	4	1
1.2	Installation of TexStudio and MikTex, Understanding Latex compilation-Basic Syntax, Writing equations, Matrix, Tables.	6	2
1.3	Basic Syntax: Creating a Title Page, Page Numbering and Headings, Modifying Text etc. Using packages.	5	2
Module 2	**Advanced LATEX**	**15**	
2.1	Page Layout – Titles, Abstract Chapters, Sections, References.	1	3
2.2	Equation references, citation.	2	3
2.3	List making environments, Table of contents, Generating new commands.	2	3
2.4	Figure handling, numbering, List of figures, List of tables, Generating index.	2	4

2.5	Packages: Geometry, Hyperref, amsmath, amssymb, algorithms, algorithmic graphic, color, tilez listing.	2	4
2.6	Classes: article, book, report, beamer, slides. IEEtran.	3	4
2.7	Applications to: Writing Resume Writing question paper Writing articles/ research papers Presentation using beamer.	3	4
Module 3	**Introduction to R Markdown**	**15**	
3.1	Introduction to the concept of reproducible documents, applying markdown syntax to format text, running code chunks in R Markdown, formatting tables in R Markdown, generating figures in R Markdown, formatting references in R Markdown.	15	5
Module 4	**Document preparing using LATEX and R Studio**	**15**	2,3,4
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 20 marks** Quiz, Assignments, Seminar ***Summative assessment*** **Theory: 10 marks** Written tests

	B. End Semester Evaluation(ESE) **Total:70 marks** i) Short answer type questions: Answer any 10 questions out of 12 (10*3=30). ii) Short essay type questions: Answer any 4 questions out of 6 (4*7=28). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12).

References:

1. Lamport, L. (1994). A Document Preparation System, User's Guide and Reference Manual, Addison -Wesley, New York, Second Edition.
2. Van Dongen, M.R.C.. (2012):LATEX and Friends, Springer-Verlag Berlin Heidelberg.
3. Stefan Kottwitz. (2015). LATEX Cookbook, Packt Publishing.
4. David F. Griffths and Desmond J. Higham. (2016). Learning LATEX. Second Edition.Siam.

Suggested Readings:

1. Xie, Yihui, Joseph J. Allaire, and Garrett Grolemund. R markdown. (2018.). The definitive guide. CRC Press.
2. Allaire, JJ, Yihui Xie, Christophe Dervieux, Jonathan McPherson, Javier Luraschi, Kevin Ushey, Aron Atkins, et al.(2023) Rmarkdown: Dynamic Documents for r. https://github.com/rstudio/rmarkdown.

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Programme	**BSc (Hons) Statistics**					
Course Name	**Statistical Data Visualization** **(Those who are opting Statistics as minor)**					
Type of Course	**DSE**					
Course Code	**MG7DSESTA401**					
Course Level	**400**					
Course Summary & Justification	Students will be able to understand data visualisation techniques and apply visualisation packages.					
Semester	**7**	**Credits**			**4**	**Total Hours**
Total Student Learning Time (SLT)	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		4				**60**
Pre-requisites						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Understand the principles of visual perception.	U	1
2	To identify and eliminate clutter and improve visual perception and understand data design concepts.	A, U	2

3	Understand data visualisation techniques.	U	1
4	Apply analysis visualisation packages.	A	2
**Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module1	**Data Visualisation**	**15**	
1.1	Purpose of visualisation, cognitive load and clutter, Gestalt principles of visual perception.	6	1
1.2	Identifying and eliminating clutter and improving visual perception.	5	2
1.3	Data Design Concepts.	4	2
Module 2	**Multidimensional Visualisation Techniques**	**15**	
2.1	Multidimensional visualisation: Visualising proportions (eg: histograms, bar charts, pie charts) and relationships (eg: scatter plot, line chart, area chart, heat maps).	7	3
2.2	Tree visualisation and graph visualisation.	4	3
2.3	Time series data visualisation techniques.	4	3
Module 3	**Interaction Techniques**	**15**	
3.1	Understanding analytics output and their usage.	3	4
3.2	Basic interaction techniques such as selection and distortion, evaluation.	5	4

3.3	Examples of information visualisation applications and systems.	5	4
3.4	User tasks and analysis visualisation packages.	2	4
Module 4	**Data Visualisation Packages**	**15**	
4.1	Grammar of graphics using R-Construct/Deconstruct a graphic into a data order of accuracy of perceptual tasks and its impact.	**6**	4
4.2	Case study presentations and lab based on R package of Data Visualisations.	**5**	4
4.3	Data Visualization with Python – Matplotlib.	**4**	4
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 20 marks** Quiz, Assignments, Seminar ***Summative assessment*** **Theory: 10 marks** Written tests

	B. End Semester Evaluation(ESE) **Total:70 marks** i) Short answer type questions: Answer any 10 questions out of 12 (10*3=30). ii) Short essay type questions: Answer any 4 questions out of 6 (4*7=28). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12).

