ST. TERESA'S COLLEGE (AUTONOMOUS)
ERNAKULAM

Affiliated to Mahatma Gandhi University, Kottayam

CURRICULUM FOR
M.Sc Applied Statistics and Data Analytics

Under Credit & Semester System
(2025 Admissions Onwards)

ST. TERESA'S COLLEGE (AUTONOMOUS), ERNAKULAM

BOARD OF STUDIES IN MATHEMATICS AND STATISTICS

LIST OF MEMBERS

1. **Dr. Elizabeth Reshma M.T**, HoD and Assistant Professor, Department of Mathematics and Statistics(Aided), St. Teresa's College(Autonomous), Ernakulam (Chairperson).

2. **Dr. Angel Mathew**, Professor, Department of Statistics, Maharaja's College, Ernakulam (University Nominee).

3. **Dr. Asha Gopalakrishnan,** Senior Professor, Department of Statistics, CUSAT (Subject Expert).

4. **Dr. Linu Pinto**, Assistant Professor, Department of Mathematics, CUSAT (Subject Expert).

5. **Mr. Nasif N. M**, Evangelist and Community Lead, Kerala Startup Mission (Industry Expert).

6. **Ms. Teena Mary**, Data Analyst, impress.ai(Infopark), Kakkanad, Kochi (Alumnae Representative).

7. **Dr. Susan Mathew Panakkal**, Assistant Professor, Department of Mathematics (aided), St. Teresa's College(Autonomous), Ernakulam .

8. **Dr. Ursala Paul**, Assistant Professor, Department of Mathematics (aided), St. Teresa's College(Autonomous), Ernakulam.

9. **Smt. Neenu Susan Paul**, Assistant Professor, Department of Mathematics (aided), St. Teresa's College(Autonomous), Ernakulam.

10. **Ms. Parvathy T. S**, Government Guest Faculty, Department of Statistics (aided), St. Teresa's College(Autonomous), Ernakulam.

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14. **Smt. Nisha Oommen**, HoD and Assistant Professor, Department of Mathematics and Statistics (Self Financing), St. Teresa's College(Autonomous), Ernakulam.

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23. **Ms. Jesna Babu**, Assistant Professor, Department of Statistics(Self Financing), St. Teresa's College(Autonomous), Ernakulam.

24. **Ms. Aksa Mathew**, Assistant Professor, Department of Mathematics(Self Financing), St. Teresa's College(Autonomous), Ernakulam.

MINUTES OF THE BOARD OF STUDIES MEETING OF THE DEPARTMENT OF MATHEMATICS AND STATISTICS HELD ON

14 - 03 - 2025

This is to certify that the revised syllabus of the M.Sc Applied Statistics and Data Analytics for 2025 admissions onwards has been scrutinized and approved at the Board of Studies Meeting which was held on 14-03-2025. The complete revised syllabus of M.Sc Applied Statistics and Data Analytics programme was presented before the Board of Studies and discussed in detail. The revised syllabus was approved by the Board of Studies

The following members attended the meeting.

1. **Dr. Elizabeth Reshma M.T**, HoD and Assistant Professor, Department of Mathematics and Statistics(Aided), St. Teresa's College(Autonomous), Ernakulam (Chairperson).

2. **Dr. Angel Mathew**, Professor, Department of Statistics, Maharaja's College, Ernakulam (University Nominee).

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FACULTY OF THE DEPARTMENT WHO HAVE CONTRIBUTED TOWARDS CURRICULUM AND SYLLABUS IN M.Sc APPLIED STATISTICS AND DATA ANALYTICS

1. **Dr. Elizabeth Reshma M.T**, HoD and Assistant Professor, Department of Mathematics and Statistics(Aided), St. Teresa's College(Autonomous), Ernakulam (Chairperson).

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ACKNOWLEDGEMENT

I acknowledge with gratitude all the guidance and help given by our Directors, Rev.Sr.Tessa CSST and Rev. Sr. Francis Ann CSST and Principal, Prof. Dr.Alphonsa Vijaya Joseph during the course of restructuring the syllabus of M.Sc Applied Statistics and Data Analytics. I also remember and acknowledge with gratitude all the members of the Board of Studies for their constructive suggestions and contributions in restructuring of all the courses of this Masters Programme. I thank Smt. Mary Andrews, Coordinator of the PG syllabus restructuring in Statistics . I thank all the Faculty members of the Department, for taking great effort to prepare this syllabus. I am also grateful to all the members of the Curriculum Committee of the college for their guidance during the syllabus framing process. Above all, I bow my head before God Almighty for all the guidance he has continuously given to us in all our endeavours.

Dr. Elizabeth Reshma M.T
HOD, DEPARTMENT OF MATHEMATICS AND STATISTICS
CHAIRMAN
BOARD OF STUDIES OF MATHEMATICS AND STATISTICS

PREFACE

As an autonomous institution under Mahatma Gandhi University, St. Teresa's College is committed to enhancing its curriculum while adhering to the essential guidelines set by the University and Higher Education Council. Our aim is to cultivate a well-rounded educational experience. Within the framework of the prescribed syllabi, we have unified our efforts to foster an inspiring academic environment that empowers both teachers and students to delve deeper into knowledge and contribute to its dissemination and growth. It is crucial to emphasize that the generation and sharing of Quality Knowledge—which is vital for the growth and development of students and society as a whole—constitute the core mission of any educational institution.

The revised syllabi of our programs are designed in such a way to offer students innumerable opportunities for authentic, real-world learning experiences that will enhance their reasoning, creativity, intelligence and problem-solving abilities. This approach will enable them to attain knowledge of universal significance and relevance, fostering personal growth, civic responsibility, economic proficiency and the overall welfare of community, society and world at large.

We would like to acknowledge the dedication of our teachers in restructuring the syllabi and defining course outcomes that prioritize the cognitive and intellectual development of our learners. This initiative instills the confidence necessary for them to conduct independent and scholarly research in their areas of professional interest, positioning them as effective global cross-cultural educators.

We extend our congratulations to Prof. Dr. Alphonsa Vijaya Joseph, Principal, Dr. Kala M.S., Dean of Self Financing, Dr. Mary Liya C.A ,Faculty Coordinator for syllabus revision ,who have effectively coordinated the syllabus restructuring across all programs. We strive to transform lives and make a meaningful impact both locally and globally through the creation, sharing, and application of knowledge. We look forward to sharing the outcomes of our curriculum restructuring and hope that these resources will inspire reflection on the advancements in learning within our institution, as well as contribute to the global educational landscape.

Sr. Tessa CSST & Sr. Francis Ann CSST

Directors, St. Teresa's College

FOREWORD

Autonomy in higher education signifies a commitment to responsibility and accountability, which ultimately fosters excellence in academics and proactive governance. St. Teresa's College was granted autonomous status in 2014, and since then, we have made concerted efforts to uphold a high standard of quality in the education we provide. In 2019, the college achieved re-accreditation by NAAC with an A++ grade (CGPA 3.57).

This academic autonomy has empowered us to refine our syllabus to meet the evolving needs of today's students. The current educational landscape presents numerous challenges, and it is essential that our curricula and syllabi reflect the significant shifts occurring across various disciplines. To this end, we have gathered structured feedback from students, alumni and industry experts, incorporating their suggestions into our syllabi.

Our Board of Studies, established for each department, meets regularly within the designated timeframe to engage in thorough discussions regarding various aspects of the curricula and syllabi. The IQAC team has facilitated numerous workshops and conferences to equip our faculty with the necessary skills to design syllabi and formulate question papers for internal assessments, ensuring that the learning outcomes outlined in the syllabus are met and that examinations are conducted fairly and transparently.

The responsibilities that come with our autonomy are indeed substantial, but we have united in our efforts to tackle the challenges that arise. Our focus has been on shaping young women into responsible citizens who will contribute to nation-building in exemplary ways. To enhance industry-academia linkage and ensure students are placement-ready, the curriculum will emphasize the importance of internships and application-oriented research projects, fostering a sense of social responsibility and equipping students with practical skills to facilitate entrepreneurship. We are dedicated to nurturing their academic aspirations alongside their skills in co-curricular activities. To align with the needs of the new generation of students, we plan to restructure our postgraduate programs in the upcoming academic year.

I extend my heartfelt gratitude for the unwavering support and guidance provided by Rev. Sr. Tessa CSST and Rev. Sr.Francis Ann CSST, the Directors of the College. I would also like to express my special thanks to the team led by Dr. Kala M.S and Dr. Mary Liya C.A. for coordinating the syllabus restructuring of our programs, as well as to the Heads of Departments and all faculty members for their dedication, commitment and exceptional contributions to this important initiative

PROF. ALPHONSA VIJAYA JOSEPH , PRINCIPAL

CONTENTS

PREAMBLE

The aim of the Postgraduate education is to provide high quality education as well as a supportive learning environment for the students to reach their full academic potential. The higher education has to inculcate in students the spirit of hard work and research aptitude to pursue further studies in the nationally/internationally reputed institutions as well as prepare them for a wider range of career opportunities in interdisciplinary fields.

The Board of Studies in Mathematics and Statistics has restructured the syllabi for M.Sc Applied Statistics and Data Analytics so as to monitor, review and enhance educational experience which ensures that the Post Graduate Education remains intellectually demanding and relevant to current needs of Statistics graduates. The thrust is given in fostering a friendly and stimulating learning environment which will motivate the students to reach high standards, enable them to acquire real insight into Statistics and become self-confident, committed and adaptable graduates. With this in mind, we aim to provide a firm foundation in every aspect of Statistics and to develop analytical, experimental, computational, logical and reasoning skills of students.

The Board of Studies acknowledges and appreciates the good effort put in by the faculty members of the Department of Mathematics and Statistics to restructure the syllabus for M.Sc Applied Statistics and Data Analytics in the institution which will be implemented for the admissions from 2025 onwards.

PROGRAMME OUTCOMES (POs) OF POSTGRADUATE PROGRAMMES:

The integration of Outcome-Based Education (OBE) stands as a cornerstone of the postgraduate programmes at St. Teresa's College (Autonomous), Ernakulam, with the Programme Outcomes (POs) intricately aligned to the vision and mission of the college. By adopting OBE, the institution meticulously cultivates graduates who are not only equipped with advanced knowledge and critical skills but are also adept in addressing professional challenges, contributing to society, and embracing lifelong learning, thereby fostering well-rounded, responsible individuals committed to excellence in their fields. The POs for the post graduates of St. Teresa's college are listed below:

PO1: Advanced Knowledge and Application

Graduates will demonstrate an advanced and integrated understanding of their discipline, to effectively apply this knowledge to solve complex, real-world challenges, showing originality in developing innovative solutions that contribute to their field and to society.

PO2: Critical Thinking and Analytical Skills

Graduates will critically evaluate complex problems, synthesize information from diverse sources, and employ advanced analytical reasoning to formulate evidence-based solutions in line with contemporary needs.

PO3: Research and Innovation

Graduates will be able to conduct independent, original research using appropriate scientific or creative methodologies, thereby contributing new knowledge or insights to implement innovative practices and provide solutions to the issues of the contemporary world.

PO4: Interdisciplinary and Collaborative Skills

Graduates will collaborate effectively in interdisciplinary and multicultural teams, leveraging the strengths of various disciplines to address multifaceted problems, reflecting the global best practice of professionals who can operate in diverse group settings.

PO5: Communication Skills

Graduates will be skilled in articulating their ideas, research findings, and solutions clearly and effectively in both oral and written formats, ensuring engagement and understanding across diverse audiences.

PO6: Technological Proficiency and Innovation

Graduates will be proficient in using modern technologies and digital tools relevant to their field, applying technological innovations to enhance research, professional practice, and societal well-being, and ensuring they remain at the cutting edge of their discipline.

PO7: Global Awareness and Societal Engagement

Graduates will integrate knowledge of global trends, cultural diversity, and sustainable development principles into their work, actively engaging with society to promote inclusivity, equity, and environmental stewardship in line with global citizenship values.

PO8: Ethical and Professional Responsibility

Graduates will uphold the highest standards of ethics and professionalism in all their academic and professional endeavours and will make informed decisions that reflect integrity and ethical consideration, including respect for diverse perspectives and awareness of the social and environmental implications of their actions.

PO9: Advocacy for Social Justice and Inclusive Development

Graduates will leverage their knowledge, skills, and experiences to advocate for social justice, equality, and the empowerment of marginalized communities, engaging in initiatives that promote inclusive and sustainable development, thereby contributing to the well-being of society

PO10: Lifelong Learning and Professional Development

Graduates will embrace a mindset of lifelong learning, continually adapting to new technologies and societal needs by proactively seeking new learning opportunities and adapt to emerging technologies and evolving industry trends, engaging in ongoing professional development to remain at the forefront of their field.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

The M.Sc. Applied Statistics and Data Analytics programme prepares graduates to achieve key objectives within a few years of completion, focusing on professional success, societal contributions, and lifelong learning. The Programme Educational Objectives (PEOs) of M.Sc. Applied Statistics and Data Analytics programme, outlined below, are designed to equip graduates with the skills and knowledge for continued growth and advancement in the field of Applied Statistics and Data Analytics.

PEO1: Graduates will be equipped with a strong foundation in statistical theory, data science, and advanced analytical techniques, enabling them to solve complex real-world problems across diverse fields such as business, healthcare, and research.

PEO2: Graduates will be proficient in programming languages and apply advanced statistical methods for data analysis, modeling, and visualization in a variety of industries.

PEO3: Graduates will be able to foster a commitment to continuous learning, adaptability to evolving technologies, and addressing societal and environmental challenges by leveraging statistical and data science expertise to make informed, impactful decisions.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

The Department of Statistics is committed to provide an enriched educational experience to develop the knowledge, skills and attributes of students to equip them for life in a complex and rapidly changing world.

On completion of the M.Sc. Applied Statistics and Data Analytics, our students should be able to demonstrate the programme specific outcomes listed below:

PSO1: Articulate theoretical and practical core statistical concepts, data visualization, statistical software, and programming tools to analyze data, and solve real-world problems. (Apply)

PSO2: Analyze datasets using advanced methods such as time series analysis, multivariate analysis and experimental design in applied fields. (Analyze)

PSO3: Evaluate results from statistical experiments, enabling them to address multidisciplinary challenges in academia and industry. (Evaluate)

PSO4: Apply concepts of Big Data Analytics, Artificial Intelligence, DBMS, and Machine Learning to implement models, utilize database systems for real-world problems. (Apply)

PSO5: Apply research methodologies and statistical techniques in applied statistics and data science projects. (Apply)

Job Opportunities

A post-graduation in M.Sc in Applied Statistics and Data Analytics opens careers in finance, healthcare, technology, and government. Graduates work as data scientists, statisticians, or analysts, applying statistical models and machine learning. Roles include quantitative and risk analysts in finance, biostatisticians in healthcare, and statisticians in research and policy-making. Teaching opportunities exist in India and abroad.

Eligibility for admission

B.Sc. Degree in Statistics /Mathematics main/ B.Sc. Computer Application (triple main) with Mathematics Statistics and Computer science as main subjects with at least 50%marks for the optional subjects (Core + Complementary + Open Courses) taken together. Or Graduation in Statistics/Mathematics/ Computer Application with not less than CGPA of 5 out of 10 in the Core Group (Core + Complementary + Open Courses)

Duration of the Programme : Four Semesters

Examination : Credit and Semester system (CSS)
Direct Grading system with 7 point scale

Medium of instruction and assessment: English

Faculty under which the Degree is awarded: Faculty of Science

PROGRAMME STRUCTURE
STRUCTURE OF M.Sc .APPLIED STATISTICS AND DATA ANALYTICS.

The programme shall include two types of courses, Core courses and Elective courses. There shall also be a Project and Comprehensive Viva Voce as core courses. The programme also includes assignment/ seminar/ Class tests etc. The total credit for the programme is fixed at 80.

THEORY COURSES:

There are twenty courses out of which 18 are theory papers, spread equally in all four semesters in the M.Sc. Programme. Distribution of courses is as follows. There are seventeen core courses common to all students. Semester I, Semester II and Semester III will have five core courses each and Semester IV will have two core courses and three elective courses. The three elective courses can be chosen as per the interest of the students, availability of faculty and academic infrastructure.

PRACTICAL

There are two practical papers that appear in the even semesters, Semester II and Semester IV.

PROJECT

The project of the PG program should be relevant and innovative in nature. The type of project can be decided by the student and the guide (a faculty of the department or other department/college/university/institution). The project work should be taken up seriously by the student and the guide. The project should be aimed to motivate the inquisitive and research aptitude of the students. The students may be encouraged to present the results of the project in seminars/symposia. The conduct of the project may be started at the beginning of Semester III, with its evaluation scheduled at the end of Semester IV. The project is evaluated by one external and one internal examiners.

COMPREHENSIVE VIVA VOCE

A viva voce examination will be conducted by one external examiner and one internal examiner at the time of evaluation of the project. The components of viva consists of subject of special interest, fundamental concepts, topics covering all semesters and awareness of current and advanced topics.

