PROVIDENCE WOMEN’S COLLEGE

(AUTONOMOUS)

KOZHIKODE, KERALA

Syllabus

Four Year Under Graduate Programme

BSc MATHEMATICS HONOURS

(Major, Minor and General foundation Courses)

w.e.f. 2024-25 Admissions

No.PWC/GA/BoS/MAT/001/2024 Dated: 27/05/2024

NOTIFICATION

It is hereby notified that the following members have been nominated to the Board of Studies in Mathematics of Providence Women's College (Autonomous), Kozhikode as per the sub section 68 H Amendment of Calicut University Act 5 of 1975. The nominated members shall hold the office for a period of three years from the date of this notification. Their appointments are ratified by the Governing Body meeting held on 22/05/2024.

	Name and Designation	Institution
1.	Aiswarya Paul Assistant Professor, Department of Mathematics. Chairman, Head of the Department.	Providence Women's College, Calicut.
2.	(i) Dr. Sunil Mathew Associate Professor, Department of Mathematics. External expert. (ii) Dr. Vani Lakshmi R Assistant Professor, Department of Data Science. External expert.	NIT, Calicut. Prasanna School of Public Health, Manipal Academy of Higher Education.
3.	Dr. Aswin VS Associate Professor, Industry Expert.	School of Digital Sciences, Thiruvananthapura m.
4.	Dr. Vineesh KP Assistant Professor, Department of Mathematics. Member. Ms. Reshmi KM Assistant Professor, Department of Mathematics. Member.	Sree Narayana Guru College, Chelannur, Kozhikode. Govt. Arts and Science College, Kozhikode.

PROVIDENCE WOMEN'S COLLEGE

B.Sc. MATHEMATICS HONOURS

(MAJOR, MINOR AND GENERAL FOUNDATION COURSES)

SYLLABUS & MODEL QUESTION PAPERS

w.e.f. 2024 Admission Onwards

(PWC FYUGP Regulations 2024)

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B.Sc. MATHEMATICS HONOURS

(MAJOR, MINOR AND GENERAL FOUNDATION COURSES)

SYLLABUS

PROGRAMME OUTCOMES (PO):

At the end of the graduate programme at Providence Women's College, a student would:

PO1	**Knowledge Acquisition:** **Demonstrate a profound understanding of knowledge trends and their impact on the chosen discipline of study.**
PO2	**Communication, Collaboration, Inclusiveness, and Leadership:** **Become a team player who drives positive change through effective communication, collaborative acumen, transformative leadership, and a dedication to inclusivity.**
PO3	**Professional Skills:** **Demonstrate professional skills to navigate diverse career paths with confidence and adaptability.**
PO4	**Digital Intelligence:** **Demonstrate proficiency in varied digital and technological tools to understand and interact with the digital world, thus effectively processing complex information.**
PO5	**Scientific Awareness and Critical Thinking:** **Emerge as an innovative problem-solver and impactful mediator, applying scientific understanding and critical thinking to address challenges and advance sustainable solutions.**
PO6	**Human Values, Professional Ethics, and Societal and Environmental Responsibility:** **Become a responsible leader, characterized by an unwavering commitment to human values, ethical conduct, and a fervent dedication to the well-being of society and the environment.**
PO7	**Research, Innovation, and Entrepreneurship:** **Emerge as a researcher and entrepreneurial leader, forging collaborative partnerships with industry, academia, and communities to contribute enduring solutions for local, regional, and global development.**

PROGRAMME SPECIFIC OUTCOMES (PSO):

At the end of the B.Sc. Mathematics Honours Programme at Providence Women's College, a student would:

Programme Specific Outcome (Major)	
PSO1	**Advanced Mathematical Knowledge: Understand core mathematical abstract concepts/theories and demonstrate a high level of mathematical rigor and logical reasoning**
PSO2	**Modelling and Problem-Solving Skills: Apply mathematical techniques to solve complex problem situations across various domains and interpret the result, demonstrating critical thinking and analytical skills.**
PSO3	**Computational Proficiency: Apply mathematical understanding to solve problems and explicitly work out step by step either by self or by software based computational tools.**
PSO4	**Research Aptitude: Analyse mathematical abstract ideas effectively and present/communicate mathematical arguments and solutions in a clear and coherent manner leading to research in Mathematics**
Programme Specific Outcome (Minor)	
PSO5	**Mathematics Proficiency: Demonstrate a strong understanding of mathematical principles and problem solving**
PSO6	**Interdisciplinary Integration: Integrate Mathematics with relevant disciplines to develop more holistic approaches to solve problems, leading to innovative solutions and advancements in various fields.**

MINIMUM CREDIT REQUIREMENTS OF THE DIFFERENT PATHWAYS

IN THE THREE-YEAR PROGRAMME IN PWC FYUGP

Sl. No.	Academic Pathway	Major	Minor/ Other Disciplines	Foundation Courses AEC: 4 MDC: 3 SEC: 3 VAC: 3	Intern-ship	Total Credits	Example
		Each course has 4 credits		Each course has 3 credits			
1	Single Major (A)	68 (17 courses)	24 (6 courses)	39 (13 courses)	2	133	Major: Mathematics + six courses in different disciplines in different combinations
2	Major (A) with Multiple Disciplines (B, C)	68 (17 courses)	12 + 12 (3 + 3 = 6 courses)	39 (13 courses)	2	133	Major: Mathematics + Statistics and Computer Science
3	Major (A) with Minor (B)	68 (17 courses)	24 (6 courses)	39 (13 courses)	2	133	Major: Mathematics Minor: Physics
4	Major (A) with Vocational Minor (B)	68 (17 courses)	24 (6 courses)	39 (13 courses)	2	133	Major: Mathematics Vocational Minor: Data Analysis
5	Double Major	A: 48	-	12 + 9+9 +9	2	133	

	(A, B)	(12 courses) B: 44 (11 courses)	The 24 credits in the Minor stream are distributed between the two Majors. 2 MDC, 2 SEC, 2 VAC and the Internship should be in Major A. Total credits in Major A should be 48 + 20 = 68 (nearly 50% of 133) 1 MDC, 1 SEC and 1 VAC should be in Major B. Total credits in Major B should be 44 + 9 = 53 (40% of 133)		Mathematics and Physics double major
Exit with UG Degree / Proceed to Fourth Year with 133 Credits					

B.Sc. MATHEMATICS HONOURS PROGRAMME

COURSE STRUCTURE FOR PATHWAYS 1 – 4

1. Single Major **2. Major with Multiple Disciplines**

3. Major with Minor **4. Major with Vocational Minor**

Semester	Course Code	Course Title	Total Hours	Hours/ Week	Credits	Marks		
						Internal	External	Total
1	MAT1CJ101/ MAT1MN100	Core Course 1 in Major – Differential Calculus	60	4	4	30	70	100
		Minor Course 1	60/ 75	4/ 5	4	30	70	100
		Minor Course 2	60/ 75	4/ 5	4	30	70	100
	ENG1FA101 (2)	Ability Enhancement Course 1– English (with Theory T & Practicum P)	30+30 (T+P)	2+2 (T+P)	2+1 (T+P)	25	50	75
		Ability Enhancement Course 2 – Additional Language	45	3	3	25	50	75
		Multi-Disciplinary Course 1 – Other than Major	45	3	3	25	50	75
		Total		22/ 24	21			525
2	MAT2CJ101/ MAT2MN100	Core Course 2 in Major – Integral Calculus	60	4	4	30	70	100
		Minor Course 3	60/ 75	4/ 5	4	30	70	100
		Minor Course 4	60/ 75	4/ 5	4	30	70	100
	ENG2FA103 (2)	Ability Enhancement Course 3– English	30+30	2+2	2+1	25	50	75

		Ability Enhancement Course 4 – Additional Language	45	3	3	25	50	75
		Multi-Disciplinary Course 2 – Other than Major	45	3	3	25	50	75
		Total		22/ 24	21			525
3	MAT3CJ201	Core Course 3 in Major– Multivariable Calculus (with Theory T & Practicum P)	45+30 (T+P)	3+2 (T+P)	3+1 (T+P)	30	70	100
	MAT3CJ202/ MAT3MN200	Core Course 4 in Major– Matrix Algebra	60	4	4	30	70	100
		Minor Course 5	60/ 75	4/ 5	4	30	70	100
		Minor Course 6	60/ 75	4/ 5	4	30	70	100
		Multi-Disciplinary Course 3 – Kerala Knowledge System	45	3	3	25	50	75
	ENG3FV108 (2)	Value-Added Course 1 – English	45	3	3	25	50	75
		Total		23/ 25	22			550
4	MAT4CJ203	Core Course 5 in Major –Real Analysis I	45+30	3+2	3+1	30	70	100
	MAT4CJ204	Core Course 6 in Major – Basic Linear Algebra	60	4	4	30	70	100
	MAT4CJ205	Core Course 7 in Major – Fundamentals of Python and SageMath (with Theory T & Practical P)	45+30 (T+P)	3+2 (T+P)	3+1 (T+P)	30	70	100

	ENG4FV109 (2)	Value-Added Course 2 – English	45	3	3	25	50	75
		Value-Added Course 3 – Additional Language	45	3	3	25	50	75
	ENG4FS111 (2)	Skill Enhancement Course 1 – English	30+30	2+2	2+1	25	50	75
		Total		24	21			525
5	MAT5CJ301	Core Course 8 in Major –Real Analysis II	45+30	3+2	3+1	30	70	100
	MAT5CJ302	Core Course 9 in Major –Abstract Algebra I	60	4	4	30	70	100
	MAT5CJ303	Core Course 10 in Major – Complex Analysis I	60	4	4	30	70	100
		Elective Course 1 in Major	60	4	4	30	70	100
		Elective Course 2 in Major	60	4	4	30	70	100
		Skill Enhancement Course 2	45	3	3	25	50	75
		Total		24	23			575
6	MAT6CJ304/ MAT8MN304	Core Course 11 in Major – Complex Analysis II (For choosing this course as minor from other departments, students must have acquainted themselves with necessary contents of MAT5CJ303, as prerequisites)	60	4	4	30	70	100
	MAT6CJ305/ MAT8MN305	Core Course 12 in Major – Elementary Number Theory	60	4	4	30	70	100

	MAT6CJ306/ MAT8MN306	Core Course 13 in Major – Methods of Differential Equations	60	4	4	30	70	100
		Elective Course 3 in Major	60	4	4	30	70	100
		Elective Course 4 in Major	60	4	4	30	70	100
	MAT6FS113	Skill Enhancement Course 3 – Data Science with Python	45	3	3	25	50	75
	MAT6CJ349	Internship in Major (Credit for internship to be awarded only at the end of Semester 6)	60		2	50	-	50
		Total		23	25			625
Total Credits for Three Years					133			3325
7	MAT7CJ401	Core Course 14 in Major– Mathematical Analysis	45+30	3+2	3+1	30	70	100
	MAT7CJ402	Core Course 15 in Major –General Topology	45+30	3+2	3+1	30	70	100
	MAT7CJ403	Core Course 16 in Major – Abstract Algebra II	45+30	3+2	3+1	30	70	100
	MAT7CJ404	Core Course 17 in Major – Linear Algebra	45+30	3+2	3+1	30	70	100
	MAT7CJ405	Core Course 18 in Major – Discrete Mathematics	45+30	3+2	3+1	30	70	100
		Total		25	20			500
8	MAT8CJ406 / MAT8MN406	Core Course 19 in Major – Basic Measure Theory	45+30	3+2	3+1	30	70	100

	MAT8CJ407 / MAT8MN407	Core Course 20 in Major – Number Theory	60	4	4	30	70	100
	MAT8CJ408 / MAT8MN408	Core Course 21 in Major– Differential Equations	60	4	4	30	70	100
	OR (instead of Core Courses 19 to 21 in Major)							
	MAT8CJ449	Project (in Honours programme)	360*	13*	12	90	210	300
	OR (instead of Core Courses 19 to 21 in Major)							
	MAT8CJ499	Project (in Honours with Research programme)	360*	13*	12	90	210	300
		Elective Course 5 in Major / Minor Course 7	60	4	4	30	70	100
		Elective Course 6 in Major / Minor Course 8	60	4	4	30	70	100
		Elective Course 7 in Major / Minor Course 9 / Major Course in any Other Discipline	60	4	4	30	70	100
	OR (instead of Elective Course 7 in Major, in the case of Honours with Research Programme)							
	MAT8CJ489	Research Methodology in Mathematics	60	4	4	30	70	100
		Total		25	24			600
Total Credits for Four Years					177			4425

* **The teacher should have 13 hrs/week of engagement (the hours corresponding to the three core courses) in the guidance of the Project(s) in Honours programme and Honours with Research programme, while each student should have 24 hrs/week of engagement in the Project work. Total hours are given based on the student's engagement.**

CREDIT DISTRIBUTION FOR PATHWAYS 1 – 4

1. Single Major **2. Major with Multiple Disciplines**

3. Major with Minor **4. Major with Vocational Minor**

Semester	Major Courses	Minor Courses	General Foundation Courses	Internship/ Project	Total
1	4	4 + 4	3 + 3 + 3	-	21
2	4	4 + 4	3 + 3 + 3	-	21
3	4 + 4	4 + 4	3 + 3	-	22
4	4 + 4 + 4	-	3 + 3 + 3	-	21
5	4 + 4 + 4 + 4 + 4	-	3	-	23
6	4 + 4 + 4 + 4 + 4	-	3	2	25
Total for Three Years	68	24	39	2	133
7	4 + 4 + 4 + 4 + 4	-	-	-	20
8	4 + 4 + 4	4 + 4 + 4	-	12*	24
*Instead of three Major courses					
Total for Four Years	88 + 12 = 100	36	39	2	177

DISTRIBUTION OF MAJOR COURSES IN Mathematics

FOR PATHWAYS 1 – 4

1. Single Major **2. Major with Multiple Disciplines**

3. Major with Minor **4. Major with Vocational Minor**

Semester	Course Code	Course Title	Hours/ Week	Credits
1	MAT1CJ101 /MAT1MN100	Core Course 1 in Major – Differential Calculus	4	4
2	MAT2CJ101 /MAT2MN100	Core Course 2 in Major – Integral Calculus	4	4
3	MAT3CJ201	Core Course 3 in Major – Multivariable Calculus	5	4
	MAT3CJ202 /MAT3MN200	Core Course 4 in Major – Matrix Algebra	4	4
4	MAT4CJ203	Core Course 5 in Major – Real Analysis I	5	4
	MAT4CJ204	Core Course 6 in Major – Basic Linear Algebra	4	4
	MAT4CJ205	Core Course 7 in Major – Fundamentals of Python and SageMath (P)	5	4
5	MAT5CJ301	Core Course 8 in Major – Real Analysis II	5	4
	MAT5CJ302	Core Course 9 in Major – Abstract Algebra I	4	4
	MAT5CJ303	Core Course 10 in Major – Complex Analysis I	4	4
		Elective Course 1 in Major	4	4
		Elective Course 2 in Major	4	4
6	MAT6CJ304 / MAT8MN304	Core Course 11 in Major – Complex Analysis II	4	4

	MAT6CJ305 /MAT8MN305	Core Course 12 in Major – Elementary Number Theory	4	4
	MAT6CJ306 /MAT8MN306	Core Course 13 in Major – Methods of Differential Equations	4	4
		Elective Course 3 in Major	4	4
		Elective Course 4 in Major	4	4
	MAT6CJ349	Internship in Major	-	2
Total for the Three Years				70
7	MAT7CJ401	Core Course 14 in Major - Mathematical Analysis	5	4
	MAT7CJ402	Core Course 15 in Major – General Topology	5	4
	MAT7CJ403	Core Course 16 in Major – Abstract Algebra II	5	4
	MAT7CJ404	Core Course 17 in Major – Linear Algebra	5	4
	MAT7CJ405	Core Course 18 in Major – Discrete Mathematics	5	4
	MAT8CJ406 / MAT8MN406	Core Course 19 in Major – Basic Measure Theory	5	4
	MAT8CJ407 / MAT8MN407	Core Course 20 in Major – Number Theory	4	4
	MAT8CJ408 / MAT8MN408	Core Course 21 in Major – Differential Equations	4	4
	OR (instead of Core Courses 19 - 21 in Major)			
	MAT8CJ449	Project (in Honours programme)	13	12
	MAT8CJ499	Project (in Honours with Research programme)	13	12
		Elective Course 5 in Major	4	4
		Elective Course 6 in Major	4	4

8		Elective Course 7 in Major	4	4
	OR (instead of Elective course 7 in Major, in Honours with Research programme)			
	MAT8CJ489	Research Methodology in Mathematics	4	4
Total for the Four Years				114

ELECTIVE COURSES IN MATHEMATICS WITH SPECIALISATION

Group No.	Sl. No	Course Code	Title	Semester	Total Hrs	Hrs/ Week	Credits	Marks		
								Internal	External	Total
1		MATHEMATICAL COMPUTING								
	1	MAT5EJ301 (1)	Mathematical Foundations of Computing	5	60	4	4	30	70	100
	2	MAT5EJ302 (1)	Data Structures and Algorithms	5	60	4	4	30	70	100
	3	MAT6EJ301 (1)	Numerical Analysis	6	60	4	4	30	70	100
	4	MAT6EJ302 (1)	Mathematics for Digital Images	6	60	4	4	30	70	100
2		DATA SCIENCE*								
	1	MAT5EJ303 (2)	Convex Optimization	5	60	4	4	30	70	100
	2	MAT5EJ304 (2)	Applied Probability	5	60	4	4	30	70	100
	3	MAT6EJ303 (2)	Machine Learning I	6	60	4	4	30	70	100
	4	MAT6EJ304 (2)	Machine Learning II	6	60	4	4	30	70	100

ELECTIVE COURSES IN MATHEMATICS WITH NO SPECIALISATION

Sl. No.	Course Code	Title	Semester	Total Hrs	Hrs/ Week	Credits	Marks		
							Internal	External	Total
1	MAT5EJ305	Higher Algebra.	5	60	4	4	30	70	100
2	MAT5EJ306	Linear Programming	5	60	4	4	30	70	100
3	MAT6EJ305	Topology of Metric Spaces.	6	60	4	4	30	70	100
4	MAT6EJ306	Introduction to Fourier Analysis	6	60	4	4	30	70	100
5	MAT8EJ401	Advanced Topology	8	60	4	4	30	70	100
6	MAT8EJ402	Partial Differential Equations	8	60	4	4	30	70	100
7	MAT8EJ403	Rings and Modules	8	60	4	4	30	70	100
8	MAT8EJ404	Coding Theory	8	60	4	4	30	70	100
9	MAT8EJ405	Foundations of Mathematics	8	60	4	4	30	70	100
10	MAT8EJ406	Operations Research	8	60	4	4	30	70	100
11	MAT8EJ407	Cryptography	8	60	4	4	30	70	100
12	MAT8EJ408	Introduction to Fractals	8	60	4	4	30	70	100

*These courses are beyond the minimum course requirements and their syllabi are under preparation and will be updated soon.

**

GROUPING OF MINOR COURSES IN MATHEMATICS

Group No.	Sl. No.	Course Code	Title	Semester	Total Hrs	Hrs/ Week	Credits	Marks		
								Internal	External	Total
1		Minor Group I - Mathematical Methods for Science								
	1	MAT1MN101	Calculus	1	60	4	4	30	70	100
	2	MAT2MN101	Differential Equations and Matrix Theory	2	60	4	4	30	70	100
	3	MAT3MN201	Calculus of Several Variables	3	60	4	4	30	70	100
2		Minor Group II – Foundations for Mathematical Applications								
	1	MAT1MN102	Differential Calculus	1	60	4	4	30	70	100
	2	MAT2MN102	Calculus and Matrix Algebra	2	60	4	4	30	70	100
	3	MAT3MN202	Differential Equations and Fourier Series	3	60	4	4	30	70	100
3		Minor Group III - Integrated Mathematical Methods								
	1	MAT1MN103	Basic Calculus	1	60	4	4	30	70	100
	2	MAT2MN103	Analysis and Some Counting Principles	2	60	4	4	30	70	100
	3	MAT3MN203	Matrix Algebra and Vector Calculus	3	60	4	4	30	70	100

4		Minor Group IV - Discrete Mathematics								
	1	MAT1MN104	Mathematical Logic, Set Theory and Combinatorics	1	60	4	4	30	70	100
	2	MAT2MN104	Graph theory and Automata	2	60	4	4	30	70	100
	3	MAT3MN204	Boolean Algebra and System of Equations	3	60	4	4	30	70	100
		Minor Group V – Linear Algebra								
	1	MAT1MN105	Matrix Theory	1	60	4	4	30	70	100
	2	MAT2MN105	Vector Spaces and Linear Transformations	2	60	4	4	30	70	100
	3	MAT3MN205	Optimization Techniques	3	60	4	4	30	70	100
		Minor Group VI – Mathematical Economics								
	1	MAT1MN106	Principles of Micro Economics	1	60	4	4	30	70	100
	2	MAT2MN106	Optimization Techniques in Economics	2	60	4	4	30	70	100
	3	MAT3MN206	Applied Mathematics for Economic Analysis	3	60	4	4	30	70	100

*** Students from other disciplines can choose up to one group (comprising three courses in total) from the first three options, as these groups share partially overlapping topics.**

**** Students from major mathematics can enrol only in minor group VI or a vocational minor group as per the clauses 7.2.12 and 7.2.13 (amended).**

GROUPING OF VOCATIONAL MINOR COURSES IN MATHEMATICS

VOCATIONAL MATHEMATICS – DATA ANALYTICS											
Group No.	Sl. No.	Course Code	Title	Semester	Total Hrs	Hrs/ Week	Credits	Marks		
								Internal	External	Total
1		**Introduction to AI**								
	1	MAT1VN 101	Python Programming	1	75	5	4	30	70	100
	2	MAT2VN 101	Linear Algebra for Machine Learning	2	75	5	4	30	70	100
	3	MAT3VN 201	Introduction to Machine Learning	3	75	5	4	30	70	100
	4	MAT8VN 401	Introduction to Artificial Intelligence	8	75	5	4	30	70	100
2	**Introduction to Data Science**									
	1	MAT1VN 102	Statistics for Data Science	1	75	5	4	30	70	100
	2	MAT2VN 102	R Programming	2	75	5	4	30	70	100
	3	MAT3VN 202	Data Mining	3	75	5	4	30	70	100
	4	MAT8VN 402	Data Visualization	8	75	5	4	30	70	100

(i). Students in Single Major pathway can choose course/courses from any of the Minor/ Vocational Minor groups offered by a discipline other than their Major discipline.

(ii). Students in the Mathematics with Multiple Disciplines pathway who wish to choose a minor from within the same department are limited to selecting either the sixth minor group (Mathematical Economics) or one of the vocational minor groups listed above as one of their multiple disciplines. For their second multiple discipline choice, students must select a Minor or Vocational Minor group offered by a discipline other than mathematics. If students opt for Mathematical Economics or another vocational group from mathematics, the title of that group will serve as their multiple discipline title.

(iii). Students in Major with Minor pathway can choose all the courses from any two Minor groups offered by a discipline other than their Major discipline. If the students from other major disciplines choose any two Minor groups in Mathematics as given above, then the title of the Minor will be Mathematics.

(iv). Students in Major with Vocational Minor pathway can choose all the courses from any two Vocational Minor groups offered by a discipline other than their Major discipline. If the students from other Major disciplines choose any two Vocational Minor groups in Mathematics as given above, then the title of the Vocational Minor will be Data Analytics.