References:

1. Storytelling with Data: A Data Visualization Guide for Business Professionals, Cole Nussbaumer Knaflic (Ch:3, 4, 5).
2. Tufte, E., & Graves-Morris, P. (2014). The visual display of quantitative information.
3. Data Visualization: a successful design process, Andy Kirk (Ch-5)

Suggested Readings:

1. Wickham, H. (2016). Ggplot2: Elegant Graphics for Data Analysis. Springer.2nd Edition
2. Keen, K. J. (2010). Graphics for Statistics and Data Analysis with R. CRC Press.
3. Buja, A., Swayne, D. F. & Cook, D., (2007). Interactive and Dynamic Graphics for Data Analysis: with R and Ggobi. Springer Science & Business Media.
4. Dalgaard, P. (2008). Introductory statistics with R. Springer Science & Business Media.
5. Verzani, J. (2014). Using R for introductory statistics. CRC Press.
6. Murrell, P. (2016). R graphics. CRC Press.
7. Cleveland, W. S. (1993). Visualising data. Hobart Press.
8. Tufte, E. R., Goeler, N. H., & Benson, R. (1990). Envisioning information (Vol. 126). Cheshire, CT: Graphics press.

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Programme	**BSc (Hons) Statistics**				
Course Name	**Population Dynamics** **(Those who are opting Statistics as minor)**				
Type of Course	**DSE**				
Course Code	**MG7DSESTA402**				
Course Level	**400**				
Course Summary	Students will be aware about life table preparation and various fertility models.				
Semester	**7**	**Credits**		**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**
		4			**60**
Pre-requisites					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Understand the sources and gradation of mortality data.	U	1
2	Remember life table construction and estimation of survival probability by method of MLE.	K	2
3	Understand fertility models.	U	1

4	Apply population growth indices and projections.	A	2
**Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Mortality rates**	**15**	
1.1	Sources of mortality data,mortality measures,ratios and proportions.	5	**1**
1.2	Crude mortality rates, specific rates- standardisation of mortality rates, direct and indirect methods.	5	**1**
1.3	Gradation of mortality data, fitting Gompertz and Makeham curves.	5	**1**
Module 2	**Life Tables**	**15**	
2.1	Life tables: Complete life table, relation between life table functions, abridged life table, relation between abridged life table functions.	5	**2**
2.2	Construction of life tables, Greville's formula, Reed and Merrell's formula: Sampling distribution of life table functions.	5	**2**
2.3	Multivariate pgf , estimation of survival probability by method of MLE.	5	**2**
Module 3	**Fertility Models**	**15**	
3.1	Fertility models, fertility indices: Relation between CBR,GFR,TFR and NRR.	5	**3**
3.2	Stochastic models on fertility and human reproductive process.	4	**3**
3.3	Dandekar's modified binomial and Poisson models, Brass, Singh models: Models for waiting time distributions.	4	**3**

3.4	Sheps and Perrin models.	2	**3**
Module 4	**Population Growth Indices and Projections**	**15**	
4.1	Population growth indices, logistic model, fitting logistic, other growth models.	4	**4**
4.2	Lotka's stable population, analysis, quasi stable population, effect of declining mortality and fertility on age structure.	4	**4**
4.3	Population projections, component method-Leslie matrix technique.	4	**4**
4.4	Properties of time independent Leslie matrix-models under random environment.	3	**4**
Module 5	**Teacher Specific content.** This can be classroom teaching, practical session, field visit etc. as specified by the teacher concerned. This content will be evaluated internally.		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, Interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 20 marks** Quiz, Assignments, Seminar ***Summative assessment*** **Theory: 10 marks** Written tests

	B. End Semester Evaluation(ESE) **Total:70 marks** i) Short answer type questions: Answer any 10 questions out of 12 (10*3=30). ii) Short essay type questions: Answer any 4 questions out of 6 (4*7=28). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12).

References:

1. Biswas S (1988) Stochastics processes in Demography and applications, Wiley Eastern.
2. Biswas S (2007) Applied Stochastic Processes-A Biostatistical and Population Oriented Approach, Second Edition, New Central Book Agency.
3. Keyfitz N (1977) Applied Mathematical Demography A Wiley Interscience publication.
4. Pollard J.H (1975) Mathematical Models for the growth of Human population, Cambridge University Press.

Suggested Readings:

1. Ramkumar R (1986) Technical Demography, Wiley Eastern.
2. Srinivasan K (1970) Basic Demographic Techniques and Applications.