COURSE CODE

The courses in the programme are coded according to the following criteria. The first two letters of the code indicates the name of programme, ie. ST stands for Statsitics. Next digit is to indicate the semester. i.e.,ST1 (Statistics,1st semester). This is followed by the letter C or E indicating whether the course is a core course or elective course as the case may be. (However in the case of Project/Comprehensive viva voce this letter is omitted.) Next two digits indicate the course number (avoided in the case of Project/Comprehensive viva voce). The letter/letters T/P/ PR/V follows it and is used to indicate theory/ practical/ project/ viva. The next letter will be M which indicates that the programme is for masters. The last two digits 25 represent the year in which restructuring is done.

Example: Theory- ST1C01TM25 and for Practical ST2C01PM25

DISTRIBUTION OF COURSES AND CREDITS

CORE COURSES

Semester	Course Code	Course Title	Teaching hours per week	Credit	Total credit
I	ST1C01TM25	Probability and Measure Theory	5	4	19
	ST1C02TM25	Distribution Theory	5	4	
	ST1C03TM25	Linear Algebra for Statistics	5	4	
	ST1C04TM25	Sampling Theory	5	4	
	ST1C05TM25	Database Management systems and Data Science	5	3	
II	ST2C06TM25	Estimation Theory	5	4	19
	ST2C07TM25	Stochastic Processes	5	4	
	ST2C08TM25	Multivariate Analysis	5	4	
	ST2C01PM25	Data Science using R/Python	5	3	
	ST2C09TM25	Data Mining and their Applications	5	4	
III	ST3C10TM25	Testing of Hypotheses	5	4	19
	ST3C11TM25	Research Methodology and SPSS	5	4	
	ST3C12TM25	Time Series Analysis	5	4	
	ST3C13TM25	Design and Analysis of Experiments	5	4	

	ST3C14TM25	**Machine Learning and Data Analysis**	**5**	**3**	
IV	**ST4C15TM25**	**Big data analytics and artificial intelligence**	**5**	**4**	**23**
	ST4C02PM25	**Statistical Computing and Biostatistics Using SAS**	**5**	**3**	
		Elective 1	**5**	**3**	
		Elective 2	**5**	**3**	
		Elective 3	**5**	**3**	
	ST4PRM25	**Project/Dissertation**	**----**	**3**	
	ST4VM25	**Viva Voce**		**4**	
	TOTAL				**80**

ELECTIVE COURSES:

Course code	Course Title	Teaching hours per week	Credit
ST4E01TM25	Categorical Data Analysis	5	3
ST4E02TM25	Statistical Quality Control	5	3
ST4E03TM25	Survival Analysis	5	3
ST4E04TM25	Operation Research	5	3

ST4E05TM25	Biostatistics	5	3
ST4E06TM25	Econometric Methods	5	3
ST4E07TM25	Advanced Bayesian Computing With R	5	3
ST4E08TM25	Population Studies	5	3
ST4E09TM25	Actuarial Statistics	5	3

ELECTIVE (Credit 3*3=9)		
GROUP A	**GROUP B**	**GROUP C**
Categorical Data Analysis	Operation Research	Advanced Bayesian Computing With R
Statistical Quality Control	Biostatistics	Population Studies
Survival Analysis	Econometric Methods	Actuarial Statistics

DISTRIBUTION OF CREDITS:

The total credit for the programme is fixed at 80. The distribution of credit points in each semester and allocation of the number of credit for theory courses, project and viva is as follows. The credit of theory courses is 3 or 4 per course in the first, second and third semesters. The core courses in the fourth semester will have 4 credits and elective core courses will have 3 credits. The practical courses have a credit of 3. The project will have a credit of 3 and viva voce will have a credit of 4. The distribution of credit is shown below.

Semester	Courses	Credit	Total Credits
I	4 Theory Core Courses 1 Theory Core Course	4 3	4 X 4 = 16 1 X 3 =3
II	4 Theory Core Courses 1 Practical Core course	4 3	4 X 4 = 16 1 X 3 =3
III	4 Theory Core Courses 1 Theory Core Course	4 3	4 X 4 = 16 1 X 3 =3
IV	1 Theory Core Course	4	1 X 4= 4
	3 Elective Core Courses	3	3 X 3 = 9
	1 Practical Core Course	3	1 X 3 = 3
	1 Project / Dissertation	3	1 X 3 = 3
	1 Viva- Voce	4	1 X 4= 4
GRAND TOTAL			**80**

EVALUATION AND GRADING

The evaluation for each course shall contain two parts such as In-Semester Assessment (ISA) and End Semester Assessment (ESA). The ratio between ISA and ESA shall be 1:3 and 25% weightage shall be given to ISA and 75% to ESA. Both ISA and ESA shall be carried out using a direct grading system.

Evaluation (Both ISA and ESA) to be done by the teacher is based on a Six point scales shown in the table below:

GRADE	GRADE POINT	RANGE
A^+	5	4.50 to 5.00
A	4	4.00 to 4.49
B	3	3.00 to 3.99
C	2	2.00 to 2.99
D	1	0.01 to 1.99
E	0	0.00

Direct Grading System based on a 7 – point scale is used to evaluate the performance of students in both ISA and ESA.

For all courses (theory & practical), semester/ overall programme, the letter grades for **GPA/SGPA/CGPA** and its indicators are given in the following table.

RANGE	GRADE	INDICATOR
4.50 to 5.00	A+	Outstanding
4.00 to 4.49	A	Excellent
3.50 to 3.99	B+	Very good
3.00 to 3.49	B	Good
2.50 to 2.99	C+	Fair
2.00 to 2.49	C	Marginal
0.00 to 1.99	D	Deficient (Fail)

IN-SEMESTER ASSESSMENT (ISA)

The In Semester Assessment is to be done by continuous assessments of the components given below. The components of ISA for theory and practical and their weightage are as in the following tables

THEORY		PRACTICALS	
COMPONENTS	**WEIGHTAGE**	**COMPONENTS**	**WEIGHTAGE**
Assignment	2	Written / Lab test	3
Seminar	4	Lab involvement and record	1
Test Papers (Average of 2)	4	Viva	1
TOTAL	**10**	**TOTAL**	**5**

The two test papers in the Theory component should be in the same model as the ESA question paper. For test papers, questions shall be set in such a way that the answers can be awarded A^+, A, B, C, D or E grade.

The performance of students in the seminar and assignment should also be documented in terms of grades.

The components for assignments and seminars are as in the following table:

ASSIGNMENT COMPONENTS	SEMINAR COMPONENTS
Punctuality	Content
Content	Presentation

The components of ISA for project and their weightage are as in the following table.

COMPONENTS	WEIGHTAGE
Relevance of the topic and analysis	2
Project content and presentation	2
Project viva	1
TOTAL	**5**

The ISA of the project is done by the supervising guide of the department or the member of the faculty decided by the head of the department. The project work may be started at the end of Semester II. The supervising guide should keenly and sincerely observe the performance of the student during the course of project work. The supervising guide is expected to inculcate in students, the research aptitude and aspiration to learn and aim high in the realm of research and development. A maximum of two students may be allowed to perform one project work if the volume of the work demands it. Project evaluation begins with (i) The selection of problem, (ii) Literature survey, (iii) Work plan, (iv) Experimental / theoretical setup/data collection, (v) Characterization techniques/ computation/ analysis (vi) Use of modern software for data analysis/experiments (R/ Python/SAS/SPSS) and (vi) Preparation of project report . The project internal grades are to be submitted at the end of Semester IV.

The components of ISA for comprehensive viva voce and their weightage are as in the following table.

COMPONENTS	WEIGHTAGE
Fundamental concepts	3
Awareness of current /advanced topics	2
TOTAL	**5**

GENERAL INSTRUCTIONS FOR ISA

- The In-Semester assessment should be fair and transparent. The responsibility of evaluating the ISA is vested on the teacher(s) who teach the course. The evaluation of the components should be published and acknowledged by students.
- The assignments/ seminars / test papers are to be conducted at regular intervals. These should be marked and promptly returned to the students.
- One teacher appointed by the Head of the Department will act as a coordinator for consolidating grade sheet for ISA in the department in the format provided by the Controller of the examinations. The consolidated grade sheets are to be published in the department notice board, one week before the closing of the classes for ESA. The grade sheet should be signed by the coordinator and counter signed by the Head of the Department and the Principal.
- There shall be no separate minimum grade point for ISA of theory, practical, project and comprehensive viva voce. Though no separate minimum is required for internal evaluation for a pass, a minimum C grade is required for a pass in an external evaluation. And a minimum C grade is required for pass in a course.
- The consolidated grades in specific format are to be kept in the college for future references for 2 years. The consolidated grades in each course should be uploaded to the Institution Portal at the end of each semester as directed by the Controller of Examinations.
- There shall not be any chance for the improvement of ISA grade points.

Grievance Redressal Mechanism for ISA

There will be provision for grievance redressal at three levels, viz,

1. At the level of teacher concerned,
2. At the level of departmental committee consisting of Head of the Department, Coordinator and teacher concerned,

3. At the level of college committee consisting of the Principal, Controller of Examinations and Head of the Department.

END SEMESTER ASSESSMENT (ESA)

The End Semester Assessment of all semesters shall be conducted by the institution on the close of each semester. The End Semester Assessment will be of 3 hours duration for each lecture based and practical courses. A minimum C grade is required for a pass in ESA. A minimum C grade is required for a pass in ESA. Also in aggregate, a minimum C grade is required for a pass in a course.

Students with less than 73% aggregate attendance during a semester are not eligible to attend ESA of any course.

If a student represents her Institution/ University / State/ Nation in Sports /NCC/ NSS or Cultural or any other officially sponsored activities such as college union/university union etc, she shall be eligible to claim the attendance for the actual number of days participated subject to a maximum of 15 days in a semester based on the specific recommendations of the Head of the Department or teacher concerned.

For reappearance/ improvement, students may appear along with the next batch.

However, the students who fail in Semester 3 will have the opportunity to appear for a special supplementary (SAVE AN YEAR-SAY) exam conducted at the end of Semester 3.

QUESTION PAPER PATTERN FOR THEORY COURSES.

All the theory question papers are of three hour duration. All question papers will have three parts. The question shall be prepared in such a way that the answers can be awarded the grades A+, A, B, C, D or E.

The questions in each section will be grouped according to the Course Outcomes (COs), with the selection of questions to be answered falling under a single CO. Thus, the mandatory attempt of all COs can be ensured for the calculation of course outcome attainment.

Part A: Questions in Part A are very short answer type. A total of eight questions need to be answered, each carrying a weightage of 1, contributing to a cumulative weightage of 8 for the section.

For courses with 4 COs, there will be 4 bunches of 3 questions each, assigned to each CO, and students must answer 2 questions from each bunch.

For courses with 5 COs, there will be 2 bunches of 2 questions each, assigned to the COs assessed in Part C, from which 1 question must be answered. Additionally, 3 bunches containing 3 questions each will be allotted to the remaining COs, from which 2 questions must be answered

Part B: Part B consists of problem solving and short essay type questions related to the course. A total of six questions need to be answered, each carrying a weightage of 2, contributing to a cumulative weightage of 12 for the section.

For courses with 4 COs, there will be 2 bunches of 4 questions each, assigned to those COs not assessed in Part C, and students must answer 3 questions from each bunch.

For courses with 5 COs, there will be 3 bunches of 3 questions each, assigned to the COs not assessed in Part C, from which students must answer 2 questions from each bunch.

Part C: Part C will have four questions, grouped into two bunches, with each bunch containing two questions related to the same CO. Students must answer one question from each set. Each question will carry a weightage of 5, contributing to a total weightage of 10 for Part C.

Maximum weightage for End-Semester Assessment is 30. Therefore Maximum Weighted Grade Point (WGP) is 150.

DIRECTIONS FOR QUESTION SETTERS:

1) Questions shall be set to assess knowledge acquired, standard and application of knowledge in new situations, critical evaluation of knowledge and the ability to synthesize knowledge.
2) Due weightage shall be given to each module on content/teaching hours allotted to each module.
3) The question setter shall ensure that questions are set as per the course outcomes.
4) A question paper shall be a judicious mix of short answer type, short essay type/problem solving type and long essay type questions.
5) The questions shall be set in such a way that the answers can be awarded A^+, A, B, C, D or E grade.
6) Different types of questions shall be given different weightage to quantify their range as shown below:

Sections	Type of Questions	Weightage	No. of COs	Number of questions to be answered (CO*- COs assessed in Part C)
Part A	Short Answer type	1	4	2 out of 3 from each CO bunch
Part B	Short essay/ problem solving type	2	4	3 out of 4 from each CO bunch
Part C	Long Essay type	5	4	1 out of 2 from each CO* bunch

BLUEPRINT (For Courses with 4 COs or 90 hours)

CO	**Part A Weight 1 each (Total weights=8)**	**Part B Weight 2 each (Total weights =12)**	**Part C Weight 5 each (Total weights = 10)**	**Total Weights (30 out of 48)**
	Part Ai (2 out of 3 questions of each CO)	**Part Bi (3 out of 4 questions of a given CO)**	**Part Ci (1 out of 2 questions of a given CO)**	
CO1	3	0/0/0/4/4/4	2/2/2/0/0/0	13/13/13/11/11/11
CO2	3	0/4/4/0/0/4	2/0/0/2/2/0	13/11/11/13/13/11
CO3	3	4/0/4/0/4/0	0/2/0/2/0/2	11/13/11/13/11/13
CO4	3	4/4/0/4/0/0	0/0/2/0/2/2	11/11/13/11/13/13

- Part A will contain section Ai (A1 to A4)
- Part B will contain sections Bi (B1 to B2)
- Part C will contain sections Ci (C1 to C2)
- COs assessed in Part C (Essay) will not appear in Part B section.
- The blueprint models are numbered as BP_1 to BP_6 denoted by each slash in the table.

PRACTICAL, PROJECT AND VIVA VOCE EXAMINATIONS

PRACTICAL EXAMINATION

First and Second Semester practical examinations are conducted at the end of Semester II and third and fourth semester practical examinations are conducted at the end of Semester IV. The practical examinations are conducted immediately after the second and fourth semester theory examinations. There will be two practical examination boards every year to conduct these practical exams. All practical examinations will be of three hours duration.

One external examiner will be selected from the panel of examiners and one internal examiner will be selected by the department.

EVALUATION OF PRACTICAL EXAMINATIONS:

The scheme of evaluation of the practical examination will be decided by the board of examiners. The different weights for assessment of different components is shown in the following table

COMPONENTS	WEIGHTAGE
Written/Lab test	10
Record	3
Viva	2
Total	**15**

PROJECT EVALUATION

The project is evaluated by one external and one internal examiner. The project is examined along with the oral presentation of the project by the candidate. The examiners should ascertain that the project and report are genuine. Innovative projects or the results/

findings of the project presented in national seminars may be given maximum advantage. The supervising guide or the faculty appointed by the head of the department may be allowed to be present at the time of project evaluation. This is only to facilitate proper evaluation of the project. The different weightage for assessment of different components is shown in the following table.

COMPONENTS	WEIGHTAGE
Relevance of the topic and analysis	2
Project content and presentation	10
Project viva	3
TOTAL	**15**

COMPREHENSIVE VIVA- VOCE EXAMINATION

Viva-voce shall be conducted by one external examiner and one internal examiner of the board of examiners. The viva-voce shall cover questions from all courses in the programme..

The components of the ESA for comprehensive viva- voce and their weightage are as in the following table.

COMPONENTS	WEIGHTAGE
Fundamental concepts	9
Awareness of current topic/advanced topic	6
TOTAL	**15**

Both project evaluation and viva voce are to be conducted in batches of students formed for practical examinations.

REAPPEARANCE / IMPROVEMENT

- A student who fails to secure a minimum grade (Grade C) for a pass in a course will be permitted to write the examination along with the next batch.
- The candidate who wishes to improve the grade/grade point of the End-Semester Assessment of a course / courses she has passed can do the same by appearing in the End-Semester Assessment of the semester concerned along with the immediate junior batch. This facility is restricted to first and second semesters of the programme.
- There shall be supplementary examinations (no improvement) for third semester.

PROMOTION

- A student who registers for a particular semester examination shall be promoted to the next semester.
- A student having 73% attendance and fails to register for examination of a particular semester will be allowed to register notionally and is promoted to the next semester, provided application for notional registration shall be submitted within 15 days of the commencement of the next semester.

COMPUTATION OF GPA/SGPA/CGPA

Grade Point Average (GPA): ISA and ESA are separately graded using a six point scale and the combined grade point with weightage 1 for ISA and 3 for ESA shall be applied to calculate the grade point average (GPA) of each course.

The Semester Grade Point Average (SGPA): After the successful completion of a semester SGPA of a student in that semester is calculated using the formula given below.

Semester Grade Point Average (SGPA) = $\frac{\Sigma(C_i \; X \; GPA_i)}{\Sigma C_i}$ where C_i and GPA_i are the credit point and GPA of each course respectively.