DISTRIBUTION OF GENERAL FOUNDATION COURSES IN MATHEMATICS

Semester	Course Code	Course Title	Total Hours	Hours / Week	Credits	Marks		
						Internal	External	Total
1	MAT1FM105(1)	Multi-Disciplinary Course 1 - Matrices and Basics of Probability theory	45	3	3	25	50	75
1	MAT1FM105(2)	Multi-Disciplinary Course 2 -Mathematics for Competitive Examinations - Part I	45	3	3	25	50	75
2	MAT2FM106(1)	Multi-Disciplinary Course 3 -Graph Theory and LPP	45	3	3	25	50	75
2	MAT2FM106(2)	Multi-Disciplinary Course 4 – Mathematics for Competitive Examinations - Part II	45	3	3	25	50	75

3	MAT3FV109(1)	Value-Added Course 1 - History of Mathematics	45	3	3	25	50	75
3	MAT3FV109(2)	Value-Added Course 2 - Computational Logic	45	3	3	25	50	75
4	MAT4FV110(1)	Value-Added Course 3 - Statistics and Mathematics with R	45	3	3	25	50	75
4	MAT4FV110(2)	Value-Added Course 4 - The Mathematical Practices of Medieval Kerala	45	3	3	25	50	75
5	MAT5FS112	Skill Enhancement Course 2 - Mathematical Type Setting System - LaTeX	45	3	3	25	50	75
6	MAT6FS113	Skill Enhancement Course 3 - Data Science with Python	45	3	3	25	50	75

COURSE STRUCTURE FOR BATCH A1(B2)

IN PATHWAY 5: DOUBLE MAJOR

A1: 68 credits in Mathematics (Major A) ***B1: 68 credits in Major B***

A2: 53 credits in Mathematics (Major A) ***B2: 53 credits in Major B***

The combinations available to the students: (A1 & B2), (B1 & A2)

Note: Unless the batch is specified, the course is for all the students of the class

Semester	Course Title	Total Hours	Hours/ Week	Credits	Marks		
					Internal	External	Total
1	Core Course 1 in Major Mathematics – Differential Calculus	60	4	4	30	70	100
	Core Course 1 in Major B	60/ 75	4/ 5	4	30	70	100
	Core Course 2 in Major Mathematics – Matrix Algebra (for batch A1 only)	60	4	4	30	70	100
	Ability Enhancement Course 1 English	30+30	2+2	2+1	25	50	75
	Ability Enhancement Course 2 Additional Language	45	3	3	25	50	75
	Multi-Disciplinary Course 1 in Mathematics – Matrices and Basics of Probability theory *Or* Mathematics for Competitive Exams – Part I (for batch A1 only)	45	3	3	25	50	75
	Total		24/ 25	21			525

2	Core Course 3 in Major Mathematics – Integral Calculus	60	4	4	30	70	100
	Core Course 2 in Major B	60/ 75	4/ 5	4	30	70	100
	Core Course 3 in Major B – (for batch B2 only)	60/ 75	4/ 5	4	30	70	100
	Ability Enhancement Course 3 English	30+30	2+2	2+1	25	50	75
	Ability Enhancement Course 4 Additional Language	45	3	3	25	50	75
	Multi-Disciplinary Course 2 in Mathematics – Graph Theory and LPP *Or* Mathematics for Competitive Exams – Part II	45	3	3	25	50	75
	Total		23 / 25	21			525
3	Core Course 4 in Major Mathematics – Multivariable Calculus.	75	5	4	30	70	100
	Core Course 5 in Major Mathematics – Basic Linear Algebra	60	4	4	30	70	100
	Core Course 4 in Major B	60/ 75	4/ 5	4	30	70	100
	Core Course 5 in Major B	60/ 75	4/ 5	4	30	70	100
	Multi-Disciplinary Course 1 in B	45	3	3	25	50	75

	Value-Added Course 1 in Mathematics – History of Mathematics *Or* Computational Logic (for batch A1 only)	45	3	3	25	50	75
	Total		23 / 25	22			550
4	Core Course 6 in Major Mathematics – Real Analysis	45+30	3+2	2+2	30	70	100
	Core Course 6 in Major B	60/ 75	4/ 5	4	30	70	100
	Core Course 7 in Major Mathematics - Abstract Algebra I	60	4	4	30	70	100
	Value-Added Course 2 in Mathematics – Statistics and Mathematics with R *Or* The Mathematical Practices of Medieval Kerala	45	3	3	25	50	75
	Value-Added Course 1 in B	45	3	3	25	50	75
	Skill Enhancement Course 1 in Mathematics – Fundamentals of Python and SageMath	30+30	2+2	3	25	50	75
	Total		23/ 24	21			525
5	Core Course 8 in Major – Complex Analysis	45+30	3+2	2+2	30	70	100
	Core Course 7 in Major B –	60/ 75	4/ 5	4	30	70	100

	Core Course 9 in Major Mathematics – Methods of Differential Equations (for batch A1 only)	60	4	4	30	70	100
	Elective Course 1 in Major Mathematics	60	4	4	30	70	100
	Elective Course 1 in Major B	60	4	4	30	70	100
	Skill Enhancement Course 1 in B	45	3	3	25	50	75
	Total		24/ 25	23			575
6	Core Course 10 in Major Mathematics – Elementary Number Theory	60	4	4	30	70	100
	Core Course 8 in Major B –	60/ 75	4/ 5	4	30	70	100
	Core Course 9 in Major B – (for batch B2 only)	60	4	4	30	70	100
	Elective Course 2 in Major Mathematics	60	4	4	30	70	100
	Elective Course 2 in Major B	60	4	4	30	70	100
	Skill Enhancement Course 2 in Mathematics – Mathematical Type Setting System - LaTeX (for batch A1 only)	45	3	3	25	50	75
	Internship in Major Mathematics (Credit for internship to be awarded only at the end of Semester 6)	60		2	50	-	50
	Total		24/ 25	25			625
				133			3325

CREDIT DISTRIBUTION FOR BATCH A1 (B2)

IN PATHWAY 5: DOUBLE MAJOR

Semester	Major Courses in Mathematics	General Foundation Courses in Mathematics	Internship/ Project in Mathematics	Majo Courses in B	General Foundation Courses in B	AEC	Tota l
1	4 + 4	3	-	4	-	3 + 3	21
2	4	3	-	4 + 4	-	3 + 3	21
3	4 + 4	3	-	4 + 4	3	-	22
4	4 + 4	3 + 3	-	4	3	-	21
5	4 + 4 + 4	-	-	4 + 4	3	-	23
6	4 + 4	3	2	4 + 4 + 4	-	-	25
Total for Three Years	48	18	2	44	9	12	133
	68			53		12	133
	Major Courses in Mathematics	Minor Courses					
7	4 + 4 + 4 + 4 + 4	-			-	-	20
8	4 + 4 + 4	4 + 4 + 4	12*		-	-	24
*Instead of three Major courses							
Total for Four Years	88 + 12 = 100	12					177

COURSE STRUCTURE FOR BATCH B1(A2)

IN PATHWAY 5: DOUBLE MAJOR

A1: 68 credits in Mathematics (Major A) ***B1: 68 credits in Major B***

A2: 53 credits in Mathematics (Major A) ***B2: 53 credits in Major B***

Note: Unless the batch is specified, the course is for all the students of the class

Semester	Course Title	Total Hours	Hours/ Week	Credits	Marks		
					Internal	External	Total
1	Core Course 1 in Major Mathematics – Differential Calculus	60	4	4	30	70	100
	Core Course 1 in Major B	60/ 75	4/ 5	4	30	70	100
	Core Course 2 in Major B (for batch B1 only)	60/ 75	4/ 5	4	30	70	100
	Ability Enhancement Course 1 English	60	4	3	25	50	75
	Ability Enhancement Course 2 Additional Language	45	3	3	25	50	75
	Multi-Disciplinary Course 1 in B – (for batch B1 only)	45	3	3	25	50	75
	Total		23 / 25	21			525
2	Core Course 3 in Major Mathematics – Integral Calculus	60	4	4	30	70	100
	Core Course 3 in Major B –	60/ 75	4/ 5	4	30	70	100
	Core Course 2 in Major Mathematics – Elementary Number Theory (for batch A2 only).	60	4	4	30	70	100
	Ability Enhancement Course 3 English	60	4	3	25	50	75

	Ability Enhancement Course 4 Additional Language	45	3	3	25	50	75
	Multi-Disciplinary Course 1 Matrices and Basics of Probability theory *or* Mathematics for Competitive Exams - Part I	45	3	3	25	50	75
	Total		24/ 25	21			525
3	Core Course 5 in Major Mathematics – Multivariable Calculus	45+30	3+2	3+1	30	70	100
	Core Course 4 in Major Mathematics – Elementary Linear Algebra	45+30	3+2	3+1	30	70	100
	Core Course 4 in Major B	60/ 75	4/ 5	4	30	70	100
	Core Course 5 in Major B	60/ 75	4/ 5	4	30	70	100
	Multi-Disciplinary Course 2 in B –	45	3	3	25	50	75
	Value-Added Course 1 in B – (for batch B1 only)	45	3	3	25	50	75
	Total		23/25	22			550
4	Core Course 6 in Major Mathematics – Real Analysis	45+30	3+2	3+1	30	70	100
	Core Course 6 in Major B	60/ 75	4/ 5	4	30	70	100
	Core Course 7 in Major B – (for batch B1 only)	60/ 75	4/ 5	4	30	70	100

	Value-Added Course 1 in Mathematics – History of Mathematics *or* Computational Logic	45	3	3	25	50	75
	Value-Added Course 2 in B –	45	3	3	25	50	75
	Skill Enhancement Course 1 in Mathematics – Fundamentals of Python and SageMath		4	3	25	50	75
	Total		22 / 24	21			525
5	Core Course 7 in Major Mathematics – Abstract Algebra I	60	4	4	30	70	100
	Core Course 8 in Major B –	60/ 75	4/ 5	4	30	70	100
	Core Course 9 in Major B – (for batch B1 only)	60	4	4	30	70	100
	Elective Course 1 in Major Mathematics	60	4	4	30	70	100
	Elective Course 1 in Major B	60	4	4	30	70	100
	Skill Enhancement Course 1 in B	45	3	3	25	50	75
	Total		24/ 25	23			575
6	Core Course 8 in Major Mathematics – Methods of Differential Equations	60	4	4	30	70	100
	Core Course 10 in Major B –	60/ 75	4/ 5	4	30	70	100
	Core Course 9 in Major Mathematics – Complex Analysis (for batch A2 only)	45+30	3+2	2+2	30	70	100

	Elective Course 2 in Major Mathematics	60	4	4	30	70	100
	Elective Course 2 in Major B	60	4	4	30	70	100
	Skill Enhancement Course 2 in B – (for batch B1 only)	45	3	3	25	50	75
	Internship in Major B (Credit for internship to be awarded only at the end of Semester 6)	60		2	50	-	50
	Total		24/ 25	25			625
Total Credits for Three Years				133			3325

CREDIT DISTRIBUTION FOR BATCH B1(A2)

IN PATHWAY 5: DOUBLE MAJOR

Semester	Major Courses in B	General Foundation Courses in B	Internship/ Project in B	Major Courses in Mathematics	General Foundation Courses in Mathematics	AEC	Total
1	4 + 4	3	-	4	-	3 + 3	21
2	4	-	-	4 + 4	3	3 + 3	21
3	4 + 4	3 + 3	-	4 + 4	-	-	22
4	4 + 4	3	-	4	3 + 3	-	21
5	4 + 4 + 4	3	-	4 + 4	-	-	23
6	4 + 4	3	2	4 + 4 + 4	-	-	25
Total for Three Years	48	18	2	44	9	12	133
	68			53		12	133
	Major Courses in B	Minor Courses					
7	4 + 4 + 4 + 4 + 4	-			-	-	20
8	4 + 4 + 4	4 + 4 + 4	12*		-	-	24
* instead of three Major courses							
Total for Four Years	88 + 12 = 100	12					177

EVALUATION SCHEME

1. The evaluation scheme for each course contains two parts: internal evaluation (about 30%) and external evaluation (about 70%). Each of the Major and Minor courses is of 4-credits. It is evaluated for 100 marks, out of which 30 marks are from internal evaluation and 70 marks, from external evaluation. Each of the General Foundation Course is of 3-credits. It is evaluated for 75 marks, out of which 25 marks are from internal evaluation and 50 marks, from external evaluation.

2. The 4-credit courses (Major and Minor courses) are of two types: (i) courses with only theory and (ii) courses with 3-credit theory and 1-credit Practical/Practicum.

In 4-credit courses with only theory component, out of the total 5 modules of the syllabus, one open-ended module with 20% content is designed by the faculty member teaching that course, and it is internally evaluated for 10 marks. The internal evaluation of the remaining 4 theory modules is for 20 marks.

In 4-credit courses with 3-credit theory and 1-credit Practical/Practicum components, out of the total 5 modules of the syllabus, 4 modules are for theory and the fifth module is for Practical/Practicum. The Practical/Practicum component is internally evaluated for 20 marks. The internal evaluation of the 4 theory modules is for 10 marks.

3. All the 3-credit courses (General Foundational Courses) in Mathematics are with only theory component. Out of the total 5 modules of the syllabus, one open-ended module with 20% content is designed by the faculty member teaching that course, and it is internally evaluated for 5 marks. The internal evaluation of the remaining 4 theory modules is for 20 marks.

Sl. No.	Nature of the Course		Internal Evaluation in Marks (About 30% of the Total)		External Exam on 4 Modules (Marks)	Total Marks
			Open-ended Module / Practical/Practicum	On the other 4 Modules		
1	4-credit course	only theory (5 modules)	10	20	70	100
2	4-credit course	Theory (4 modules) + Practical/Practicum	20	10	70	100
3	3-credit course	only theory (5 modules)	5	20	50	75

1. MAJOR AND MINOR COURSES

1.1. INTERNAL EVALUATION OF THEORY COMPONENT

Sl. No.	Components of Internal Evaluation of Theory Part of a Major / Minor Course	Internal Marks for the Theory Part of a Major / Minor Course of 4-credits			
		Theory Only		Theory + Practical/Practicum	
		4 Theory Modules	Open-ended Module	4 Theory Modules	Practical/Practicum
1	Test paper/ Mid-semester Exam	10	4	5	-
2	Seminar/ Viva/ Quiz	6	4	3	-
3	Assignment	4	2	2	-
Total		20	10	10	20*
		30		30	

* Refer the table in section 1.2 for the evaluation of Practical/Practicum component

1.2. EVALUATION OF PRACTICAL/PRACTICUM COMPONENT

The evaluation of Practical/Practicum component in Major and Minor courses is completely by internal evaluation.

- Continuous evaluation of Practical/Practicum by the teacher-in-charge shall carry a weightage of 50%.
- The end-semester Practical/Practicum examination and viva-voce, and the evaluation of Practical/Practicum records shall be conducted by the teacher in-charge and an internal examiner appointed by the Department Council.
- The process of continuous evaluation of Practical/Practicum courses shall be completed before 10 days from the commencement of the end-semester examination.
- Those who passed in continuous evaluation alone will be permitted to appear for the end-semester examination and viva-voce.

The scheme of continuous evaluation and the end-semester examination and viva-voce of Practical/Practicum component shall be as given below:

Sl. No.	Evaluation of Practical/Practicum Component of Credit-1 in a Major / Minor Course	Marks for Practical/Practicum	Weightage
1	Continuous evaluation of Practical/Practicum/ exercise performed in Practical/Practicum classes by the students	10	50%
2	End-semester examination and viva-voce to be conducted by teacher-in-charge along with an additional examiner arranged internally by the Department Council	7	35%
3	Evaluation of the Practical/Practicum records submitted for the end semester viva–voce examination by the teacher-in-charge and additional examiner	3	15%
	Total Marks	20	

1.3. EXTERNAL EVALUATION OF THEORY COMPONENT

External evaluation carries 70% marks. Examinations will be conducted at the end of each semester. Individual questions are evaluated in marks and the total marks are converted into grades by the Providence Women's College based on 10-point grading system (refer section 5).

PATTERN OF QUESTION PAPER FOR MAJOR AND MINOR COURSES

Duration	Type	Total No. of Questions	No. of Questions to be Answered	Marks for Each Question	Ceiling of Marks
2 Hours	Short Answer	10	8 – 10	3	24
	Paragraph/ Problem	8	6 – 8	6	36
	Essay	2	1	10	10
				Total Marks	70

2. INTERNSHIP

- All students should undergo Internship of 2-credits during the first six semesters in Research Institutions, Universities, Firms, Industry or Organizations, or training in labs with faculty and researchers of their own institution or other Higher Educational Institutions (HEIs) or research institutions.
- Internship can be for enhancing the employability of the student or for developing the research aptitude.
- Internship can involve hands-on training on a particular skill/ equipment/ software. It can be a short project on a specific problem or area. Attending seminars or workshops related to an area of learning or skill can be a component of Internship.

A faculty member/ scientist/ instructor of the respective institution, where the student does the Internship, should be the supervisor of the Internship

2.1. GUIDELINES FOR INTERNSHIP

1. Internship can be in Mathematics or allied disciplines.
2. There should be minimum 60 hrs. of engagement from the student in the Internship.
3. Summer vacations and other holidays can be used for completing the Internship.
4. In B.Sc. Mathematics Honours programme, institute/ industry visit or study tour is a requirement for the completion of Internship. Visit to minimum one national research institute, research laboratory and place of scientific importance should be part of the study tour. A brief report of the study tour has to be submitted with photos and analysis.
5. The students should make regular and detailed entries in to a personal log book through the period of Internship. The log book will be a record of the progress of the Internship and the time spent on the work, and it will be useful in writing the final report. It may contain mathematical results, ideas, expressions, experimental conditions, rough work and calculation, computer file names etc. All entries should be dated. The Internship supervisor should periodically examine and countersign the log book.
6. The log book and the typed report must be submitted at the end of the Internship.
7. The institution at which the Internship will be carried out should be prior-approved by the Department Council of the college where the student has enrolled for the UG Honours programme.

2.2. VALUATION OF INTERNSHIP

- The evaluation of Internship shall be done internally through continuous assessment mode by a committee internally constituted by the Department Council of the college where the student has enrolled for the UG Honours programme.
- The credits and marks for the Internship will be awarded only at the end of semester 6.
- The scheme of continuous evaluation and the end-semester viva-voce examination based on the submitted report shall be as given below:

Sl. No.	Components of Evaluation of Internship		Marks for Internship 2 Credits	Weightage
1	Continuous evaluation of internship through interim presentations and reports by the committee internally constituted by the Department Council	Acquisition of skill set	10	40%
2		Interim Presentation and Viva-voce	5	
3		Punctuality and Log Book	5	
4	Report of Institute Visit/ Study Tour		5	10%
5	End-semester viva-voce examination to be conducted by the committee internally constituted by the Department Council	Quality of the work	6	35%
6		Presentation of the work	5	
7		Viva-voce	6	
8	Evaluation of the day-to-day records, the report of internship supervisor, and final report submitted for the end semester viva–voce examination before the committee internally constituted by the Department Council		8	15%
	Total Marks		50	

3. PROJECT

3.1. PROJECT IN HONOURS PROGRAMME

- In Honours programme, the student has the option to do a Project of 12-credits instead of three Core Courses in Major in semester 8.
- The Project can be done in the same institution/ any other higher educational institution (HEI)/ research centre/ training centre.
- The Project in Honours programme can be a short research work or an extended internship or a skill-based training programme.
- A faculty member of the respective institution, where the student does the Project, should be the supervisor of the Project.

3.2. PROJECT IN HONOURS WITH RESEARCH PROGRAMME

- Students who secure 75% marks and above (equivalently, CGPA 7.5 and above) cumulatively in the first six semesters are eligible to get selected to Honours with Research stream in the fourth year.
- A relaxation of 5% in marks (equivalently, a relaxation of 0.5 grade in CGPA) is allowed for those belonging to SC/ ST/ OBC (non-creamy layer)/ Differently-Abled/ Economically Weaker Section (EWS)/ other categories of candidates as per the decision of the UGC from time to time.
- In Honours with Research programme, the student has to do a mandatory Research Project of 12-credits instead of three Core Courses in Major in semester 8.
- The approved research centres or any HEI can offer the Honours with Research programme. The departments in the affiliated colleges under University, which are not the approved research centres of the University, should get prior approval from the Providence Women's College to offer the Honours with Research programme. Such departments should have minimum two faculty members with Ph.D., and they should also have the necessary infrastructure to offer Honours with Research programme.

- A faculty member of the College with a Ph.D. degree can supervise the research project of the students who have enrolled for Honours with Research. One such faculty member can supervise maximum five students in Honours with Research stream.

The maximum intake of the department for Honours with Research programme is fixed by the department based on the number of faculty members eligible for project supervision, and other academic, research, and infrastructural facilities available.

- If a greater number of eligible students are opting for the Honours with Research programme than the number of available seats, then the allotment shall be based on the existing rules of reservations and merits.

3.3. GUIDELINES FOR THE PROJECT IN HONOURS PROGRAMME

AND HONOURS WITH RESEARCH PROGRAMME

1. Project can be in Mathematics or allied disciplines.
2. Project should be done individually.
3. Project work can be of theoretical/ experimental /computational in nature.

4. There should be minimum 360 hrs. of engagement from the student in the Project work in Honours programme as well as in Honours with Research programme.
5. There should be minimum 13 hrs./week of engagement (the hours corresponding to the three core courses in Major in semester 8) from the teacher in the guidance of the Project(s) in Honours programme and Honours with Research programme.
6. The various steps in project works are the following:
   - Wide review of a topic.
   - Investigation on a problem in a systematic way using appropriate techniques.
   - Systematic recording of the work.
   - Reporting the results with interpretation in a standard documented form.

Presenting the results before the examiners.

7. During the Project the students should make regular and detailed entries in to a personal log book through the period of investigation. The log book will be a record of the progress of the Project and the time spent on the work, and it will be useful in writing the final report. It may contain mathematical models and results, ideas, mathematical expressions, rough work and calculation, computer file names etc. All entries should be dated. The Project supervisor should periodically examine and countersign the log book.

8. The log book and the typed report must be submitted at the end of the Project. A copy of the report should be kept for reference at the department. A soft copy of the report too should be submitted, to be sent to the external examiner in advance.
9. It is desirable, but not mandatory, to publish the results of the Project in a peer reviewed journal.
10. The project report shall have an undertaking from the student and a certificate from the research supervisor for originality of the work, stating that there is no plagiarism, and that the work has not been submitted for the award of any other degree/ diploma in the same institution or any other institution.
11. The project proposal, institution at which the project is being carried out, and the project supervisor should be prior-approved by the Department Council of the college where the student has enrolled for the UG Honours programme.

3.4. EVALUATION OF PROJECT

- The evaluation of Project will be conducted at the end of the eighth semester by both internal and external modes.
- The Project in Honours programme as well as that in Honours with Research programme will be evaluated for 300 marks. Out of this, 90 marks are from internal evaluation and 210 marks, from external evaluation.
- The internal evaluation of the Project work shall be done through continuous assessment mode by a committee internally constituted by the Department Council of the college where the student has enrolled for the UG Honours programme. 30% of the weightage shall be given through this mode.
- The remaining 70% shall be awarded by the external examiner appointed by the Providence Women's College.
- The scheme of continuous evaluation and the end-semester viva-voce of the Project shall be as given below:

Sl. No	Components of Evaluation of Project	Marks for the Project (Honours/ Honours with Research)	Weightage
1	Continuous evaluation of project work through interim presentations and reports by the committee internally constituted by the Department Council	90	30%
2	End-semester viva-voce examination to be conducted by the external examiner appointed by the Providence Women's College.	150	50%
3	Evaluation of the day-to-day records and project report submitted for the end-semester viva–voce examination conducted by the external examiner	60	20%
	Total Marks	300	

INTERNAL EVALUATION OF PROJECT

Sl. No	Components of Evaluation of Project	Marks for the Project (Honours/ Honours with Research)
1	Skill in doing project work	30
2	Interim Presentation and Viva-Voce	20
3	Punctuality and Log book	20
4	Scheme/ Organization of Project Report	20
Total Marks		90

EXTERNAL EVALUATION OF PROJECT

Sl. No	Components of Evaluation of Project	Marks for the Project (Honours/ Honours with Research) 12 credits
1	Content and relevance of the Project, Methodology, Quality of analysis, and Innovations of Research	50
2	Presentation of the Project	50
3	Project Report (typed copy), Log Book and References	60
4	Viva-Voce	50
Total Marks		210

4. GENERAL FOUNDATION COURSES

All the General Foundation Courses (3-credits) in Mathematics are with only theory component.

4.1. INTERNAL EVALUATION

Sl. No.	Components of Internal Evaluation of a General Foundation Course in Mathematics	Internal Marks of a General Foundation Course of 3-credits in Mathematics	
		4 Theory Modules	Open-ended Module
1	Test paper/ Mid-semester Exam	10	2
2	Seminar/ Viva/ Quiz	6	2
3	Assignment	4	1
Total		20	5
		25	

4.2. EXTERNAL EVALUATION

External evaluation carries about 70% marks. Examinations will be conducted at the end of each semester. Individual questions are evaluated in marks and the total marks are converted into grades by the Providence Women's College based on 10-point grading system (refer section 5)

PATTERN OF QUESTION PAPER FOR GENERAL FOUNDATION COURSES

Duration	Type	Total No. of Questions	No. of Questions to be Answered	Marks for Each Question	Ceiling of Marks
1.5 Hours	Short Answer	10	8 – 10	2	16
	Paragraph/ Problem	5	4 – 5	6	24
	Essay	2	1	10	10
				Total Marks	50

5. LETTER GRADES AND GRADE POINTS

- Mark system is followed for evaluating each question.
- For each course in the semester letter grade and grade point are introduced in 10-point indirect grading system as per guidelines given below.
- The Semester Grade Point Average (SGPA) is computed from the grades as a measure of the student's performance in a given semester.
- The Cumulative GPA (CGPA) is based on the grades in all courses taken after joining the programme of study.
- Only the weighted grade point based on marks obtained shall be displayed on the grade card issued to the students.

LETTER GRADES AND GRADE POINTS

Sl. No.	Percentage of Marks (Internal & External Put Together)	Description	Letter Grade	Grade Point	Range of Grade Points	Class
1	95% and above	Outstanding	O	10	9.50 – 10	First Class with Distinction
2	Above 85% and below 95%	Excellent	A+	9	8.50 – 9. 49	
3	75% to below 85%	Very Good	A	8	7.50 – 8.49	
4	65% to below 75%	Good	B+	7	6.50 – 7.49	First Class
5	55% to below 65%	Above Average	B	6	5.50 – 6.49	
6	45% to below 55%	Average	C	5	4.50 – 5.49	Second Class
7	35% to below 45% aggregate (internal and external put together) with a minimum of 30% in external valuation	Pass	P	4	3.50 – 4.49	Third Class
8	Below an aggregate of 35% or below 30% in external evaluation	Fail	F	0	0 – 3.49	Fail
9	Not attending the examination	Absent	Ab	0	0	Fail

- When students take audit courses, they will be given Pass (P) or Fail (F) grade without any credits.
- The successful completion of all the courses and capstone components prescribed for the three-year or four-year programme with 'P' grade shall be the minimum requirement for the award of UG Degree or UG Degree Honours or UG Degree Honours with Research, as the case may be.

5.1. COMPUTATION OF SGPA AND CGPA

- The following method shall be used to compute the Semester Grade Point Average (SGPA):

  The SGPA equals the product of the number of credits (Ci) with the grade points (Gi) scored by a student in each course in a semester, summed over all the courses taken by a student in the semester, and then divided by the total number of credits of all the courses taken by the student in the semester,

  i.e. SGPA (Si) = Σi (Ci x Gi) / Σi (Ci)

  where Ci is the number of credits of the i^{th} course and Gi is the grade point scored by the student in the i^{th} course in the given semester. Credit Point of a course is the value obtained by multiplying the credit (Ci) of the course by the grade point (Gi) of the course.