SEMESTER 8

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Programme	**BSc (Hons) Statistics**				
Course Name	**Advanced Probability Theory and Sampling Techniques**				
Type of Course	**DCC**				
Course Code	**MG8DCCSTA400**				
Course Level	**400**				
Course Summary	The course explores in detail the fundamental concepts of characteristic functions, Law of large numbers , CLT and advanced sampling techniques, This course provides a basis to introduce higher Statistical theory and applications.				
Semester	**8**	**Credits**		**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**
		3			**1**	**75**
Pre-requisites					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Synthesise various Concepts of characteristic function.	U & An	1
2	Explore various properties of characteristic functions.	An & E	2
3	Investigate various forms of law of large numbers and their relevance in statistics.	A &A	4
4	Investigate various forms of CLT s and their relevance in statistics.	A & An	3

5	Apply ratio and regression method of estimation.	A	2
6	Investigate PPS sampling.	E	2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Characteristic Function, Law of Large Numbers and Central Limit Theorems**	**15**	
1.1	Characteristic function of a random variable, properties, continuity and inversion theorems of characteristic functions.	2	1
1.2	Convex combinations of characteristic functions and distribution functions, characteristic function of a vector random variable.	3	2
1.3	Uniform continuity and non-negative definiteness, statement of Bochner's Theorem.	2	2
1.4	Law of large numbers: Weak law of large numbers - Bernoulli, Chebychev's, Poisson and Khintchine WLLN, Necessary and sufficient condition for weak law of large numbers.	3	3
1.5	Strong law of large numbers, Kolmogorov strong law of large numbers for iid random variables.	2	3
1.6	Central limit theorem, De Moivre-Laplace central limit theorem, Lindeberg-Levy central limit theorem, Liaponov's central limit theorem, Lindberg-Feller central limit theorem (Without proof), Statement of Multivariate central limit theorem.	3	4
Module 2	**Ratio and Regression Methods of Estimation**	**15**	
2.1	Ratio method of estimation, estimation of population ratio, mean and total.	2	5

2.2	Bias and relative bias of ratio estimator, comparison with SRS estimation. Unbiased ratio type estimators: Hartley- Ross estimator, Regression method of estimation. Comparison of ratio and regression estimators with mean per Module method.	4	5
2.3	Cluster sampling, single stage cluster sampling with equal and unequal cluster sizes, estimation of the population mean and its standard error.	4	5
2.4	Two- stage cluster sampling with equal and unequal cluster sizes.	3	5
2.5	Multistage and Multiphase sampling (Basic Concepts), estimation of the population mean and its standard error.	2	5
Module 3	**PPS Sampling**	**15**	
3.1	Varying probability sampling, PPS sampling with and without replacement.	2	6
3.2	Cumulative total method, Lahiri's method, Midzuno-Zen method and its inclusion probabilities, estimation of the population total and its estimated variance under PPS wr sampling.	4	6
3.3	Ordered and unordered estimators of the population total under PPS wor, Horwitz – Thomson estimator and its estimated S. E.	4	6
3.4	Des-Raj's ordered estimator, Murthy's unordered estimator (properties of these estimators for n=2 only). Inclusion probability proportional to size sampling procedures.	5	6
Module 4	**Practical using R/Python** (Record with minimum 10 problems should be submitted)	**30**	**2,3,5**
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, Explicit teaching, E-learning, Interactive Instruction, Active Cooperative learning, Seminar, Library work and Group discussion, Group Assignments, Authentic learning, Presentation by students by group.

Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** ***Theory:* 15 marks** Quiz, Assignments ***Practical:* 15 marks** Lab involvement, Practical Record,Viva voce ***Summative assessment*** **Theory: 10 marks** Written tests
	B. End Semester Evaluation (ESE) **Theory : 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12). **Practical: 35 marks** Problem solving skills: 30 marks Record: 5 marks

References:

1. Ash R.B. and Doléans-Dade C.A. (2000) Probability and measure theory, Academic Press.
2. Bhat B.R (1999). Modern Probability theory, Third Edition, Wiley Eastern Ltd, New Delhi.
3. Cochran W.G (1992): Sampling Techniques, Wiley Eastern, New York.
4. Mukhopadhyay,P (2009) Theory and Methods of Survey Sampling, Second Edition, PHI Learning (P) Ltd.
5. Singh,D and Chowdhary,F.S. (1999): Theory and Analysis of Sample Survey Designs, Wiley Eastern (New Age International), New Delhi.

Suggested Readings:

1. Basu A.K. (2012). Measure Theory and Probability, Second Edition, PHI Learning Pvt. Ltd, New Delhi.
2. Billingsley P. (2012) Probability and Measure, Anniversary edition, Wiley Eastern ltd.
3. Loeve M. (1977) Probability Theory, Fourth edition, Springer-Verlag.
4. Rohatgi V.K. and SalehM. (2015) An introduction to probability and statistics, Third edition, Wiley.
5. Robert G. Bartle (2001), A Modern Theory of Integration, American Mathematical Society (RI)
6. Laha R.G. and Rohatgi V.K. (1979) Probability theory, John Wiley.
7. Sukhatmeet., P.V. et. al. (1984): Sampling Theory of Surveys with Applications. IOWA State University Press, USA.
8. Murthy, M.N. (1977) Sampling Theory and Methods, Statistical Publishing Society
9. Sampath S. C. (2001) Sampling Theory and Methods, Alpha Science International Ltd., India.
10. Thomas Lumley (1969) Complex Surveys- A guide to analysis using R, Wiley eastern Ltd.
11. Desraj (1967) Sampling theory. Tata McGraw Hill , New Delhi