Cumulative Grade Point Average (CGPA) for the programme is calculated as follows:

CGPA = $\frac{\Sigma(C_i \, X \, SGPA_i)}{\Sigma C_i}$ where C_i and $SGPA_i$ are the total credit point and SGPA of each semester respectively.

Note: A separate minimum of **C** Grade for ESA (for both theory and practical) is required for pass for a course. For a pass in a programme, a separate minimum of Grade **C** is required for all the individual courses. If a candidate secures **D** Grade for any one of the courses offered in a Semester/Programme, only **D** grade will be awarded for that Semester/Programme until she improves this to **C** grade or above within the permitted period.

Note: On compliance with the UGC minimum standards for the conduct and award of postgraduate degrees: Credit and semester system is followed in this program. The program has 4 semesters with eighteen weeks in each semester. In each semester there are 450 hours including both lecture and practical hours which is in compliance with the minimum 390 hours stipulated by the UGC.

All Rules and regulations are subject to change as and when modified by MG University to which St Teresa's College (Autonomous) is affiliated.

SYLLABI FOR THE COURSES OF

M.Sc APPLIED STATISTICS AND DATA ANALYTICS

SYLLABI FOR CORE COURSES

SEMESTER I

SEMESTER I

CORE COURSE

ST1C01TM25 – Probability and Measure Theory

Credits: 4

Total Lecture Hours: 90

Course Outcomes:

CO1: Explain the basic concepts of set theory and Integrals of functions. **(Ap)**

CO2: Examine the concepts of random variables and probability spaces in the context of measure theory. **(Ap)**

CO3: Analyze the properties of random variables using key inequalities in measure theory and different modes of convergence. **(An)**

CO4: Apply the weak and strong laws of large numbers, along with the central limit theorem in probability theory. **(Ap)**

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	2	1	1
CO2	3	1	2	1	1
CO3	2	1	2	1	1
CO4	3	1	2	1	1

Syllabus Content

MODULE I (CO1) (25 hours)

Algebra of sets, limit of a sequence of sets, Fields, Sigma fields, General measure space, Lebesgue measure, Lebesgue-Stieltjes measure, Counting measure and their simple properties. Measurable functions and their properties. Integrals of indicator function, simple function and measurable functions, basic integration theorems. Monotone convergence theorem, Fatou's

Lemma, Bounded convergence theorem and Lebesgue dominated convergence theorem. Lebesgue, Lebesgue-Stieltjes Integral and Riemann Integral (Basic concepts only).

MODULE II (CO2) (20 hours)

Discrete and Continuous probability spaces and their properties. Monotone, continuity and other properties. Conditional probability, multiplication theorem, total probability and Bayes theorem. Independence of events, Random variables, properties of random variables. Distribution function and its properties. Jordan decomposition theorem, Correspondence theorem (statement only).Independence of random variables. Mathematical expectation and its properties.

MODULE III (CO3) (25 hours)

Basic, Chebychev's, Markov's, Liaponov's, Jensen's, Cr, Cauchy-Swartz's, Holder's, Minkowski's inequalities.Convergence: Modes of convergence, Convergence in probability, in distribution, in rth mean, almost sure convergence and their inter-relationships,Borel 0-1 criterion, Characteristic function of a random variable, properties, statement of Bochner's Theorem. Continuity and inversion theorems of characteristic functions (statements only).

MODULE IV (CO4) (20 hours)

Law of large numbers: Weak law of large numbers – Chebychev's WLLN and Khinchine WLLN, Strong law of large numbers - Kolmogrov strong law of large numbers. Central limit theorem: Lindberg-Levy central limit theorem, Liaponov's central limit theorem, Lindberg-Feller central limit theorem (Without proof).

TEXT BOOKS

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. Laha R.G. and Rohatgi V.K. (1979) Probability theory, John Wiley.

REFERENCES

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)

Question Paper format as per the Blueprint model BP 1

Module	CO	Part A1	Part A2	Part A3	Part A4	Part B1	Part B2	Part C1	Part C2	Total Weights (30 out of 48)
		Any 2 out of 3 questions of				Any 3 out of 4 questions of		Any 1 out of 2 questions of		
		CO1	CO2	CO3	CO4	CO3	CO4	CO1	CO2	
Module I	CO1	3	0	0	0	0	0	2	0	13
Module II	CO2	0	3	0	0	0	0	0	2	13
Module III	CO3	0	0	3	0	4	0	0	0	11
Module IV	CO4	0	0	0	3	0	4	0	0	11

*** End Semester evaluation of the course can be done using any blueprint model (BP 1 to BP 6)**

MODEL QUESTION PAPER
(as per the Blueprint model BP 1)

ST1C01TM25 – Probability and Measure Theory

Time: Three hours **Maximum Weight: 30**

Part A

Part A1. Answer any 2 questions from the bunch for CO1. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
1.	Explain the term field and give an example.	CO1	Ap
2.	Define a measurable function.	CO1	R
3.	Write Lebesgue dominated convergence theorem, and give its significance.	CO1	Ap

(2x 1= 2 weights)

Part A2. Answer any 2 questions from the bunch for CO2. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
4.	Write an Axiomatic definition of probability.	CO2	Ap
5.	Explain the concept of independence of a collection of random variables.	CO2	Ap
6.	Write the statement of continuity property of probability measure.	CO2	Ap

(2x 1= 2 weights)

Part A3. Answer any 2 questions from the bunch for CO3. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
7.	Explain Jensen's inequality.	CO3	An
8.	Write Cramer-Rao inequality.	CO3	Ap
9.	Describe Borel 0-1 Criterion.	CO3	U

(2x 1= 2 weights)

Part A4. Answer any 2 questions from the bunch for CO 4. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
10.	Distinguish between WLLN and SLLN.	CO4	U
11.	Write Liaponov's central limit theorem.	CO4	Ap
12.	Explain Strong Law of Large numbers.	CO4	Ap

(2x 1= 2 weights)

Part B

Part B1. Answer any 3 questions from the bunch for CO3. Each question carries 2 weights

Q. No	Questions	CO	Level of Question

13.	Explain Markov inequality. Deduce Tchebysev's inequality	CO3	An
14.	Explain Jenson's inequality with proof.	CO3	Ap
15.	Establish that a characteristic function is uniformly continuous.	CO3	Ap
16.	Write Basic inequality with proof.	CO3	Ap

(3x 2= 6 weights)

Part B2. Answer any 3 questions from the bunch for CO4. Each question carries 2 weights

Q. No	Questions	CO	Level of Question
17.	Establish the set of values of α for which the following sequence of independent random variables satisfies WLLN. Where $P[X_n = \pm n^{\alpha}] = ½$.	CO4	Ap
18.	Explain Khintchine's WLNN.	CO4	Ap
19.	Explain Kolmogrov's SLLN for independent sequence of random variables.	CO4	Ap
20.	Explain Helly-Bray Lemma and Helly-Bray theorem.	CO4	Ap

(3x 2= 6 weights)

Part C

Part C1. Answer any 1 question from the bunch for CO1. Each question carries 5 weights

Q. No	Questions	CO	Level of Question
21.	(a) Explain Fatou's Lemma. (b) Explain the concepts of (i) Riemann Integral (ii) Lesbesgue Integral (iii)Lesbegue- Stieltjes Integral	CO1	Ap
22.	Explain the term measure and discuss in detail about different types of measures	CO1	Ap

(1x 5= 5 weights)

Part C2. Answer any 1 question from the bunch for CO2. Each question carries 5 weights

Q. No	Questions	CO	Level of Question
23.	Explain Jordan decomposition theorem and hence prove it.	CO2	Ap
24.	Explain the following terms with proofs. 1.Bayes theorem 2.multiplication theorem	CO2	Ap

(1x 5= 5 weights)

SEMESTER I

CORE COURSE

ST1C02TM25– Distribution Theory

Credits: 4

Total Lecture Hours: 90

Course Outcomes:

CO1: Explain the concepts of probability generating functions and moment generating functions, along with their properties, and provide an introduction to various discrete distributions. **(Ap)**

CO2: Establish a well-grounded knowledge of various continuous probability distributions and their properties.**(Ap**)

CO3: Apply the concepts of functions of random variables and their distributions.**(Ap)**

CO4: Analyze the concepts of sampling distributions, order statistics, and their distributions.**(An)**

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	2	1	1
CO2	3	2	2	1	1
CO3	3	2	2	1	2
CO4	2	1	2	1	2

Syllabus Content

MODULE I (CO1) **(25 hours)**

Probability Generating functions, Moment generating functions and their properties, Quick review of Discrete Distributions:-(Degenerate, Bernoulli, Binomial, Uniform, Geometric, Poisson), Negative binomial and Hypergeometric, Logarithmic series, Modified Power series and Generalized Power series (Binomial, Poisson, Negative binomial, Logarithmic series etc. as special cases)

MODULE II (CO2) (20 hours)

Continuous Distributions :- (Quick review of Rectangular, Triangular, Exponential, Normal, Lognormal) Weibull, Beta, Gamma, Pareto, Cauchy, Laplace, Logistic, Inverse Gaussian. Pearson family and Exponential family of distributions – Definition and Identification of members.

MODULE III (CO3) (20 hours)

Functions of Random variables and their distributions. Probability integral transform, Distributions of sums, products and ratios of independent random variables distributions, Compound, Truncated and mixture distributions.

MODULE IV (CO4) (25 hours)

Sampling distributions:- Chi-square, t and F distributions (concept of non-central forms -Chi-square, t, F (definition only), Sampling distributions of mean and variance, independence of sample mean and variance, Order statistics and their distributions:- joint , marginal and conditional distributions; Distributions of sample median, range and mid– range (Exponential and Uniform).

TEXT BOOKS

1. Hogg R.V and Craig A.T. (2013) Introduction to Mathematical Statistics, Macmillian publishing company.
2. Johnson N.L, Kotz S. and Kemp A.W. (1992) Univariate discrete distributions, Wiley.
3. Johnson N.L, Kotz S. and Balakrishnan N. (1991) Continuous Univariate distributions I & II, Wiley.

REFERENCES

1. Anderson T.W. (1984) An Introduction to Multivariate Statistical Analysis, Macmillan Publishing Company.
2. Fisz M (1963) Probability Theory and Mathematical Statistics, 3rd Edition, John Wiley.
3. Hogg R.V. and Craig, A.T. (1989) Introduction to Mathematical Statistics, Macmillan Publishing Company.
4. Johnson N.L. and Kotz S. (1969) Distributions in Statistics; Discrete distributions. John Wiley and Sons, New York.

Question Paper format as per the Blueprint model BP 1

Module	CO	Part A1	Part A2	Part A3	Part A4	Part B1	Part B2	Part C1	Part C2	Total Weights (30 out of 48)
		Any 2 out of 3 questions of				Any 3 out of 4 questions of		Any 1 out of 2 questions of		
		CO1	CO2	CO3	CO4	CO3	CO4	CO1	CO2	
Module I	CO1	3	0	0	0	0	0	2	0	13
Module II	CO2	0	3	0	0	0	0	0	2	13
Module III	CO3	0	0	3	0	4	0	0	0	11
Module IV	CO4	0	0	0	3	0	4	0	0	11

*** End Semester evaluation of the course can be done using any blueprint model (BP 1 to BP 6)**

MODEL QUESTION PAPER
(as per the Blueprint model BP 1)

ST1C02TM25 – Distribution Theory

Time: 3 hours **Maximum Weight: 30**

Part A

Part A1. Answer any 2 questions from the bunch for CO1. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
1.	Explain probability generating function. Deduce variance from pgf.	CO1	Ap
2.	Establish the recurrence relation for central moments of Binomial distribution	CO1	Ap
3.	Determine the moment generating function of Poisson distribution	CO1	Ap

(2x 1= 2 weights)

Part A2. Answer any 2 questions from the bunch for CO2. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
4.	Determine the Characteristic function of Beta distribution	CO2	Ap
5.	Determine the distribution of X+Y, Given X and Y are two independent exponential random variables with parameter θ.	CO2	Ap
6.	Determine the distribution of X^2 , where X follows N(0,1).	CO2	Ap

(2x 1= 2 weights)

Part A3. Answer any 2 questions from the bunch for CO3. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
7.	Define a compound distribution.	CO3	R
8.	Give an example of a Poisson-gamma compound distribution.	CO3	U
9.	Explain a mixture distribution and a compound distribution.	CO3	Ap

(2x 1= 2 weights)

Part A4. Answer any 2 questions from the bunch for CO 4. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
10.	Define r^{th} order statistic. Determine the pdf of X(r)	CO4	R
11.	Explain order Statistics.	CO4	Ap
12.	Write first order statistic and the pdf of X(1)	CO4	Ap

(2x 1= 2 weights)

Part B

Part B1. Answer any 3 questions from the bunch for CO3. Each question carries 2 weights

Q. No	Questions	CO	Level of Question
13.	Explain Truncated distribution and pmf of Truncated, Poisson and Binomial distribution.	CO3	Ap
14.	Determine the conditional Distribution of x/x+y, where X and Y are independent negative random variables with parameters (r_1,p) and (r_2,p) respectively.	CO3	Ap
15.	Compute the density function for u= x+y and v= xy, if f(x,y) =x+y ;$0\leq x\leq 1$ and $0\leq y\leq 1$.	CO3	Ap
16.	Solve for the distribution of x_2 , if x_1 follows Uniform (0,1) and conditional distribution of x_2 /x_1 follows follows Binomial (n, x).	CO3	Ap

(3x 2= 6 weights)

Part B2. Answer any 3 questions from the bunch for CO4. Each question carries 2 weights

Q. No	Questions	CO	Level of Question
17.	Estimate the joint pdf of rth and sth order statistics	CO4	An
18.	Determine the mean and mode of F distribution	CO4	Ap

19.	Write the interrelationship between $\chi2$,t and F distribution and give proof.	CO4	Ap
20.	Compute the distribution of range.	CO4	Ap

(3x 2= 6 weights)

Part C

Part C1. Answer any 1 question from the bunch for CO1. Each question carries 5 weights

Q. No	Questions	CO	Level of Question
21.	Explain lack of memory property in detail.	CO1	Ap
22.	Compute the mgf of Power series distribution. Find the mgf of Poisson from the mgf of Power series distribution. Derive the recurrence relation for cumulants of Power series distribution.	CO1	Ap

(1x 5= 5 weights)

Part C2. Answer any 1 question from the bunch for CO2. Each question carries 5 weights

Q. No	Questions	CO	Level of Question
23.	Establish that for a normal distribution the mean , mode and median are equal.	CO2	Ap
24.	Explain standard Weibull distribution and derive its mean and variance	CO2	Ap

(1x 5= 5 weights)

SEMESTER I
CORE COURSE

ST1C03TM25– Linear Algebra for Statistics

Credits: 4

Total Lecture Hours: 90

Course Outcomes:

CO1: Establish a solid understanding of the concepts of linear algebra and vector spaces. **(Ap)**

CO2:Analyze the algebra of matrices, including special matrix structures, the row and column spaces of matrices, and linear transformations.**(An)**

CO3: Examine concepts in linear algebra, including eigenvalues, spectral representation, singular value decomposition, and characteristic roots.**(Ap)**

CO4: Explain the concepts of linear equations, generalized inverses (including their properties and computation), and quadratic forms.**(Ap)**

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	2	1	1
CO2	2	1	2	1	1
CO3	3	1	2	1	2
CO4	3	1	2	1	2

Syllabus Content

MODULE I (CO1) **(20 hours)**

Basics of linear algebra: Definition of a vector space, sub spaces, linear dependence and independence, basis and dimensions, direct sum and complement of a subspace, caution spaces, inner product and orthogonality.

MODULE II (CO2) **(20 hours)**

Algebra of Matrices Linear transformations and matrices, Matrices with special structures – triangular matrix, idempotent matrix, Nilpotent matrix, symmetric Hermitian and skew Hermitian matrices unitary matrix. Row and column space of a matrix, inverse of a matrix. Inverse of a partitioned matrix, Elementary operations and reduced forms.Linear transformations. Change of basis.

MODULE III (CO3) **(25 hours)**

Eigenvalues, spectral representation and singular value decomposition. Characteristic roots, Cayley Hamilton theorem, minimal polynomial, Eigenvalues and Eigenspaces, spectral representation of a semi simple matrix, algebraic and geometric multiplicities, Diagonal forms, triangular forms ,Jordan canonical form, spectral representation of a real symmetric, singular value decomposition.

MODULE IV (CO4) **(25 hours)**

Linear equations generalized inverses and quadratic forms Homogenous system, general system, Rank Nullity Theorem, generalized inverses, properties of g-inverse, Moore Penrose inverse, properties, computation of g-inverse, definition of quadratic forms, classification of quadratic forms, rank and signature, positive definite and non negative definite matrices, extreme of quadratic forms.

TEXT BOOKS

1. Gilbert Strang (2014) Linear Algebra and its Applications, 15th Re-Printing edition, Cengage Learning.
2. Hoffman K. and Kunze R. (2014) Linear Algebra, Second edition, Phi Learning.