ILLUSTRATION – COMPUTATION OF SGPA

Semester	Course	Credit	Letter Grade	Grade point	Credit Point (Credit x Grade)
I	Course 1	3	A	8	3 x 8 = 24
I	Course 2	4	B+	7	4 x 7 = 28
I	Course 3	3	B	6	3 x 6 = 18
I	Course 4	3	O	10	3 x 10 = 30
I	Course 5	3	C	5	3 x 5 = 15
I	Course 6	4	B	6	4 x 6 = 24
	Total	20			139
	SGPA				139/20 = 6.950

The Cumulative Grade Point Average (CGPA) of the student shall be calculated at the end of a programme. The CGPA of a student determines the overall academic level of the student in a programme and is the criterion for ranking the students.

CGPA for the three-year programme in FYUGP shall be calculated by the following formula.

CGPA for the four-year programme in FYUGP shall be calculated by the following formula.

- The SGPA and CGPA shall be rounded off to three decimal points and reported in the transcripts.
- Based on the above letter grades, grade points, SGPA and CGPA, the Providence Women's College shall issue the transcript for each semester and a consolidated transcript indicating the performance in all semesters.

MAJOR COURSES

Programme	B. Sc. Mathematics Honours			
Course Code	MAT1CJ101 / MAT1MN100			
Course Title	**DIFFERENTIAL CALCULUS**			
Type of Course	**Major**			
Semester	I			
Academic Level	100-199			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites	Basic knowledge of Sets, Relations and Functions, School Level Algebra and Real Numbers (0-99 level).			
Course Summary	The course covers fundamental concepts in calculus, including functions, shifting of graphs, limits, continuity, differentiation, extreme values, the Mean Value Theorem, graphing with derivatives, and limits at infinity with asymptotes. Students learn techniques for evaluating limits, finding extrema, and graphing functions using derivatives, preparing them for further studies in calculus and related fields.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Analyse a function for its limits, continuity and differentiability and evaluate limits and derivatives.	An	F	Internal Exam/Assignment /Seminar/Viva/ End Sem Exam
CO2	Apply first and second derivatives and related theorems to find extrema of functions.	Ap	F	Internal Exam/Assignment /Seminar/Viva/ End Sem Exam
CO3	Sketch the graph of functions by analysing critical points and asymptotes	An	F	Internal Exam/Assignment /Seminar/Viva/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge (F), Conceptual Knowledge (C), Procedural Knowledge (P), Metacognitive Knowledge (M)				

Detailed Syllabus:

Textbook	Calculus and Analytic Geometry, 9th Edition, George B. Thomas, Jr. Ross L. Finney, Pearson Publications, 2010, ISBN: 978-8174906168.			
Module	**Unit**	**Content**	**Hrs (48+12)**	**Marks Ext: 70**
I		**Module I**	12	Min.15
	1	Preliminaries: Section 3 - Functions		
	2	Preliminaries: Section 4 - Shifting Graphs.		
	3	Section 1.1-Rates of Change and Limits - Limits of Function Values onwards.		
	4	Section 1.2 - Rules for Finding Limits. Topics up to and including Example 3.		
	5	Section 1.2 - Rules for Finding Limits. Rest of the section.		
	6	Section 1.4- Extensions of the Limit Concept. Topics up to and including Example 6.		
II		**Module II**	15	Min.15
	7	Section 1.5 - Continuity.		
	8	Section 2.1 - The Derivative of a Function (The topic Graphing f' from estimated values is optional).		
	9	Section 2.2 - Differentiation Rules.		
	10	Section 2.3 - Rates of Change. Topics up to and including Example 5.		
	11	Section 2.5 - The Chain Rule. Topics up to and including Example 6.		
	12	Section 2.6- Implicit Differentiation and Rational Exponents. Topics up to and including Example 5.		
III		**Module III**	11	Min.15
	13	Section 3.1 - Extreme Values of Functions. Topics up to Finding Extrema.		
	14	Section 3.1 - Extreme Values of Functions- Topics from Finding Extrema onwards.		
	15	Section 3.2 - The Mean Value Theorem -Topics up to and including Example 4. (Proof of Theorem 3 is optional).		
	16	Section 3.2 - The Mean Value Theorem- Increasing Functions and Decreasing Functions		

	17	Section 3.3 - The First Derivative Test for Local Extreme Values.		
IV	**Module IV**		**10**	**Min.15**
	18	Section 3.4 - Graphing with y' and y'' - Topics up to and including Example 5.		
	19	Section 3.4 - Graphing with y' and y''- Topics from The Second Derivative Test for Local Extreme Values onwards.		
	20	Section 3.5 - Limits as $x \to \pm\infty$, Asymptotes and Dominant Terms. - Topics up to and including Summary for Rational Functions.		
	21	Section 3.5 - Limits as $x \to \pm\infty$, Asymptotes and Dominant Terms- Topics from Horizontal and Vertical Asymptotes up to and including Example 12.		
	22	Section 3.5 - Limits as $x \to \pm\infty$, Asymptotes and Dominant Terms-Topics from Graphing with Asymptotes and Dominant Terms onwards.		
V	**Module V (Open Ended)**		**12**	
	Trigonometric Functions, Tangent Values and Formal Definitions of Limits, Derivatives of Trigonometric Functions, Power Rule of Differentiation for rational powers, Optimization, Linearization and Differentials.			

References

1. Howard Anton, Biven, & Stephen Davis, Calculus, 7th Ed., Wiley India
2. Erwin Kreyszig, Advanced Engineering Mathematics, 10th Ed, John Wiley & Sons.
3. Robert T Smith and Roland B Minton, Calculus, 4th Ed. McGraw-Hill Companies
4. Soo T Tan, Calculus, 9th Ed.Brooks/Cole Pub Co.
5. Tom M. Apostol, Calculus, Vol 1: One Variable Calculus with an Introduction to Linear Algebra, 2nd Ed, John Wiley & Sons.
6. Michael Van Biezen Calculus Lectures: https://youtu.be/YZYxPclo2rg?si=qKCt6ty8m5dBR4DG

***Optional topics are exempted for end semester examination**

****70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.**

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	2	1	3	0	2	1	3	0	1
CO 2	2	3	2	1	3	0	2	1	3	0	1
CO 3	2	3	2	1	3	0	2	2	3	0	1

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	BSc Mathematics Honours			
Course Code	MAT2CJ101 / MAT2MN100			
Course Title	**INTEGRAL CALCULUS**			
Type of Course	**Major**			
Semester	II			
Academic Level	100-199			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites	Basic knowledge of Functions, Limits, Continuity and Differentiation (MAT1CJ101 - Differential Calculus).			
Course Summary	The course provides a comprehensive exploration of integral calculus, covering techniques such as indefinite integrals, Riemann sums, definite integrals, properties of integrals, the Fundamental Theorem, L'Hopital's Rule, basic integration formulas, and applications in finding areas between curves, volumes of solids, lengths of plane curves, and areas of surfaces of revolution. Through these topics, students gain proficiency in solving a wide range of mathematical problems involving integration and its applications in various fields.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Solve indefinite and definite integrals of functions.	Ap	F	Internal Exam/Assignment /Seminar/Viva/ End Sem Exam
CO2	Learn logarithmic, exponential, inverse trigonometric functions and to evaluate derivatives and integrals of the above transcendental functions and use it for computations of other limits	U	F	Internal Exam/Assignment /Seminar/Viva/ End Sem Exam
CO3	Apply integration formulas to find the area between two curves, the surface area and volume of a solid of revolution.	Ap	F	Internal Exam/Assignment /Seminar/Viva/ End Sem Exam

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Textbook	Calculus and Analytic Geometry, 9th Edition, George B. Thomas, Jr. Ross L. Finney, Pearson Publications, 2010, ISBN: 978-8174906168.			
Module	**Unit**	**Content**	**Hrs (48+12)**	**Marks Ext: 70**
		Module I		
I	1	Section 4.1 - Indefinite Integrals.	**14**	**Min.15**
	2	Section 4.3 - Integration by Substitution - Running the Chain Rule Backward.		
	3	Section 4.5 - Riemann Sums and Definite Integrals. (Example 9 is optional.)		
	4	Section 4.6 - Properties, Area, and the Mean Value Theorem - Topics up to and including Example 6.		
	5	Section 4.6 - Properties, Area, and the Mean Value Theorem- Topics from The Average Value of an Arbitrary Continuous Function onwards.		
		Module II		
II	6	Section 4.7 – The Fundamental Theorem (Example 6 is optional).	**11**	**Min.15**
	7	Section 4.8 - Substitution in Definite Integrals.		
	8	Section 6.2 - Natural Logarithms- Topics up to and including The Graph and Range of ln x.		
	9	Section 6.2 - Natural Logarithms. -Topics from Logarithmic Differentiation onwards.		
	10	Section 6.3 - The Exponential Function- Topics up to and including Example 4.		
	11	Section 6.3 - The Exponential Function- Topics from The Derivative and Integral of e^x onwards.		
		Module III		
III	12	Section 6.6 - L' Hopital's Rule	**12**	**Min.15**
	13	Section 6.9 - Derivatives of Inverse Trigonometric Functions; Integrals.		
	14	Section 7.1 - Basic Integration Formulas.		
	15	Section 7.2 - Integration by Parts		
	16	Section 7.3 Partial Fractions.		
		Module IV		
IV	17	Section 5.1 - Areas Between Curves. - Topics up to and including Example 2.	**11**	**Min.15**

	18	Section 5.1 - Areas Between Curves- Topics from Boundaries with Changing Formulas		
	19	Section 5.2 - Finding Volumes by Slicing. (Example 2 may be done as open ended).		
	20	Section 5.3 - Volumes of Solids of Revolution- Disks and Washers - Topics up to and including Example 4.		
	21	Section 5.5 - Lengths of Plane Curves. - Topics up to and including Example 2.		
	22	Section 5.6 - Areas of Surfaces of Revolution- Topics up to and including Example 2.		
V	**Module V (Open Ended)**		**12**	
	Inverse Functions and their Derivatives, a^x and $\log_a x$, Inverse Trigonometric Functions and their derivatives, Hyperbolic Functions, Integrals and their derivatives, Integration using trigonometric substitutions, Moments and Center of Mass.			

References

1. Howard Anton, Biven, & Stephen Davis, Calculus, 7th Ed., Wiley India
2. Erwin Kreyszig, Advanced Engineering Mathematics, 10th Ed, John Wiley & Sons.
3. Robert T Smith and Roland B Minton, Calculus, 4th Ed. McGraw-Hill Companies
4. Soo T Tan, Calculus, 9th Ed. Brooks/Cole Pub Co.
5. Tom M. Apostol, Calculus, Vol 1: One Variable Calculus with an Introduction to Linear Algebra, 2nd Ed, John Wiley & Sons.
6. Michael Van Biezen Calculus Lectures: https://youtu.be/YZYxPclo2rg?si=qKCt6ty8m5dBR4DG

***Optional topics are exempted for end semester examination**

****70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.**

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	2	1	3	0	3	1	3	0	1
CO 2	2	3	2	1	3	0	3	1	3	0	1
CO 3	2	3	2	1	3	0	3	2	3	0	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B.Sc. Mathematics Honours			
Course Code	MAT3CJ201			
Course Title	**MULTIVARIABLE CALCULUS**			
Type of Course	**Major**			
Semester	III			
Academic Level	200-299			
Course Details	Credit	Lecture/ Tutorial per week	Practical per week	Total Hours
	4	3	2	75
Pre-requisites	Basic knowledge of vectors, dot product, cross product, triple products, lines and planes in 3-dimensional space			
Course Summary	Multivariable Calculus takes the concepts learned in the single variable calculus course and extends them to multiple dimensions. Topics discussed include: Parameterizations of Plane Curves, Polar Coordinates, Lines and Planes in Space, Cylinders and Quadric Surfaces, Cylindrical and Spherical Coordinates, functions of many variables, limit, continuity, differentiation, and integration of vector-valued functions; application of vector-valued functions limits, and derivatives of multivariable functions, tangent planes and normal lines of surfaces, applying double and triple integrals to multivariable functions to find area, volume, surface area, vector fields, finding curl and divergence of vector fields; line integrals; Green’s Theorem; parametric surfaces, including normal vectors, tangent planes, and areas; orientation of a surface; Divergence Theorem; and Stokes’s Theorem.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Describe various coordinate systems—Cartesian, polar, cylindrical, and spherical—to represent, analyse, and interpret geometric figures and spatial relationships.	Ap	C	Internal Examination/ Assignment/ End Sem examination
CO2	Compute and apply limits, partial derivatives, and multiple integrals for functions of several variables to solve complex mathematical and real-world problems.	Ap	C	Internal Examination/Seminar/ Assignment/ Report/ End Sem examination
CO3	Apply advanced integration techniques and vector calculus principles to evaluate integrals in various coordinate systems and analyse vector fields and their applications in physics and engineering.	An	C	Internal Examination/Seminar/ Assignment/ Report/ End Sem examination
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Textbook	Calculus and Analytical Geometry, George B Thomas, Ross L Finney- Addison Wesley- 9th Edition.		
Module	**Unit**	**Content**	**Hrs (45+ 30)**
I		**Module I**	
	1	Section 9.4: Parameterizations of Plane Curves Topics up to and including Example 7	**10**
	2	Section 9.6: Polar Coordinates Definition of Polar Coordinates, Negative Values of r, Elementary Coordinate Equations and Inequalities, Cartesian Versus Polar Coordinates.	
	3	Section 10.5: Lines and Planes in Space Lines and Line Segments in Space, The Distance from a Point to a Line in Space, Equations for Planes in Space, Angles Between Planes; Lines of Intersection.	
	4	Section 10.6: Cylinders and Quadric Surfaces Cylinders, Drawing Lesson, Quadric Surfaces, Drawing Lesson.	
	5	Section 10.7: Cylindrical and Spherical Coordinates Cylindrical Coordinates, Spherical Coordinates	
II		**Module II**	
	6	Section 12.1: Functions of Several Variables Functions and Variables, Graphs and Level Curves of Functions of Two Variables, Contour Lines, Level Surfaces of Functions of Three Variables.	**12**
	7	Section 12.2: Limits and Continuity Limits, Continuity, Functions of More Than Two Variables.	
	8	Section 12.3: Partial Derivatives Definitions and Notation, Calculations, Functions of More Than Two Variables, The Relationship Between Continuity and the Existence of Partial Derivatives, Second Order Partial Derivatives, Euler's Theorem, Partial Derivatives of Still Higher Order.	
	9	Section 12.4: Differentiability, Linearization, and Differentials	

		Differentiability, How to Linearize a Function of Two Variables, How Accurate is the Standard Linear Approximation? Predicting Change with Differentials (Topics up to and including Example 7)	
	10	Section 12.5: The Chain Rule The Chain Rule for Functions of Two Variables (Proof of Theorem 5 is optional), The Chain Rule for Functions of Three Variables, The Chain Rule for Functions Defined on Surfaces, Implicit Differentiation, Remembering the Different Forms of the Chain Rule, The Chain Rule for Functions of Many Variables.	
III		**Module III**	
	11	Section 12.7: Directional Derivatives, Gradient Vectors, and Tangent Planes Directional Derivatives in the Plane, Geometric Interpretation of the Directional Derivative, Calculation, Properties of Directional Derivatives, Gradients and Tangent to Level Curves, Functions of Three Variables.	**11**
	12	Section 12.7: Directional Derivatives, Gradient Vectors, and Tangent Planes Equations for Tangent Planes and Normal Lines, Planes Tangent to a Surface z=f(x,y), Algebra Rules for Gradients.	
	13	Section 12.8: Extreme Values and Saddle points The Derivative Tests.	
	14	Section 12.8: Extreme Values and Saddle points Absolute Maxima and Minima on Closed Bounded Regions, Conclusion.	
	15	Section 12.9: Lagrange Multipliers Constrained Maxima and Minima, The Method of Lagrange Multipliers (Theorem 9 and Corollary of Theorem 9 are optional).	
	16	Section 12.9: Lagrange Multipliers Lagrange Multipliers with Two Constraints.	
IV		**Module IV**	
	17	Section 13.1: Double Integrals, Double Integrals over Rectangles, Properties of Double Integrals, Double Integrals as Volumes, Fubini's Theorem for Calculating Double Integrals.	**12**
	18	Section 13.1: Double Integrals	

		Double Integrals over Bounded Nonrectangular Regions, Finding the Limits of Integration.	
	19	Section 13.2: Areas, Moments and Centers of Mass Areas of Bounded Regions in the Plane, Average Value.	
	20	Section 13.3: Double Integrals in Polar Form Integrals in Polar Coordinates, Limits of Integration, Changing Cartesian Integrals into Polar Integrals.	
	21	Section 13.4: Triple Integrals in Rectangular Coordinates Triple Integrals, Properties of Triple Integrals, Volume of a Region in Space, Evaluation.	
	22	Section 13.4: Triple Integrals in Rectangular Coordinates Average Value of a Function in Space.	
V	**Practicum**		**30**
	Triple Integrals in Cylindrical Coordinates, Spherical coordinates Substitution in Multiple Integrals Vector Valued Functions and Space Curves Line Integrals Vector Fields, Work, Circulation and Flux Path Independence, Potential Functions and Conservative Fields. Green's Theorem in the Plane (Proof is Optional) Surface area and surface integrals Parametrized surfaces Stoke's theorem (Proof is optional) The Divergence theorem (Proof is Optional)		

References:

1. Anton, Bivens & Davis : Calculus Early Transcendentals (10/e) John Wiley & Sons, Inc.(2012) ISBN: 9780470647691
2. Arnold Ostebee & Paul Zorn: Multivariable Calculus (2/e) W. H. Freeman Custom Publishing, N.Y.(2008)ISBN: 9781429230339
3. James Stewart : Calculus (8/e) Brooks/Cole Cengage Learning(2016) ISBN:9781285740621
4. Jerrold E. Marsden & Anthony Tromba :Vector Calculus (6/e) W. H. Freeman and Company ,New York(2012) ISBN: 9781429215084
5. Joel Hass, Christopher Heil & Maurice D. Weir : Thomas' Calculus (14/e) Pearson(2018) ISBN 0134438981
6. Jon Rogawski: Multivariable Calculus Early Transcendentals (2/e) W. H. Freeman and Company (2012) ISBN: 1429231874

7. Robert A Adams & Christopher Essex : Calculus: A complete Course (8/e) Pearson Education Canada (2013) ISBN: 032187742X
8. William Wade: An Introduction to Analysis, (4/e) Pearson Education

***Optional topics are exempted for end semester examination **70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.**

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	3	3	3	3	2	1	1	1	1	3
CO 2	3	2	2	2	3	2	1	-	3	-	1
CO 3	3	2	1	1	3	2	1	1	1	-	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Report
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Seminar	Report	End Semester Examinations
CO 1	√	√			√
CO 2	√		√	√	√
CO 3	√		√	√	√

Programme	BSc Mathematics Honours			
Course Code	MAT3CJ202 / MAT3MN200			
Course Title	**MATRIX ALGEBRA**			
Type of Course	**Major**			
Semester	III			
Academic Level	200 – 299			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	4	-	60
Pre-requisites	1. System of linear equations and their solution sets. 2. Euclidean Spaces and their algebraic and geometric properties.			
Course Summary	This course covers matrix theory and linear algebra, emphasizing topics useful in many other disciplines. It begins with the study of systems of linear equations and the properties of matrices. Emphasis is given to topics including systems of equations, vector spaces, linear dependence and independence, dimension, linear transformations, eigenvalues and diagonalization.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand row reductions and echelon forms of a matrix and their uses in solving a linear system.	U	C	Internal Exam/Assignment/Seminar/Viva/ End Sem Exam
CO2	Define and compute eigen values and eigen vectors of a square matrix.	An	P	Internal Exam/Assignment/Seminar/Viva/ End Sem Exam
CO3	Interpret Linear Transformations using matrices and visualize geometrically.	An	C	Internal Exam/Assignment/Seminar/Viva/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Text Book	Linear Algebra and its Applications, Third Edition, David .C. Lay, Pearson Publications 2006.			
Module	**Unit**	**Content**	**Hrs (60)**	**External Marks (70)**
I		**Module I**		
	1	Section 1.1: Systems of Linear Equations Systems of Linear Equations, Matrix Notation, Solving a Linear System.		**Min. 15**
	2	Section 1.1: Systems of Linear Equations Elementary Row Operations, Existence and Uniqueness Questions.		
	3	Section 1.2: Row Reduction and Echelon Forms Row Reduction and Echelon Forms, Pivot Positions, The Row Reduction Algorithm.		
	4	Section 1.2: Row Reduction and Echelon Forms Solutions of Linear Systems, Parametric Descriptions of Solution Sets, Back Substitution, Existence and Uniqueness Questions.	14	
	5	Section 1.3: Vector Equations Vector Equations, Vectors in $\mathbb{R}^2$, Geometric Descriptions of $\mathbb{R}^2$, Vectors in $\mathbb{R}^3$, Vectors in $\mathbb{R}^n$.		
	6	Section 1.3: Vector Equations Linear Combinations, A Geometric Description of Span{□} and Span {□, □}, Linear Combinations in Applications.		
	7	Section 1.4: The Matrix Equation Ax = b The Matrix Equation Ax = b, Existence of Solutions, Computation of Ax, Properties of the Matrix-Vector Product Ax.		
II		**Module II**		
	8	Section 1.5: Solution Sets of Linear Systems Homogeneous Linear Systems, Parametric Vector Form, Solutions of Non-Homogenous Systems.		
	9	Section 1.7: Linear Independence	13	

		Linear Independence, Linear Independence of Matrix Columns, Sets of One or Two Vectors, Sets of Two or More Vectors.		Min. 15
	10	Section 1.8: Introduction to Linear Transformations Introduction to Linear transformations, Matrix Transformations.		
	11	Section 1.8: Introduction to Linear Transformations Linear Transformations		
	12	Section 1.9: The Matrix of a Linear Transformation The Matrix of a Linear Transformation, Geometric Linear Transformation of $\mathbb{R}^2$.		
	13	Section 1.9: The Matrix of a Linear Transformation Existence and Uniqueness Questions. (Topics up to and including Theorem 11).		
III		**Module III**		Min. 15
	14	Section 2.1: Matrix Operations Matrix Operations, Sums and Scalar Multiples, Matrix Multiplication, Properties of Matrix Multiplication, Powers of a Matrix, The Transpose of a Matrix.	11	
	15	Section 2.2: The Inverse of a Matrix The Inverse of a Matrix (Example 3 is optional), Elementary Matrices (Proof of Theorem 7 is optional).		
	16	Section 2.2: The Inverse of a Matrix An Algorithm for Finding A^{-1}, Another View of Matrix Inversion.		
	17	Section 2.8 : Subspaces of $\mathbb{R}^n$ Subspaces of $\mathbb{R}^n$, Column Space and Null Space of a Matrix, Basis for a Subspace.		
	18	Section 2.9: Dimension and Rank Coordinate Systems, The Dimension of a Subspace (Topics up to and including Theorem 15).		
IV		**Module IV**		
	19	Section 5.1: Eigen Vectors and Eigen Values Eigen Vectors and Eigen Values (Topics up to and including Theorem 2).	10	

	20	Section 5.2: The Characteristic Equation The Characteristic Equation, Determinants (Topics up to and including Theorem 3).		Min. 15
	21	Section 5.2: The Characteristic Equation The Characteristic Equation, Similarity (Topics up to and including Theorem 4).		
	22	Section 5.3: Diagonalization Diagonalization (Proof of Theorem 5 is optional), Diagonalizing Matrices, Matrices Whose Eigen Values Are Not Distinct.		
V	**Module V (Open Ended)**		**12**	
	Determinants, Properties of Determinants, Applications of Linear Systems, Characterizations of Invertible Matrices, Partitioned Matrices, Application to Computer Graphics, Eigen Vectors and Linear Transformations.			

References

1. Elementary Linear Algebra, Howard Anton, Chris Rorres, Wiley Publications
2. Linear Algebra Done Right, 3/e, Sheldon Axler, Springer Nature,2015.
3. Introduction to Linear Algebra, 6/e, Gilbert Strang, Wellesley•Cambridge Press.
4. Basic Linear Algebra, 2/e, T. S. Blyth and E.F. Robertson, Springer, 2002.
5. Linear Algebra And its Applications, 4/e, Gilbert Strang, Cengage India Private Limited
6. Linear Algebra – A Geometric Approach, S.Kumaresan, Prentice Hall of India.
7. Bretscher, Otto. *Linear algebra with applications*. Vol. 52. Eaglewood Cliffs, NJ: Prentice Hall, 1997.
8. Holt, Jeffrey. *Linear Algebra with Applications*. wh freeman, 2017.