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Programme	**BSc (Hons) Statistics**				
Course Name	**Advanced Estimation Theory**				
Type of Course	**DCC**				
Course Code	**MG8DCCSTA401**				
Course Level	**400**				
Course Summary	The course explores in detail the advanced concepts of estimation theory , and their properties, This course provides a basis to introduce higher statistical theory and applications				
Semester	**8**	**Credits**		**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**
		3		**1**	**75**
Pre-requisites					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Synthesise various concepts of estimation theory and obtain the estimates of parameters.	U & An	1
2	Explore various properties of Estimators.	An & E	2
3	Investigate various information measures and their relevance in Statistics.	A &A	4
4	Apply and evaluate various methods of estimation.	A & E	3

5	Construct confidence intervals.	C	2
6	Explore Bayesian inference.	An & E	1
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Point Estimation and Fisher Information Measure**	**15**	
1.1	Point estimation: Properties of estimators:Unbiasedness , consistency, sufficient condition for consistency, sufficiency, minimal sufficiency.	3	1
1.2	Completeness, bounded completeness, Fisher-Neyman factorization theorem.	2	2
1.3	Exponential families, UMVUE estimators and their characterization.	2	2
1.4	Rao-Blackwell theorem, Lehmann – Scheffe theorem.	2	1
1.5	Ancillary statistics, Basu's theorem.	2	2
1.6	Fisher information measure and its properties, Fisher information matrix.	1	6
1.7	Lower bound to the variance of an unbiased estimator, Cramer - Rao inequality, Bhattacharyya's bounds.	2	4
1.8	Efficiency, minimum variance.	1	2
Module 2	**Methods of Estimation**	**15**	
2.1	Method of moments, method of maximum likelihood and their properties, Cramer- Huzurbazar theorem, Fisher's scoring method.	4	4

2.2	Method of minimum chi-square and method of modified minimum chi-square.	3	4
2.3	Interval estimation : Pivotal method of construction, shortest confidence intervals and their construction (minimum average width).	4	5
2.4	Construction of shortest confidence intervals in large samples.	4	5
Module 3	**Basic Elements of Bayesian Inference**	**15**	
3.1	Basic elements of Bayesian inference, Loss function and risk functions, Standard forms of loss functions.	6	6
3.2	Prior distribution, Bayes Theorem, posterior distribution.	4	6
3.3	Bayes risk, Bayes principle, Bayes estimators, minimax estimators.	5	6
Module 4	**Practical using R/Python** (Record with minimum 10 problems should be submitted)	**30**	**4,5,6**
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, Explicit teaching, E-learning, Interactive Instruction, Active Cooperative learning, Seminar, Library work and Group discussion, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** ***Theory:* 15 marks** Quiz, Assignments ***Practical:* 15 marks**

	Lab involvement, Practical Record,Viva voce ***Summative assessment*** **Theory: 10 marks** Written tests
	B. End Semester Evaluation (ESE) **Theory : 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12). **Practical: 35 marks** Problem solving skills: 30 marks Record: 5 marks

References:

1. Rohatgi V.K. and Saleh A.K. (2015) An Introduction to Probability Theory and Mathematical Statistics, Wiley.
2. Berger J.O. (1993) Statistical Decision Theory and Bayesian Analysis, Third Edition, Springer.
3. Casella, G and Berger, R.L (2007) Statistical Inference, Second Edition,Cengage Learning.

Suggested Readings:

1. Hogg R. V. and Craig A. T. (2013) Introduction to Mathematical Statistics, Pearson
2. Kale B. K. (2005) A First Course on Parametric Inference, Alpha Science International.
3. Lehmann E.L. (1983) Theory of point estimation – Wiley, New York.
4. Lindgren B.W (1976) Statistical Decision Theory (3rd Edition), CollierMac Millian, New York.
5. Rao C.R (2009) Linear Statistical Inference and its Applications, John Wiley, New York.