REFERENCES

1. Rao A.R. and Bhimasankaram P. (2000) Linear Algebra, Second edition, Hindustan Book Agency
2. Rao C.R. (2009) Linear Statistical Inference and its Applications, Second edition, Wiley Eastern.

Question Paper format as per the Blueprint model BP 1

Module	CO	Part A1	Part A2	Part A3	Part A4	Part B1	Part B2	Part C1	Part C2	Total Weights (30 out of 48)
		Any 2 out of 3 questions of				Any 3 out of 4 questions of		Any 1 out of 2 questions of		
		CO1	CO2	CO3	CO4	CO3	CO4	CO1	CO2	
Module I	CO1	3	0	0	0	0	0	2	0	13
Module II	CO2	0	3	0	0	0	0	0	2	13
Module III	CO3	0	0	3	0	4	0	0	0	11
Module IV	CO4	0	0	0	3	0	4	0	0	11

*** End Semester evaluation of the course can be done using any blueprint model (BP 1 to BP 6)**

MODEL QUESTION PAPER
(as per the Blueprint model BP 1)

ST1C03TM25– Linear Algebra for Statistics

Time: Three hours **Maximum Weight: 30**

Part A

Part A1. Answer any 2 questions from the bunch for CO1. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
1.	Define basis and dimension of basis.	CO1	R
2.	Establish that every vector in a vector space V has a unique representation in terms of a given basis.	CO1	Ap
3.	Define linear dependence and independence of vectors.	CO1	R

(2x 1= 2 weights)

Part A2. Answer any 2 questions from the bunch for CO2. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
4.	Distinguish between symmetric and skew symmetric matrix.	CO2	An
5.	Explain row and column space of a matrix.	CO2	Ap
6.	Establish that every non-singular matrix is a product of elementary matrices.	CO2	Ap

(2x 1= 2 weights)

Part A3. Answer any 2 questions from the bunch for CO3. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
7.	Explain characteristic roots of a vector with example	CO3	Ap
8.	Establish that if $\lambda \neq 0$ is a characteristic root of A, then $\frac{1}{\lambda}$ is a characteristic root of A-1.	CO3	Ap
9.	Write Cayley- Hamilton theorem.	CO3	Ap

(2x 1= 2 weights)

Part A4. Answer any 2 questions from the bunch for CO 4. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
10.	Explain Moore Penrose inverse of a matrix.	CO4	Ap
11.	Establish that every positive definite matrix or positive semi definite matrix can be represented as a Gram-matrix.	CO4	Ap
12.	Establish that If A is a positive definite matrix, then |A| > 0.	CO4	Ap

(2x 1= 2 weights)

Part B

Part B1. Answer any 3 questions from the bunch for CO3. Each question carries 2 weights

Q. No	Questions	CO	Level of Question
13.	Establish that characteristic roots of a real symmetric matrix are all real.	CO3	Ap
14.	Establish that if λ is a characteristic root of A the λ^k is a characteristic root of A^k.	CO3	Ap
15.	Establish that the characteristic roots of an orthogonal matrix are +1 or -1.	CO3	Ap
16.	Establish that any two characteristic vectors corresponding to two distinct characteristic roots of a Hermitian matrix are orthogonal.	CO3	Ap

(3x 2= 6 weights)

Part B2. Answer any 3 questions from the bunch for CO4. Each question carries 2 weights

Q. No	Questions	CO	Level of Question
17.	a) Define Moore - Penrose g inverse. b) Establish that a Moore - Penrose g inverse is unique.	CO4	Ap
18.	Transform the quadratic form to the canonical form. Also, give the linear transformation.. xy+xz+yz	CO4	U
19.	a) Define g inverse and reflexive g inverse of a matrix. b) Establish that If $\bar{A}_1$ and $\bar{A}_2$ are two g - inverses of A, then $\bar{A}_r = \bar{A}_1 A \bar{A}_2$ is a reflexive g inverse of A.	CO4	Ap

20.	Establish the definiteness of a quadratic form Q is invariant under non singular linear transformation.	CO4	Ap

(3x 2= 6 weights)

Part C

Part C1. Answer any 1 question from the bunch for CO1. Each question carries 5 weights

Q. No	Questions	CO	Level of Question
21.	Explain Gram-Schmidt orthogonalization process.	CO1	Ap
22.	a) Define linear independence of vectors (b) A set of non zero vectors $x_1, x_2, x_3, \ldots\ldots, x_n$ are linearly dependent if and only if at least one vector x_i among this vectors is a linear combination of the preceding members. (c) Write the statement and the proof of Bayes' Extension Theorem.	CO1	Ap

(1x 5= 5 weights)

Part C2. Answer any 1 question from the bunch for CO2. Each question carries 5 weights

Q. No	Questions	CO	Level of Question
23.	a) Define column nullity and row nullity of a matrix. b) Write the statement and the proof osylvester law of nullity. c) Explain system of linear equations and show that the general solution of the system of linear equations AX=B is the sum of the general solution of AX=0 and any particular solution of AX=B.	CO2	An
24.	Write the statement and the proof o Rank-Nullity theorem.	CO2	A

(1x 5= 5 weights)

SEMESTER I

CORE COURSE

ST1C04TM25– Sampling Theory

Credits: 4

Total Lecture Hours: 90

Course Outcomes:

CO1: Explain the principles of sampling, probability and non-probability sampling techniques, and the estimation methods for population mean, total, proportions, and their properties.**(Ap)**

CO2: Analyze the systematic and stratified sampling methods, their comparison, and the estimation of various population parameters.**(An)**

CO3: Apply various estimation techniques, including the ratio method, regression method, and cluster sampling method, to estimate population parameters.**(Ap)**

CO4: Illustrate varying probability sampling techniques, including PPS sampling with and without replacement, the cumulative total method etc., and the estimation of the population total and variance under PPS sampling. **(Ap)**

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	2	1	2
CO2	2	2	2	1	2
CO3	3	1	2	1	2
CO4	3	1	2	1	2

Syllabus Content

MODULE I (CO1) (25 hours)

Official Statistical Systems in India – Role of NSSO and CSO and their activities – For general awareness of students (1 or 2 hours), Census and Sampling methods, Advantages and disadvantages, Principles of sampling theory, Principal steps in a sample survey, probability sampling and non-probability sampling, sampling and non-sampling errors, bias, variance and

MSE , simple random sampling with and without replacement - estimation of population mean, total and proportions, estimation of sample size. Properties of the estimators, variance and standard error of the estimators, confidence intervals, determination of the sample size.

MODULE II (CO2) (20 hours)

Stratified random sampling, estimation of the population mean, total and proportion, properties of estimators, various methods of allocation of a sample, comparison of the precision of estimators under proportional allocation, optimum allocation and SRS.Systematic sampling – Linear and Circular, estimation of the mean and its variance, intraclass correlation coefficient, comparison of systematic sampling, SRS and stratified random sampling for a population with a linear trend.

MODULE III (CO3) (25 hours)

Ratio method of estimation, estimation of population ratio, means and total, 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 unit method, Cluster sampling, single stage cluster sampling with equal and unequal cluster sizes, estimation of the population mean and its standard error. Two-stage cluster sampling with equal and unequal cluster sizes, Multi stage and Multiphase sampling (Basic Concepts), estimation of the population mean and its standard error.

MODULE IV (CO4) (20 hours)

Varying probability sampling, PPS sampling with and without replacement, 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, ordered and unordered estimators of the population total under PPS wor, Horwitz – Thompson estimator and its estimated S. E, Des-Raj's ordered estimator, Murthy's unordered estimator (properties of these estimators for n=2 only). Inclusion probability proportional to size Sampling Procedures. Problems regarding the above sampling concepts.

TEXT BOOKS

1. Cochran W.G (1992): Sampling Techniques, Wiley Eastern, New York.
2. Singh, DandChowdhary, F.S. (1999): Theory and Analysis of Sample Survey Designs, Wiley Eastern (New Age International), New Delhi.

REFERENCES

1. ParimalMukhopadhyay (2009) Theory and Methods of Survey Sampling, Second Edition,PHI Learning (P) Ltd
2. P.V.Sukhatme Et.al. (1984): Sampling Theory of Surveys with Applications. IOWA State University Press, USA.

3. M.N. Murthy (1977) Sampling Theory and Methods, Statistical Publishing Society,
4. Sampath S. C. (2001) Sampling Theory and Methods, Alpha Science International Ltd., India.
5. Thomas Lumley (1969) Complex Surveys. A guide to analysis using R , Wiley eastern Ltd.
6. Desraj (1967) Sampling theory. Tata McGraw Hill, New Delhi. 7) MOSPI website.

Question Paper format as per the Blueprint model BP 1

Module	CO	Part A1	Part A2	Part A3	Part A4	Part B1	Part B2	Part C1	Part C2	Total Weights (30 out of 48)
		Any 2 out of 3 questions of				Any 3 out of 4 questions of		Any 1 out of 2 questions of		
		CO1	CO2	CO3	CO4	CO3	CO4	CO1	CO2	
Module I	**CO1**	**3**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**13**
Module II	**CO2**	**0**	**3**	**0**	**0**	**0**	**0**	0	2	**13**
Module III	**CO3**	**0**	**0**	**3**	**0**	**4**	**0**	**0**	**0**	**11**
Module IV	**CO4**	**0**	**0**	**0**	**3**	**0**	**4**	**0**	**0**	**11**

*** End Semester evaluation of the course can be done using any blueprint model (BP 1 to BP 6)**

MODEL QUESTION PAPER
(as per the Blueprint model BP 1)

ST1C04TM25– Sampling Theory

Time: Three hours **Maximum Weight: 30**

Part A

Part A1. Answer any 2 questions from the bunch for CO1. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
1.	Differentiate between Census and Sampling methods.	CO1	U
2.	Explain the concept of bias, variance, and MSE in sampling.	CO1	Ap
3.	Articulate thre sample size affects the confidence interval of an estimator.	CO1	Ap

(2x 1= 2 weights)

Part A2. Answer any 2 questions from the bunch for CO2. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
4.	Define stratified random sampling.	CO2	R
5.	Differentiate between Linear Systematic Sampling and Circular Systematic Sampling.	CO2	An
6.	Write the formula for variance of the estimator under stratified sampling.	CO2	Ap

(2x 1= 2 weights)

Part A3. Answer any 2 questions from the bunch for CO3. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
7.	Define bias and relative bias in ratio estimators.	CO3	U
8.	Define Cluster Sampling and mention its types.	CO3	U
9.	Differentiate between single-stage and two-stage cluster sampling.	CO3	U

(2x 1= 2 weights)

Part A4. Answer any 2 questions from the bunch for CO 4. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
10.	Differentiate between PPS sampling with replacement (PPS WR) and without replacement (PPS WOR).	CO4	U
11.	Explain the Cumulative Total Method in PPS Sampling.	CO4	Ap
12.	Define ordered and unordered estimators in PPS sampling.	CO4	U

(2x 1= 2 weights)

Part B

Part B1. Answer any 3 questions from the bunch for CO3. Each question carries 2 weights

Q. No	Questions	CO	Level of Question

13.	Illustrate the bias and relative bias of the ratio estimator and compare its efficiency with simple random sampling for population mean estimation.	CO3	Ap
14.	Articulate the efficiency of single-stage and two-stage cluster sampling for a given dataset. When is two-stage sampling preferred	CO3	Ap
15.	Illustrate the formula for standard error in single-stage cluster sampling with unequal cluster sizes and justify its efficiency over simple random sampling.	CO3	Ap
16.	Illustrate the bias and standard error of the ratio estimator and explain its efficiency compared to the mean per unit estimator.	CO3	Ap

(3x 2= 6 weights)

Part B2. Answer any 3 questions from the bunch for CO4. Each question carries 2 weights

Q. No	Questions	CO	Level of Question
17.	Determine the efficiency of Des-Raj's ordered estimator and Murthy's unordered estimator for n=2.	CO4	Ap
18.	Determine the differences between ordered and unordered estimators in PPS sampling. How do they affect variance estimation	CO4	Ap
19.	Write the formula for Horwitz-Thompson estimator and explain its properties. Compare its efficiency with the Des-Raj ordered estimator.	CO4	Ap
20.	Determine the variance of the Horvitz-Thompson estimator and discuss its role in PPS Sampling Without Replacement (PPS WOR).	CO4	Ap

(3x 2= 6 weights)

Part C

Part C1. Answer any 1 question from the bunch for CO1. Each question carries 5 weights

Q. No	Questions	CO	Level of Question
21.	Explain the key principles of sampling theory and their relevance in designing an efficient survey. Illustrate with examples.	CO1	Ap
22.	Compute the estimators for population mean, total, and proportion under simple random sampling (SRS) with and without replacement. Compare their properties.	CO1	Ap

(1x 5= 5 weights)

Part C2. Answer any 1 question from the bunch for CO2. Each question carries 5 weights

Q. No	Questions	CO	Level of Question
23.	Compare the estimators of population mean, total, and proportion in stratified random sampling. Discuss their efficiency relative to simple random sampling.	CO2	An
24.	Explain the different methods of allocation of sample size in stratified sampling (Proportional, Optimum, Neyman). Compare their efficiencies.	CO2	An

(1x 5= 5 weights)

SEMESTER I
CORE COURSE
ST1C05TM25– Database Management Systems and Data Science

Credits: 3

Total Lecture Hours: 90

Course Outcomes:

CO1: Examine the fundamentals of database systems, including database languages, E-R models, relational models, their associated structures, the design of E-R schemas, and the use of query languages for database management.**(Ap)**

CO2: Apply the concepts of SQL, including basic structure, set operations, aggregate functions, and nested subqueries, as well as the knowledge of data definition languages, integrity constraints, and relational database design principles.**(Ap)**

CO3: Apply the concepts of R programming, including variables, data types, functions, data structure, control statements and loops, to efficiently represent data in R.**(Ap)**

CO4: Explain the concepts of random number generation and data visualization tools, including Power BI, Tableau, matplotlib, ggplot2, and Looker studio, for visualizing data**.(Ap)**

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	2	3	1
CO2	3	1	2	3	1
CO3	3	1	2	2	2
CO4	3	1	2	1	2

Syllabus Content

MODULE I (CO1) **(20 hours)**

Introduction: Purpose of dB Systems, View of Data, Data Models, Database Languages: DDL and DML,Database Administrator, Transaction Management, Storage Management. E-R Model: Basic Concepts, Mapping Constraints, Keys, E-R Diagrams, Weak Entity Sets

Extended ER Features, Design of an E-R dB Schema. Relational Model: Structure of Relational dB, Query Languages.

MODULE II (CO2) (25 hours)

SQL : Basic Structure , Set Operations, Aggregate Functions , Null Values , Nested Sub queries , Modification of the Database, Joined Relations , Data Definition Language: Schema Definition in SQL. Integrity constraints, Domain Constraints, Referential Integrity in SQL, Relational Database Design-First Normal Form, Pitfalls in Relational database Design,Functional Dependencies, Decomposition, 2NF, 3NF,BCNF,4NF and 5NF,ACID Property.

MODULE III (CO3) (25 hours)

R programing :Basics of R and R-Studio, R Sessions and Functions, Basic math, variables, data types, vectors, data frames, lists, Matrices, Arrays, Classes, Importing data files,Control Statements, Loops.

MODULE IV (CO4) (20 hours)

Random number generation , Introduction to popular data visualization tools (e.g., Tableau, Power BI, matplotlib, ggplot2, Looker Studio) , Introduction to PowerBI, Use cases and BI Tools , Power BI components, Power BI Desktop, workflows and reports , Data Extraction with Power BI, Dashboard creation.

TEXT BOOKS

1. Ramez Elmasri and Shamkant B.Navathe - DATABASE SYSTEMS , Sixth Edition, Pearson Education.
2. Jones, O., Maillardet. R. and Robinson, A. (2014). Introduction to Scientific Programming and Simulation Using R. Chapman & Hall/CRC, The R Series.
3. Crawley, M, J. (2012). The R Book, 2nd Edition. John Wiley & Sons.

REFERENCES

1. Database System Concepts Author: Abraham Silberschatz, Henry F.Korth,S.Sudarshan. (McGrawHill Publications)
2. Chambers, J. M. (2008). Software for Data Analysis-Programming with R. Springer-Verlag, New York.
3. Jammalamadaka, S. R. (2007). Essential Statistics with python and R. Kendal Hunt publishing.
4. Larson, B. (2022). Data Analysis with Microsoft Power BI. McGraw-Hill Education.
5. Jose, J. (2025). Beginner's Guide for Data Analysis using R Programming (1st ed.). Khanna Publishing House.