***Optional topics are exempted for end semester examination**

****70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.**

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	3	1	3	0	3	0	3	0	0
CO 2	1	3	2	2	3	0	3	0	3	0	0
CO 3	2	1	3	3	3	0	3	0	3	0	0

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	BSc Mathematics Honours			
Course Code	MAT4CJ203			
Course Title	**REAL ANALYSIS I**			
Type of Course	**Major**			
Semester	IV			
Academic Level	200 – 299			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	3	2	75
Pre-requisites	1. Mathematical Logic and necessary exposure to set theory. 2. Basic Calculus			
Course Summary	After introducing the basic notions in set theory, the course develops into the construction of the Real number system. Thereafter Real functions are introduced and the notions of limit and continuity are developed.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Demonstrate Proficiency in Set Theory Fundamentals and Real Number Properties	An	C	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO2	Apply the completeness property of $\mathbb{R}$, and solve problems involving intervals and applications of the supremum property.	U	C	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO3	Analyse sequences and their limits, apply limit theorems, and demonstrate an understanding of concepts such as monotone sequences, sub-sequences, and the Cauchy Criterion, as well as their applications in solving problems related to sequences and limits.	An	C	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Textbook	Introduction to Real Analysis, 4/e, Robert G Bartle, Donald R Sherbert John Wiley & Sons (2011)			
Module	**Unit**	**Content**	**Hrs (45+30)**	**External Marks (70)**
I		**Introduction to Set theory**	**8**	**Min.15**
	1	Section 1.1 - Sets and functions (for review only)		
	2	Section 1.2 - Mathematical Induction (Proofs of results included in practicum part).		
	3	Section 1.3 – Finite and Infinite sets.		
	4	Section 1.3 – Countable and Uncountable sets.		
II		**The Real numbers**	**13**	**Min.15**
	5	Section 2.1 – The algebraic properties of $\mathbb{R}$.		
	6	Section 2.1 – The order properties of $\mathbb{R}$.		
	7	Section 2.2 – Absolute value and the Real Line.		
	8	Section 2.3 – Completeness property of $\mathbb{R}$ (Proofs included in Practicum).		
	9	Section 2.4 – Applications of the Supremum property - 2.4.3 to 2.4.6 and 2.4.8 to 2.4.9 (All other discussions included in Practicum).		
	10	Section 2.5 – Intervals – 2.5.2 to 2.5.4 (All other discussions included in Practicum).		
III		**Sequences and Limits**	**12**	**Min.15**
	11	Section 3.1 – Sequences and their limits.		
	12	Section 3.1 – Problems to find limits of sequence.		
	13	Section 3.2 – Limit theorems.		
	14	Section 3.2 – Problems using Limit theorems.		
	15	Section 3.3 – Monotone sequences – Monotone Convergence Theorem.		
	16	Section 3.3 – Applications of Monotone Convergence Theorem – Euler's number introduction only.		
IV		**Sequences and Limits (continued)**	**12**	**Min.10**
	17	Section 3.4 – Sub sequences and the Bolzano Weierstrass theorem (Second proof of Theorem 3.4.8 is omitted for external exam and limits superior and inferior are included in practicum).		
	18	Section 3.4 – Problems using Divergence criteria.		
	19	Section 3.5 – The Cauchy Criterion (Examples 3.5.9, 3.5.11 and Corollary 3.5.10 are included in Practicum).		
	20	Section 4.1- Limits of functions (Proofs included in Practicum).		
	21	Section 4.2: Limit theorems of functions (Proofs included in Practicum).		

	22	Section 4.3: Some extensions of limit concepts (Proofs included in Practicum).		
V		**Practicum:** The goal is for the students to learn the following topics in 15 practicum sessions of two hours each via self-study and group activities. The lecturer may assist by running group discussions, supervising class seminars and referring library books for self-study and note preparation.	**30**	**-**
	1	Section 1.2 - for detailed discussions including proofs		
	2	Section 2.3 – re do it with all the proofs		
	3	Section 2.4 – Worked out examples for applying the ideas of supremum and infimum and the existence of square root of 2		
	4	Section 2.5 – Characterization theorem for intervals and representations of real numbers		
	5	Section 3.4 – discussions of limit inferior and limit superior with examples		
	6	Section 3.5 – Estimation of errors in contractive sequences with examples		
	7	Section 3.6 – Properly divergent Sequences		
	8	Section 3.7 – Introduction to Infinite Series – conditions for convergence – Harmonic Series		
	9	Section 3.7 – Comparison Tests with examples		
	10	Section 4.1 – Formulate a precise definition of limit and illustrate with examples		
	11	Section 4.1 – Sequential Criterion for Limits for convergence and divergence with examples		
	12	Section 4.2 – Limit theorems for functions in parallel to that of sequences.		
	13	Section 4.3 – One sided and infinite limits.		
	14	Section 11.1 – Open sets, their properties and characterization.		
	15	Section 11.1 - Closed sets, their properties and characterization.		

References

1. Tom.M. Apostol, Calculus I, Wiley & Sons.
2. Tom.M. Apostol, Mathematical Analysis, 2/e, Addison-Wesley.
3. Richard R Goldberg, Methods of Real Analysis, 2/e, Wiley
4. Raymond L Wilder, Introduction to the Foundations of Mathematics,2/e, John WileySons

Optional Programming References for Practicum:

(1) SageMath Calculus Tutorial https://www.sagemath.org/calctut/limits.html

(2) SageMath 2D plotting https://doc.sagemath.org/html/en/reference/plotting/sage/plot/plot.html#

***70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.**

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	1	3	2	3	0	3	0	3	0	0
CO 2	1	3	2	2	3	0	3	0	3	0	0
CO 3	3	2	3	3	3	0	3	0	3	0	0

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Report
- Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment/ Report	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	BSc Mathematics Honours			
Course Code	MAT4CJ204			
Course Title	**BASIC LINEAR ALGEBRA**			
Type of Course	**Major**			
Semester	IV			
Academic Level	200 – 299			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	4	--	60
Pre-requisites	1. Familiarity with system of equations and their solutions 2. Knowledge about matrices and matrix operations.			
Course Summary	This course is a quick review of linear algebra, intended for students who have already taken a previous course in linear algebra or have some experience with vectors and matrices. It begins with the concepts of vector spaces, subspaces, bases and dimension. Linear transformations are introduced as 'natural maps' between vector spaces. The course opens up the classical finite dimensional inner product theory for the canonical reduction of a matrix as a special case of a self-adjoint operator.			

Course Outcomes:

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand and apply concepts related to vector spaces and subspaces, including determining whether a set forms a subspace and finding the span of a set	U	C	Internal Exam/Assignment/Seminar/ Viva/ End Sem Exam
CO2	Demonstrate proficiency in analysing null spaces, column spaces, and linear transformations, including understanding the kernel and range of a linear transformation and contrasting the properties of null space and column space.	An	P	Internal Exam/Assignment/Seminar/ Viva/ End Sem Exam
CO3	Evaluate and apply concepts related to bases, dimensionality, and rank of vector spaces, including understanding bases for null space and column space, determining dimensions of subspaces, and applying the rank theorem to systems of equations.	E	C	Internal Exam/Assignment/Seminar/ Viva/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Text Book	Linear Algebra and its Applications, Third Edition, David .C. Lay, Pearson Publications			
Module	**Unit**	**Content**	**Hrs (48+ 12)**	**External Marks (70)**
I		**Module I**		**Min 15**
	1	Section 4.1: Vector Spaces and Subspaces Vector Spaces and Subspaces, Subspaces, A Subspace Spanned by a Set.	**14**	
	2	Section 4.2: Null Spaces, Column Spaces, and Linear Transformations. The Null Space of a Matrix, An Explicit Description of Nul A.		
	3	Section 4.2: Null Spaces, Column Spaces, and Linear Transformations. The Column Space of a Matrix, The Contrast Between Nul A and Col A.		
	4	Section 4.2: Null Spaces, Column Spaces, and Linear Transformations. Kernel and Range of a Linear Transformation.		
	5	Section 4.3: Linearly Independent Sets; Bases. Linearly Independent Sets; Bases, The Spanning Set Theorem.		
	6	Section 4.3: Linearly Independent Sets; Bases. Bases for Nul A and Col A, Two Views of a Basis.		
II		Module II		Min 15
	7	Section 4.4: Coordinate Systems. Coordinate Systems, A Graphical Interpretation of Coordinates, Coordinates in $\mathbb{R}^n$.	**12**	
	8	Section 4.4: Coordinate Systems. The Coordinate Mapping.		
	9	Section 4.5: The Dimension of a Vector Space. The Dimension of a Vector Space.		
	10	Section 4.5: The Dimension of a Vector Space. Subspaces of a Finite-Dimensional Space, The Dimensions of Nul A and Col A.		
	11	Section 4.6: Rank Rank, The Row Space.		
	12	Section 4.6: Rank The Rank Theorem, Applications to Systems of Equations (Topics up to and including Example 5).		
III		Module III		Min 15
	13	Section 6.1: Inner Product, Length and Orthogonality The Inner Product, The Length of a Vector, Distance in $\mathbb{R}^n$.	**12**	
	14	Section 6.1: Inner Product, Length and Orthogonality Orthogonal Vectors, Orthogonal Complements, Angles in $\mathbb{R}^2$ and $\mathbb{R}^3$.		

	15	Section 6.2: Orthogonal Sets Orthogonal Sets, An Orthogonal Projection (Topics up to and including Example 4).		
	16	Section 6.2: Orthogonal Sets Orthonormal Sets.		
	17	Section 6.4: The Gram-Schmidt Process The Gram -Schmidt Process, Orthonormal Bases.		
	18	Section 6.4: The Gram -Schmidt Process QR Factorization of Matrices.		
IV	Module IV			Min 15
	19	Section 7.1: Diagonalization of Symmetric Matrices Diagonalization of Symmetric Matrices.	**10**	
	20	Section 7.1: Diagonalization of Symmetric Matrices The Spectral Theorem. Spectral Decomposition.		
	21	Section 7.2: Quadratic Forms Quadratic Forms (Topics up to and including Example 3), Classifying Quadratic Forms.		
	22	Section 7.4: The Singular Value Decomposition The Singular Value Decomposition, The Singular Values of an $m \times n$ Matrix , The Singular Value Decomposition (Topics up to and including Example 4 only).		
V	**OPEN ENDED**		12	
	Linear Algebra Lab Sessions Book: Mike Cohen, Practical Linear Algebra for Data Science, O'Reilly, 2019, ISBN 978-1-098-12061-0. Jupyter: https://github.com/mikexcohen/LinAlg4DataScience Choose lab demos and exercises for 12 hours as per lecturer's discretion. For Module I & II, Ch 2, 3, 5, 6 of book for Lab. For Module III, Ch 2 and Ch 9 of book for Lab. For Module IV, Ch 14 of book for Lab. Python and Jupyter review in Ch 16 of book.			

References

1. Elementary Linear Algebra: Application Version,11/e, Howard Anton & Chris Rorres Wiley
2. Algebra Done Right, 3/e, Sheldon Axler, Springer Nature,2015.
3. Introduction to Linear Algebra, 6/e, Gilbert Strang, Wellesley•Cambridge Press.
4. Basic Linear Algebra, 2/e, T. S. Blyth and E.F. Robertson, Springer, 2002.
5. Linear Algebra, 2/e, Hoffman K and Kunze R, Prentice Hall of India,1991.
6. Bretscher, Otto. *Linear algebra with applications*. Vol. 52. Eaglewood Cliffs, NJ: Prentice Hall, 1997.
7. Blyth, Thomas Scott, and Edmund F. Robertson. *Basic linear algebra*. Springer Science & Business Media, 2013.

***70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.**

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	1	2	2	3	0	3	0	3	0	0
CO 2	1	3	2	2	3	0	3	0	3	0	0
CO 3	3	2	3	3	3	0	3	0	3	0	0

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	BSc Mathematics Honours			
Course Code	MAT4CJ205			
Course Title	**FUNDAMENTALS OF PYTHON AND SAGEMATH**			
Type of Course	**Major**			
Semester	IV			
Academic Level	200-299			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	3	2	75
Pre-requisites	1) Basic knowledge to start a desktop/laptop computer 2) A basic course in calculus with an understanding of differential and integral calculus (higher secondary level and one or two semester courses from Bsc) 3) A basic course in linear algebra ((higher secondary level))			
Course Summary	In the first part of the course, it intends to give a quick introduction to writing python programs using various popular interfaces. How to handle data and save and read them files is introduced next along with the concepts of repeating the tasks using conditionals and loops. The problems connected with matrices and arrays is solved using the python module numpy. The python module SymPy is used to do various mathematical problems related with symbolic computations. A brief introduction of python module pandas is given, which is used to do data analysis. Using the Python programming structure, an introduction to the advance mathematics software sagemath is given in the second part of the course. Various practical problems making use of concepts from the calculus and linear algebra are to be solved using the sagemath software so that the students will come to know some of the applications of mathematics in real life.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category #	Evaluation Tools used
CO1	Develop proficiency in fundamental to advanced Python programming concepts, including variables, data types, control structures, functions, modules, file handling, and matrix operations.	C	C	Internal Exam/Quiz/End Sem
CO2	Demonstrate competence in data visualization techniques using Matplotlib, encompassing plotting mathematical functions, 2D and 3D graphics, and animated plots.	Ap	C	Internal Exam /Assignment/ End Sem
CO3	Develop proficiency in symbolic computation with SymPy, data manipulation with Pandas, and algebraic computations with SageMath, enabling them to solve diverse mathematical problems numerically and analytically.	C	C	Internal Exam /viva/ Seminar/End Sem

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Textbook	1. Ajith Kumar B.P., Python for Education, https://scischool.in/python/pythonForEducation.pdf 2. Gregory V. Bard, Sage for Undergraduates (online version) http://www.people.vcu.edu/~clarson/bard-sage-for-undergraduates-2014.pdf 3. Tuan A. Le and Hieu D. Nguyen, SageMath Advice For Calculus, https://users.rowan.edu/~nguyen/sage/SageMathAdviceforCalculus.pdf		
Module	**Unit**	**Content**	**Hrs (45+ 30)**
I		**Introductory Python and Arrays (Text 1: Chapter 2, Chapter 3)**	
	1	Section 2.1: Getting started with Python Section 2.2: Variables and Data Types, Keywords, Section 2.3: Operators and their Precedence.	**12**
	2	Section 2.4: Python Strings Section 2.5: Python Lists Section 2.6: Mutable and Immutable Types. Section 2.7: Input from the Keyboard Section 2.8: Python Syntax, Colon & Indentation	
	3	Section 2.9: Controlling the Programe Flow Section 2.10: Iteration: for loops Section 2.11: Conditional Execution: if, elif and else Section 2.12: Modify loops: break and continue..	
	4	Section 2.15: Functions Section 2.17: Python Modules and Packages. Section 2.18: File Input/Output Section 2.19: Formatted Printing. Section 2.21: Matrices in pure Python.	
	5	All topics up to Section 3.1, Section: 3.1: NumPy Arrays	
	6	Section: 3.2: Vectorizing Functions.	

II		**Data Visualization (Text 1: Chapter 4)**	
	7	Section: 4.1: The Matplotlib Module	**10**
	8	Section: 4.2: Plotting mathematical functions Section: 4.3: Plotting Error Bars, Section: 4.4: Simple 2D animation.	
	9	Section: 4.5: Famous Curves Section: 4.6: 2D plot using colors.	
	10	Section: 4.7: 3D Plots.	
III		**Introduction to SymPy and Pandas (Text 1: Chapter 5 and Chapter 6)**	
	11	All topics up to Section 5.1, Section 5.1: SymPy, Symbolic Computation in Python.	**10**
	12	Section 5.2: SymPy, Derivative and Integral	
	13	Section 5.3: SymPy, Operation on sets	
	14	Section 6.1: Series	
	15	Section 6.2: Data Frame	
	16	Section 6.3: Practical Examples	
IV		**Sagemath – An Introduction**	
		(Text 2: Chapter 1, For units 17,18,19)	
	17	Getting and installing sagemath in Windows, Ubuntu OS Using sagemath using cocalc (online) Section 1.1: Using Sage as a Calculator Section 1.2: Using Sage with Common Functions Section **1.3:** Using Sage for Trigonometry	**13**
	18	Section 1.5: Matrices and Sage, Part One 1.5.1: A First Taste of Matrices 1.5.3: Doing the RREF in Sage	
	19	Section 1.5: Using Sage to Manipulate Polynomials	
		(Text 3: Chapter 2, 3, 5, For units 20,21,22)	
	20	Section 2.1: Plotting Graphs	

	21	Section 3.1: The Derivative Section 3.2: Higher-Order Derivatives	
	22	Section 5.1: Antiderivatives (Indefinite Integral), Section 5.2: Riemann Sums and the Definite Integral All topics up to 5.2.1, 5.2.1: Riemann Sum Using Left Endpoints	
	Practical (Open-ended)		30
	Online References for Practical		
	1 Python official website and documentation, https://www.python.org/ 2 Spyder official website and documentation, https://www.spyder-ide.org/ 3 Getting Started: Python and IDLE, MIT Courseware, https://web.mit.edu/6.s189/www/handouts/GettingStarted.html 4 Jupyter Notebook, https://jupyter.org/ 5 Google Colaboratory (colab), https://colab.google/ 6 Pydroid 3 IDE for Android (https://play.google.com/store/apps/details?id=ru.iiec.pydroid3&hl=en_US&pli=1) with Pydroid 3 repository plugin (https://play.google.com/store/apps/details?id=ru.iiec.pydroid3.quickinstallrepo&gl=US).		
	Practical problems in basic Python 1) Write a programme to work as a basic Income Tax Calculator 2) Write a program that takes the length of an edge (an integer) as input and prints the cube's surface area as output. 3) Write a loop that counts the number of space characters in a string. Recall that the space character is represented as ' '. 4) Write a while loop that computes the factorial of a given integer N.		

	5) Write a program that computes square roots. 6) Write a programme for data Encryption based on Caeser shift. 7) Develop a program that computes the Flesch Index for a text file. 8) Using a List to Find the Median of a Set of Numbers 9) Finding the Mode of a List of Values. **Numerical methods using python (Text1: Chapter 7)(7.1 - 7.10, 7.12)** 1) Evaluate a Taylor series numerically. 2) Interpolate a function using a) Newton's forward interpolation b) Newton's backward interpolation c) Lagrange's Interpolation d) Newton's General Interpolation 3) Find integral of function using a) Trapezoidal rule b) Simpson's 1/3-rule 4) Find derivative of function numerically. 5) Solve first order differential equations numerically. a) Euler method b) Fourth order Runge-Kutta method 6) Solve algebraic equations numerically. a) The Bisection method b) Regula Falsi Method **Practical problems using numpy, matplotlib, pandas and sympy** **1)** Various vector operations. such as dot product, cross product and divergent using numpy module. **2)** Various matrix operations such as determinant, inverse and transpose using numpy module. **3)** Solve system of linear equations using numpy module. **4)** Plot various 2-D, 3-D curves using matplotlib module.	

5) Plot various 3-D surfaces using matplotlib module.

6) Find maxima and minima of a function using SymPy module.

7) Necessary data analysis of a given data using pandas module.

Practical problems in Sage

1) Solve a system of linear equations (Text 2)

2) Constrained Optimization by Lagrange Multipliers (Text 2, 4.18.2)

3) Traffic Flow (Text 3)

4) Minimum Cost (Text 3)

5) Packaging (Minimum Surface Area) (Text 3)

6) Maximize Revenue (Text 3)

7) Area Between Curves (Text 3)

8) Average Value and mean value theorem (Text 3, 6.2)

9) Newton's Method to find approximate roots (Text 3)

References:

1 Amit Saha, Doing Math with Python, No Starch Press, 2015.
2 Vernon L. Ceder, The Quick Python Book, Second Edition, Manning.
3 Python tutorial online, https://www.geeksforgeeks.org/python-programming-language/
4 2D plotting, https://doc.sagemath.org/html/en/reference/plotting/sage/plot/plot.html
5 3D Graphics, https://doc.sagemath.org/html/en/reference/plot3d/index.html
6 Linear Algebra, https://doc.sagemath.org/html/en/tutorial/tour_linalg.html
7 John Harris, Karen Kohl, and John Perry, Peering into Advanced Mathematics through Sage-colored Glasses
8 Paul Zimmermann, Alexandre Casamayou, Computational Mathematics with SageMath, https://www.sagemath.org/sagebook/english.html
Kenneth A Lambert, Fundamentals of Python First Programs, Edn 2, Cengage

***70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.**

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	2	3	1	3	2	3	3	1	1	2
CO 2	2	2	3	1	3	2	3	3	1	1	2
CO 3	2	2	3	1	3	2	3	3	1	1	2

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Quiz
- Practical Based Assessment
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Quiz	Viva	Practical based assessment	End Semester Examinations
CO 1	√			√		√	√
CO 2	√	√				√	√
CO 3	√		√		√	√	√

Programme	B. Sc. Mathematics Honours			
Course Code	MAT5CJ301			
Course Title	**REAL ANALYSIS II**			
Type of Course	**Major**			
Semester	V			
Academic Level	300 – 399			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	3	2	75
Pre-requisites	1. Mathematical Logic and necessary exposure to set theory. 2. Basic Calculus 3. Real Analysis I			
Course Summary	Continuous real functions are introduced rigorously using the epsilon-delta argument. The equivalent sequential criterion is established later. Differentiable and (Riemann) Integrable functions are introduced followed by the fundamental theorem of calculus connecting the two notions. The course concludes with a discourse on series of functions and various results discussing the compatibility of the above three notions with the limiting operations on series of functions.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Analyse and explain the concept of continuous functions and their properties on intervals, and apply the principles of uniform continuity.	An	C	Internal Exam/Assignment/ Seminar/ Viva/Report/ End Sem Exam
CO2	Analyse the vitality of continuous functions when they are defined on intervals.	An	C	Internal Exam/Assignment/ Seminar/ Viva/Report/ End Sem Exam
CO3	Apply the derivative and the Mean Value Theorem to solve problems and prove related theorems.	Ap	P	Internal Exam/Assignment/ Seminar/ Viva/Report/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Textbook	Introduction to Real Analysis, 4/e, Robert G Bartle, Donald R Sherbert John Wiley & Sons(2011)			
Module	**Unit**	**Content**	**Hrs (45+30)**	**Marks Ext:70**
I		**Continuous Functions**	**14**	**Min.15**
	1	Section 5.1 – Continuous functions		
	2	Section 5.3 – Continuous functions on intervals — 5.3.1 to 5.3.5		
	3	Section 5.3 – from 5.3.7 - 5.3.10		
	4	Section 5.4 – Uniform Continuity-up to 5.4.3		
	5	Section 5.4 – Uniform Continuity-5.4.4 to 5.4.14(proof of Weierstrass Approximation Theorem is optional)		
	6	Selected problems from the above sections.		
II		**Differentiation**	**10**	**Min.15**
	7	Section 6.1 – The Derivative – 6.1.1 to 6.1.7		
	8	Section 6.2- The Mean Value Theorem - 6.2.1 to 6.2.6		
	9	Section 6.2 - from 6.2.7 to 6.2.9		
	10	Section 6.2-The Mean Value Theorem- 6.2.10 to 6.2.13		
	11	Selected problems in the above sections.		
III		**The Riemann Integral**	**14**	**Min.20**
	12	Section 7.1 – Riemann Integral – up to 7.1.4 (a)		
	13	Section 7.1 – from 7.1.5 to 7.1.7 (proof of 7.1.7 is optional)		
	14	Section 7.2 – Riemann Integrable functions – 7.2.1 to 7.2.5 (Examples 7.2.2 are optional)		
	15	Section 7.2 – from 7.2.7 to 7.2.13		
	16	Section 7.3 – The Fundamental Theorem – 7.3.1 to 7.3.7		
	17	Section 7.3 – from 7.3.8 to 7.3.18 (proof of theorem 7.3.18 is optional)		
	18	Selected problems in the above sections.		
IV		**Sequences and Series of functions**	**7**	**Min.10**
	19	Section 8.1 – Pointwise and Uniform Convergence – 8.1.1 to 8.1.3		
	20	Section 8.1 – from 8.1.4 to 8.1.10		
	21	Section 8.2 – Interchange of limits – 8.2.1		
	22	Section 8.2 – Interchange of limits- 8.2.3		
V		**Practicum:** The goal is for the students to learn the following selected topics in 15 practicum sessions of two hours each via self-study and group activities. The lecturer may assist by running group discussions, overseeing class seminars and referring library books for self-study and note preparation.	**30**	
	1	Section 5.2 – Combinations of continuous functions		

	2	Section 5.6 – from 5.6.5 to 5.6.7		
	3	Section 6.1 – Inverse Functions – 6.1.8 to 6.1.10		
	4	Section 6.3 – from 6.3.5 to 6.3.7		
	5	Section 6.4 – Taylor's theorem – 6.4.1 to 6.4.4		
	6	Section 6.4 – from 6.4.5 to 6.4.8		
	7	Section 9.1 – Absolute Convergence – 9.1.1 to 9.1.3		
	8	Section 9.1 – 9.1.4 to 9.1.5		
	9	Section 9.2 – Limit Comparison Test with examples		
	10	Section 9.2 – Root Test with examples		
	11	Section 9.2 – Ratio Test with examples		
	12	Section 9.2 – Integral Test with examples		
	13	Section 9.2 – Raabe's Test with examples		
	14	Section 9.3 – Alternating Series Test		
	15	Section 9.4 – Infinite Series – Series of Functions – 9.4.1 to 9.4.7		

Reference

1. Apostol, Tom M. Calculus, Volume 1. John Wiley & Sons, 1991.
2. Tom.M. Apostol, Mathematical Analysis, 2/e, Addison-Wesley, 2002.
3. Richard R Goldberg, Methods of Real Analysis, 2/e, Wiley, 2020
4. Raymond L Wilder, Introduction to the Foundations of Mathematics,2/e, John Wiley & Sons
5. Malik, Subhash Chandra, and Savita Arora. Mathematical analysis. New Age International, 1992.