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Programme	**BSc (Hons) Statistics**					
Course Name	**Advanced Testing Statistical Hypotheses**					
Type of Course	**DCE**					
Course Code	**MG8DCESTA400**					
Course Level	**400**					
Course Summary	The course explores in detail the advanced concepts of Testing of hypotheses , and their properties, This course provides a basis to introduce higher statistical theory and applications					
Semester	**8**	**Credits**			**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		3		**1**		**75**
Pre-requisites						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Synthesise various concepts of Testing of hypotheses and apply these concepts.	U & An	1
2	Explore Neyman -Pearson method of testing.	An & E	2
3	Analyse MLR property.	An	1
4	Explore the GLR test.	A &An	4
5	Analyse similar region tests and its relevance.	An & E	2
6	Construct UMP and UMPU similar size-tests.	E & C	3

7	Construct confidence sets.	C	3
8	Explore Hotelling's T-square and apply .	C	2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate I, Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	**Hours**	**CO No.**
Module 1	**Basic Concepts in Statistical Hypotheses Testing and Similar Regions Tests**	**22**	
1.1	Basic concepts in statistical hypotheses testing: Simple and composite hypothesis, critical regions, Type-I and Type-II errors, significance level, p-value, and power of a test.	4	1
1.2	Neyman-Pearson lemma and its applications, Construction of tests using NP lemma, Most powerful test, uniformly most powerful test.	4	2
1.3	Monotone Likelihood ratio and testing with MLR property, Testing in one-parameter exponential families-one sided hypothesis.	3	3
1.4	Unbiased and Uniformly Most Powerful Unbiased tests for different two-sided hypotheses, Extension of these results to Pitman family when only upper or lower end depends on the parameters.	3	5
1.5	Similar regions tests, Neyman structure tests, Likelihood Ratio (LR) criterion and its properties.	2	5
1.6	LR tests for testing equality of means and variances of several normal populations, Testing in multi-parameter exponential families-tests with Neyman structure.	2	4
1.7	UMP and UMPU similar size-tests.	2	6
1.8	Confidence sets, UMA and UMAU confidence sets, Construction of UMA and UMAU confidence sets using UMP and UMPU tests respectively.	2	7

Module 2	**Sequential Probability Ratio Tests (SPRT)**	**13**	
2.1	Sequential Probability Ratio Tests (SPRT), Properties of SPRT, Determination of the boundary constants.	4	1
2.2	Construction of sequential probability ratio tests, Wald's fundamental identity.	4	1
2.3	Operating Characteristic (OC) function and Average Sample number (ASN) functions for Normal, Binomial, Bernoulli's, Poisson and exponential distribution.	5	1
Module 3	**Hotelling's T^2 and Mahalanobis D^2**	**10**	
3.1	Notion of likelihood ratio tests, Hotellings-T^2 and Mahalnobis-D^2 statistics: Their properties, inter-relationships and uses.	4	8
3.2	Null distributions (one sample and two sample cases), Testing equality of mean vectors of two independent multivariate normal populations with the same dispersion matrix.	4	8
3.3	Problem of symmetry, Multivariate Fisher- Behren problem.	2	8
Module 4	**Practical using R/Python** (Record with minimum 10 problems should be submitted)	**30**	**2,3,4**
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, Explicit teaching, E-learning, Interactive Instruction, Active Cooperative learning, Seminar, Library work and Group discussion, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** ***Theory:* 15 marks** Quiz, Assignments ***Practical:* 15 marks**

	Lab involvement, Practical Record,Viva voce ***Summative assessment*** **Theory: 10 marks** Written tests
	B. End Semester Evaluation (ESE) **Theory : 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12). **Practical: 35 marks** Problem solving skills: 30 marks Record: 5 marks

References :

1. Rohatgi V.K. (1976) An Introduction to Probability Theory and Mathematical Statistics, John Wiley & Sons, New York.
2. Anderson T.W. (1984): An introduction to multivariate statistical analysis, Second edition, John Wiley.

Suggested Readings:

1.Casella G. and Berger R.L. (2002) Statistical Inference, Second Edition Duxbury, Australia.
2.Lehman E.L. (1998) Testing of Statistical Hypothesis. John Wiley, New York.
3. Wald (1947) Sequential Analysis, Wiley, Doves, New York.
4. Parimal Mukhopadhyay (2006): Mathematical Statistics, 3/e, Books and Allied (P) Ltd, Kolkata.
5. Rao C.R. (1973) Linear Statistical Inference and its Applications, Wiley.

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Programme	**BSc (Hons) Statistics**					
Course Name	**Stochastic Processes**					
Type of Course	**DCE**					
Course Code	**MG8DCESTA401**					
Course Level	**400**					
Course Summary	The course explores in detail the advanced concepts stochastic processes , and their properties, This course provides a basis to introduce higher statistical theory and applications					
Semester	**8**	**Credits**			**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		3		**1**		**75**
Pre-requisites						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Synthesise various concepts of Stochastic process and apply.	U & An	1
2	Explore various properties of the Markov process.	An & E	2
3	Analyse Random walk.	A & E	3
4	Analyse Poisson process.	C	2
5	Analyse Renewal process.	An & E	1

Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Introduction**	**15**	
1.1	Introduction to Stochastic processes: Classification of stochastic processes according to state space and time space, wide sense and strict sense stationary processes, processes with stationary independent increments.	3	1
1.2	Markov process, Markov chains-transition probability matrices, Chapman-Kolmogorov equation.	3	2
1.3	First passage probabilities, generating functions, classification of states, criteria for recurrent and transient states.	3	2
1.4	Mean recurrence time, mean ergodic theorem, the basic limit theorem of Markov chains (statement only).	3	1
1.5	Reducible and irreducible Markov chains, stationary distributions, limiting probabilities and absorption probabilities.	3	1
Module 2	**Random Walk and Poisson Process**	**15**	
2.1	Random walk, gambler's ruin problem.	2	3
2.2	Galton-Watson branching process, generating function relations.	2	3
2.3	Mean and variance functions, extinction probabilities, criteria for extinction.	2	3
2.4	Continuous time Markov chains, Poisson processes.	1	4
2.5	Pure birth processes and Yule processes, birth and death processes.	2	4
2.6	Kolmogorov forward and backward differential equations, linear growth process with immigration.	2	4
2.7	Steady-state solutions of Markovian queueing models: M/M/1, M/M/1 with limited waiting space.	2	4

2.8	M/M/s, M/M/s with limited waiting space.	2	
Module 3	**Renewal Process**	**15**	
3.1	Renewal processes: concepts, examples.	3	5
3.2	Poisson process viewed as a renewal process, renewal equation, elementary renewal theorem.	4	5
3.3	Asymptotic expansion of renewal function, central limit theorem for renewals.	4	5
3.4	key renewal theorem (statement only), delayed renewal processes.	4	5
Module 4	**Practical using R/Python** (Record with minimum 10 problems should be submitted)	**30**	**1,2,3**
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, Explicit teaching, E-learning, Interactive Instruction, Active Cooperative learning, Seminar, Library work and Group discussion, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** ***Theory:* 15 marks** Quiz, Assignments ***Practical:* 15 marks** Lab involvement, Practical Record,Viva voce ***Summative assessment*** **Theory: 10 marks**

	Written tests
	B. End Semester Evaluation (ESE) **Theory : 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12). **Practical: 35 marks** Problem solving skills: 30 marks Record: 5 marks

References:

1. Medhi J. (2017) Stochastic Processes, Second Edition, Wiley Eastern, New Delhi.
2. Ross S.M. (2007) Stochastic Processes. Second Edition, Wiley Eastern, New Delhi.
3. Ross S.M. (2014) Introduction to Probability Models. Eleventh Edition, Elsevier.

Suggested Readings:

1. Feller W. (1968) Introduction to Probability Theory and its Applications, Vols. I & II, John Wiley, New York.
2. Karlin S. and Taylor H.M. (1975) A First Course in Stochastic Processes, Second edition, Academic Press, New-York.
3. Cinlar E. (1975) Introduction to Stochastic Processes, Prentice Hall, New Jersey.
4. Basu A.K. (2003) Introduction to Stochastic Processes, Narosa, New- Delhi.
5. Bhat U.N. and Miller G. (2003) Elements of Applied Stochastic Processes. (Third Edition), John Wiley, New York.

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Programme	**BSc (Hons) Statistics**				
Course Name	**Operations Research**				
Type of Course	**DCE**				
Course Code	**MG8DCESTA402**				
Course Level	**400**				
Course Summary	Students can understand the role of Linear Programming Problem in finding solutions to complex real-life situations.				
Semester	**8**	**Credits**		**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**
		3		**1**	**75**
Pre-requisites					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Describe the origin of Operations Research as a discipline and various models and different solution methods.	U	1
2	Understand the role of Linear Programming Problem in finding solutions to complex real-life situations.	U	2
3	Formulate real-life decision-making problems as linear programming problems.	An	3
4	Solve linear programming problems using graphical and simplex methods.	A	2
5	Understand the various methods to find the initial basic feasible solutions of transportation problems.	U	1

6	Solve transportation problems using the MODI method and stepping stone methods.	A	2
7	Understand thoroughly the application of assignment problems and solve them.	A	2
8	Explain how to draw a network diagram of a project and calculate project completion time using CPM and PERT.	A & E	2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Operations Research and LPP**	**15**	
1.1	Origin and Development of OR, Objectives of OR, Modeling and types of models in OR.	2	1
1.2	Introduction to Linear Programming Problem, structure of LPP.	2	2
1.3	Mathematical formulation of LPP.	1	3
1.4	Graphical and Simplex methods for solving LPP.	2	4
1.5	Two phase method.	2	4
1.6	Big M-method.	2	4
1.7	Concept of Duality in L.P.P, Dual simplex method, Concept of Sensitivity analysis.	4	4
Module 2	**Transportation and Assignment Problems**	**15**	
2.1	General transportation problem, Methods for finding initial basic feasible solutions by North West corner rule, Least cost method and Vogel's Approximation Method (VAM).	6	5