Question Paper format as per the Blueprint model BP 1

Module	CO	Part A1	Part A2	Part A3	Part A4	Part B1	Part B2	Part C1	Part C2	Total Weights (30 out of 48)
		Any 2 out of 3 questions of				Any 3 out of 4 questions of		Any 1 out of 2 questions of		
		CO1	CO2	CO3	CO4	CO3	CO4	CO1	CO2	
Module I	CO1	3	0	0	0	0	0	2	0	13
Module II	CO2	0	3	0	0	0	0	0	2	13
Module III	CO3	0	0	3	0	4	0	0	0	11
Module IV	CO4	0	0	0	3	0	4	0	0	11

*** End Semester evaluation of the course can be done using any blueprint model (BP 1 to BP 6)**

MODEL QUESTION PAPER
(as per the Blueprint model BP 1)

ST1C05TM25 – Database Management System and Data Science

Time: 3 hours **Maximum Weight: 30**

Part A

Part A1. Answer any 2 questions from the bunch for CO1. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
1.	Describe tuple, attribute and domain.	CO1	U
2.	Explain weak entity set in ER Model.	CO1	U
3.	Differentiate generalization and specialization.	CO1	U

(2x 1= 2 weights)

Part A2. Answer any 2 questions from the bunch for CO2. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
4.	Define trivial functional dependency	CO2	R
5.	Explain Logical operators in SQL	CO2	Ap

6.	Discuss ORDER BY clause with example.	CO2	U

(2x 1= 2 weights)

Part A3. Answer any 2 questions from the bunch for CO3. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
7.	Explain the purpose of the 'break' statement in loops?	CO3	Ap
8.	Explain a function in R and mention its key components.	CO3	Ap
9.	Write any two advantages of using R for data analysis.	CO3	Ap

(2x 1= 2 weights)

Part A4. Answer any 2 questions from the bunch for CO 4. Each question carries 1 weight

Q. No	Questions	CO	Level of Question
10.	Explain the purpose of using random number generation in statistical analysis.	CO4	Ap
11.	Write two popular data visualization tools used in industry.	CO4	Ap

12.	Discuss how data extraction be performed in Power BI.	CO4	U

(2x 1= 2 weights)

Part B

<u>Part B1. Answer any 3 questions from the bunch for CO3. Each question carries 2 weights</u>

Q. No	Questions	CO	Level of Question
13.	Construct a Pivot Table in Excel for population growth by decade and compute summary statistics in R.	CO3	Ap
14.	Write an R program to simulate 100 coin tosses, calculate the proportion of heads, and visualize results using a bar chart.	CO3	Ap
15.	Prepare a random dataset of 500 individuals with age, income, and education level, then classify them into income groups.	CO3	Ap
16.	Illustrate missing data is handled in R during analysis. Include functions used to detect, remove, or impute missing values.	CO3	Ap

(3x 2= 6 weights)

Part B2. Answer any 3 questions from the bunch for CO4. Each question carries 2 weights

Q. No	Questions	CO	Level of Question
17.	Describe the workflow of creating a report in Power BI Desktop. Explain the importance of data modeling, data extraction, and data visualization in report creation.	CO4	Ap
18.	Explain the process of creating a dashboard in Power BI. Discuss the importance of selecting relevant data, designing visualizations, and configuring interactions	CO4	Ap
19.	Explain the importance of interactive visualization in data analysis.	CO4	Ap
20.	Discuss the importance of data extraction in Power BI and its applications.	CO4	Ap

(3x 2= 6 weights)

Part C

Part C1. Answer any 1 question from the bunch for CO1. Each question carries 5 weights

Q. No	Questions	CO	Level of Question
21.	Illustrate the DBMS system environment with a well-labeled diagram and explain its various components.	CO1	Ap

22.	Explain ER Model. Draw ER model of Library Management System.	CO1	Ap

(1x 5= 5 weights)

Part C2. Answer any 1 question from the bunch for CO2. Each question carries 5 weights

Q. No	Questions	CO	Level of Question
23.	Explain different DDL Query statements in SQL. Explain with Syntax and Example schema.	CO2	Ap
24.	Explain informal design guidelines in the relational model and describe different keys.	CO2	Ap

(1x 5= 5 weights)

SEMESTER II

SEMESTER II
CORE COURSE

ST2C06TM25– Estimation Theory

Credits: 4

Total Lecture Hours: 90

Course Outcomes:

CO1: Apply point estimation techniques by applying properties of estimators, sufficiency, and factorization theorems to derive optimal estimators.**(Ap)**

CO2: Analyze Fisher information, Cramer-Rao inequality, and Bhattacharyya's bounds to evaluate the efficiency and variance of estimators.**(An)**

CO3: Illustrate the properties of UMVUE estimators using the Rao-Blackwell and Lehmann-Scheffé theorems and justify their practical significance in statistical inference.**(Ap)**

CO4: Examine Bayesian inference principles by implementing Bayes estimators, loss functions, and minimax estimation for decision-making in statistical problems.**(Ap)**

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	1	1	1
CO2	2	1	1	1	1
CO3	3	1	2	1	1
CO4	3	1	2	1	2

Syllabus Content

MODULE I (CO1) **(25 hours)**

Criteria for estimators - properties of estimators – unbiasedness - consistency, sufficient condition for consistency – Sufficiency, minimal sufficiency, completeness, bounded completeness, Fisher-Neyman factorization theorem, exponential families, UMVUE estimators and their characterization, Rao-Blackwell theorem, Lehmann -Scheffe theorem, ancillary statistics, Basu's theorem.

MODULE II (CO2) **(20 hours)**

Point estimation - Fisher information measure and its properties, Fisher information matrix , Lower bound to the variance of an unbiased estimator, Cramer-Rao inequality, Bhattacharyya's bounds, Efficiency, minimum variance.

MODULE III (CO3) **(25 hours)**

Methods of estimation: Point Estimation-method of moments, method of maximum likelihood & their properties, Cramer Huzurbazar theorem, Fisher's scoring method, method of minimum chi-square and method of modified minimum chi-square- Interval estimation – Pivotal method of construction - shortest confidence intervals and their construction (minimum average width) -Construction of shortest confidence intervals in large samples.

MODULE IV (CO4) **(20 hours)**

Basic elements of Bayesian inference, Loss function and risk functions, Standard forms of loss functions, Prior distribution, Bayes Theorem, Posterior distribution, Bayes risk, Bayes principle, Bayes estimators, Minimax estimators.

TEXT BOOKS

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.

REFERENCES

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), Collier Macmillian, New York.
5. Rao C.R (2009) Linear Statistical Inference and its Applications, John Wiley, New York.

SEMESTER II
CORE COURSE

ST2C07TM25– Stochastic Processes

Credits: 4

Total Lecture Hours: 90

Course Outcomes:

CO1: Apply classification techniques to distinguish different types of stochastic processes and solve problems related to Markov chains using transition probabilities and recurrence properties.**(Ap)**

CO2: Analyze stochastic models such as random walks, gambler's ruin problem, and branching processes by deriving their statistical properties and extinction probabilities. **(An)**

CO3: Illustrate the performance of continuous-time Markov chains, birth-death processes, and queuing models such as M/M/1 and M/M/s using Kolmogorov equations. **(Ap)**

CO4: Establish the concepts of renewal theory to model stochastic processes and solve problems involving Poisson and delayed renewal processes using renewal equations.**(Ap)**

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	2	1	2
CO2	2	2	2	1	2
CO3	3	2	2	1	2
CO4	3	2	2	1	2

Syllabus Content

MODULE I (CO1) **(25 hours)**

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, Markov process, Markov chains-transition probability matrices, Chapman-Kolmogorov equation, first passage probabilities, generating functions, classification of states, criteria for recurrent and transient states, mean recurrence time, mean ergodic theorem, the basic limit theorem of Markov chains (statement only), reducible and irreducible Markov chains, stationary distributions, limiting probabilities and absorption probabilities.

MODULE II (CO2) (20 hours)

Random walk, gambler's ruin problem; Galton-Watson branching process, generating function relations, mean and variance functions, extinction probabilities, criteria for extinction.

MODULE III (CO3) (25 hours)

Continuous time Markov chains, Poisson processes,pure birth processes and the Yule processes, birth and death processes, Kolmogorov forward and backward differential equations, linear growth process with immigration, steady-state solutions of Markovian queuing models--M/M/1, M/M/1 with limited waiting space,M/M/s, M/M/s with limited waiting space.

MODULE IV (CO4) (20 hours)

Renewal processes– concepts, examples, Poisson process viewed as a renewal process, renewal equation, elementary renewal theorem, asymptotic expansion of renewal function, central limit theorem for renewals, key renewal theorem (statement only), delayed renewal processes.

TEXT BOOKS

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

REFERENCES

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.

SEMESTER II

CORE COURSE

ST2C08TM25– Multivariate Analysis

Credits: 4

Total Lecture Hours: 90

Course Outcomes:

CO1: Apply multivariate normal distribution concepts to estimate mean vectors, covariance matrices, and analyze marginal and conditional distributions. **(Ap)**

CO2: Analyze the properties of Wishart distribution, Hotelling's T^2, and Mahalanobis D^2 statistics, and their role in multivariate hypothesis testing.**(An)**

CO3: Articulate statistical tests for independence, equality of covariance matrices, and sphericity to assess multivariate data structures.**(Ap)**

CO4: Explain classification techniques, principal component analysis, and canonical correlation methods to solve real-world multivariate problems.**(Ap)**

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	1	2
CO2	2	3	2	1	2
CO3	3	2	2	1	2
CO4	3	2	2	1	2

Syllabus Content

MODULE I (CO1) **(20 hours)**

Multivariate data, preliminary analysis, notion of multivariate distributions, multivariate normal distribution, marginal and conditional distributions, characteristic function, estimation of mean vector and covariance matrix.

MODULE II (CO2) **(25 hours)**

Wishart distribution and its properties,sample dispersion matrix ,simple, partial and multiple correlations(Basic Properties only),Hotelling'sT^2 and Mahalanobis D^2 statistics, properties of T^2 and D^2, multivariate Fisher-Behren's problem.

MODULE III (CO3) **(20 hours)**

Testing independence of sets of variates, testing equality of covariance matrices and means, Sphericity tests, testing the hypothesis that a covariance matrix equal to given matrix, Mean and covariance equal to a given vector and given matrix.

MODULE IV (CO4) **(25 hours)**

Classification problem - standards of good classification, procedures of classification into one of two populations with known probability distributions, classification into one of two known multivariate normal populations, classification into one of several populations; principal component analysis- definition, properties and ML estimation; canonical variables, canonical correlation.

TEXT BOOKS

1. Anderson, T.W. (1984) An Introduction to Multivariate Statistical Analysis, John Wiley.
2. Johnson, R.A. and Wichern, D.W. (1990) Applied Multivariate Statistical Analysis, Prentice Hall.

REFERENCES

1. Seber, G.A.F. (1977) Multivariate Observations, Wiley.
2. Giri, N., Multivariate Statistical Inference, Academic Publishers.
3. Morrison, D.F. (1976) Multivariate Statistical Methods, John Wiley.
4. Rao, C.R. (1973) Linear Statistical Inference and the Application, Wiley.
5. Rancher, A.C. (1995) Methods of Multivariate Analysis, John Wiley.

SEMESTER II

CORE COURSE

ST2C01PM25– Data Science using R/Python

Credits: 3

Total Lecture Hours: 90

Course Outcomes:

CO1: Apply Python programming concepts, including data structures, loops, functions, and object-oriented programming, to develop efficient computational solutions.**(Ap)**

CO2: Analyze different parameter estimation methods, such as the method of moments, maximum likelihood estimation, and minimum chi-square estimation, to determine their applicability and efficiency in statistical inference.**(An)**

CO3: Evaluate stochastic processes by computing transition probabilities, classifying states, and determining characteristics of Markov chains, queuing models, and branching processes.**(E)**

CO4: Solve multivariate statistical methods, including hypothesis testing, principal component analysis, and classification techniques, to interpret and analyze high-dimensional data.**(Ap)**

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	3	1
CO2	2	3	2	1	2
CO3	2	2	3	1	2
CO4	3	2	2	1	2

Syllabus Content

MODULE I (CO1) (20 hours)

Introduction to python: Python installation and setup, variables, data types, data structures, operators, conditional statements, loops, functions and object-oriented programming (OOP) concepts such as classes, objects, and inheritance.Sampling Theory:Estimation of population mean, total, and proportion; confidence intervals and variance estimation under SRS and stratified sampling; regression and cluster sampling efficiency; PPS sampling methods, including DesRaj, Murthy's, and Horvitz-Thompson estimators

MODULE II (CO2) (20 hours)

Estimation Theory: Estimation of parameters, Method of moments, Method of maximum likelihood, Fisher's Scoring method, Method of minimum chi square, Uniformly Minimum Variance Unbiased Estimates.Distribution Theory: Fitting of Binomial distribution,Poisson distribution,Negative binomial distribution,Geometric distribution,Exponential distribution,Normal distribution,log normal distribution,Goodness of fit.

MODULE III (CO3) (25 hours)

Stochastic Processes : Calculation of transition probabilities of a MC, Calculation of first passage transition probabilities of a MC, Classification of states of a MC, Stationary distributions of MCs, Determination of various characteristics of different queuing models like M/M/1 & M/M/2, Determination of mean & variance of a BP, Determination of extinction probabilities of BP.

MODULE IV (CO4) (25 hours)

Multivariate Analysis: Testing of hypothesis related to mean vectors(One sample and two sample cases), Construction of confidence region for the mean vector, Profile Analysis, Principal component analysis, Factor analysis, Canonical correlation analysis, Classification into one of the two populations, Classification into several populations, Cluster analysis, Testing independence of sets of variables, Testing equality of dispersion matrices.

REFERENCES

1. Jammalamadaka, S. R. (2007). *Essential statistics with Python and R*. Kendall Hunt Publishing.
2. Raschka, S., Mirjalili,V. (2019). Python Machine learning, Packt Publishing, UK.
3. Anderson T.W. (1984) An Introduction to Multivariate Statistical Analysis, Macmillan Publishing Company.
4. Purohit, S.G., Gore,S.D. and Deshmukh,S.R. (2008). Statistics using R, Alpha Science
5. Karlin S. and Taylor H.M. (1975) A First Course in Stochastic Processes, Second edition, Academic Press, New-York.
6. Giri N (1984): Multivariate Statistical Inference, Academic publishers.
7. Johnson R.A. and Wichern D.W. (2008) Applied Multivariate Statistical Analysis.(6 thed.) Pearson education.

8. Keeping, E.S. (1964). Introduction to Statistical Inference. Affiliated East West Press Pvt L
9. P.V.Sukhatme Et.al. (1984): Sampling Theory of Surveys with Applications. IOWA State University Press, USA.
10. M.N. Murthy (1977) Sampling Theory and Methods, Statistical Publishing Society.
11. Johnson N.L. and Kotz S. (1969) Distributions in Statistics; Discrete distributions. John Wiley and Sons, New York.

SEMESTER II

CORE COURSE

ST2C09TM25– Data Mining and their Applications

Credits: 4

Total Lecture Hours: 90

Course Outcomes:

CO1: Apply data mining techniques, including data cleaning, transformation, and association rule mining, to preprocess and analyze large datasets effectively.**(Ap)**

CO2: Analyze the effect of outliers in univariate and multivariate data, and compare different clustering techniques to enhance data classification accuracy.**(An)**

CO3: Evaluate regression models, including ridge regression and robust regression, to handle multicollinearity and detect various types of outliers in time series data**.(Ap)**

CO4: Illustrate python-based implementations of data mining, clustering, and regression techniques to solve real-world analytical problems.**(An)**

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	1	3	1
CO2	2	2	2	1	2
CO3	3	2	2	2	2
CO4	2	2	2	2	2

Syllabus Content

MODULE I (CO1) (25 hours)

Data mining- History-Definitions-Data Mining Functionalities- Classification of Data mining System- Major Issues in Data mining. Data Preprocessing-Data Cleaning- Data Integration and Transformation- Data Reduction Discretization and concept of Hierarchy Generation- Concept Description characterization and comparison. Association Rule Mining- Mining Single

Dimensional –Multilevel Association Rules-mining to correlation analysis-classification and prediction

MODULE II (CO2) (20 hours)

Overview on outliers – nature of Outliers - Outliers in Univariate Data – Outliers in Multivariate Data - Cluster Analysis, Cluster Vs Classification - impact of Outliers on clustering - clustering problems - Clustering Approaches.

MODULE III (CO3) (20 hours)

Data-outliers in regression analysis and Time series - Regression and collinearity: Tools for handling multi- collinearity, methods based on singular value decomposition – Robust Regression-ridge regression. Properties of ridge estimator. Additive outlier – Multiplicative outlier and innovational outlier.

MODULE IV (CO4) (25 hours)

Implementation of data preprocessing techniques, association rule mining, and classification models. Detection and analysis of outliers in univariate and multivariate data. Application of clustering techniques and evaluation of their effectiveness. Regression analysis with multicollinearity handling using singular value decomposition and robust regression methods. Practical execution of ridge regression and identification of additive, multiplicative, and innovational outliers using Python.