***Optional topics are exempted for end semester examination**

****70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.**

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	2	2	1	2	0	2	0	3	0	0
CO 2	2	2	2	1	2	0	2	0	3	0	0
CO 3	3	2	3	1	3	0	3	0	3	0	0

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Report
- Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment/ Report	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT5CJ302			
Course Title	**ABSTRACT ALGEBRA I**			
Type of Course	**Major**			
Semester	V			
Academic Level	300-399			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites	Basic set theory, algebra of Integers, operations on functions, basic proof techniques etc.			
Course Summary	This course explores the algebraic concepts of Binary Operations, Binary Structures, Groups, Rings, Integral Domains and Fields. We further study the Theory of Groups. Elementary properties, Subgroups, Finite Groups, Cyclic Groups, Groups of Permutations, Orbits, Cycles, Alternating Groups, Cosets and the Theorem of Lagrange are studied. Then we study mappings between groups or Homomorphisms. Finally, the Open-ended section points to Generating sets, Factor Groups and Field of Quotients of an Integral Domain.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Discuss about binary operations, isomorphic binary structures and groups	U	C	Internal Exam/ Assignment/Seminar/ Viva/End Sem Exam
CO2	Analyse and classify subgroups and cyclic groups, and determine their properties using group theory.	An	P	Internal Exam/ Assignment/Seminar/ Viva/End Sem Exam
CO3	Evaluate and apply theorems related to cosets, Lagrange's theorem, homomorphisms, rings, and fields to solve complex algebraic problems.	E	F	Internal Exam/ Assignment/Seminar/ Viva/End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Text book	A first course in abstract algebra, Fraleigh, John B.. Seventh Edition, Pearson Education India, 2003			
Module	**Unit**	**Content**	**Hrs (48+12)**	**Marks Ext(70)**
I		**Module I**	**12**	**Min.15**
	1	Section 2- Binary Operations (2.1 to 2.10)		
	2	Section 2- Binary Operations (2.11 to 2.25)		
	3	Section 3- Isomorphic Binary Structures (3.1 to 3.11).		
	4	Section 3- Isomorphic Binary Structures (3.12 to 3.17)		
	5	Section 4- Groups (4.1 to 4.14)		
	6	Section 4- Groups – Elementary Properties of Groups, Finite Groups and Group tables (4.15 onwards)		
II		**Module II**	**14**	**Min.15**
	7	Section 5- Subgroups (5.1 to 5.16)		
	8	Section 5 -Subgroup - Cyclic Subgroups (5.17 to 5.23)		
	9	Section 6 -Cyclic Groups (6.1 to 6.9) (Proof of Theorem 6.3 is optional)		
	10	Section 6- Cyclic Groups (6.10 to 6.17) (Proof of Theorem 6.14 is optional).1		
	11	Section 8-Groups of Permutations (up to 8.6)		
	12	Section 8- Groups of Permutations (8.7 to 8.18)		
III		**Module III**	**10**	**Min.15**
	13	Section 9 - Orbits, Cycles, and the Alternating Groups (Up to 9.10)		
	14	Section 9 - Orbits, Cycles, and the Alternating Groups (9.11 to 9.21) (Proof 2 of theorem 9.15 is optional).		
	15	Section 10- Cosets and the theorem of Lagrange (Up to 10.9)		
	16	Section 10- Cosets and the theorem of Lagrange (10.10 to 10.14)		

IV		**Module IV**	**12**	**Min.15**
	17	Section 13- Homomorphisms (13.1 to 13.10)		
	18	Section 13-Homomorphism (13.11 to 13.20)		
	19	Section 18-Rings and Fields (18.1 to 18.13)		
	20	Section 18-Rings and Fields (18.14 to 18.18)		
	21	Section 19-Integral Domains (19.1 to 19.8)		
	22	Section 19-Integral Domains (19.9 to 19.15)		
V		**Module V (Open Ended)**	**12**	**-**
		Generating Sets in Groups		
		Factor Groups		
		The Field of Quotients of an Integral Domain		

References

1. Herstein, Israel Nathan. *Topics in algebra*. John Wiley & Sons, 1991.

2. Gallian, Joseph. *Contemporary abstract algebra*. Chapman and Hall/CRC, 2021.

3. Wallace, David AR. *Groups, rings and fields*. Springer Science & Business Media, 2001

4. Reis, Clive. *Abstract algebra: an introduction to groups, rings and fields*. World Scientific Publishing Company, 2011.

5. Allan Clark*, Elements of Abstract Algebra,* Dover Publications, 1984

6. C Musili, *Introduction to Rings and Modules*, Narosa Publications, 2009

Suggested Programming Exercises for Open-Ended

1. Form congruence groups, their Cayley tables (Section 9.2, Ref (3)).
2. Form symmetric groups of various orders, list the elements, find the power of some elements, find out the product of some of the elements. Find the order of the elements. Form a group table using conditionals and loops. (Section 9.3, Ref (3) or Ref (1)).
3. List S_3. Find a subgroup from this group. How many distinct subgroups can be found from this group? List all of them.
4. Form the Dihedral group D_4, check if it is abelian using is_abelian(). Conduct the same experiments as listing the elements ,finding the orders etc as above. (Section 9.4, Ref (3) or Ref (1)).
5. Test the command is normal () on a few subgroups of S_3. (Ref (1)).
6. Create cyclic groups. (Section 9.5, Ref (3)).

7. Form finitely generated abelian groups. (Section 9.6, Ref (3)).

8. Form a subgroup of a group (say, S_3) (Section 9.8, Ref (3)).

References

1. Robert A. Beezer; Group Theory and SAGE: A Primer, http://people.reed.edu/~davidp/332/sage-group-theory.pdf

2. Group Theory and Sage - SageMath tutorial https://doc.sagemath.org/html/en/thematic_tutorials/group_theory.html

3. Ajit Kumar, Vikas Bist; Group Theory An Expedition with SageMath, Narosa Publishing House.

4. Thomas W. Judson, Robert A. Beezer; Abstract Algebra Theory and Applications with Sage Exercises for Abstract Algebra, http://abstract.ups.edu/download/ aata-20130816.pdf

***Optional topics are exempted for end semester examination.**

****70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.**

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	2	1	0	2	0	0	0	2	0	0
CO 2	1	2	3	0	2	0	2	0	3	0	0
CO 3	0	1	2	3	2	0	3	0	3	0	0

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT5CJ303			
Course Title	**COMPLEX ANALYSIS I**			
Type of Course	**Major**			
Semester	V			
Academic Level	300-399			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	4	-	60
Pre-requisites	Basics of Real Number System and Calculus.			
Course Summary	This course begins with the concepts of complex numbers. complex plane, polar form of complex numbers, powers and roots, etc. Next we discuss complex functions including power functions and nth root functions. Then we discuss limits, continuity, differentiability and analyticity of complex functions. Cauchy Riemann equations and Harmonic conjugates are also studied. Finally the course discusses some standard complex functions like Exponential functions, Logarithmic functions, Trigonometric and Hyperbolic functions.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand and explain the properties and representations of complex numbers, including their polar form and operations.	U	C	Internal Exam/ Assignment/Seminar/ Viva/End Sem Exam
CO2	Apply the principles of limits, continuity, and differentiability to complex functions and utilize the Cauchy-Riemann equations.	Ap	P	Internal Exam/ Assignment/Seminar/ Viva/End Sem Exam
CO3	Evaluate and create complex exponential, logarithmic, trigonometric, and hyperbolic functions, understanding their properties and applications.	C	F	Internal Exam/ Assignment/Seminar/ Viva/End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Textbook	Complex Analysis (Third Edition): Dennis G. Zill & Patric D. Shanahan, Jones & Bartlett Learning, 2018.			
Module	**Unit**	**Content**	**Hrs 60**	**External Marks (70)**
I		**Module I**	**13**	**Min.15**
	1	Section 1.1-Complex Numbers and Their Properties		
	2	Section 1.2-Complex Plane		
	3	Section 1.3- Polar Form of Complex Numbers		
	4	Section 1.4- Powers and Roots		
	5	Section 1.5 -Sets of Points in Complex Plane		
II		**Module II**	**12**	**Min.15**
	6	Section 2.1 -Complex Functions		
	7	Section 2.2- Complex Functions as Mappings- up to and including Example 4.		
	8	Section 2.4- Special Power Functions- The Power Function $\square^{\square}$(All the topics in 2.4.1)		
	9	Section 2.4- Special Power Functions-The power function $\square^{\frac{1}{\square}}$(Topics in 2.4.2, up to and including Example 5.)		
	10	Section 2.4- Special Power Functions-Principal nth Root Functions and Example 9.		
III		**Module III**	**15**	**Min.20**
	11	Section 3.1- Limits and Continuity-Limits (All the topics in 3.1.1)		
	12	Section 3.1- Limits and Continuity-Continuity (Topics in 3.1.2, up to Example 7.)		
	13	Section 3.1-Limits and Continuity-Continuity (Theorem 3.1.4 to up to and including a bounding property.		
	14	Section 3.2- Differentiability and Analyticity- up to and including Example 2.		
	15	Section 3.2- Differentiability and Analyticity- All the topics after Example 2.		
	16	Section 3.3- Cauchy-Riemann Equations-up to and including Theorem 3.3.2		
	17	Section 3.3 - Cauchy Riemann Equations: -All the topics after Theorem 3.3.2.		
	18	Section 3.4 - Harmonic Functions		
IV		**Module IV**	**8**	**Min.15**
	19	Section 4.1 Exponential and Logarithmic Functions-Complex Exponential Function (Topics in 4.1.1 up to and including Periodicity)		

	20	Section 4.1 Exponential and Logarithmic Functions- Complex Logarithmic Function (Topics in 4.1.2 up to and including Example 4)		
	21	Section 4.3 Trigonometric and Hyperbolic Functions- Complex Trigonometric Functions (Topics in 4.3.1, up to and excluding trigonometric mapping.)		
	22	Section 4.3 Trigonometric and Hyperbolic Functions- Complex Hyperbolic Functions (All the topics in 4.3.2)		
V	**Module V (Open Ended)**		**12**	
		Linear Mappings, Reciprocal Functions		
		Branches, Branch Cuts and Points, Complex Powers		
		Inverse Trigonometric and Hyperbolic Functions.		

References

1. Brown, James Ward, and Ruel V. Churchill. Complex variables and applications. McGraw-Hill, 2009.
2. Stein, Elias M., and Rami Shakarchi. Complex analysis. Vol. 2. Princeton University Press, 2010.
3. Burckel, Robert B. An Introduction to Classical Complex Analysis: Vol. 1. Vol. 64. Birkhäuser, 2012
4. Hormander, Lars. An introduction to complex analysis in several variables. Elsevier, 1973.
5. Priestley, Hilary A. Introduction to complex analysis. OUP Oxford, 2003.
6. Silverman, Richard A. Introductory complex analysis. Courier Corporation, 2013
7. Bak, Joseph, Donald J. Newman, and Donald J. Newman. *Complex analysis*. Vol. 8. New York: Springer, 2010.

***70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.**

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	1	0	0	3	0	0	0	2	0	0
CO 2	0	3	1	0	2	0	3	0	3	0	0
CO 3	1	0	3	0	2	0	3	0	3	0	0

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT6CJ304 / MAT8MN304			
Course Title	**COMPLEX ANALYSIS-II**			
Type of Course	**Major**			
Semester	VI			
Academic Level	300-399			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	4	-	60
Pre-requisites	Idea of complex numbers, Polar representations, Differentiability and Analyticity.			
Course Summary	We continue from Complex Analysis-I and begin by discussing complex integrals, followed by Cauchy-Goursat Theorem. Independence of path, Cauchy's Integral formula, sequence and series of complex numbers are next studied. It is then followed by Taylor series, Laurent series. zeros and poles, and Residue Theorem. Applications of Residue theorem are also discussed.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand and apply the principles of real and complex integrals, including the Cauchy-Goursat theorem	Ap	P	Internal Exam/ Assignment/Seminar/ Viva/End Sem Exam
CO2	Analyse the independence of path and evaluate the Cauchy's integral formulas, along with understanding their consequences and applications.	An	C	Internal Exam/ Assignment/Seminar/ Viva/End Sem Exam
CO3	Create and utilize Taylor and Laurent series, and apply the residue theorem to evaluate complex functions and integrals.	C	F	Internal Exam/ Assignment/Seminar/ Viva/End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Textbook	Complex Analysis (Third Edition): Dennis G. Zill & Patric D. Shanahan, Jones & Bartlett Learning, 2018.			
Module	**Unit**	**Content**	**Hrs (60)**	**External Marks (70)**
		Module I		
I	1	Section 5.1-Real Integrals.	12	Min.15
	2	Section 5.2-Complex Integrals-up to and including Example 2		
	3	Section 5.2- Complex Integrals- All the topics after Example 2		
	4	Section 5.3- Cauchy- Goursat Theorem-up to and including Example 4.		
	5	Section 5.3 -Cauchy- Goursat Theorem-All the topics after Example 4.		
		Module II		
II	6	Section 5.4- Independence of Path	12	Min.15
	7	Section 5.5 -Cauchy's Integral Formulas and Their Consequences- Cauchy's Two Integral Formulas (All the topics in 5.5.1)		
	8	Section 5.5 -Cauchy's Integral Formulas and Their Consequences- Some Consequences of the Integral Formulas (All the topics in 5.5.2)		
	9	Section 6.1 -Sequences and Series- up to and including Example 4.		
	10	Section 6.1- Sequences and Series- All the topics after Example 4.		
		Module III		
III	11	Section 6.2 -Taylor Series-up to and Excluding Theorem 6.2.4.	14	Min.15
	12	Section 6.2- Taylor Series-From Theorem 6.2.4 to Example 3.		
	13	Section 6.3 -Laurent Series-up to and including Example 1.		
	14	Section 6.3- Laurent Series- All the topics after Example 1(proof of Laurent's Theorem is optional)		
	15	Section 6.4 -Zeros and Poles- up to and including Example 2.		
	16	Section 6.4- Zeros and Poles- All the topics after Example 2.		
		Module IV		
IV	17	Section 6.5 -Residues and Residue Theorem-up to and including Example 3.	10	
	18	Section 6.5 - Residues and Residue Theorem-All the topics after Example 3.		
	19	Section 6.6- Some Consequences of the Residue Theorem- Evaluation of Real Trigonometric Functions (up to and including example1 of 6.6.1)		

	20	Section 6.6 -Some Consequences of the Residue Theorem- Evaluation of Real Improper Integrals (up to and including Example 2)		**Min.15**
	21	Section 6.6 -Some Consequences of the Residue Theorem- Theorem 6.6.1 and Example 3.		
	22	Section 6.6 -Some Consequences of the Residue Theorem- Theorem 6.6.2 and Example 4.		
V	**Module V (Open Ended)**		**12**	
		Definite Integrals, Line Integrals in the Plane, Indented Contours		
		Integration along a Branch Cut, The Argument Principle		
		Rouche's Theorem and its applications		
References				
	1	Brown, James Ward, and Ruel V. Churchill. Complex variables and applications. McGraw-Hill, 2009.		
	2	Stein, Elias M., and Rami Shakarchi. Complex analysis. Vol. 2. Princeton University Press, 2010.		
	3	Burckel, Robert B. An Introduction to Classical Complex Analysis: Vol. 1. Vol. 64. Burkhouse, 2012.		
	4	Hormander, Lars. An introduction to complex analysis in several variables. Elsevier, 1973.		
	5	Priestley, Hilary A. Introduction to complex analysis. OUP Oxford, 2003.		
	6	Silverman, Richard A. Introductory complex analysis. Courier Corporation, 2013.		
	7	Bak, Joseph, Donald J. Newman, and Donald J. Newman. *Complex analysis*. Vol. 8. New York: Springer, 2010.		

***Optional topics are exempted for end semester examination.**

****70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.**

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	1	1	0	3	0	3	0	3	0	0
CO 2	1	2	1	0	2	0	3	0	3	0	0
CO 3	1	2	1	0	3	0	3	0	3	0	0

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT6CJ305 / MAT8MN305			
Course Title	**ELEMENTARY NUMBER THEORY**			
Type of Course	**Major**			
Semester	VI			
Academic Level	300-399			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	4	-	60
Pre-requisites	Arithmetic of integers, basic set theory and proof techniques.			
Course Summary	We start number theory with the division algorithm, g.c.d., and the Euclidean algorithm for computing it, essential for solving Diophantine equations like ax + by = c. We then prove the Fundamental Theorem of Arithmetic, discuss the infinitude of primes and the sieve of Eratosthenes. Following that, we cover Linear Congruences, the Chinese Remainder theorem, and Fermat's Little Theorem. Finally, we explore Wilson's Theorem, Euler's Phi Function, and Euler's Theorem.			

Course Outcomes:

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Apply the division algorithm and Euclidean algorithm to compute greatest common divisors (gcd) and solve related divisibility problems.	Ap	C	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO2	Solve Diophantine equations for integer solutions, deduce prime factorization through the fundamental theorem of arithmetic, and identify prime numbers using the sieve of Eratosthenes.	Ap	C	Internal Exam/ Assignment/ Seminar/Viva/ End Sem Exam
CO3	Apply the properties of congruence and the Chinese Remainder Theorem to solve systems of linear congruences.	Ap	C	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Textbook	Elementary Number Theory, David Burton, M, Seventh Edition, Mcgraw – Hill (2007).			
Module	**Unit**	**Content**	**Hrs (60)**	**External Marks (70)**
I		**Module I**	**12**	**Min.15**
	1	Section 2.2 The division algorithm (proof of theorem 2.1 omitted).		
	2	Section 2.3 The greatest common divisor – up to and including theorem 2.3 and its corollary.		
	3	Section 2.3 The greatest common divisor – All topics from definition 2.3 onwards.		
	4	Section 2.4 The Euclidean algorithm – up to Theorem 2.7.		
	5	Section 2.4 The Euclidean algorithm – All topics from Theorem 2.7 onwards.		
II		**Module II**	**11**	**Min.15**
	6	Section 2.5 The Diophantine equation ax+by = c – up to and including Theorem 2.9.		
	7	Section 2.5 - All topics from Example 2.4 onwards.		
	8	Section 3.1 The fundamental theorem of arithmetic – up to Theorem 3.2.		
	9	Section 3.1 The fundamental theorem of arithmetic – All topics from Theorem 3.2 onwards.		
	10	Section 3.2 The sieve of Eratosthenes (up to and including theorem 3.4 only)		

III	**Module III**			
	11	Section 4.2 Basic properties of congruence - up to Theorem 4.2.	**13**	**Min.15**
	12	Section 4.2 Basic properties of congruence - All topics from Theorem 4.2 onwards.		
	13	Section 4.4 Linear congruences and the Chinese remainder theorem - up to Theorem 4.8.		
	14	Section 4.4 Linear congruences and the Chinese remainder theorem - All Topics from Theorem 4.8 (proof of Theorem 4.8 omitted).		
	15	Section 5.2 Fermat's little theorem and pseudo primes - up to Lemma. (omit a different proof for Fermat's theorem)		
	16	Section 5.2 Fermat's little theorem and pseudo primes - All topics from Lemma onwards.		
IV	**Module IV**		**12**	**Min.15**
	17	Section 5.3 Wilson's theorem - Up to Theorem 5.5.		
	18	Section 5.3 Wilson's theorem - All topics from Theorem 5.5 onwards.		
	19	Section 7.2 Euler's phi-function - up to Lemma.		
	20	Section 7.2 Euler's phi-function - All Topics from Lemma onwards. (proof of Theorem 7.2 omitted).		
	21	Section 7.3 Euler's theorem. (Second proof of Euler's theorem omitted).		
	22	Section 7.4 Some properties of the phi-function (Proof of Theorem 7.8 omitted).		

V	Module V (Open Ended)		
	Proof of Theorem 4.8. Chinese Remainder Theorem and remaining portions of Section 4.4 Section 6.1 The sum and the number of divisors Linear congruences and the Chinese remainder theorem. Section 6.3 The Greatest Integer Function – up to Theorem 6.11.	**12**	

References

1. Rosen, Kenneth H. *Elementary number theory*. London: Pearson Education, 2011.
2. Eynden, Charles Vanden. *Elementary number theory*. Waveland Press, 2006.
3. Gehring, F. W., and P. R. Halmos. G*raduate Texts in Mathematics*, 1976.
4. Hsiung, C. Y. *Elementary theory of numbers*. World Scientific, 1992.
5. Hoffman P., *The man who loved only numbers: The story of Paul Erdös and the search for mathematical truth*, Little Brown & Company, 1999.

***70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.**

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	1	1	0	0	3	0	3	0	3	0	0
CO 2	1	1	0	0	3	0	3	0	3	0	0
CO 3	0	0	1	0	3	0	3	0	3	0	0

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT6CJ306 / MAT8MN306			
Course Title	**METHODS OF DIFFERENTIAL EQUATIONS**			
Type of Course	**Major**			
Semester	VI			
Academic Level	300-399			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites	Foundations of basic calculus (0-99 level)			
Course Summary	The course enhances the skill to solve ordinary differential equation using specific methods analytically and computationally for first and higher order differential equations.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Classify and solve first order differential equation by applying appropriate methods	Ap	C	Internal Exam/ Assignment/Seminar/ Viva/End Sem Exam
CO2	Apply different methods to solve higher order homogeneous and non-homogeneous linear differential equations with constant coefficients	Ap	C	Internal Exam/ Assignment/Seminar/ Viva/End Sem Exam
CO3	Use Laplace transform and inverse Laplace transform to solve linear differential equations	Ap	C	Internal Exam/ Assignment/Seminar/ Viva/End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Textbook	Dennis G. Zill , A First Course in Differential Equations with Modeling Applications 10th Edn, Cengage Learning (2012) ISBN-13 978-1111827052			
Module	**Unit**	**Content**	**Hrs (60)**	**Marks Ext: 70**
I		**First order differential equations**	14	Min.15
		Quick review of Introduction to differential equations (Definitions only)		
	1	2.1.1-Direction Fields		
	2	2.1.2 - Autonomous First-Order DEs		
	3	2.2 - Separable Equations		
	4	2.3 - Linear Equations		
	5	2.4- Exact Equations		
	6	2.5- Solutions by Substitutions		
	7	Problems from the above sections		
II		**Higher-Order Differential Equations**	12	Min.15
	8	4.1.1 Initial-Value and Boundary-Value Problems		
	9	4.1.2 Homogeneous Equations (proof of Theorems 4.1.2 and 4.1.5 are optional)		
	10	4.1.3 Nonhomogeneous Equations		
	11	4.2 Reduction of Order		
	12	4.3 Homogeneous Linear Equations with Constant Coefficients		
III		**Higher-Order Differential Equations (Cont..)**	14	Min.20
	13	4.4 -Undetermined Coefficients—Superposition Approach (up to and including Example 9)		
	14	4.5 - Undetermined Coefficients—Annihilator Approach (up to and including Example 3)		
	15	4.5 - Undetermined Coefficients—Annihilator Approach (all the topics after Example 3)		
	16	4.6- Variation of Parameters		
	17	4.7 - Cauchy-Euler Equation (up to and including Example 4)		
	18	4.7 - Cauchy-Euler Equation (all the topics after Example 4)		
	19	4.9 - Solving Systems of Linear DEs by Elimination		
IV		**Laplace Transforms**	8	Min.10
	20	7.1 Definition of the Laplace Transforms (proof of Theorems 7.1.2 and 7.1.3 are optional)		
	21	7.2.1 Inverse Transforms		
	22	7.2.2 Transforms of Derivatives		
V		**Open Ended: Mastering differential equation using software**	12	
		IVP and BVP Problem-solving using mathematical software like Sage/Python/ Mathematica/Matlab/ Maple/Scilab etc (Instructor may choose any software appropriately)		

	Suggestions: ● Plotting solution curves -2 hrs ● Solve first order initial value problems -2 hrs ● Solve second order initial value problems -2 hrs ● Plot Laplace transform of given function -2 hrs ● find Laplace transform and inverse Laplace transform - 2 hrs ● Solve the initial value problem using Laplace transform -2 hrs		

References

1. G. F. Simmons and S. G. Krantz, Differential Equations: Theory, Technique, and Practice, McGraw Hill (2006), ISBN-13. 978-0072863154
2. E. A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall India (2009). ISBN: 9788120303614
3. E. Boyce , Richard C. Diprima, Douglas B Meade, Elementary Differential Equations and Boundary Value Problems, 11 Edn. William John Wiely & Sons (2017) ISBN: 1119169879
4. William F. Trench, Elementary Differential Equations with Boundary Value Problems, S.Chand (G/L) & Company Ltd (2013) ISBN 13: 9780534368418.
5. S. L. Ross, Differential Equations, 3rd edition, Wiley India, (2007) ISBN-13. 978-8126515370
6. Martha L. Abell, James P. Braselton, Differential Equations with Mathematica, 5th edn. Elsevier Science Publishing Co Inc (2022), ISBN: 9780128241608
7. Amit Saha, Doing Math with Python", No Starch Press, US . (2015), ISBN 13 978-1593276409

***Optional topics are exempted for end semester examination.**

****70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.**

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	2	1	3	0	3	0	3	0	0
CO 2	2	3	1	2	3	0	3	0	3	0	0
CO 3	2	1	3	3	3	0	3	0	3	0	0