2.2	MODI and stepping stone method to find the optimal solution of TP, Unbalanced transportation problem and degeneracy (definitions and simple problems only).	5	6
2.3	Assignment problem-Hungarian method to find optimal assignment.	4	7
Module 3	**Network Analysis**	**15**	
3.1	Drawing the Network Diagram.	5	8
3.2	Analysis of Network- Calculation of Critical Path :Expected Project completion time.	5	8
3.3	PERT-Expected Completion Time and its Variance.	5	8
Module 4	**Practicals using R/Spreadsheet** (A practical record with minimum 10 problems has to be submitted.)	**30**	
4.1	1. Formulation of LPP. 2. Graphical Method. 3. Simplex Method. 4. Two Phase Method. 5. Big M Method. 6. Dual Simplex Method. 7. IBFS of Transportation Problem using NWCR. 8. IBFS of Transportation Problem using Row Minima Method. 9. IBFS of Transportation Problem using Column Minima Method. 10. IBFS of Transportation Problem using Matrix Minima Method. 11. IBFS of Transportation Problem using VAM. 12. Solve Transportation Problem using MODI Method. 13. Solve Transportation Problem using Stepping Stone Method. 14. Unbalanced TP. 15. Assignment Problem. 16. Network Diagram. 17. Project Completion Time using CPM. 18. Project Completion Time using PERT.		3, 4, 5,6,7, 8

Module 5	Teacher Specific Content.

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, Explicit teaching, E-learning, Interactive Instruction, Active Cooperative learning, Seminar, Library work and Group discussion, Group Assignments, Authentic learning, Presentation by students by group.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** ***Theory:* 15 marks** Quiz, Assignments ***Practical:* 15 marks** Lab involvement, Practical Record,Viva voce ***Summative assessment*** **Theory: 10 marks** Written tests
	B. End Semester Evaluation (ESE) **Theory : 50 marks** i) Short answer type questions: Answer any 7 questions out of 10 (7*2=14). ii) Short essay type questions: Answer any 4 questions out of 6 (4*6=24). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12). **Practical: 35 marks** Problem solving skills: 30 marks

	Record: 5 marks

References:

1. Kanti Swarup, Gupta P.K., Man Mohan (2010): Operations Research, Sultan Chand and Sons, New Delhi.
2. Taha, H.A. (2019). Operations Research, 10th Edition., Pearson Education Publication.

Suggested Readings:

1. Gupta R.K. (2020): Operations Research, Krishna Prakashan Media (P) Ltd., Meerut.
2. Kapoor,V.K .(2012).Operation Research, Sultan Chand & Co. New Delhi.
3. Mahajan, M.(2016): Operations Research, Dhanpat Rai & Co.

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Department						
Programme	**Economics**					
Course Name	**Statistical Techniques for Economic Analysis-II** **(For Economics Students)**					
Type of Course	**DCC**					
Course Code	**MG8DCCSTA402**					
Course Level	**400**					
Course Summary	Students will be proficient in using various estimation techniques to derive point estimates of population parameters and they can understand how to apply linear programming techniques to solve problems in Economics such as production planning, resource allocation and cost minimization.					
Semester	**8**	**Credits**			**4**	**Total Hours**
Course Details	**Learning Approach**	**Lecture**	**Tutorial**	**Practical**	**Others**	
		4				**60**
Pre-requisites						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Able to make valid inferences about population parameters based on sample statistic.	K,A	PO1, PO2
2	Ability to formulate and test hypotheses using tests such as Chi- Square, t and F tests and interpret the results in the context of economic research questions.	U,An	PO1
3	Understand and apply different sampling strategies including the determination of sample size.	U,A	PO2
4	Proficient in using various estimation techniques to derive point estimates of population parameters.	U,A	PO2
5	Possess the skills to construct confidence intervals around point estimates, providing a range within which the true population parameter is likely to lie with a certain level of confidence.	S,U	PO1,PO2
6	Develop skills in interpreting the results of hypothesis tests, understanding the implications of Statistical significance or non-significance in the Economic Analysis.	U,S	PO1
7	Understand how to apply linear programming techniques to solve problems in Economics such as production planning, resource allocation and cost minimization.	U,S	PO2

Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)

COURSE CONTENT

Content for Classroom Transaction (Sub-units)

	Course Description	Hours	CO No.
Module 1	**Estimation**	**25**	
1.1	Parameter and Statistic-Definition and examples. Sampling distributions-Standard error.	2	1
1.2	Sampling and non-sampling errors. Determination of sample size. Sampling distributions-Chi-square, t and F distribution-definition.	4	1
1.3	Properties and tables of distribution. Examples of statistics following Chi-square, t and F distributions.	3	2
1.4	Estimate and estimator, point estimator, confidence interval estimator,(concepts only). Properties of a good estimator.	6	2
1.5	Methods of Estimation- Maximum Likelihood estimators and estimation using the method of moments.	6	4
1.6	Interval estimation-Confidence interval of Population mean when population SD is known and unknown.	4	4
Module2	**Hypothesis Testing**	**10**	6
2.1	Steps in hypothesis testing, formulation of null and alternative hypothesis.	**2**	6
2.2	level of significance, Type I and Type II error, P value, power of the test.	**2**	6
2.3	One tailed test and two tailed tests.	**6**	6
Module3	**Testing Problems**	**15**	
3.1	Testing population mean	3	6