REFERENCES

1. Daniel T. Larose, (2006): Data Mining: Methods and Models, Wiley-Interscience, NewJersey.
2. Draper, N.R, and H. Smith, Applied regression analysis,(2nd Ed) John Wiley and sons,New York.
3. Hawkins, D.M, (1980): Identification of Outliers, Chapman and Hall, London.
4. Jiawei Han, MichelineKamber, (2006): Data Mining: Concepts and Techniques, MorganKaufmann Publishers, second edition, San Francisco.
5. Krzysztof J.Cios, WiltoldPedrycz, Roman W. Swiniarski, LukaszA.Kurgan, (2007): DataMining: A Knowledge Discovery Approach, Springer Science +Business Media, NewYork.
6. Paolo Giudici, (2005): Applied Data Mining: Statistical Methods for Business andIndustry, John Wiley & Sons Ltd, England.
7. Peter J.Rousseeuw and AnnickM.Lorey, (1987): Robust Regression and OutlierDetection, John Wiley & Sons, United States.
8. Vic Barnett and Toby Lewis, (1978): Outliers in Statistical Data, John Wiley & sons.

SEMESTER III

SEMESTER III

CORE COURSE

ST3C10TM25– Testing of Hypotheses

Credits: 4

Total Lecture Hours: 90

Course Outcomes:

CO1: Apply the fundamental concepts of hypothesis testing by computing Type-I and Type-II errors, determining significance levels, interpreting p-values, and constructing tests using Neyman-Pearson lemma, Most Powerful (MP), and Uniformly Most Powerful (UMP) tests. **(Ap)**

CO2: Analyze hypothesis testing techniques in single and multi-parameter settings using methods like Monotone Likelihood Ratio (MLR), Neyman structure tests, and Likelihood Ratio (LR) tests for normal populations. **(An)**

CO3: : Employ sequential testing procedures, including Sequential Probability Ratio Tests (SPRT), Wald's fundamental identity, Operating Characteristic (OC) function, and Average Sample Number (ASN) for different distributions. **(Ap)**

CO4: Employ non-parametric tests such as Sign test, Chi-square test, Kolmogorov-Smirnov test, Wilcoxon Signed Rank test, and Mann-Whitney U-test for real-life categorical data, along with power and asymptotic relative efficiency comparisons. **(Ap)**

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	1	3
CO2	3	2	2	1	3
CO3	3	2	2	1	3
CO4	3	2	3	1	3

Syllabus Content

MODULE I (CO1) (25 hours)

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; Neyman-Pearson lemma and its applications; Construction of tests using NP lemma- Most powerful test, uniformly most powerful test; Monotone Likelihood ratio and testing with MLR property; Testing in one-parameter exponential families-one sided hypothesis, Unbiased and Uniformly Most Powerful Unbiased tests for different two sided hypothesis; Extension of these results to Pitman family when only upper or lower end depends on the parameters**.**

MODULE II (CO2) (25 hours)

Similar regions tests, Neyman structure tests, Likelihood ratio (LR) criterion and its properties, LR tests for testing equality of means and variances of several normal populations. Testing in multi-parameter exponential families-tests with Neyman structure, UMP and UMPU similar size-tests; Confidence sets, UMA and UMAU confidence sets, Construction of UMA and UMAU confidence sets using UMP and UMPU tests respectively.

MODULE III (CO3) (20 hours)

Sequential probability ratio tests (SPRT), Properties of SPRT, Determination of the boundary constants Construction of sequential probability ratio tests, Wald's fundamental identity, Operating characteristic (OC) function and Average sample number (ASN) functions for Normal Binomial, Bernoulli's, Poisson and exponential distribution.

MODULE IV (CO4) (20 hours)

Non-parametric tests-- Sign test, Chi-square tests, Kolmogorov-Smirnov one sample and two samples tests, Median test, Wilcoxon Signed Rank test, Mann- Whitney U-test , Test for Randomness, Runs up and runs down test, Wald–Wolfowitz run test for equality of distributions, Kruskall–Wallis one-way analysis of variance, Friedman's two-way analysis of variance, Power and asymptotic relative efficiency.

TEXT BOOKS

1. Rohatgi V.K.(1976),An Introduction to Probability Theory and Mathematical Statistics, John Wiley & Sons, New York.
2. Gibbons J.K. (1971) Non-Parametric Statistical Inference, McGraw Hill.

REFERENCES

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 A. (1947) Sequential Analysis, Wiley, Doves, New York.
4. Parimal Mukhopadhyay(2006):Mathematical Statistics, 3/e, Books and Allied (P) Ltd, Kolkata.
5. Siegel S. and Castellan Jr. N. J. (1988) Non-parametric Statistics for the Behavioural Sciences, McGraw Hill, New York.
6. Rao C.R. (1973) Linear Statistical Inference and its Applications, Wiley.

SEMESTER III

CORE COURSE

ST3C11TM25– Research Methodology and SPSS

Credits: 4

Total Lecture Hours: 90

Course Outcomes:

CO1: Apply the fundamental concepts of research, including meaning, objectives, types, and research formulation. **(Ap)**

CO2: Analyze data collection methods, sampling techniques, and data analysis strategies, and apply statistical techniques to draw meaningful conclusions. **(An)**

CO3: Evaluate a research instrument, ensuring face validity, content validity, construct validity, criterion validity, reliability, and internal consistency. **(E)**

CO4: Employ statistical analysis techniques using SPSS, interpret results, and communicate findings effectively through reporting and presentation. **(Ap)**

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	2	1	3
CO2	3	3	3	2	3
CO3	3	3	3	1	3
CO4	3	3	3	2	3

Syllabus Content

MODULE I (CO1) **(20 hours)**

Meaning and Objectives of Research, Types of Research -Descriptive, Analytical, Applied, Fundamental, Research Formulation -Problem Statement, Literature Review, Research Design -Exploratory, Descriptive, Experimental, Developing a Research Plan -Research Questions, Objectives, Hypotheses.

MODULE II (CO2) (20 hours)

Data Collection Methods -Surveys, Interviews, Observations, Sampling Methods -Probability, Non-Probability-, Data Analysis Strategies -Qualitative, Quantitative, Hypothesis Testing, Reporting and Thesis Writing -Structure, Style, Format, Oral Presentation and Communication -Preparation, Delivery, Visual Aids, Application of Results and Ethics -Implications, Limitations, Future Research.

MODULE III (CO3) (25 hours)

Formulating a Questionnaire: Identifying Research Objectives, Developing Survey Questions, Scaling Techniques, Questionnaire Design, Pilot Testing, Instrument Validation including Face Validity, Content Validity, Construct Validity, Criterion Validity, Reliability, Internal Consistency, Sample Size Calculation including Determining Sample Size, Sampling Error, Confidence Intervals, Power Analysis.

MODULE IV (CO4) (25 hours)

Introduction to SPSS: Overview of SPSS, Data Entry, Data Management, and Data Transformation. Descriptive Statistics: Measures of Central Tendency, Measures of Variability, Data Visualization using SPSS. Inferential Statistics: Hypothesis Testing, Confidence Intervals, Regression Analysis using SPSS. Data Analysis using SPSS: Data Analysis Procedures, Statistical Tests, Interpretation of Results.

REFERENCES

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
2. Kothari, C.R., 1990.Research Methodology: Methods and Techniques. New Age International. 418p.
3. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, Ess Ess Publications. 2 volumes.
4. Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.
5. Wadehra, B.L. 2000.Law relating to patents, trade marks, copyright designs and geographical indications. Universal Law Publishing.
6. Day, R.A.,1992.How to Write and Publish a Scientific Paper,Cambridge University Press.
7. Creswell, J. W., & Creswell, J. D. (2018). Research design: Qualitative, quantitative, and mixed methods approaches. Sage publications.
8. Spector, P. E. (2019). Summated rating scale construction: An introduction. Sage publications.

9. Field, A. (2018). Discovering statistics using IBM SPSS statistics. Sage publications.
10. George, D., & Mallery, P. (2019). IBM SPSS statistics 26 step by step: A simple guide and reference. Routledge.

SEMESTER III

CORE COURSE

ST3C12TM25– Time Series Analysis

Credits: 4

Total Lecture Hours: 90

Course Outcomes:

CO1: Apply regression modeling techniques by estimating and testing regression coefficients, handling correlated errors, detecting and correcting multicollinearity, and selecting appropriate models for forecasting. (**Ap**)

CO2: Analyze time series data by identifying its components, testing for trend and seasonality, and applying smoothing techniques such as exponential and moving averages for forecasting. (**An**)

CO3: Construct stationary and non-stationary time series models, including AR, MA, ARMA, and ARIMA, using autocorrelation and partial autocorrelation functions for model identification. (**Ap**)

CO4: Evaluate forecasting models using ARMA and ARIMA, implementing estimation techniques like Yule-Walker and least squares, and interpreting correlogram and periodogram analyses. (**E**)

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	1	3
CO2	3	3	2	1	3
CO3	3	3	2	1	3
CO4	3	3	3	1	3

Syllabus Content

MODULE I (CO 1) (20 hours)

Regression models, estimation and testing of regression coefficients, model selection techniques, problem of correlated errors, autocorrelation, Durbin-Watson statistics, detection and correction of multicollinearity, and indicator variables. Method of least squares for curve fitting, concept of weighted least squares, non-linear regression, and fitting of quadratic, exponential, and power curves, with applications in forecasting.

MODULE II (CO 2) (20 hours)

Time series components, exploratory time series analysis, tests for trend and seasonality, smoothing techniques including exponential and moving average smoothing, Holt-Winter smoothing, and forecasting based on smoothing methods.

MODULE III (CO 3) (25 hours)

Stationary time series, autocorrelation and partial autocorrelation functions, linear stationary models such as autoregressive (AR), moving average (MA), and autoregressive moving average (ARMA) models, along with linear non-stationary models like autoregressive integrated moving average (ARIMA) models.

MODULE IV (CO 4) (25 hours)

Forecasting using ARMA and ARIMA models, MMSE methods, different forms of ARIMA models, estimation techniques including Yule-Walker and least squares methods, and time series analysis using correlogram and periodogram.

REFERENCES

1. Abraham, B. and Ledolter,J.(1983). Statistical Methods for forecasting, John Wiley and Sons, New York.
2. Box,G.E.P.and Jenkins,G.M.(1976). Time Series Analysis : Forecasting and Control,Holden Day
3. Brockwell,P.J. and Davis,R.A.(2002).Introduction to Time Series and Forecasting, 2 nd ed.,,Springer
4. Draper, N.R. and Smith,H. (1998).Applied Regression Analysis, 3 rd ed.John Wiley
5. Ezekiel, M. (1963).Methods of correlation and Regression Analysis. John Wiley
6. Kleinbaum, D.G.,Kupper,L.L.,Muller,K.E.and Nizam,A.(1998).Applied Regression Analysis and Multivariable Methods,Duxbury Press.
7. Kutner,M,.H.,Nachtsheim, C.J. and Neter,J.(2004). Applied Linear Regression Models, 4 th ed.with student CD.Mc Graw Hill.
8. Makridakis,S. and Wheelwright,S.C. Forecasting Methods and Applications, John Wiley and Sons

SEMESTER III

CORE COURSE

ST3C13TM25– Design and Analysis of Experiments

Credits: 4

Total Lecture Hours: 90

Course Outcomes:

CO1: Apply linear estimation techniques by implementing the Gauss-Markov setup, performing least squares estimation, and conducting analysis of variance (ANOVA) in different classification models. **(Ap)**

CO2: Construct experimental design principles, including Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD), and Graeco-Latin Square Design, along with Analysis of Covariance (ANACOVA) for improved statistical analysis. **(Ap)**

CO3: Analyze incomplete block designs, particularly Balanced Incomplete Block Design (BIBD) and Partially Balanced Incomplete Block Design (PBIBD), by understanding parametric relations, incidence matrices, and intra-block analysis. **(An)**

CO4: Illustrate factorial experiments (2^n and 3^n), confounding schemes, and split-plot designs, while explaining the basics of Fractional Factorial Designs and Response Surface Methodology for efficient experimental planning. **(Ap)**

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	1	3
CO2	3	3	3	1	3
CO3	3	3	2	1	3
CO4	2	3	2	1	3

Syllabus Content

MODULE I (CO1) (25 hours)

Linear estimation: Gauss Markov setup, Estimability of parameters, Method of least squares, best linear unbiased Estimators, Gauss-Markov Theorem, Tests of linear hypotheses, Analysis of variance- one-way, two-way and three-way classification models.

MODULE II (CO2) (25 hours)

Planning of experiments: Basic principles of experimental design, Uniformity trails, Completely randomized design (CRD), Randomized block design (RBD), Latin square design (LSD) and Graeco latin square designs, Analysis of covariance (ANACOVA), ANACOVA with one concomitant variable in CRD and RBD.

MODULE II (CO3) (20 hours)

Incomplete block design: Balanced incomplete block design (BIBD); Incidence Matrix, C-Matrix, Parametric relations; Intra-block analysis of BIBD, Connectedness, Construction of BIBD by developing initial blocks, Basic ideas of partially balanced incomplete block design (PBIBD).

MODULE IV (CO4) (20 hours)

Factorial experiments, 2n and 3n factorial experiments, Analysis of 2^2 , 2^3 and 3^2 factorial experiments, Confounding in 2n and 3n factorial experiments, Construction of confounded scheme in 2^n factorial experiments, Split plot experiments (RBD).Basics of Fractional Factorial Designs and Response Surface Methodology.

TEXT BOOKS

1. Montgomery C.D. (2012) Design and Analysis of Experiments, John Wiley, New York.
2. Das M.N. and Giri N.C. (1994) Design and analysis of experiments, Wiley Eastern Ltd.
3. Joshi D.D. (1987) Linear estimation and Design of Experiments, Wiley Eastern.

REFERENCES

1. Agarwal B.L (2010) Theory and Analysis of Experimental Designs, CBS Publishers & Distributors
2. Dean A. and Voss D. (1999) Design and Analysis of Experiments, Springer Texts in Statistics
3. Dey A. (1986) Theory of Block Designs, Wiley Eastern, New Delhi.

4. Gomez K.A. and Gomez A.A. (1984) Statistical Procedures for Agricultural Research, Wiley Eastern Ltd.
5. Kempthrone O. (1952) Design and Analysis of Experiments, Wiley Eastern, New York.
6. Rangaswamy, R (2010) A textbook on Agricultural Statistics, New Age International publishers.

SEMESTER III

CORE COURSE

ST3C14TM25– Machine Learning and Data Analysis

Credits: 3

Total Lecture Hours: 90

Course Outcomes:

CO1: Classify machine learning paradigms, including supervised, unsupervised, and semi-supervised learning, while explaining theoretical concepts like VC dimension, PAC learning, and noise handling. **(Ap)**

CO2: Analyze and compare model selection techniques, Bayesian decision theory, and parametric methods, including Maximum Likelihood Estimation, Bayes' Estimator, and the Bias-Variance tradeoff in classification and regression. **(An)**

CO3: Employ data reduction, clustering, and classification techniques such as k-Means, Decision Trees, Neural Networks, Support Vector Machines, and Naïve Bayes to solve real-world machine learning problems. **(Ap)**

CO4: Apply statistical testing methods in R and Python by evaluating test size and power, constructing confidence intervals, performing hypothesis tests, and implementing various experimental designs such as ANOVA, CRD, RBD, LSD, GLSD, BIBD, factorial, and split-plot designs. **(Ap)**

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	3	2
CO2	3	3	2	3	3
CO3	3	2	2	3	3
CO4	3	3	3	2	3

Syllabus Content

MODULE I (CO1) (20 hours)

Introduction: Machine Learning, Applications, Supervised Learning: Learning a Class from Examples, Unsupervised Learning, Semi Supervised learning, Dimensions of a Supervised Machine Learning Algorithm, Vapnik - Chervonenkis (VC) Dimension, Probably Approximately Correct (PAC) Learning, Noise, Learning Multiple Classes.

MODULE II (CO2) (25 hours)

Model Selection and Generalization, Bayesian Decision Theory: Introduction, Classification, Losses and Risks, Discriminant Functions, Utility Theory, Association Rules. Parametric Methods: Introduction, Maximum Likelihood Estimation, Evaluating an Estimator Bias and Variance, The Bayes' Estimator, Parametric Classification, Regression, Tuning Model Complexity: Bias/Variance Dilemma.

MODULE III (CO3) (20 hours)

Data Reduction and Classification: Introduction, Mixture Densities, k-Means Clustering, Nearest Neighbour Method, Supervised Learning after Clustering, Hierarchical Clustering, Choosing the Number of Clusters, Principles of Decision Trees, Neural Network and Random Forests. Support Vector Machine, Naive Bayes Methods.