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT7CJ401			
Course Title	**MATHEMATICAL ANALYSIS**			
Type of Course	**Major**			
Semester	VII			
Academic Level	400-499			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	3	2	75
Pre-requisites	1. Mathematical Logic and necessary exposure to set theory. 2. Basic Calculus 3. Real Analysis I, Real Analysis II			
Course Summary	The topology of the real line is explored in detail, as is necessary later for an in-depth understanding of the theory of real functions. Limits, Continuity & Differentiation are rigorously covered. Riemann-Stieltjes Integration is introduced as a generalisation of the Riemann integration covered in earlier semesters, enabling the student to view summation of series and integration as extensions of the same concept. After a discourse on series of functions and various results discussing the compatibility of the above three notions with the limiting operations on series of functions, the course concludes with a presentation of the famous Stone-Weierstrass' Theorem.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Analyse and differentiate between finite, countable, and uncountable sets, and apply these concepts to problems in R	An	C	Internal Exam/Assignment/Seminar/ Viva/Report/ End Sem Exam
CO2	Evaluate the properties of compact, perfect, and connected sets in the context of metric spaces.	E	P	Internal Exam/Assignment/Seminar/ Viva/Report/ End Sem Exam
CO3	Synthesize the principles of continuity, differentiability, integrability and convergence of sequences and series including the application of the Mean Value Theorem and L'Hospital's Rule, to solve complex problems involving real-valued and vector-valued functions.	E	P	Internal Exam/Assignment/Seminar/ Viva/Report/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Textbook	Principles of Mathematical Analysis, Walter Rudin,, (3/e), McGraw Hill Inc(2013)			
Module	**Unit**	**Content**	**Hrs (45+30)**	**External Marks (70)**
I		**Basic Topology of the Real Line**	**13**	**Min.15**
	1	Chapter 2 – Finite, Countable & Uncountable Sets – 2.1 to 2.14		
	2	Chapter 2 – Metric Spaces – 2.15 to 2.24		
	3	Chapter 2 – Metric Spaces – 2.25 to 2.30		
	4	Chapter 2 – Compact Sets – 2.31 to 2.42		
	5	Chapter 2 – Perfect Sets – 2.43 to 2.44		
	6	Chapter 2 – Connected Sets – 2.45 to 2.47		
II		**Continuity and Differentiation**	**16**	**Min.20**
	7	Chapter 4 – Limits of Functions and Continuous Functions – 4.1 to 4.12		
	8	Chapter 4 – Continuity and Compactness – 4.13 to 4.21		
	9	Chapter 4 - Continuity and Connectedness – 4.22 to 4.24		
	10	Chapter 4 – Discontinuities and Monotonic Functions – 4.25 to 4.30		
	11	Chapter 5 – The Derivative – 5.1 to 5.6		
	12	Chapter 5 – Mean Value Theorems – 5.7 to 5.12		
	13	Chapter 5 – L'Hospital's rule, Higher Derivatives & Taylor's Theorem, Differentiation of Vector Valued Functions – 5.13 to 5.19 (proof of theorem 5.13 and theorem 5.15 are optional)		
III		**The Riemann-Stieltjes Integral**	**9**	**Min.15**
	14	Chapter 6 – Definition and Existence – 6.1 to 6.6		
	15	Chapter 6 – Definition and Existence – 6.6 to 6.11		
	16	Chapter 6 – Properties – 6.12 to 6.13		
	17	Chapter 6 – Properties – 6.14 to 6.19 (proof of theorem 6.19 is optional)		
	18	Chapter 6 – Integration & Differentiation – 6.20 to 6.22		
IV		**Sequences & Series of functions**	**7**	**Min.10**
	19	Chapter 7 – Discussion of Main Problem - 7.1 to 7.3		
	20	Chapter 7 – Discussion of Main Problem - 7.4 to 7.6		
	21	Chapter 7 –Uniform Convergence – 7.7-7.10		
	22	Chapter 7 –Uniform Convergence & Continuity – 7.11 to 7.13		
V		**Practicum :** The goal is for the students to learn the following selected topics via self-study and group activities. The lecturer may	**30**	**-**

	assist by running and overseeing group discussions and class seminars and referring library books for self-study and note preparation.			
	1	Chapter 3 – Convergent Sequences, Subsequences		
	2	Chapter 3 – Cauchy Sequences, Upper and Lower Limits		
	3	Chapter 3 – Some Special Sequences, Series		
	4	Chapter 3 – Series of Non-Negative Terms, The Root and Ratio Tests		
	5	Chapter 3 – Power Series, Absolute Convergence		
	6	Chapter 3 – Addition and Multiplication of Series, Rearrangements.		
	7	Chapter 4 – Infinite Limits & Limits at Infinity – 4.32 to 4.34		
	8	Chapter 6 – Integration of Vector-valued Functions and Rectifiable curves - 6.23 to 6.27		
	9	Chapter 7 – Uniform Convergence, Integration and Differentiation – 7.16 to 7.18		
	10	Chapter 7 –Equicontinuity and Stone-Weierstrass Theorem – 7.19 to 7.27		

References

1. Mathematical Analysis,T. M. Apostol, (2nd Edn.); Narosa; 2002.
2. Introduction to Real Analysis, R. G. Bartle and D.R. Sherbert:; John Wiley Bros; 1982.
3. Real Analysis- a first course, R. A. Gordon:(2nd Edn.); Pearson; 2009.
4. Analysis-I, H. Amann and J. Escher, Birkhuser, 2006
5. The way of Analysis, Robert Strichartz, (R/e), Jones and Bartlett Mathematics (2000)
6. A first course in Real Analysis, M. H. Protter and C. B. Moray, Springer Verlag UTM (1977)

***Optional topics are exempted for end semester examination**

****70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.**

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	1	0	3	0	3	0	3	0	0
CO 2	2	3	2	0	3	0	3	0	3	0	0
CO 3	3	3	3	1	3	0	3	0	3	0	0

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Report
- Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment/ Report	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours				
Course Code	MAT7CJ402				
Course Title	**GENERAL TOPOLOGY**				
Type of Course	**Major**				
Semester	VII				
Academic Level	400-499				
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours	
	4	3	2	75	
Pre-requisites	1. Mathematical Logic and necessary exposure to set theory. 2. Basic Calculus 3. Real Analysis I, Real Analysis II				
Course Summary	The subject of general topology is introduced with motivations from the theory of real functions and of metric spaces. Basic concepts like open and closed sets, interiors, closures, boundaries, neighbourhoods, bases and sub-bases are introduced. After a discussion of continuity and related topics, the universal properties of strong and weak topologies are discussed. Compactness, connectedness, and various countability axioms are studied in some detail. After a detailed study of the hierarchy of separation axioms and their interplay with other properties such as compactness, the course concludes with a presentation of the famous Urysohn & Tietze characterisations of normality.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Define and classify topological spaces, bases, and subspaces, and apply these concepts to identify examples of different topological structures.	Ap	C	Internal Exam/Assignment/Seminar/ Viva/Report/ End Sem Exam
CO2	Analyse and evaluate closed sets, interior points, and accumulation points within topological spaces, and understand the concepts of continuity and related topological properties.	An	P	Internal Exam/Assignment/Seminar/ Viva/Report/ End Sem Exam
CO3	Synthesize the concepts of connectedness, separation axioms, and compactness to determine specific topological properties of spaces and analyse their applications in solving problems related to paths and separation.	E	C	Internal Exam/Assignment/Seminar/ Viva/Report/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Textbook	Introduction to General Topology, K. D. Joshi,, New Age International Publishers, 1983**.**			
Module	**Unit**	**Content**	**Hrs (45+30)**	**External Marks (70)**
I		**Topological Spaces**	**12**	**Min.15**
	1	Chapter 4 – Section 1: Definition of Topological Space		
	2	Chapter 4 – Section 2: Examples of Topological Spaces		
	3	Chapter 4 – Section 3: Bases and Sub-bases – 3.1 to 3.7		
	4	Chapter 4 – Section 3: Bases and Sub-bases – 3.8 to 3.10		
	5	Chapter 4 – Section 4: Subspaces – 4.1 to 4.6		
II		**Basic concepts**	**10**	**Min.15**
	6	Chapter 5 – Section 1: Closed Sets and Closure (Proof of Theorem 1.5 is optional)		
	7	Chapter 5 – Section 2: Neighbourhoods, Interior and Accumulation Points – 2.1 to 2.8		
	8	Chapter 5 – Section 2: Neighbourhoods, Interior and Accumulation Points –2.9 to 2.10 and 2.13		
	9	Chapter 5 – Section 3: Continuity and Related Concepts – 3.1 to 3.6		
	10	Chapter 5 – Section 3: Continuity and Related Concepts – 3.7 to 3.11		
III		**Spaces with special properties**	**12**	**Min.15**
	11	Chapter 5 – Section 4: Making Functions Continuous, Quotient Spaces – 4.1 to 4.7		
	12	Chapter 5 – Making Functions Continuous, Quotient Spaces – 4.8 to 4.12		
	13	Chapter 6 – Section 1: Smallness Conditions on a Space – 1.1 to 1.9		
	14	Chapter 6 – Section 1: Smallness Conditions on a Space – 1.10 to 1.18		
	15	Chapter 6 – Section 2: Connectedness – 2.1 to 2.6 (Proof of Theorem 2.5 is optional)		
	16	Chapter 6 – Connectedness – 2.7 to 2.15		
IV		**Separation axioms**	**11**	**Min.15**
	17	Chapter 6 – Section 3: Local Connectedness and Paths – 3.1 to 3.8		
	18	Chapter 7 – Hierarchy of Separation Axioms - 1.1 to 1.6.		
	19	Chapter 7 – Hierarchy of Separation Axioms - 1.7 to 1.12		
	20	Chapter 7 – Hierarchy of Separation Axioms - 1.13 to 1.17		

	21	Chapter 7 – Section 2: Compactness and Separation Axioms - 2.1 to 2.6		
	22	Chapter 7 – Section 2: Compactness and Separation Axioms- 2.7 to 2.10		
V Practicum	**Practicum:** The goal is for the students to learn the following selected topics in 10 practicum sessions of hours each via self-study and group activities. The lecturer may assist by running group discussions, supervising class seminars and referring library books for self-study and note preparation.		**30**	**-**
1	Chapter 1 - Logical Warm-up			
2	Chapter 2 – Preliminaries			
3	Chapter 3 – Motivation for Topology			
4	Chapter 6 - Connectedness: Theorem 2.5 and its proof			
5	Chapter 6 - Local connectedness and Paths - 3.9 to 3.11			
6	Chapter 7 - Compactness and Separation Axioms - 2.11 to 2.16			
7	Chapter 7 – Section 3: Urysohn Characterisation of Normality -3.1 to 3.4			
8	Chapter 7 – Section 3: Urysohn Characterisation of Normality - 3.5 to 3.6			
9	Chapter 7 –Section 4: Tietze Characterisation of Normality - 4.1 to 4.5			
10	Chapter 7 –Section 4: Tietze Characterisation of Normality - 4.6 to 4.8			

References

1. Topology, J. R. Munkres, Prentice Hall of India, 2000.
2. General Topology, S. Willard, Addison Wesley Pub. Company, 1976.
3. General Topology, J. L. Kelley, D. van Nostrand, 1955.
4. Introduction to Topology and Modern Analysis, G. F. Simmons, McGraw-Hill, 1963.
5. Topology, James Dugundji, Prentice Hall of India, 1975.

***Optional topics are exempted for end semester examination.**

****70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.**

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	1	2	0	3	0	3	0	3	0	0
CO 2	3	2	2	1	3	0	3	0	3	0	0
CO 3	3	3	3	2	3	0	3	0	3	0	0

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Report
- Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment/ Report	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT7CJ403			
Course Title	**ABSTRACT ALGEBRA II**			
Type of Course	**Major**			
Semester	VII			
Academic	400-499			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	3	2	75
Pre-requisites	1. Mathematical Logic and necessary exposure to set theory. 2. First Course on Group Theory			
Course Summary	The subject of group theory is taken upon from where it was left off in previous introductory courses. The basic constructions in group theory – those of direct products and quotient groups are introduced. The Fundamental Theorem of Finitely Generated Abelian Groups is introduced (without proof) and the consequences explored in order to compare the challenges in the theory of Abelian vs non-Abelian groups. After an introductory delving into normal and subnormal series of groups, group actions are introduced and Sylow Theory discussed in the context of classifying non-Abelian groups. The course concludes with a basic discussion on polynomial rings and their factorisation, paving the way for the theory of extension fields in later, more advanced courses.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Apply the concept of direct products of groups and factor groups to construct new groups from existing ones.	Ap	P	Internal Exam/Assignment/Seminar/ Viva/Report/ End Sem Exam
CO2	Analyse and evaluate the isomorphism theorems, series of groups, and Sylow theorems to understand the structural properties and classifications of groups.	E	C	Internal Exam/Assignment/Seminar/ Viva/Report/ End Sem Exam
CO3	Synthesize the concepts of rings of polynomials, factorization of polynomials, and ideal structures within rings and fields, with a focus on homomorphisms and factor rings.	E	P	Internal Exam/Assignment/Seminar/ Viva/Report/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Textbook	A First Course in Abstract Algebra, J. B. Fraleigh, 7th Edition, Pearson Education Limited, 2014.			
Module	**Unit**	**Content**	**Hrs (45+30)**	**External Marks (70)**
I	**Basic Constructions – New Groups From Old**		**11**	**Min.15**
	1	Section 11 – Direct Products of Groups (11.1 to 11.11)		
	2	Section 11 – Finitely Generated Abelian Groups (11.12 to 11.17)		
	4	Section 14 – Factor Groups		
	5	Section 15 – Factor Group Computations (15.1 to 15.13)		
	6	Section 15 – Simple Groups, The Centre and Commutator Subgroups (15.14 to 15.21).		
II	**Advanced Group Theory** (Pre-requisites: Sections 16 and 17 of Practicum)		**14**	**Min.20**
	7	Section 34 – Isomorphism Theorems		
	8	Section 35 – Series of Groups - 35.1 to 35.19 (Proofs of Zassenhaus Lemma and Schreier Theorem are optional)		
	9	Section 36 – Sylow Theorems (36.1 to 36.4)		
	10	Section 36 – Sylow Theorems (36.5 to 36.13).		
	11	Section 37 – Applications of the Sylow Theory (37.1 to 37.6)		
	12	Section 37 – Further Applications (37.7 to 37.15)		
III	**Rings and Fields**		**11**	**Min.15**
	13	Section 22 – Rings of Polynomials – (22.1 to 22.3) (proof of Theorem 22.2 is optional)		
	14	Section 22 – The Evaluation Homomorphisms (22.4 to 22.11)		
	15	Section 23 – Factorisation of Polynomials over a Field (23.1 to 23.6)		

	16	Section 23 – Irreducible Polynomials (23.7 to 23.21)		
	17	Section 24 – Non-commutative Examples. (24.1 to 24.3)		
	18	Section 24 – Non-commutative Examples (24.4 to 24.10)		
IV	**More Ring Theory**		**8**	**Min.10**
	19	Section 26 – Homomorphism and Factor Rings (26.1 to 26.6).		
	20	Section 26 – Factor Rings (26.7 to 26.19)		
	21	Section 27 – Prime and Maximal Ideals (27.1 to 27.20).		
	22	Section 27 – Ideal Structure in F[x] (27.21 to 27.27)		
V	**Practicum:** The goal is for the students to learn the following selected topics in 5 practicum sessions of six hours each via self-study and group activities. The lecturer may assist by running group discussions, supervising class seminars and referring library books for self-study and note preparation.		**30**	**-**
1	Section 12 – Plane isometries			
2	Section 16 – Group Action on a Set			
3	Section 17 – Application of G-sets to Counting			
4	Section 21 – The Field of Quotients of an Integral Domain			
	Section 35 - Series of Groups - Ascending central series - 35.20 to 35.21			
5	Section 39 – Free Groups			

References

1. Abstract Algebra, Dummitt and Foote, Wiley India, 2011.
2. Contemporary Abstract Algebra, Joseph A. Gallian, CRC Press, 1986.
3. Topics in Algebra, I. N. Herstein, John Wiley and Sons, 2006.
4. Algebra, T. W. Hungerford, Springer-Verlag, 1987.
5. Algebra, Micheal Artin, Birkhauser, 2011
6. Algebra, Serge Lang, Springer, 2002.
7. Advanced Higher Algebra, J G Chakravorthy and P R Gosh, Kolkata U N Dhur, 2014 (ISBN: 9789380673059)

Suggested Programming Exercises for Practicum:

1. Form congruence groups Z_3, Z_2. Verify that $Z_3 \times Z_2 \cong Z_6$. Form its

cosets (Section 9.11, Ref (3)).

2. Find the centre of the dihedral group. (Section 9.12, Ref (3))
3. For an element from the dihedral group, find its stabilizer. (Section 9.12, Ref (3))
4. Find the conjugacy classes of an element from the dihedral group. (Section 9.12, Ref (3))
5. Take a subgroup (say H) of S_3. List the conjugacy classes using the command conjugacy classes subgroups (). Can you find out all the subgroups using these conjugacy classes? (Ref (1) or Section 9.12, Ref (3))
6. Find Sylow-2-subgroups and Sylow-3-subgroups or D_{18} (Section 9.13, Ref (3))

References

1. Robert A. Beezer; Group Theory and SAGE: A Primer, http://people.reed.edu/~davidp/332/sage-group-theory.pdf

2. Group Theory and Sage - SageMath tutorial https://doc.sagemath.org/html/en/thematic_tutorials/group_theory.html

3. Ajit Kumar, Vikas Bist; Group Theory An Expedition with SageMath, Narosa Publishing House.

4. Thomas W. Judson, Robert A. Beezer; Abstract Algebra Theory and Applications with Sage Exercises for Abstract Algebra, http://abstract.ups.edu/download/ aata-20130816.pdf

***Optional topics are exempted for end semester examination.**

****70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.**

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	2	1	3	0	3	0	2	0	1
CO 2	2	3	1	2	3	0	3	0	3	0	2
CO 3	2	1	3	3	3	0	3	0	3	0	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Report
- Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment/ Report	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT7CJ404			
Course Title	**LINEAR ALGEBRA**			
Type of Course	**Major**			
Semester	VII			
Academic Level	400-499			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	3	2	75
Pre-requisites	1. Mathematical Logic and necessary exposure to set theory. 2. Matrices and Determinants 3. Systems of Linear Equations and their solutions			
Course Summary	Vector spaces in the abstract are introduced. Linear transformations are introduced as structure preserving maps between them. Representation of linear transformations as matrices is discussed. The algebraic dual and double dual space of a vector space are studied in some detail. The concept of the transpose of a linear transformation is introduced and discussed as well. The course then passes on to spectral theory on finite dimensional spaces, introducing characteristic values and vectors. After an extended discussion leading up to the characterisation of diagonalisable and triangulable operators, an elementary decomposition of a linear operator is established. The course ends with a short discussion of inner products and inner product spaces.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Analyse and apply the concepts of vector spaces, subspaces, and bases to solve problems involving linear independence and dimensionality.	An	P	Internal Exam/Assignment/Seminar/ Viva/Report/ End Sem Exam
CO2	Evaluate the properties of linear transformations and their algebraic representations using matrices.	E	C	Internal Exam/Assignment/Seminar/ Viva/Report/ End Sem Exam
CO3	Synthesize the concepts of linear functionals, the double dual space, and the transpose of linear transformations to understand advanced topics in linear algebra and apply them to canonical forms	E	P	Internal Exam/Assignment/Seminar/ Viva/Report/ End Sem Exam

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Textbook	Linear Algebra, Kenneth Hoffman and Ray Kunze, 2nd Edition, Prentice Hall of India, 1991.			
Module	**Unit**	**Content**	**Hrs (45+30)**	**External Marks (70)**
I		**Vector Spaces**	12	Min.15
	1	Section 2.1 – Vector Spaces		
	2	Section 2.2 – Subspaces		
	3	Section 2.3 – Bases and Dimension – up to Theorem 5		
	4	Section 2.3 – Bases and Dimension – rest of the section starting from Theorem 5		
	5	Section 2.4 – Coordinates – up to and including Theorem 7		
	6	Section 2.4 – Coordinates – rest of the section		
II		**Linear Transformations**	11	Min.15
	7	Section 3.1 – Linear Transformations – upto and including Example 7		
	8	Section 3.1 – Linear Transformations – rest of the section.		
	9	Section 3.2 – The Algebra of Linear Transformations – up to and including Theorem 5		
	10	Section 3.2 – The Algebra of Linear Transformations – rest of the section		
	11	Section 3.3 – Isomorphism		
	12	Section 3.4 – Representation of Transformations by Matrices – up to and including Example 15		
III		**Linear Transformations**	11	Min.15
	13	Section 3.4 – Representation of Transformations by Matrices – rest of the section		
	14	Section 3.5 – Linear Functionals – upto and including Example 22.		
	15	Section 3.5 – Linear Functionals – rest of the section.		
	16	Section 3.6 – The Double Dual – upto and including Theorem 18.		
	17	Section 3.6 – The Double Dual – the rest of the section		
	18	Section 3.7 – The Transpose of a Linear Transformation – up to and including Theorem 22		
	19	Section 3.7 – The Transpose of a Linear Transformation – rest of the section.		
IV		**Elementary Canonical Forms**	11	Min.15
	20	Section 6.1 and 6.2 – Introduction and Characteristic Values		
	21	Section 6.3 – Annihilating Polynomials (Proof of Theorem 4 omitted)		
	22	Section 6.4 – Invariant Subspaces.		

V	**Practicum** The goal is for the students to learn the following selected topics in 10 practicum sessions of three hours each via self-study and group activities. The lecturer may assist by running group discussions, supervising class seminars and referring library books for self-study and note preparations. 1 Section 1.3 – Matrices and Elementary Row Operations 2 Section 1.4 – Row Reduced Echelon Matrices 3 Section 1.5 – Matrix Multiplication 4 Section 1.6 – Invertible Matrices 5 Section 6.4 – Triangulation and Diagonalisation 6 Section 6.6 – Direct-sum Decompositions 7 Section 6.7 – Invariant Direct Sums 8 Section 8.1 – Inner Products 9 Section 8.2 – Inner Product Spaces 10 Section 6.8 – The Primary Decomposition Theorem	**30**	-

References

1. Finite Dimensional Vector Spaces, P. R. Halmos, Narosa Pub House, 1980..
2. Linear Algebra, S. Lang, Addison Wesley Pub Company, 1972.
3. Topics in Algebra, I. N. Herstein, John Wiley & Sons, 2006.
4. Linear Algebra, R. R. Stoll & E. T. Wong, Academic Press International Edition, 1968.

Suggested Programming Exercises for Practicuum :

1. Form a four-dimensional vector space over Q. Take two vectors from this, find its span. (Chapter VS, Ref (1))
2. Find basis of the vector subspace found in the above question. (Chapter VS, Ref (1))
3. Take some elements from this vector space, test for linear independence. (Chapter V Section LI, Ref (1))
4. Form two vector spaces over Q. Define symbolic linear transformations between them, find the image of selected elements under it. (Chapter LT, Ref (1))
5. Define linear transformations (LT) from matrices. (Chapter LT, Ref (1))
6. Check if linear transformation is injective (Section ILT , Ref (1))
7. Define two LT, add them. Find the individual matrices of these with respect to certain bases. Verify that the matrix of the sum of LT is the sum of matrices of individual LT .(Section OLT, , Ref (1)))
8. Find the kernel of an LT, find its nullitty. (Section ILT, Ref (1))
9. Find inverse of LT (Section IVLT, Ref (1))
10. Take a matrix, find Eigenvalues, Eigen vectors, check if it is

diagonalizable, diagonalize if it is. (Chapter E ILT, Ref (1))

References

1. Robert A. Beezer, Sage for Linear Algebra A Supplement to A First Course in Linear Algebra http://linear.ups.edu/sage•fcla.html
2. Sang-Gu Lee *et al.*, Linear Algebra with Sage https://www.researchgate.net/publication/280093747_Linear_Algebra_with_Sage_BigBook_Free_e•book_English_ Version_All

***70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.**

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	2	1	3	0	3	1	3	0	2
CO 2	3	3	2	1	3	0	3	2	3	0	2
CO 3	3	3	2	2	3	0	3	2	3	0	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Report
- Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment/ Report	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT7CJ405			
Course Title	**DISCRETE MATHEMATICS**			
Type of Course	**Major**			
Semester	VII			
Academic Level	400-499			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	3	2	75
Pre-requisites	Basic Logical thinking and Set theory.			
Course Summary	The "Discrete Mathematics" course (MAT7CJ405) covers essential concepts in discrete structures and their applications. Students explore topics like graph theory, automorphisms, connectivity, and order relations through carefully structured modules. The course includes practical exercises and references to foundational works in the field, providing students with theoretical understanding and problem-solving skills necessary for further studies or real-world applications in mathematics and related areas.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Describe and explain fundamental concepts in graph theory, including subgraphs, vertex degrees, paths, connectedness, and operations on graphs.	U	C	Internal Exam/ Assignment/ Seminar/ Viva /Report/ End Sem Exam
CO2	Apply and analyse concepts related to automorphisms of graphs, vertex and edge cuts, and graph connectivity, utilizing definitions, theorems, and exercises.	An	P	Internal Exam/ Assignment/ Seminar/ Viva/ Report/ End Sem Exam
CO3	Evaluate and compare order relations in mathematical contexts and their implications for understanding and applying order theory.	E	C	Internal Exam/ Assignment/ Seminar/ Viva/ Report/ End Sem Exam

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Textbook				
	1. A Textbook of Graph Theory. (2/e) Balakrishnan, R, & Ranganathan, K, Springer-Verlag, New York Inc., 2020 **2.** Foundations of Discrete Mathematics, K. D Joshi, New Age International (P) Limited, New Delhi, 1989. **3.** An Introduction to Formal Languages and Automata (2/*e*), Peter Linz, Narosa Publishing House, New Delhi, 1997			
Module	**Unit**	**Content**	**Hrs (75)**	**External Marks (70)**
I	**Fundamentals of Graph Theory**		**12**	**Min.15**
	1	Section 1.0 Introduction (Text 1)		
	2	Section 1.1 Basic Concepts (Text 1)		
	3	Section 1.2 Sub Graphs (Text 1)		
	4	Section 1.3 Degrees of Vertices (Text 1)		
	5	Section 1.4 Paths and Connectedness (Text 1)		
II	**Graph Operations and Connectivity**		**11**	**Min.15**
	6	Section 1.5 Automorphisms of a simple graph (Definition 1.5.1 to Theorem 1.5.3) (Text 1)		
	7	Section 1.5 Automorphisms of a simple (Exercise 5.1 to Exercise 5.5) (Text 1)		
	8	Section 1.7 Operations on Graphs (Definition 1.7.1 to Example 1.7.10) (Text 1)		
	9	Section 1.7 Operations on Graphs (Exercise 7.3 to Exercise 7.6) (Text 1)		
	10	Section 3.1 Vertex Cuts and edge Cuts (Definition 3.1.1 to Theorem 3.1.10) (Text 1)		
	11	Section 3.1 Vertex Cuts and edge Cuts (Proposition 3.1.2 to Exercise 1.4) (Text 1)		
	12	Section 3.2 Connectivity and Edge - Connectivity (Definition 3.2.1 to Exercise 2.10) (Text 1)		
	13	Section 3.2 Connectivity and Edge - Connectivity (Theorem 3.2.10 to Theorem 3.2.11) (Text 1)		
III	**Order Relations**		**11**	**Min.15**
	14	Section 3 Order Relations (Sections 3, 3.1, 3.2 of Text 2)		
	15	Section 3 Order Relations (Sections 3.3, 3.4 of Text book 2)		
	16	Section 3 Order Relations (Sections 3.5, 3.6 of Text book 2)		
	17	Section 3 Order Relations (Sections 3.7 of Text book 2)		
	18	Section 3 Order Relations (Sections 3.8, 3.9, 3.10 of Text 2)		
	19	Section 3 Order Relations (Sections 3.11 of Text book 2)		
IV	**Finite Automata and Acceptors**		**11**	**Min.15**
	20	Section 2.1 Deterministic Finite Accepters (Text 3)		
	21	Section 2.2 Non-Deterministic Finite Accepters (Text 3)		
	22	Section 2.3 Equivalence of Deterministic and Nondeterministic Finite Accepters (Text 3)		

V	**Practicum**		**30**	
		Line Graphs and Directed Graphs		
		Eulerian Graphs and Hamiltonian Graphs		
		Planar and Non planar Graphs		
		Applications of Lattices in Switching Circuits		
		Applications of Automata in Theory of Computing		

References

1. J. C. Abbot: Sets, lattices and Boolean Algebras; Allyn and Bacon, Boston; 1969.
2. J. A. Bondy, U.S.R. Murty: Graph Theory; Springer; 2000.
3. S. M. Cioaba and M.R. Murty: A First Course in Graph Theory and Combinatorics; Hindustan Book Agency; 2009
4. R. P. Grimaldi: Discrete and Combinatorial Mathematics- an applied introduction(5th edn.); Pearson; 2007.
5. J. L. Gross: Graph theory and its applications(2nd edn.); Chapman & Hall/CRC; 2005
6. Graph Theory and Decomposition, Jomon Kottarathil, Sudev Naduvath and Joseph Varghese Kureethara, CRC Press, London, New York, 2024.