3.2	Testing population proportion.	3	6
3.3	comparing two populations- comparing two means, paired t test, comparing two proportions.	6	6
3.4	Chi- square independence test.(2x2 only)	3	6
Module 4	**LPP**	**10**	
4.1	Optimisation of economic functions- Optimisation with equality constraints : Lagrange method - Optimisation with inequality constraints	5	7
4.2	Linear programming -Characteristics of Linear Programming Problem(LPP) - Formulation of LPP - Solution of LPP using Simplex method –Duality - Uses of dual LPP and Shadow prices.	5	7
Module 5	**Teacher Specific Content.**		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Brainstorming lecture, E-learning, interactive Instruction, Seminar, Group Assignments, Authentic learning, Presentation by students by group.

Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** ***Formative assessment*** **Theory: 20 marks** Quiz, Assignments, Seminar ***Summative assessment*** **Theory: 10 marks** Written tests
	B. End Semester Evaluation(ESE) **Total:70 marks** i) Short answer type questions: Answer any 10 questions out of 12 (10*3=30). ii) Short essay type questions: Answer any 4 questions out of 6 (4*7=28). iii) Essay type questions: Answer any 1 question out of 2 (1*12=12).

References:

1. Murray R Spiegel, Larry J Stephens (2010) – Statistics, 4th Edition, Schaum's Outline series
2. Vohra, N .D. (2013) _ Business Statistics , MCGraw hill
3. Gupta, S. P. (2016) – Statistical Methods, sultan Chand and Sons.
4. Neil A Weiss (2017) – Introductory statistics, 10th Edition, Pearson.
5. Amir D Aczel, Jayavel Sounderpandian, Palanisamy Saravavan and Rohit Joshi (2012) Complete Business Statistics, 7th Edition, Tata McGrawhill.

Suggested Readings:

1. Douglas A Lind, William G Marchal and Samuel W Wathen (2008). Statistical techniques in Business and Economics, 13th Edition, Tata McGrawhill.
2. David R Anderson, Dennis J Sweeney and Thomas A Williams (2011) – Statistics for Business and Economics , 110th Edition Cengage.
3. Gupta, S. P. (2016) – Statistical Methods, sultan Chand and Sons.
4. Intriligator(1996) - Mathematical Optimization and Economic Theory, Prentice Hall

Internship

The internship provides students with a unique opportunity to apply their theoretical knowledge and skills in a real-world setting. Through hands-on experience in statistical analysis, data interpretation, and problem-solving, students will gain practical insights into how statistical methods are utilised across various industries and sectors. Under the guidance of experienced professionals, interns will have the chance to contribute to meaningful projects, conduct research and collaborate with interdisciplinary teams. This internship aims to bridge the gap between academia and industry, fostering the development of essential skills and preparing students for future careers in Statistics and related fields.

In the fourth semester, an internship is included as a vital component. The undergraduate students will engage in a two-week internship, either through industry or institute visits. This internship opportunity, worth 50 marks, is designed to provide hands-on experience and practical insights into real-world settings. Evaluation will be split into 35 external marks and 15 internal marks, ensuring a well-rounded assessment of the learning experience.

Internship Evaluation (Total 50 marks)

Internal Evaluation- 15 marks Marks will be awarded internally on the basis of report submission.	
Final Evaluation-35 marks	
Presentation	20 marks
Viva Voce	15 marks

Project

The project component provides students with a platform to delve into a specific area of interest within the realm of Statistics, allowing them to explore, analyse, and present findings on a topic of their choice. Through this experiential learning opportunity, students will have the freedom to design and execute a research project, applying statistical methods to address real-world problems or investigate hypotheses. Project work encourages critical thinking, creativity, and independence, fostering the development of valuable research and analytical skills. By the end of this endeavour, students will not only deepen their understanding of statistical concepts but also enhance their ability to communicate findings effectively through written reports and presentations.

The internal assessment shall be done internally through continuous assessment mode by a committee internally constituted by the Department Council. 30% of the weightage shall be given through this mode. The remaining 70% shall be awarded by the External Examiner appointed by the University.

Honours /Honours with Research (Project with 12 credits(200 marks)

1. Internal Evaluation(60 marks)	
Synopsis presentation	20 marks
Technical Skills	20 marks
Report & overall Performance	20 marks
2. Final Evaluation(140 marks)	
Relevance of the topic	20 marks
Review of Literature	10 marks
Method	20 marks
Result and Discussion	20 marks
Conclusion	10 marks
Presentation	20 marks
Viva voce	40 marks