Module IV (CO4) (25 hours)

Size and power of a test, Confidence intervals for parameters, Testing mean and variance, Testing equality of means and variances, Most Powerful and Uniformly Most Powerful Test, SPRT for unknown parameters, OC and ASN of SPRT, Non-parametric tests, ANOVA - One way classified data, two way classified data., CRD. RBD, RBD with missing observations. LSD, LSD with missing observations, GLSD, BIBD., 2n and 3n factorial experiments., Split plot design with main plots laid out in RBD. Using R and Python

TEXT BOOKS

1. G. James, R. Tibshirani, An Introduction to Statistical Learning: with applications in R, Springer.
2. T. Hastie, R. Tibshirani, Elements of Statistical Learning: Data mining, Inference and Predicton, Springer.

REFERENCES

1. Shalev-Shwartz, S., & Ben-David, S. (2014). Understanding Machine Learning: From Theory to Algorithms. Cambridge University Press.

2. Alpaydin, E. (2020). Introduction to Machine Learning (4th ed.). MIT Press.
3. Bishop, C. M. (2006). Pattern Recognition and Machine Learning. Springer.
4. Murphy, K. P. (2012). Machine Learning: A Probabilistic Perspective. MIT Press.
5. Hastie, T., Tibshirani, R., & Friedman, J. (2009). The Elements of Statistical Learning: Data Mining, Inference, and Prediction (2nd ed.). Springer.
6. Haslwanter, T. (2016). An Introduction to Statistics with Python. Springer.
7. Stephens, M. P. (2013). Statistical Design and Analysis of Experiments: With Applications to Engineering and Science (2nd ed.). Wiley.
8. Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press.

SEMESTER IV

SEMESTER IV

CORE COURSE

ST4C15TM25– Big Data Analytics and Artificial Intelligence

Credits: 4

Total Lecture Hours: 90

Course Outcomes:

CO1: Illustrate the key issues in big data management and its uses in intelligent business and scientific computing. **(An)**

CO2: Apply enabling techniques and scalable algorithms like Hadoop, Map Reduce and NO SQL in big data analytics. **(Ap)**

CO3: Employ AI building blocks presented in intelligent agents, to choose an appropriate problem-solving method and knowledge representation technique. **(Ap)**

CO4: Interpret business models and scientific computing paradigms, by using software tools for bigdata analytics. **(Ap)**

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	1	2	3	2
CO2	1	2	3	3	2
CO3	1	1	3	3	2
CO4	1	1	3	3	2

Syllabus Content

MODULE I (CO1) (20 hours)

Big Data – Introduction, Structuring Big Data, Elements of Big data, Big data analytics, Big data applications. Big Data in business context.Technologies for handling big data – Distributed and Parallel computing for Big Data, Data Models, Computing Models.

MODULE II (CO2) (20 hours)

Understanding Analytics and Big data – Comparison of Reporting and Analysis, Types of Analytics, Analytical approaches. Hadoop Eco System, Hadoop Distributed file system, HDFS architecture, MapReduce, Hadoop YARN, Introducing HBase, Hive and Pig.

MODULE III (CO3) (25 hours)

MapReduce framework, Techniques to Optimize MapReduce, Uses of MapReduce, Role of HBase in Big data processing, Processing Data with MapReduce – Framework, Developing simple MapReduce Application.

MODULE IV (CO4) (25 hours)

MapReduce execution and Implementing MapReduce Programs, YARN Architecture – Limitations of MapReduce, Advantages of YARN, Working of YARN, YARN Schedulers, Configurations, Commands, Containers.

REFERENCES

1. Berson, A. and Smith, S.J. (1997): Data Warehousing, Data Mining, and OLAP. McGraw-Hill.
2. Breiman, L. Friedman, J.H. Olshen, R.A. and Stone, C.J. (1984): Classification and Regression Trees. Wadsworth and Brooks/Cole.
3. Han, J. and Kamber, M. (2000): Data Mining; Concepts and Techniques. Morgan Gaufmann.
4. Mitchell, T.M. (1997): Machine Learning. McGraw-Hill.
5. Ripley, B.D. (1996): Pattern Recognition and Neural Networks. Cambridge University.

SEMESTER IV

CORE COURSE

ST4C02PM25– Statistical Computing and Biostatistics Using SAS

Credits: 3

Total Lecture Hours: 90

Course Outcomes:

CO1 : Compute model coefficients using SAS functions in regression models.**(Ap)**
CO2: Illustrate time series methods for trend and seasonality estimation, forecasting with smoothing techniques, and ARIMA model identification, fitting, diagnostics, and forecasting.**(An)**
CO3: Evaluate survival function estimation for censored data, survival curve comparisons, and Cox model fitting with diagnostics.**(E)**
CO4: Explain competing risk models and statistical estimation techniques to analyze clinical trial outcomes. **(An)**

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	2	3
CO2	3	3	3	2	3
CO3	3	2	3	1	3
CO4	3	2	3	1	3

Syllabus Content

MODULE I (CO1) **(15 hours)**

Production Functions, Elasticity of production, Input- Output analysis, Simple linear regression models, Multiple linear regression model, Dummy variable regression models, Polynomial regression models, Step-wise regression, Multicollinearity, Heteroscedasticity and

Autocorrelation, Stochastic regressors, Regression Diagnostics, Simultaneous equation models -Rank and Order condition, ILS, 2SLS, LIML

MODULE II (CO2) (30 hours)

Estimation of trend and seasonal indices, Forecasting using moving averages, exponential smoothing, Holt's exponential smoothing, Holt's Winters exponential smoothing, Computation of ACF and PACF, Model identification of ARIMA models, Diagnostic checking of ARIMA models, Forecasting using ARIMA models

MODULE III (CO3) (15 hours)

Estimation of the survival function for censored data, Computation of Kaplan-Meier estimator, Computation of Nelson–Aalen cumulative hazard estimator, Computation of Nelson–Aalen cumulative hazard estimator, Fitting of Cox proportional hazard model, Checking the assumptions of Cox proportional hazard model, Fitting of parametric regression models

MODULE IV (CO4) (30 hours)

Competing risk theory, Indices for measurement of probability of death under competing risks and their inter-relations. Estimation of probabilities of death under competing risks by maximum likelihood and modified minimum Chi-square methods. Theory of independent and dependent risks. Bivariate normal dependent risk model. Conditional death density functions. Stochastic epidemic models: Simple and general epidemic models (by use of random variable technique). Planning and design of clinical trials, Phase I, II, and III trials. Consideration in planning a clinical trial, designs for comparative trials. Sample size determination in fixed sample designs.

REFERENCES

1. Biswas S. (1995): Applied Stochastic Processes. A Biostatistical and Population Approach, Wiley Eastern Ltd.
2. Cox, D.R and Oakes, D. (1984): Analysis of Survival Data, Chapman and Hall.
3. Elandt RC. and Johnson (1975): Probability Models and Statistical Methods in John Wiley & Sons.
4. Ewens, W. J. (1979): Mathematics of Population Genetics, Springer Verlag.
5. Ewens, W. J. and Grant, G.R (2001): Statistical methods in Bioinformatics: An Springer. Oriented Genetics, Introduction,

SEMESTER IV

ST4PRM25- Project/Dissertation

Credits:3

Course Outcomes:

CO1: Apply Statistical methods and data Analytics tools to solve complex real-world or theoretical problems. **(Ap)**

CO2: Employ appropriate research methodologies and ethical practices to conduct Statistical investigations. **(Ap)**

CO3: Create Statistical and machine learning models using advanced analytical techniques and software tools. **(C)**

CO4: Interpret research findings effectively through well-structured written reports and oral Presentations. **(Ap)**

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	2	2
CO2	2	3	3	2	3
CO3	2	2	2	3	3
CO4	2	1	2	1	2

Guidelines for Project Report

- All students shall prepare and submit project report as part of the programme.
- The project of the PG program should be relevant and innovative in nature.
- The type of project can be decided by the student and the guide (a faculty of the department or other department/ college/ university/ institution).
- The project should be aimed to motivate the inquisitiveness and research aptitude of the students.

- The conduct of the project may be started at the beginning of Semester III, with its evaluation scheduled at the end of Semester IV.
- The students may either present the results of the project in seminars/symposia or publish in a reputed journal
- The project is evaluated by one external and one internal examiner.

SEMESTER IV

ST4VM25 - VIVA-VOCE

Credits: 4

Course Outcome:

CO1: Evaluate the depth of conceptual knowledge of the subject through critical assessment and logical reasoning. **(E)**

CO2: Assess the clarity, coherence, and effectiveness of verbal communication in presenting statistical and analytical concepts and solutions. **(E)**

CO3: Assess the ability to apply statistical software and tools effectively to analyze and visualize data, and to interpret results in the context of real-world problems.**(E)**

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	3	2
CO2	3	3	2	3	2
CO3	2	3	2	3	3

Guidelines for Viva -Voce

- A comprehensive viva voce examination will be conducted by one external and one internal examiner at the time of evaluation of the project.
- The components of viva consist of subjects of special interest, fundamental concepts, topics covering all semesters and awareness of current and advanced topics.

SYLLABI OF ELECTIVE COURSES

SEMESTER IV
ELECTIVE COURSE

ST4E01TM25 - Categorical Data Analysis

Credits: 3

Total Lecture Hours: 90

Course Outcomes:

CO1: Articulate Odds ratio, Relative risk, Sensitivity and Specificity, the association between attributes, categorical variables in probability models and GLM's **(Ap)**

CO2: Analyse binary and multinomial outcomes using logit, probit, and multiple logistic regression models, by conducting logistic regression technique and regression diagnostics **(An)**

CO3: Illustrate advanced regression models (Poisson, Negative Binomial, and Proportional Hazards models) for predictions in the real-life scenario. **(An)**

CO4: Apply Bayesian inference techniques, including Markov Chain Monte Carlo (MCMC) methods, Gibbs sampler and Metropolis-Hastings algorithm for simulations from standard distributions **(Ap)**

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	2	2	3
CO2	3	1	2	3	3
CO3	3	1	2	2	3
CO4	3	1	2	2	3

Syllabus Content

MODULE I (CO1) (20 hours)

Odds ratio, Relative risk, Sensitivity and Specificity, ROC curves, Fishers exact test and McNemar's test, Inference for contingency table, Chi-square test, Binomial response models and Likelihood ratio. Linear probability models, Link functions for categorical data, General form of GLM,

MODULE II (CO2) (20 hours)
Logistic Regression Analysis, Logit and Probit Models with Categorical Predictors, Multiple logistic regression, Inference for logistic Regression, Interpreting parameters in logistic Regression, Regression diagnostics, Predictions, Multinomial logistic regression

MODULE III (C03) (25 hours)
Poisson regression models, Negative Binomial Regression Models, Proportional hazards regression models, Estimation and Interpretations of coefficients, Regression diagnostics, Predictions

MODULE IV (C04) (25 hours)
Principles of Bayesian statistics, Bayesian Inference for Categorical Data, Inference using simulations from Standard distributions, Markov Chain Monte Carlo (MCMC), The Gibbs sampler, The Metropolis-Hastings algorithm.

TEXT BOOKS

1. Montgomery, D.C., Peck, E.A. and Vining, G.G. (2001) Introduction to Regression Analysis, Third edition. Wiley.
2. Seber, A.F. and Lee, A.J. (2003) Linear Regression Analysis, John Wiley, Relevant sections from chapters 3, 4, 5,

REFERENCES

1. Agresti, A. (2002) Categorical Data Analysis. New York: John Wiley.
2. Agresti, A. (2007) Introduction to Categorical Data Analysis 2nd edn, New York: John Wiley
3. Carlin, B.P. and Louis, T.A. (2000) Bayes and Emperical Bayes Methods for Data Analysis, Second Edition
4. Congdon P. (2006) Bayesian Statistical Modelling, Second Edition, John Wiley & Sons, Ltd. ISBN: 0-470-01875-5
5. Ntzoufras I. (2009) Bayesian Modeling using WinBUGS John Wiley & Sons Inc.
6. Powers D.A. (1999) Statistical methods for Categorical data analysis. Academic press Inc.
7. Shewhart, W.A. and Wilks, S.S. (2013) Case Studies in Bayesian Statistical Modelling and Analysis. Wiley.

SEMESTER IV
ELECTIVE COURSE

ST4E02TM25 - Statistical Quality Control

Credits: 3

Total Lecture Hours: 90

Course Outcomes:

CO1: Illustrate various types of control charts, design control charts**. (An)**

CO2: Analyse process capability studies ,six sigma philosophy , CUSUM Charts, EWMA Charts **(An)**

CO3: Apply different statistical quality control techniques including various types sampling plans for attributes and measure the performance of these plans. **(Ap)**

CO4: Illustrate acceptance sampling by variables , Sampling Plans for a single and double specification limits with known and unknown variance, Sampling plans with double specification limits. **(An)**

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	1	3
CO2	3	3	2	1	3
CO3	3	3	2	1	3
CO4	3	2	2	1	3

Syllabus Content

MODULE I (CO1) (20 hours)
Meaning of quality, and need for quality control. Meaning and scope of statistical process control. General theory of control charts, Shewhart control charts for variables- mean charts, R-charts, and S-charts, Moving-average control charts. Attribute control charts - p, np, c, u charts. OC and ARL curves of control charts.

MODULE II (CO2) (20 hours)
Modified control charts. Control charts with memory - EWMA charts, CUSUM charts. Process capability analysis, process capability indices – Cp and Cpk. Economic design of mean charts.

MODULE III (CO3) (25 hours)
Statistical product control- basic ideas. Acceptance sampling for attributes - single sampling, double sampling, multiple sampling and sequential sampling plans. ASN curves. Measuring performance of sampling plans through OC curves. Rectifying inspection plans. AOQ and ATI curves.

MODULE IV (CO4) (25 hours)
Acceptance sampling by variables. Sampling plan for a single specification limit with known and unknown variance. Performance evaluation through OC curves. Designing a variable sampling plan with a specified OC curve.

TEXT BOOKS

1. Montgomery, R.C. (1985). Introduction to Statistical Quality Control, Fourth edition,Wiley.
2. Mittag, H.J. & Rinne, H. (1993) Statistical Methods for Quality Assurance, Chapman &Hall, Chapters 1, 3 and 4,15
3. Schilling, E.G. (1982) Acceptance Sampling in Quality Control, Marcel Dekker.

REFERENCES

1. Duncan, A.J. (1986) Quality control and Industrial Statistics.
2. Grant E.L. and Leaven Worth, R.S. (1980) Statistical Quality Control, McGraw Hill.
3. Chin-Knei Cho (1987) Quality Programming, John Wiley

SEMESTER IV
ELECTIVE COURSE

ST4E03TM25 - Survival Analysis

Credits: 3

Total Lecture Hours: 90

Course Outcomes:

CO1: Apply the key features of survival analysis **(Ap)**

CO2: Analyse survival data using non-parametric methods such as the Kaplan-Meier estimator, the Nelson-Aalen estimator and the log rank test. **(An)**

CO3: Articulate the Cox proportional hazards model to examine the effects of covariates on survival and assess whether the proportional hazards assumption is justified. **(Ap)**

CO4: Infer the results of survival data by fitting parametric regression models.**(An)**

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	2	1	3
CO2	3	1	2	1	3
CO3	3	1	2	1	3
CO4	3	1	2	2	3

Syllabus Content

MODULE I (CO1) (20 hours)

Introduction to survival analysis, Survival function and Hazard function, Mean residual life function and Median life, Common parametric models for survival data, Censoring: Right, Left and Interval censoring, Truncation, Likelihood construction for censored and truncated data.

MODULE II (CO2) (25 hours)

Nonparametric estimators of the survival and cumulative hazard functions for right-censored data, Kaplan–Meier or Product-limit estimator, Nelson–Aalen cumulative hazard estimator, Estimation of the survival function for left-censored and interval-censored data, Comparing two or more survival curves, Log rank test, Gehan test

MODULE III (CO3) (25 hours)

Semiparametric Proportional hazards regression with fixed covariates, Coding covariates, Partial likelihoods for distinct-event time data, Partial likelihoods when ties are present, Model building using the Proportional hazards model, Estimation for the survival function, Regression diagnostics, Cox-Snell residuals for assessing the fit of a Cox model, Graphical checks of the Proportional hazards assumption, Deviance Residuals

MODULE IV (CO4) (20 hours)

Inference for Parametric Regression Models, Exponential, Weibull, and Log Logistics, Competing risk models, Basic characteristics and model specification, Likelihood function formulation, Nonparametric Methods

TEXT BOOKS

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 Editon, John Wiley & Sons.

REFERENCES

1. Kalbfleisch, J.D. and Prentice, R.L. (2002) The Statistical Analysis of Failure Time Data, Second Edition, John Wiley & Sons.
2. Kleinbaum D.G. and Klein, M. (2012) Survival Analysis- A Self-Learning Text, Third Edition, Springer-Verlag, New York.
3. Hosmer, D.W., Lemeshow, S. and May S. (2008). Applied Survival Analysis: Regression modeling of Time to Event Data, Second Edition, John Wiley & Sons.