****70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.**

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	1	2	2	0	3	0	2	1	3	0	2
CO 2	1	3	2	1	3	0	3	2	3	0	3
CO 3	0	2	2	1	3	0	3	1	3	0	2

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Report
- Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment/ Report	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT8CJ406 / MAT8MN406			
Course Title	**BASIC MEASURE THEORY**			
Type of Course	**Major**			
Semester	VIII			
Academic Level	400-499			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	3	2	75
Pre-requisites	1. Fundamental Mathematics Concepts: Set, Functions, Logic 2. Real Analysis			
Course Summary	This course familiarises students with the Lebesgue Measure on the real line and how it enables the construction of a theory of integration that does away with many of the drawbacks of Riemann integration.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand and explain the concepts of Lebesgue measure, including outer measure, measurable sets, and properties such as countable additivity and the Borel-Cantelli Lemma.	U	C	Internal Exam/ Assignment/ Seminar/ Viva /Report/ End Sem Exam
CO2	Apply theorems related to Lebesgue measurable functions, including Littlewood's Three Principles, Egoroff's, and Lusin's Theorems, to analyse function behaviour and approximations.	Ap	P	Internal Exam/ Assignment/ Seminar/ Viva /Report/ End Sem Exam
CO3	Evaluate and integrate functions using the Lebesgue integral, understanding its differences from the Riemann integral and applying it to bounded and non-negative measurable functions.	E	F	Internal Exam/ Assignment/ Seminar/ Viva /Report/ End Sem Exam
	* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create(C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)			

Detailed Syllabus:

Text book	Real Analysis, H. L. Royden & P. M. Fitzpatrick, 4th Edition, Prentice Hall of India, 2000			
Module	**Unit**	**Content**	**Hrs (45+ 30)**	**Ext. Marks (70)**
I		**Chapters 0, 1, 2: The Lebesgue Measure**	**15**	**Min.15**
	1	Preliminaries On Sets, Mappings & Relations (Review only)		
	2	Chapter 1: The Real Numbers: Sets, Sequences & Functions (Proofs of results included in Practicum)		
	3	2.1 Introduction – Measure as a set function		
	4	2.2 Lebesgue Outer Measure		
	5	2.3 The σ–Algebra of Lebesgue Measurable Sets		
	6	2.4 Outer & Inner Approximation of Lebesgue Measurable Sets		
	7	2.5 Countable Additivity, Continuity & the Borel-Cantelli Lemma		
	8	2.6 Non-Measurable Sets		
II		**Chapter 3: Lebesgue Measurable Functions**	**8**	**Min.15**
	10	3.1 Sums, Products & Compositions		
	11	3.2 Sequential Pointwise Limits & Simple Approximation		
	12	3.3 Littlewood's Three Principles, Egoroff's & Lusin's Theorems		
III		**Chapter 4: The Lebesgue Integral**	**12**	**Min.20**
	13	4.1 The Riemann Integral		
	14	4.2 Lebesgue Integral of Bounded Measurable Function Over a Set of Finite Measure.		
	15	4.3 Lebesgue Integral of a Non-negative Measurable Function.		
	16	4.4 The General Lebesgue Integral		
	17	4.5 Countable Additivity & Continuity of Integration (proofs included in practicum)		
	18	4.6 Uniform Integrability: The Vitali Convergence Theorem (proofs included in Practicum)		
IV		**Chapter 5: Differentiation & Lebesgue Integration**	**10**	**Min.10**
	19	6.1 Continuity of Monotone Functions.		
	20	6.2 Differentiability of Monotone Functions: Lebesgue's Theorem		
	21	6.3 Functions of Bounded Variation: Jordan's Theorem		
	22	6.4 Absolutely Continuous Functions (Proof of Theorem 9 is optional)		
	23	6.5 Integrating Derivatives: Differentiating Indefinite Integrals		
V		**Practicum:** The goal is for the students to learn the following selected topics in 10 practicum sessions of three hours each via self-study and group activities. The lecturer may assist by running group discussions and supervising class seminars and referring library books for self-study and note preparations.	**30**	
	1	Proofs in Chapter 1: The Real Numbers		
	2	Section 2.7 - The Cantor Set & the Cantor-Lebesgue Function		
	3	Proofs in Section 4.5		

	4	Proofs in Section 4.6		
	5	5.1: Uniform Integrability & Tightness		
	6	5.2: Convergence in Measure		
	7	5.3: Characterizations of Riemann & Lebesgue Integrability		
	8	7.1: Normed Linear Spaces		
	9	7.2: Inequalities		
	10	7.3: Riesz-Fischer Theorem		

References

1. R. G. Bartle, Wiley, The Elements of Integration & Lebesgue Measure,1995..
2. G. de Barra, Measure Theory & Integration, New Age International Publications, 1981.
3. David M. Bressoud, A Radical Approach to Lebesgue's Theory of Integration (ARALTI), Cambridge University Press, 2008.
4. P. R. Halmos, Measure Theory, GTM, Springer-Verlag
5. Walter Rudin, Principles of Mathematical Analysis, 3rd Edition, Tata McGraw Hill Inc., 1976.
6. Walter Rudin, Real & Complex Analysis, 3rd Edition, McGraw Hill Inc., 1987.

***Optional topics are exempted for end semester examination.**
****70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.**

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	1	0	0	3	0	2	1	3	0	2
CO 2	2	2	0	0	3	0	3	2	3	0	3
CO 3	1	0	3	0	3	0	3	1	3	0	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Report
- Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment/ Report	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT8CJ407 / MAT8MN407			
Course Title	**NUMBER THEORY**			
Type of Course	**Major**			
Semester	VIII			
Academic Level	400•499			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	4	•	60
Pre•requisites	Basic algebra of integers, basic set theory, basic proof techniques.			
Course Summary	This is a more advanced course than MAT6CJ305 / MAT8MN305 Elementary Number Theory. Here we focus on arithmetical functions, their averages, distribution of prime numbers, quadratic reciprocity and in the last open•ended section, Cryptography. Arithmetical functions are geared towards the study of prime numbers and their distribution. We provide a rigorous examination of several of them such as Mobius function, Euler's totient function, and compositions through techniques such as Dirichlet multiplication and convolution. Next we study their asymptotic behaviour using techniques such elementary estimates, partial summation and Dirichlet products. Next, we study the distribution of prime numbers. The prime number theorem is stated along with some equivalent versions and a build•up to it. Next the concept of quadratic residues, quadratic reciprocity and how to compute the same, along with applications, are studied. The open•ended part is Cryptography.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand and analyse the properties of arithmetical functions, including the Möbius function, Euler totient function, and their relationships and products.	An	C	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam
CO2	Apply Dirichlet multiplication and inversion formulas to solve problems involving arithmetical functions, including the Mangoldt function and Liouville's function.	Ap	P	Internal Exam/Assignment /Seminar/ Viva/ End Sem Exam
CO3	Evaluate and create asymptotic formulas and theorems related to the distribution of prime numbers and quadratic residues, utilizing tools such as Chebyshev's functions and the quadratic reciprocity law.	C	F	Internal Exam/Assignment /Seminar/ Viva/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Textbook	1. Introduction to Analytic Number Theory,Tom M. Apostol , Springer International Student Edition ,Narosa Publishing House, New Delhi, 1990 2. A course in Number Theory and Cryptography, second Edition,Neal Koblitz Springer, 1991			
Module	**Unit**	**Content**	**Hrs (48+ 12)**	**Marks** **Ext: 70**
I		Arithmetical Functions and their properties	**18**	**Min.15**
		Arithmetical Functions and Dirichlet Multiplication		
	1	Section 2.1-Introduction		
	2	Section 2.2- The Mobius function $\mu(n)$		
	3	Section 2.3- The Euler totient function $\phi(n)$		
	4	Section 2.4- A relation connecting μ and ϕ		
	5	Section 2.5- A product formula for $\phi(n)$		
	6	Section 2.6- The Dirichlet product of arithmetical functions		
	7	Section 2.7- Dirichlet inverses and Mobius inversion formula		
	8	Section 2.8- The Mangoldt function $\Lambda(n)$		
	9	Section 2.9- Multiplicative functions		
	10	Section 2.10- Multiplicative functions and Dirichlet Multiplication		
	11	Section 2.11- Inverse of a completely multiplicative function		
	12	Section 2.12- Liouville's function $\lambda(n)$		
	13	Section 2.13- The divisor functions $\sigma_\alpha(n)$		
	14	Section 2.14- Generalized Convolutions		
II		**Averages of Arithmetical Functions**	**10**	**Min.15**
	15	Section 3.1- Introduction		
	16	Section 3.2--The big oh notation. Asymptotic equality of functions		
	17	Section 3.3- Euler's Summation formula		
	18	Section 3.4- Some elementary asymptotic formulas		
	19	Section 3.10- The Partial sums of a Dirichlet product		
	20	Section 3.11- Applications of $\mu(n)$ and $\Lambda(n)$		
	21	Section 3.12- Another identity for the partial sums of a Dirichlet product		
III		**Some Elementary Theorems on the Distribution of Prime Numbers**	**10**	**Min.15**
	22	Section 4.1- Introduction		
	23	Section 4.2- Chebyshev's functions $\psi(x)$ and ft(x)		
	24	Section 4.3- Relations connecting ft(x) and $\pi(x)$		
	25	Section 4.4- Some equivalent forms of the prime number theorem		
	26	Section 4.5- Inequalities for $\pi(n)$ and p_n		
IV		**Quadratic Residues and the Quadratic Reciprocity Law**	**10**	**Min.15**
	27	Section 9.1- Quadratic residues		

	28	Section 9.2- Legendre's symbol and its properties		
	29	Section 9.3- Evaluation of (-1| p) and (2| p)		
	30	Section 9.4- Gauss' lemma		
	31	Section 9.5- The quadratic reciprocity law		
	32	Section 9.6- Applications of the reciprocity law		
V	**Open Ended: Cryptography**		**12**	
	Chapter III ● 1: Some simple cryptosystems -3 hrs ● 2: Enciphering Matrices-4hrs Chapter IV ● 1: The idea of public key cryptography -3 hrs ● 2: RSA-2 hrs			

References

1. A. Beautel spacher: Cryptology; Mathematical Association of America (Incorporated); 1994
2. H. Davenport: The higher arithmetic(6th Edn.); Cambridge Univ.Press;
3. G. H. Hardy and E.M. Wright: Introduction to the theory of numbers; Oxford International Edn; 1985
4. A. Hurwitz & N. Kritiko: Lectures on Number Theory; Springer Verlag ,Universi text;1986
5. T. Koshy: Elementary Number Theory with Applications; Harcourt / Academic Press;2002
6. D. Redmond: Number Theory; Monographs & Texts in Mathematics No: 220; Mar cel Dekker Inc.; 1994
7. P. Ribenboim: The little book of Big Primes; Springer-Verlag, New York; 1991
8. K.H. Rosen: Elementary Number Theory and its applications(3rd Edn.); Addison WesleyPub Co.; 1993
9. W. Stallings: Cryptography and Network Security-Principles and Practices; PHI; 2004
10. D.R. Stinson: Cryptography- Theory and Practice(2nd Edn.); Chapman & Hall / CRC (214. Simon Sing: The Code Book The Fourth Estate London); 1999
11. J. Stopple: A Primer of Analytic Number Theory-From Pythagoras to Riemann; Cambridge Univ Press; 2003
12. S.Y. Yan: Number Theory for Computing(2nd Edn.); Springer-Verlag; 2002

***70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.**

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	1	2	1	1	3	0	3	1	3	0	2
CO 2	2	3	2	1	3	0	3	2	3	0	3
CO 3	3	2	3	2	3	0	3	1	3	0	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours				
Course Code	MAT8CJ408 / MAT8MN408				
Course Title	**DIFFERENTIAL EQUATIONS**				
Type of Course	**Major**				
Semester	VIII				
Academic Level	400-499				
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours	
	4	4	-	60	
Pre-requisites	Basic knowledge of calculus of one variable and an introductory course in Real Analysis				
Course Summary	The course enhances the skill to solve ordinary differential equation using specific methods analytically and computationally for first and higher order differential equations. Most of the fundamental phenomena occurring in the nature are expressed as a differential equation. Students must know how to model any physical phenomena using differential equations.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand and apply the existence and uniqueness theorems for second-order differential equations, including methods such as the method of successive approximations and Picard's theorem.	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Analyse and solve second-order differential equations using power series methods, including ordinary points, regular singular points, and specific functions such as Gauss's Hypergeometric Equation and Legendre Polynomials.	An	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Evaluate and determine the stability of autonomous systems and critical points for linear and nonlinear systems using the phase plane analysis and Lyapunov's direct method.	E	M	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Text Book	Differential Equations With Applications And Historical Notes, Third Edition,George F. Simmons.			
Module	**Unit**	**Content**	**Hrs (48+ 12)**	**Marks** **Ext: 70**
I		**Second Order Differential Equations**	**12**	**Min.15**
		Existence and Uniqueness of Solutions and Power Series method of solving differential equations		
	1	69 Method of Successive Approximations		
	2	70 Picard's theorem, theorems A& B (proofs are optional).		
	3	71 Systems. The Second Order Equations		
	4	26 Introduction. A review of Power Series		
	5	27 Series solutions of first order equations		
	6	28 Second order Equations. Ordinary points		
	7	29 Regular singular points		
II		**Power Series Solutions and Special Functions**	**11**	**Min.15**
	8	30 Regular Singular Points continued		
	9	31 Gauss's Hypergeometric Equation		
	10	31 Gauss's Hypergeometric Equation Reduction to Hypergeometric equation		
	11	32 The Point at Infinity		
	12	44 Legendre Polynomials (proofs of Rodrigues' formula is optional)		
III		**Special Functions (Contd.)**	**12**	**Min.15**
	13	45 Properties of Legendre Polynomials		
	14	46 Bessel functions.		
	15	46 Bessel functions. The Gamma function		
	16	47 Properties of Bessel functions		
	17	47 Properties of Bessel functions Zeros and Bessel series. Bessel expansions		
IV		**Autonomous Systems. Stability of Linear and Nonlinear Systems**	**13**	**Min.15**
	18	58 Autonomous systems. The phase plane and its phenomena		
	19	59 Types of critical points		
	20	59 Types of critical points. Stability		
	21	60 Critical points and stability for linear system		
	22	61 Stability by lyapunov direct method		
V		**Open Ended**	**12**	
		• Proof of Picard's theorem • Proof of theorem B of Unit I • Proof of Rodrigues' formula for Legendre polynomials		

	• Analyse solutions of Differential Equations using softwares like Python		

References

1. G. Birkhoff and G.C. Rota: Ordinary Differential Equations (3rd Edn.); Edn. Wiley & Sons; 1978
2. W.E. Boyce and R.C. Diprima: Elementary Differential Equations and boundary value problems (2nd Edn.); John Wiley & Sons, NY; 1969
3. A. Chakrabarti: Elements of ordinary Differential Equations and special functions; Wiley Eastern Ltd., New Delhi; 1990
4. E.A. Coddington: An Introduction to Ordinary Differential Equations; Prentice Hall of India, New Delhi; 1974
5. A. K. Nandakumaran, P. S. Datti, Raju K. George: Ordinary Differential Equations: Principles and Applications, Cambridge University Press

***Optional topics are exempted for end semester examination.**

****70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.**

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	2	2	1	3	0	3	1	3	0	2
CO 2	2	2	1	0	3	0	3	2	3	0	3
CO 3	1	2	2	2	3	0	3	1	3	0	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

ELECTIVE COURSES

Programme	B. Sc. Mathematics Honours			
Course Code	MAT5EJ301(1)			
Course Title	**MATHEMATICAL FOUNDATIONS OF COMPUTING**			
Type of Course	**Elective (Specialisation- Mathematical Computing)**			
Semester	V			
Academic Level	300 - 399			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites	Fundamental Mathematics Concepts: Set, Functions, Logic			
Course Summary	This course familiarises students with a selection of topics from discrete mathematics which find regular applications in Computer Science.			

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Apply mathematical induction to solve a variety of combinatorial problems.	Ap	P	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam
CO2	Analyse and classify different types of relations and equivalences in combinatorial settings.	An	C	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam
CO3	Evaluate and demonstrate proficiency in using combinatorial techniques such as permutations, factorials, and binomial coefficients to solve complex problems.	E	P	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

TextBook	(I) Jiří Matoušek and Jaroslav Nešetřil, Invitation to Discrete Mathematics, (2/e) Oxford University Press (II) Robin J Wilson, Introduction to Graph Theory (4/e), Prentice Hall			
Module	**Unit**	**Content**	**Hrs (48+12)**	**Ext. Marks (70)**
I		**Combinatorial Counting (Text 1)**	**12**	
	1	1.1 An Assortment of problems		
	2	1.3 Mathematical Induction (Proof of Theorem 1.3.1 is optional)		
	3	1.5 Relations, 1.6 Equivalences and other special type of relation		
	4	3.1 Functions and subsets, 3.2 Permutations and factorials		
	5	3.3 Binomial Coefficients-		
	6	3.7 Inclusion-Exclusion Principle. (Third proof of Theorem 3.7.2 is optional)		
II		**Basics of Graph Theory (Text 1)**	**12**	
	7	4.1 The notion of a graph; Isomorphism		
	8	4.2 Subgraphs, Components, Adjacency Matrix		
	9	4.3 Graph Score (Proof of Theorem 4.3.3 is optional)		
	10	4.4 Eulerian Graphs (Second proof of Theorem 4.4.1 and lemma 4.4.2 are optional)		
	11	4.5 Eulerian Directed Graph		
	12	5.1 Definition and characterizations of trees		
III		**Matching and Colouring (Text 2)**	**12**	
	13	12. Planar Graphs (Proof of Theorem 12.2 and Theorem 12.3 are optional)		
	14	13. Euler's formula (up to Corollary 13.4)		
	15	13. Euler's formula (from Corollary 13.4)		
	16	17. Coloring Graphs		

	17	19. Coloring Maps (Proof of Theorem 19.2 and Theorem 19.4 are optional)		
	18	25 Hall's Marriage theorem		
IV	**Probabilistic Method (Text 1)**		**12**	
	19	10.1 Proofs by Counting (2-Coloting revisited and related topics are optional)		
	20	10.2 Finite Probability Spaces (up to Random graphs)		
	22	10.2 Finite Probability Spaces (From Random graphs)		
	22	10.3 Random Variables and their Expectations		
V	**Open Ended**		**12**	
	Hamiltonian Graphs, 2-Connectivity, Examples of applications of Probabilistic Method, Ramsey Theory, Generating Functions, simulating random experiments in python and calculating expectations. Brook's Theorem.			

References:

1. Discrete Mathematics by Norman L. Biggs (2nd Edition, 2002), Oxford University Press (ISBN- 13: 978-0198507178)
2. Discrete Mathematics and Applications by Kenneth Rosen (7th Edition, 2012), McGraw-Hill Education (ISBN-13: 978-0073383095)
3. Discrete Mathematics: Elementary and Beyond by László Lovász, József Pelikán, Katalin Vesztergombi, Springer 2003, ISBN-13: 978-0387955858.

Note: 1) Optional topics are exempted for end semester examination
2) 70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	2	1	1	3	1	3	1	3	0	2
CO 2	2	2	1	1	3	1	3	2	3	0	2
CO 3	2	3	2	2	3	1	3	2	3	0	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours				
Course Code	MAT5EJ302(1)				
Course Title	**DATA STRUCTURES AND ALGORITHMS**				
Type of Course	**Elective (Specialisation- Mathematical Computing)**				
Semester	V				
Academic Level	300 - 399				
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours	
	4	4	-	60	
Pre-requisites	1. Fundamental Mathematics Concepts: Sets, Functions 2. Discrete Mathematics				
Course Summary	This course familiarises students with computational problems and computational thinking using some of the basic algorithmic strategies.				

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Analyse and compare the efficiency of algorithms for computing Fibonacci numbers, distinguishing between exponential and polynomial approaches.	E	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Demonstrate proficiency in asymptotic analysis to assess the efficiency of algorithms.	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Apply classical algorithms for number operations, including addition, multiplication, and modular arithmetic, to solve computational problems efficiently.	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Text Book	*Algorithms* by Sanjoy Dasgupta, Christos H. Papadimitriou, Umesh Vazirani. McGraw- Hill Education, 2006. ISBN: 978-0073523408.			
Module	**Unit**	**Content**	**Hrs (48+12)**	**Ext. Marks (70)**
I		**Introduction**	**12**	
	1	Computing Fibonacci Numbers: Exponential and Polynomial Algorithms		
	2	Efficiency of Algorithms: Asymptotic Analysis, Big-O Notation		
	3	Algorithms with Numbers: Efficiency of classical Addition and Multiplication algorithms		
	4	Algorithms for Modular Arithmetic		
	5	Euclid's Algorithm for GCD		
	6	Primality Testing		
	Sections from Text: 0.2, 0.3, 1.1, 1.2, 1.3			
II		**Divide and Conquer Algorithms and Graph Search**	**12**	
	7	Fast Integer Multiplication		
	8	Recursive Relations		
	9	Binary Search		
	10	Merge Sort		
	11	Graph Representations: Adjacency Matrix, Adjacency List		
	12	Depth First Search Undirected Graphs		
	13	Depth First Search in Directed Graphs		
	Sections from Text: 2.1, 2.2. 2.3, 3.1-3.3.			
III		**Graph Algorithms**	**12**	
	14	Checking connectivity		
	15	Directed Acyclic Graphs, Strongly Connected Components		
	16	Breadth First Search and Computation of distances.		
	17	Weighted Graphs and Dijkstra's Algorithm		
	18	Priority queue implementations		

	19	Shortest Paths in Directed Acyclic Graphs		
	Sections from Text: 3.4, 4.1 to 4.4, 4.5, 4.7			
IV	**Greedy & Dynamic Programming Algorithms**		**12**	
	20	Minimum Spanning Trees: Cut Property		
	21	Kruskal's Algorithm		
	22	Data structure for disjoint sets.		
	23	Prim's algorithm		
	24	Dynamic Programming and Shortest Path in Directed Acyclic Graphs (DAG)		
	25	All pairs of Shortest Paths and Floyd Warshall Algorithm		
	Sections from Text: 5.1, 5.4, 6.1, 6.6.			
V (Open Ended)	**Advanced Topics (Practical)**		**12**	
	27	Implement the following algorithms in Python - Fibonacci Numbers (exponential and polynomial) - Euclid's algorithm (extended version) - Primality Testing - Depth First Search (and checking connectivity) - Breadth First Search (and calculating distances) - Dijkstra's Algorithm		

References:

1. *The Design and Analysis of Algorithms* by Dexter C Kozen. Texts and Monographs in Computer Science, Springer, 1992. ISBN:0-387-97687-6.
2. *Introduction to Algorithms* (3rd Edition) by Thomas H. Cormen, Charles E. Leiserson, Ronald L Rivest, Clifford Stein. PHI Learning, 2009. ISBN:978-81-203-4007-7.
3. *Algorithm Design* by Jon Kleinberg and Eva Tardos. Pearson, 2015. ISBN:978-93-325-1864.