SEMESTER IV
ELECTIVE COURSE

ST4E04TM25 - Operations Research

Credits: 3

Total Lecture Hours: 90

Course Outcomes:

CO1: Apply optimization techniques to solve linear programming, transportation, assignment, sequencing, and traveling salesman problems **(Ap)**

CO2: Illustrate dynamic and nonlinear programming techniques, including Bellman's principle, Kuhn-Tucker conditions, and modified simplex methods, to solve constrained optimization problems.**(Ap)**

CO3: Analyze deterministic and probabilistic inventory models, including EOQ variations and stochastic models, to optimize inventory management decisions.**(An)**

CO4: Determine optimal strategies for two-person zero-sum games using linear programming, dominance property, and graphical methods**.(Ap)**

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	3	1	2
CO2	3	1	3	1	2
CO3	3	1	3	1	2
CO4	3	1	3	1	2

Syllabus Content

MODULE I (CO1) (25 hours)

Linear programming: convex sets and associated theorems, Simplex method, Artificial variables technique-Big M method, Two phase method; Dual simplex method. Concept and theorems of duality, Transportation problems, Assignment problems, Sequencing, Traveling sales man problems.

MODULE II (CO2) (25 hours)

Dynamic and Quadratic programming: Bellman's principle of optimality, single additive constraint -additively separable return, single multiplicative constraint- additively separable return, single additive constraint-multiplicatively separable return, General nonlinear programming problem, Constrained optimization with equality constraints -necessary conditions for a general NLPP, sufficient conditions for a general NLPP with one constraint, sufficient conditions for a general problem with m(<n)constraints, Constrained optimization with inequality constraints, Kuhn-Tucker conditions for general NLPP with m(<n) constraints, Wolfe's modified simplex method and Beale's method.

MODULE III (CO3) (20 hours)

Inventory models:-Deterministic inventory models -general inventory model, Economic-order quantity (EOQ) models -classic EOQ model, EOQ with price breaks, multi item EOQ with storage limitation, Probabilistic inventory models:- Single period stochastic models without setup cost, General single period models

MODULE IV (CO4) (20 hours)

Theory of Games, Two person zero sum games, fundamental theorem of matrix games, Rectangular games as a Linear programming problem, Dominance property, Graphical Method of solution 2 x n and m x2 games.

TEXT BOOKS

1. KantiSwarup, Gupta, P.K. and Man Mohan (2001) Operations Research, Ninth edition, Sultan Chand & Sons
2. Sharma J.K. (2013) Operations Research: Theory and Applications, Fifth edition,Laxmi Publications-New Delhi.
3. K. V. Mital (2016) Optimization methods in Operations research and systems analysis.

REFERENCES

1. Taha H.A. (2007) Operations Research -An introduction, Eighth edition, Prentice-Hall of India Ltd.
2. Gass S.I. (1985) Linear Programming -methods and applications, Fifth edition, McGraw Hill, USA,
3. Ravindran A, Philips D.T and Soleberg J.J. (1997) Operation Research-Principles and Practice, John Wiley & Sons.
4. Sinha, S.M. (2006) Mathematical programming theory and methods, Elsevier, a division of Reed Elsevier India Pvt. Ltd., New Delhi.
5. Paneerselvam, R. (2008) Operations Research, Second edition, Prentice Hall of India Pvt. Ltd., New Delhi.

SEMESTER IV
ELECTIVE COURSE

ST4E05TM25 - Biostatistics

Credits: 3

Total Lecture Hours: 90

Course Outcomes:

CO1: Apply the principal concepts about biostaApply survival distributions (Exponential, Gamma, Weibull, Rayleigh, Lognormal) and perform goodness-of-fit tests for survival data. **(Ap)**

CO2: Analyze different types of censoring and estimate survival functions using parametric and non-parametric methods. **(An)**

CO3: Evaluate competing risk models and estimate probabilities of death under competing risks using maximum likelihood and Chi-square methods. **(E)**

CO4: Assess the design and methodology of clinical trials, considering trial phases, sample size, and comparative designs. **(E)**

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	2	1	3
CO2	3	1	2	1	3
CO3	3	1	2	1	3
CO4	3	1	2	1	3

Syllabus Content

MODULE I (CO1) **(25 hours)**

Functions of survival time, survival distributions and their applications viz. Exponential, Gamma, Weibull, Rayleigh, Lognormal, death density function for a distribution having bathtub shape hazard function. Tests of goodness of fit for survival distributions (WE test for exponential distribution, W -test for lognormal distribution, Chi-square test for uncensored observations). Parametric methods for comparing two survival distributions viz. L.R test, Cox's F-test.

MODULE II (CO2) (25 hours)

Type I, Type II and progressive or random censoring with biological examples, Estimation of mean survival time and variance of the estimator for type I and type II censored data with numerical examples. Non-parametric methods for estimating survival function and variance of the estimator viz. Actuarial and Kaplan -Meier methods.

MODULE III (CO3) (25 hours)

Competing risk theory, Indices for measurement of probability of death under competing risks and their inter-relations. Estimation of probabilities of death under competing risks by maximum likelihood and modified minimum Chi-square methods. Theory of independent and dependent risks.Bivariate normal dependent risk model. Conditional death density functions. Stochastic epidemic models: Simple and general epidemic models (by use of random variable technique).

MODULE IV (CO4) (20 hours)

Planning and design of clinical trials, Phase I, II, and III trials. Consideration in planning a clinical trial, designs for comparative trials. Sample size determination in fixed sample designs.

TEXT BOOKS

1. Kleinbaum, D.G., & Klein, M. (2012). Survival Analysis: A Self-Learning Text. Springer.
2. Hosmer, D.W., Lemeshow, S., & May, S. (2008). Applied Survival Analysis: Regression Modeling of Time to Event Data. Wiley.

REFERENCES

1. Biswas S. (1995): Applied Stochastic Processes. A Biostatistical and Population Oriented Approach, Wiley Eastern Ltd.
2. Cox, D.R and Oakes, D. (1984): Analysis of Survival Data, Chapman and Hall.
3. Elandt RC. and Johnson (1975): Probability Models and Statistical Methods in Genetics, John Wiley & Sons.
4. Ewens, W. J. (1979): Mathematics of Population Genetics, Springer Verlag.
5. Ewens, W. J. and Grant, G.R (2001): Statistical methods in Bioinformatics: An Introduction, Springer
6. Friedman, L.M., Furburg, C. and DeMets, D.L. (1998): Fundamentals of Clinical Trials, Springer Verlag

SEMESTER IV
ELECTIVE COURSE

ST4E06TM25 - Econometric Methods

Credits: 3

Total Lecture Hours: 90

Course Outcomes:

CO1: Apply simple and multiple linear regression models, estimate parameters, test hypotheses, and use dummy variables and polynomial regression models effectively. **(Ap)**

CO2:Explain multicollinearity, heteroscedasticity, autocorrelation, and errors in variables, and implement appropriate remedial measures.**(An)**

CO3: Analyze economic models such as demand and supply functions, production functions, and input-output analysis to determine market equilibrium and firm behavior. **(An)**

CO4: Evaluate methods of estimation for simultaneous equation models, including indirect least squares, two-stage least squares, and FIML methods. **(E)**

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	2	2
CO2	3	2	2	1	2
CO3	3	1	2	1	2
CO4	3	1	2	1	2

Syllabus Content

MODULE I (CO1) **(25 hours)**

Simple linear regression models, Multiple linear regression models, estimation of the model parameters, tests concerning the parameters, confidence intervals, prediction, use of Dummy variables in regression, polynomial regression models, stepwise regression.

MODULE II (CO2) (25 hours)

Multicollinearity- consequences, Detection, Farrar-Glauber test, remedial measures. Heteroscedasticity consequences, Detection, tests, remedial measures Aitken's generalized least square method. Autocorrelation-tests for autocorrelation, consequences, and estimation procedures, Errors in variables consequences, detection, remedial measures, Stochastic Regressors. Diagnostics, outlier, Influential observations, Leverage, Nonparametric regression basics.

MODULE III (CO3) (25 hours)

Demand and supply functions, Cobweb model, elasticity of demand, equilibrium of market, indifference curves, Cost Function, Utility, Firms, Marginal analysis of firms, production functions- elasticity of production, homogeneous functions, Cobb-Douglas Production function, constraint maximization of Profit, Revenue, output, input- output analysis-Open and closed system.

MODULE IV (CO4) (20 hours)

Simultaneous equation models, instrumental variables, recursive models, distributed- lag models identification problems, rank and order condition, methods of estimation- indirect least squares, least variance ratio and two-stage least squares, FIML- methods.

TEXT BOOKS

1. Damodar N Gujrati, Sangeeth (2007) Basic Econometrics 5th Ed., McGraw Hill Education Private Ltd.
2. Montgomery D.C., Peck E.A. and Vining G.G. (2007) Introduction to Linear Regression Analysis, John Wiley, India.
3. Johnston J. (1984) Econometric Methods (Third edition), McGraw Hill, New York.

REFERENCES

1. AllenR.G.D. (2008) Mathematical Analysis For Economists, Aldine Transaction.
2. Apte P.G. (1990) Text book of Econometrics, Tata Me Graw Hill.
3. Jeffrey M. Wooldridge (2012) Introductory Econometrics: A Modern Approach 5th Edition, South-Western College Pub.
4. Koutsoyiannis A. (2008) Modern Microeconomics, Second Edition, Macmillan Press Ltd
5. Kutner M. H, Nachtsheim C.J, Neter J and Li W. (2005), Applied Linear Statistical Model, Fifth edition. McGraw Hill
6. Theil H. (1982) Introduction to the Theory and Practice of Econometrics, John Wiley.

SEMESTER IV
ELECTIVE COURSE

ST4E07TM25 - Advanced Bayesian Computing with R

Credits: 3

Total Lecture Hours: 90

Course Outcomes:

CO1: Apply Bayesian inference concepts, including prior and posterior densities, conjugate priors, and single-parameter models, to real-world problems using the LearnBayes package.**(Ap)**

CO2: Analyze multi-parameter Bayesian models, such as the multinomial model and Dirichlet priors, and compute predictive distributions for decision-making using Bayesian techniques.**(An)**

CO3: Compare Bayesian computational techniques by investigating the effectiveness of Monte Carlo integration, MCMC methods, Metropolis-Hastings algorithm, and Gibbs sampling in solving complex inference problems**.(An)**

CO4:Evaluate Bayesian regression models, model comparison techniques, and hypothesis testing using Bayes factors, hierarchical models, and posterior predictive model checking with R and WinBUGS. **(An)**

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	2	1	2
CO2	3	1	2	1	2
CO3	3	2	2	1	3
CO4	3	2	2	1	3

Syllabus Content

MODULE I (CO1) **(25 hours)**

Bayesian Inference: Parametric family and likelihood, exponential family, Bayes' theorem for

Inference, prior and posterior densities, conjugate priors, non-informative prior, beta prior for binomial proportion, histogram prior, discrete prior, single parameter models, normal distribution with known variance and unknown mean, normal with known mean and unknown variance, Poisson model, introduction to LearnBayes package, Examples using LearnBayes package.

MODULE II (CO2) (25 hours)

Multi-parameter Models: Various methods for prior selection, normal distribution with both parameters unknown, multinomial model, Dirichlet prior, Bioassay experiment, comparing two proportions, predictive distribution, beta binomial distribution, multivariate normal distribution, examples using LearnBayes package.

MODULE III (CO3) (20 hours)

Bayesian Computation: Computing integrals using Monte-Carlo simulation, approximation based on posterior mode, importance sampling, multivariate- t distribution, Markov Chain Monte Carlo methods, Metropolis-Hastings algorithm, random walk, Gibbs sampling, MCMC Output Analysis.

MODULE IV (CO4) (20 hours)

Model Comparison and Regression models: Hierarchical models, shrinkage estimators, posterior predictive model checking, comparison of hypotheses, Bayes factor, one sided test for normal mean, two sided test for normal mean, normal linear regression model, prediction of future observations, examples and R codes introduction to WinBUGS package.

TEXT BOOKS

1. Albert, J. (2007). Bayesian Computation with R, New York: Springer-Verlag
2. Berger, J. (2000).Statistical Decision Theory and Bayesian Analysis, New York: Springer-Verlag

REFERENCES

1. Bolstad, W. (2004). Introduction to Bayesian Statistics, Hoboken, NJ: John Wiley
2. Gelman, A., Carlin, J., Stern, H. and Rubin, D. (2003). Bayesian Data Analysis, New York: Chapman and Hall
3. Gilks, W.R., Richardson, S and Spiegelhalter, D.J. (1996). Markov Chain Monte Carlo in Practice. Chapman & Hall/CRC, New York

4. Robert, C. and Casella, G. (2004).Monte Carlo Statistical Methods, New York: Springer
5. Spiegelhalter, D., Thomas, A., Best, N. and Lunn, D. (2003), WinBUGS 1.4 Manual.

SEMESTER IV
ELECTIVE COURSE

ST4E08TM25 – Population Studies

Credits: 3

Total Lecture Hours: 90

Course Outcomes:

CO1: Examine the various sources of mortality data, its measures, and the gradation of mortality data**.(Ap)**

CO2: Articulate the concept and structure of life tables, construct life tables, and analyze the sampling distribution of life table functions**.(Ap)**

CO3: Apply various fertility models and analyze the relationship between different stochastic models on fertility and the human reproductive process for demographic research.**(Ap)**

CO4: Explain population growth models to assess demographic changes, the impact of mortality and fertility on age structure, and perform population projections. **(Ap)**

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	2	1	2
CO2	3	1	2	1	2
CO3	3	1	2	1	2
CO4	3	1	2	1	2

Syllabus Content

MODULE I (CO1) **(20 hours)**

Sources of mortality data-mortality measures-ratios and proportions, crude mortality rates, specific rates- standardization of mortality rates, direct and indirect methods, gradation of mortality data, fitting Gompertz and Makeham curves.

MODULE II (CO2) (20 hours)

Life tables-complete life table-relation between life table functions, abridged life table relation between abridged life table functions, construction of life tables, Greville's formula, Reed and Merrell's formula- sampling distribution of life table functions, multivariate pgf –estimation of survival probability by method of MLE.

MODULE III (CO3) (25 hours)

Fertility models, fertility indices -relation between CBR,GFR,TFR and NRR stochastic models on fertility and human reproductive process, Dandekar's modified binomial and Poisson models, Brass, Singh models, models for waiting time distributions, Sheps and Perrin model.

MODULE IV (CO4) (25 hours)

Population growth indices, logistic model, fitting logistic, other growth models, Lotka's stable population, analysis, quasi stable population, effect of declining mortality and fertility on age structure, population projections, component method-Leslie matrix technique, properties of time independent Leslie matrixmodels under random environment.

TEXT BOOKS

1. Biswas S (2007) Applied Stochastic Processes-A Biostatistical and Population Oriented Approach, Second Edition, New Central Book Agency.
2. Pollard J.H (1975) Mathematical Models for the growth of Human population, Cambridge University Press.

REFERENCES

1. Biswas S (1988) Stochastics processes in Demography and applications, Wiley Eastern.
2. Keyfitz N (1977) Applied Mathematical Demography A Wiley Interscience publication.
3. Ramkumar R (1986) Technical Demography, Wiley Eastern.
4. Srinivasan K (1970) Basic Demographic Techniques and Applications.

SEMESTER IV

ELECTIVE COURSE

ST4E09TM25 - Actuarial Statistics

Credits: 3

Total Lecture Hours: 90

Course Outcomes:

CO1: Apply financial mathematics and risk assessment techniques to the data. **(Ap)**

CO2: Determine various mortality, fertility, and reproduction rates to analyze population dynamics and demographic trends. **(Ap)**

CO3: Analyze deterministic and probabilistic inventory models, including EOQ variations and stochastic models, to optimize inventory management decisions.**(An)**

CO4: Analyze the fundamentals of insurance, including loss exposures, perils, hazards, and the societal impact of insurance. **(An)**

Mapping of Course Outcomes with Program Specific Outcomes

Mapping	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	3	1	2
CO2	3	1	3	1	2
CO3	3	1	3	1	2
CO4	3	1	3	1	2

Syllabus Content

MODULE I (CO1) (20 hours)

Introduction to Actuarial Science, Basics of Financial Mathematics ,Time value of money, Present and future value calculations , Annuities and perpetuities, Introduction to Insurance and Risk Management .Types of insurance (Life, Health, General), Risk measures and assessment.

MODULE II (C02) (20 hours)

Rates and ratios mortality rates ,crude, age specific and standard death rates, fertility and reproduction rates ,crude birth rates , general and specific fertility rates , gross and net reproduction rate.

MODULE III (C03) (25 hours)

Life Table : Concepts, Assumptions, Construction of Life tables,Complete and Abridged, Various types,Force of Mortality,Uses of Life Tables. Single Decrement Associated Life tables.

MODULE IV (CO4) (25 hours)

Fundamentals of insurance: Insurance defined meaning of loss, peril, hazard and proximate cause in insurance. Costs and benefits of insurance to society–branches of insurance. Insurable loss exposures,features of loss that is deal for insurance.

TEXT BOOKS

1. Mark S Dorfman : Introduction to Risk Management and Insurance, Prentice Hall .
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