Note: 70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	2	3	2			3	1	3	3	3	0	3
CO 2	2	3	2	2			3	1	3	3	3	0	2
CO 3	2	3	3	2			3	1	3	3	3	0	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT6EJ301(1)			
Course Title	**NUMERICAL ANALYSIS**			
Type of Course	**Elective (Specialisation- Mathematical Computing)**			
Semester	VI			
Academic Level	300- 399			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites	1. Real analysis 2. Linear algebra 3. Basics of Python Programming			
Course Summary	This course familiarises students with the fundamental numerical analysis. Moreover, the course facilitates students to apply results from real analysis and linear algebra to perform quantitative analysis of numerical solutions.			

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand and apply the Bisection Method, Iteration Method, Newton-Raphson Method, and Secant Method to solve algebraic and transcendental equations numerically.	Ap	P	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam
CO2	Implement interpolation methods such as Newton's formulae, Lagrange's interpolation formula, and divided differences to approximate functions from discrete data.	Ap	P	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam
CO3	Implement numerical methods such as Euler's method, Modified Euler's Method, Runge-Kutta method, and Adams-Moulton Method to solve ordinary differential equations (ODEs).	Ap	P	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Text Book			
Text Book		[1]. S. S. Sastry, Introductory Methods of Numerical Analysis (5/e), PHI Learning (2012) [2]. Dimitrios Mitsotakis: Computational Mathematics: An Introduction to Numerical Analysis and Scientific Computing with Python, CRC Press (2023), ISBN 978-1-032-26240-6. [3]. Jupyter Notebooks of [2] available at: https://github.com/dmitsot/computational_mathematics	
Module	**Unit**	**Content**	**Hrs (48+12)**
I		**Numerical Solutions of Algebraic and Transcendental equations (Text 1)**	**12**
	1	2.1 Introduction	
	2	2.2 Bisection Method	
	3	2.4 Iteration Method (Derivation of Condition for Convergence and Acceleration of Convergence are optional)	
	4	2.5 Newton- Raphson Method (Generalized Newton's Method is optional)	
	5	2.7 Secant Method	
II		**Interpolation (Text 1)**	**12**
	6	3.1 Introduction, 3.3.1 Forward differences, 3.3.2 Backward differences	
	7	3.6 Newton's formulae for interpolation (up to and including Example 3.5)	
	8	3.6 Newton's formulae for interpolation (From Example 3.6)	
	9	3.9.1 Langrange's interpolation formula	
	10	3.10 Divided differences and their properties	
	11	3.10.1 Newton's General interpolation formula	
III		**Numerical Differentiation and Integration (Text 1)**	**12**
	12	6.1 Introduction, 6.2 Numerical Differentiation (6.2.1, 6.2.2 and 6.2.3 are optional)	
	13	6.4.1 Trapezoidal Rule	
	14	6.4.2 Simpson's 1/3-Rule	
	15	6.4.3 Simpson's 3/8 Rule	
	16	6.10 Numerical Double Integration	
IV		**Numerical Solutions of Ordinary Differential Equation (Text 1)**	**12**
	17	8.1 Introduction	
	18	8.2 Solution by Taylor's series,	
	19	8.4 Euler's method (8.4.1 is optional)	
	20	8.4.2 Modified Euler's Method	
	21	8.5 Runge-Kutta method	
	22	8.6.1 Adams-Moulton Method	
V		**Numerical Algorithms and Lab Practicals**	**12**
	1	Jupyter Lab and Notebooks. Google Colab. Instructions in [6] and [7]. Quick review of Python Programming. Ch 1 Notebook from [3].	

	2	Continue Quick Review of Python. Notebook [9]. Numpy and Scipy review from [7]. Ch 2 Notebook from [3].	
	3	Bisection Method. Algorithm and Program. Jupyter Notebook: Ch 5 of [3]. Refer also 5.1 of [2]. Optional: Program to compute speed of convergence. Optional: False Position variant from [12].	
	4	Fixed Point Method (Iteration Method). Algorithm and Program. Notebook: Ch 5 of [3]. Reference: 5.2 of [2].	
	5	Newton-Raphson Method. Algorithm and Program. Notebook: Ch 5 of [3]. Reference: 5.3 of [2].	
	6	Secant Method. Algorithm and Program. Notebook: Ch 5 of [3]. Reference: 5.4 of [2].	
	7	Fast computation using SciPy.Optimize. Notebook: Ch 5 of [3]. Reference: 5.6 of [2].	
	8.	Lagrange Interpolation. Notebook: Ch 6 of [3]. Reference: 6.1 of [2].	
	9	Newton's method for Interpolation using Divided Differences. Notebook: Ch 6 of [3]. Reference: 6.2 of [2].	
	10	Using SciPy.Interpolate Module. Lagrange Interpolation Only. Notebook: Ch 6 of [3]. Reference: 6.6 of [2].	
	11	Numerical Differentiation. Forward and Backward Differences. First Order and Second Order Derivative Approximations. Notebook: Ch 8 of [3]. Reference: 8.1 of [2].	
	12	Numerical Integration. Midpoint Rule. Composite Trapezoidal Rule. Composite Simpson's Rule. Notebook: Ch 7 of [3]. Reference: 7.1. of [2].	
	13	The Module scipy.integrate. Trapezoidal, Simpson. Reference: 7.4 of [2]. Notebook: Ch 7 of [3].	
	14	Euler's Method. Improved Euler's Method. Reference: 8.2 of [2]. Notebook: Ch 8 of [3].	

References:

1. F.B. Hildebrand: Introduction to Numerical Analysis, TMH.
2. J.B. Scarborough: Numerical Mathematical Analysis, Oxford and IBH
3. Joakim Sundnes, Introduction to Scientific Programming with Python. Springer (2020). ISBN 978-3-030-50355-0. Open Access at: https://link.springer.com/book/10.1007/978-3-030-50356-7
4. Sven Linge and Hans Petter Langtagen, Programming for Computations -- Python. A Gentle Introduction to Numerical Simulations With Python. Springer (2018). ISBN 978-3-319-81282-3. Open Access at: https://link.springer.com/book/10.1007/978-3-319-32428-9

Note: 1) Optional topics are exempted for end semester examination.
2) 70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.
3) Module V is algorithms and lab computations. Algorithms for each numerical method can be taught along with the Python code in lab sessions. The second text [2] stresses computation from the beginning and is a lab reference. The Jupyter Notebooks [3] intended for live lab lessons.

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	3	2	1	3	1	3	3	3	0	2
CO 2	2	3	3	2	3	1	3	3	3	0	2
CO 3	3	3	3	2	3	1	3	3	3	0	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours				
Course Code	MAT6EJ302(1)				
Course Title	**MATHEMATICS FOR DIGITAL IMAGES**				
Type of Course	**Elective (Specialisation- Mathematical Computing)**				
Semester	VI				
Academic Level	300 - 399				
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours	
	4	4	-	60	
Pre-requisites	Basic Geometry and Algebraic Structures				
Course Summary	The focus of this paper is mathematics underlying patterns which in converse can be used to produce patterns automatically by computer, allocating some design decisions to the user. We begin with isometries, those transformations of the plane which preserve distance and hence shape. These fall into two classes: the direct ones are rotations or translation, and the indirect ones reflections or glides. We derive the rules for combining isometries, and introduce groups, and the dihedral group in particular. We also apply this to classifying all 1-dimensional or 'braid' patterns into seven types. Our next focus is on symmetries; that is, those isometries which send a pattern onto itself, each part going to another with the same size and shape. A plane pattern is one having translation symmetries in two non-parallel directions. These are made up of parallelogram shaped cells, falling into five types. Finally, we deduce the existence of 17 pattern types, each with its own set of interacting symmetry operations.				

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Describe the concept of isometries in geometry, including translation, rotation, and reflection, and understand their properties and how they preserve distances.	U	C	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam
CO2	Demonstrate the ability to compose isometries, understand their combined effects, and analyse the outcomes of sequential transformations.	Ap	P	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam
CO3	Investigate the classification of plane patterns, including different net types such as parallelogram nets, rectangular nets, centred rectangular nets, square nets, and hexagonal nets, and analyse examples of the 17 plane pattern types.	An	F	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Text Book	MATHEMATICS FOR DIGITAL IMAGES : Creation, Compression, Restoration, Recognition. S G Hoggar- Cambridge University Press.			
Module	**Unit**	**Content**	**Hrs (48+12)**	**Ext. Marks (70)**
I		**Introduction**	**12**	
	1	Isometries and their sense		
	2	The plane and vectors		
	3	Isometries – Translation, Rotation, Reflection		
	4	The sense of an isometry		
	5	The Classification of isometries		
	6	Composing isometries		
	Sections from Text (i): Chapter 1 – 1.1, 1.2, 1.3			
II		**How Isometries Combine**	**12**	
	7	Reflections are the key		
	8	Some useful compositions		
	9	The Image of a line of symmetry		
	10	The dihedral group		
	11	Appendix on groups		
	Sections from Text (i):Chapter 2 – 2.1, 2.2, 2.3, 2.4, 2.5			
III		**The Seven Braid Patterns, Plane Patterns & Symmetries**	**12**	
	12	Classification of braids		
	13	Constructing braid patterns		
	14	Translations and nets		
	15	Cells		
	16	The five net types		
	17	Nets allowing a reflection		
	Sections from Text (i): Chapter 3, Chapter 4 – 4.1, 4.2, 4.3			
IV		**The 17 Plane Patterns**	**12**	
	18	Preliminaries		
	19	The general parallelogram net		
	20	The rectangular net		
	21	The centred rectangular net		
	22	The square net		
	23	The hexagonal net		
	24	Examples of the 17 plane pattern types		
	25	Scheme for identifying pattern types		
	Sections from Text (i): Chapter 5 – 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8			
V (Open Ended)		**Advanced Topics (Practical)**	**12**	
	26	Basic Syntax and Scalar arithmetic operations and calculations by Using MATLAB		
	27	Arithmetic operations in matrix data & Reading an Image File by Using MATLAB		
References:				

1. Baldock R and Graham J (2000) Image Processing and analysis, a practical approach, Oxford University Press
2. Gonzalez R C and Woods R E (1993) Digital Image Processing, Addison-Wesley

Note: 70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	3	2	1	3	1	2	2	3	0	2
CO 2	2	3	2	1	2	1	2	2	2	0	2
CO 3	3	3	2	1	3	1	3	3	3	0	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT5EJ305			
Course Title	**HIGHER ALGEBRA**			
Type of Course	**Elective**			
Semester	V			
Academic Level	300 - 399			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites	Fundamental Mathematics Concepts: Set, Functions, Logic			
Course Summary	This course explores topics that follow as a direct continuation of high school algebra, like the general theory of equations, and classification of second-degree curves and surfaces.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand and apply the algebraic methods used in solving polynomial equations of low degrees and place them in a general context	Ap	P	Internal Exam/Assignment/Seminar/ Viva / End Sem Exam
CO2	Understanding of the fundamental concepts of algebraic equations, including the Identity Theorem and the Fundamental Theorem of Algebra.	U	C	Internal Exam/Assignment/Seminar/ Viva / End Sem Exam
CO3	Analyse and evaluate various solutions of equations, including Cardan's Formulas and trigonometric solutions, and identify the irreducible cases.	An	C	Internal Exam/Assignment/Seminar/ Viva / End Sem Exam

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Text	1. Geometry(2/e), David A Brannan, Mathew F. Esplen, Jeremy J Gray, Cambridge University Press (2012) ISBN: 978-1-107-64783-1 2. Theory of Equations, J. V. Uspensky, McGraw Hill (1948), ISBN:07-066735-7			
Module	**Unit**	**Content**	**Hrs (48+12)**	**Ext. Marks (70**
I		**Theory of Equations**	**16**	
	1	Chapter II -Section 3**:** Division of Polynomials		
	2	Chapter II -Section 4: The Reminder Theorem		
	3	Chapter II- Section 5**:** Synthetic Division		
	4	Chapter II- Section 7: Taylor's Formula		
	5	Chapter III - Section 1: Algebraic Equations		
	6	Chapter III - Section 2: Identity Theorem		
	7	Chapter III - Section 3: The Fundamental Theorem of Algebra		
II		**Cubic And Biquadratic Equations**	**16**	
	8	Chapter III - Section 4: Imaginary Roots of Equations with Real Coefficients		
	9	Chapter III - Section 5: Relations Between Roots and Coefficients		
	10	Chapter IV - Section 1**:** Limits of Roots Section 2: A Method to Find an Upper Limit of Positive Roots		
	11	Chapter IV - Section 3**:** Limit for Moduli of Roots		
	12	Chapter V - Section 1: What is the "Solution" of an Equation?, Section 2: Cardan's Formulas, Section 3: Discussion of Solution		
	13	Chapter V - Section 4: Irreducible Case Section 5: Trigonometric Solution		
	14	Chapter V- Section 6: Solution of Biquadratic Equations		

III	**Conic Sections**		**12**	
	15	Section 1.1.1: Conic Sections, **Section 1.1.2:** Circles		
	16	Section 1.1.3: Focus-Directrix Definition of the Non-Degenerate Conics		
	17	Section 1.1.4: Focal Distance Properties of Ellipse and Hyperbola		
	18	Section 1.1.5: Dandelin Spheres		
IV	**Quadric Surfaces**		**4**	
	19	Section 1.2.2: Reflections		
	20	Section 1.3: Recognizing Conics		
	21	Section 1.4.1: Quadric Surfaces in $\mathbb{R}^3$		
	22	Section 1.4.2: Recognizing Quadric Surfaces		
V	**Open Ended Module: Affine Maps**		**12**	
	1	Geometry and Transformations - What is Euclidean Geometry? Isometry, Euclidean properties, Euclidean transformation**,** Euclidean-Congruence		
	2	Affine Transformations, Basic Properties of Affine Transformations		
	3	Fundamental Theorem of Affine Geometry		

References:

1. Higher Algebra, Barnard & Child, St. Martin's Press, NY, USA (Public Domain, Copyright exhausted)
2. Thomas & Finney, Calculus & Analytic Geometry, Addison Wesley
3. George A Jennings: Modern Geometry with Applications Universitext, Springer (1994) ISBN: 0-387-94222-X
4. Walter Meyer: Geometry and its Application(2/e) Elsever, Academic Press(2006) ISBN: 0-12-369427-0

Note: 70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	3	3	2	3	1	2	1	3	0	1
CO 2	3	3	2	2	3	1	2	1	3	0	1
CO 3	2	3	3	2	3	1	3	1	3	0	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT5EJ306			
Course Title	**LINEAR PROGRAMMING**			
Type of Course	**Elective**			
Semester	V			
Academic Level	300 - 399			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites	Basic Calculus and Linear Algebra			
Course Summary	Linear Programming is a mathematical modelling technique in which a linear function is maximized or minimized when subjected to various constraints. This technique has been useful for guiding quantitative decisions in business planning, in industrial engineering, and—to a lesser extent—in the social and physical sciences. This course begins with convex sets and extrema of functions for a sound basis of the subject. It then develops into LP problems including Transportation and Assignment problems.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Able to identify and analyse the properties of convex sets, including open and closed sets, convex hulls, and vertices.	An	C	Internal Exam/Assignment/Seminar/ Viva / End Sem Exam
CO2	To demonstrate proficiency in applying optimization techniques such as gradient descent, constrained extrema, and the method of Lagrange multipliers to solve real-valued functions.	Ap	P	Internal Exam/Assignment/Seminar/ Viva / End Sem Exam
CO3	To formulate and solve linear programming problems, including transportation and assignment problems, using techniques such as simplex method and duality.	U	P	Internal Exam/Assignment/Seminar/ Viva / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Text book	Optimization Methods in Operation Research and System Analysis (4th edition), K.V Mittal, C Mohan, New Age International (P)Limited (2016)	
Module	**Unit**	**Content**
I		**Module I**
	1	Chapter 1 Section 11: Open and Closed sets in E_n
	2	Section 12: Convex Linear Combination, Convex Sets
	3	Section 13: Intersection of Convex Sets, Convex Hull of a Set Section 14: Vertices or Extreme Points of a Convex Set
	4	Section 15: Convex Polyhedron Section 16: Hyperplanes, Half-spaces and Polytopes
	5	Section 17: Separating and Supporting Hyperplanes (Proof of Theorem 18 is optional) Section 18: Vertices of a Closed Bounded Convex Set (Proof of Theorem 21,22,23 are optional) Section 19: Summary Section 20: Quadratic Forms
II		**Module II**
	6	Chapter 2 Section 11: Convex Functions
	7	Section 12: General Problem of Mathematical Programming
	8	Chapter 3 Section 1: Introduction Section 2: LP in Two-Dimensional Space
	9	Section 3: General L P Problem Section 4: Feasible Solutions (Proof of Theorem 1 is optional) Section 5: Basic Solutions Section 6: Basic Feasible Solutions (Proof of Theorem 2,3 are optional) Section 7: Optimal Solution (Proof of Theorem 4,5 are optional) Section 8: Summary
	10	Section 9: Simplex Method Section 10: Canonical Form of Equations Section 11: Simplex Method (Numerical Example) Section 12: Simplex Tableau
	11	Section 13: Finding the First b.f.s; Artificial Variables Section 14: Degeneracy
	12	Section 15: Simplex Multipliers
III		**Module III**
	13	Chapter 3 Section 17: Duality in LP Problems
	14	Section 18: Duality Theorems (Proof of Theorem 7,8,9, 10,11 are optional) Section 19: Applications of Duality
	15	Section 20: Dual Simplex Method Section 21: Summary of Simplex Methods (III Revised Simplex Method is optional)
	16	Section 22: Applications of LP
IV		**Module IV**

	17	Chapter 4 Section 1: Introduction Section 2: Transportation Problem Section 3: Transportation Array Section 4: Transportation Matrix Section 5: Triangular Basis (Proof of Theorem 1 is optional) Section 6: Finding a Basic Feasible Solution
	18	Section 7: Testing For Optimality
	19	Section 8: Loop in Transportation Array (Proof of Theorem 2 is optional) Section 9: Changing the Basis
	20	Section 10: Degeneracy Section 11: Unbalanced Problem
	21	Section 14: Assignment Problem (Proof of Theorem 3 is optional)
	22	Section 15: Generalized Transportation Problem Exercise Questions in Assignment Problem
V	**Open Ended**	
		Linear Programming Using Scipy, Prog Reference 1.
		Dual Simplex Solved Programming Exercises in Python from Vanderbei (Reference 1), Prog Reference 2.
		Linear Programming in Python using IBM CPlex Community Edition. Prog Reference 3.
		Transportation Problem in Python. Prog Reference 4.
		Linear Programming in Julia. Prog Reference 5. Ch 3 Basics of Julia Programming Language, Ch 5 The Simplex Method.

. **References**:

1. G. Hadley : Linear Programming Addison-Wesley Pub Co Reading, Mass (1975)

2. S.S. Rao : Optimization - Theory and Applications (2nd Edn.) Wiley Eastern (P) Ltd. New Delhi.

3. Russel L Ackoff and : Fundamentals of Operation Research Maurice W.Sasioni Wiley Eastern Ltd. New Delhi. (1991)

4. Charles S. Beightler, : Foundations of Optimization D.T. Philips & D.J. Wilde (2nd Edn.) Prentice Hall of India, Delhi (1979)

Programming References for Open-Ended section:

1. Linear Programming using Scipy, https://python.quantecon.org/lp_intro.html
2. Vanderbei's book homepage: https://vanderbei.princeton.edu/LPbook/
3. CPlex Jupyter Notebook:
https://github.com/IBMDecisionOptimization/tutorials/blob/master/jupyter/Linear_Programming.ipynb

Installation: http://ibmdecisionoptimization.github.io/docplex-doc/README.md.html

	4. Solving Transportation Problem using Linear Programming in Python: https://machinelearninggeek.com/solving-transportation-problem-using-linear-programming-in-python/ 5. Changhyun Kwon, Julia Programming for Operations Research 2/e , https://www.softcover.io/read/7b8eb7d0/juliabook2/simplex

Note: 70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	2	1	3	1	2	1	3	0	1
CO 2	3	3	3	2	2	1	3	1	3	0	1
CO 3	2	3	3	2	3	1	3	1	3	0	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours				
Course Code	MAT6EJ305				
Course Title	**TOPOLOGY OF METRIC SPACES**				
Type of Course	**Elective**				
Semester	VI				
Academic Level	300 - 399				
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours	
	4	4	-	60	
Pre-requisites	1. Fundamental Mathematics Concepts: Set, Functions, Logic 2. Real Analysis				
Course Summary	This course familiarises students with the basic tools and phenomenology of topology by introducing metric spaces as a generalisation of the familiar Euclidean spaces.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Demonstrate understanding of fundamental concepts in metric spaces and basic examples of metric spaces.	U	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	To analyse and evaluate the basic topology of metric spaces, including open sets, closed sets, interior, closure, and boundary points	An	E	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Demonstrate proficiency in applying concepts of convergence, completeness, and continuity in metric spaces, including understanding Cauchy sequences, completeness, and continuity of functions.	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Textbook	Introduction to Topology and Modern Analysis, George F. Simmons, Krieger Publishing Company (1982) ISBN-0-89874-551-9		
Module	**Unit**	**Content**	**Hrs (48+ 12)**
I		**Introduction to Metric Spaces**	
	1	Chapter 1 Section 5: Partitions and Equivalence Relations	**12**
	2	Chapter 1 Section 6: Countable Sets	
	3	Chapter 1 Section 7: Uncountable Sets	
	4	Chapter 2 Section 9: The Definition and Some Examples (Topics up to and including Example 2)	
	5	Chapter 2 Section 9: The Definition and Some Examples (Topics from Example 3 onwards)	
II		**Basic Topology of Metric Spaces**	
	6	Chapter 2 Section 10: Open Sets (Topics up to and including Theorem A)	**10**
	7	Chapter 2 Section 10: Open Sets (Theorem B and Theorem C)	
	8	Chapter 2 Section 10: Open Sets (Topics from Theorem D onwards)	
	9	Chapter 2 Section 11: Closed Sets (Topics up to and including Theorem C)	
	10	Chapter 2 Section 11: Closed Sets (Topics from Theorem D onwards)	
III		**Convergence, Completeness & Continuity**	
	11	Chapter 2 Section 12: Convergence, Completeness, and Baire's Theorem (Topics up to Theorem A)	**12**
	12	Chapter 2 Section 12: Convergence, Completeness, and Baire's Theorem (Theorem A and Theorem B)	
	13	Chapter 2 Section 12: Convergence, Completeness, and Baire's Theorem (Topics from Theorem C onwards)	
	14	Chapter 2 Section 13: Continuous Mappings (Topics up to and including Theorem A)	
	15	Chapter 2 Section 13: Continuous Mappings (Theorem B and Theorem C)	
	16	Chapter 2 Section 13: Continuous Mappings (Topics from Theorem D onwards)	
IV		**Special Classes of Metric Spaces**	
	17	Chapter 2 Section 14: Spaces of Continuous Functions (Topics up to First Lemma)	**14**
	18	Chapter 2 Section 14: Spaces of Continuous Functions (First Lemma, Second Lemma)	
	19	Chapter 2 Section 14: Spaces of Continuous Functions (Topics from Theorem A onwards)	
	20	Chapter 2 Section 15: Euclidean and Unitary Spaces (Topics up to First Lemma)	
	21	Chapter 2 Section 15: Euclidean and Unitary Spaces (First Lemma, Second Lemma)	
	22	Chapter 2 Section 15: Euclidean and Unitary Spaces (Topics from Theorem A onwards)	
		Compactness In Metric Spaces	

V (Open Ended)		The Heine-Borel Property Bolzano-Weierstrass Property Lebesgue's Covering Lemma Sequential Compactness Compactness – Open Cover Formulation Total Boundedness Compactness, Completeness & Total Boundedness Equicontinuity & the Arzela-Ascoli Theorem	**12**

References:

1. Introduction to General Topology, K. D. Joshi, New Age International.
2. A First Course In Topology, James R. Munkres, Prentice Hall of India
3. Topology of Metric Spaces, S. Kumaresan, Narosa Publishing House.

Note: 70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	1	1	3	1	2	1	3	0	1
CO 2	3	3	1	1	3	1	3	1	3	0	1
CO 3	3	3	2	1	3	1	3	1	3	0	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT6EJ306			
Course Title	**INTRODUCTION TO FOURIER ANALYSIS**			
Type of Course	**Elective**			
Semester	VI			
Academic Level	300-399			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites	An introductory course in Real Analysis including series of functions			
Course Summary	Fourier analysis is a fundamental component in the tool-kit of every pure and applied mathematician with numerous applications to signal processing, image processing, tomography and several other areas of engineering. In this course we shall look at the most basic theoretical foundations of this subject. Along the way we shall have to recapitulate some of the requisite results from functional analysis.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Demonstrate proficiency in defining and applying concepts related to inner product spaces, including orthogonality and linear operators.	Ap/An	P	Internal Exam/Assignment /Seminar/ Viva/ End Sem Exam
CO2	Describe orthogonality, including definitions and examples. Demonstrate the use of orthogonal projections, including the Gram-Schmidt orthogonalization process.	Ap	C	Internal Exam/Assignment / Seminar/ Viva/ End Sem Exam
CO3	Compute Fourier series on various intervals including cosine and sine expansions, and understand the complex form of Fourier series.	Ap	P	Internal Exam/Assignment /Seminar/ Viva/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Text Book	A First Course in Wavelets with Fourier Analysis, 2e, Albert Boggess and Francis J Narcowich, Wiley.			
Module	**Unit**	**Content**	**Hrs (48+ 12)**	**Marks** **Ext: 70**
I		**Inner Product Spaces**	**12**	
		Quick review through the preface of the text book for the discussions Fourier Analysis and Wavelets		
	1	0.1 and 0.2 – Motivation, definition and examples of inner product.		
	2	0.3 – The spaces LZ and ℓZ – 0.3.1 - Construction of inner products in LZ and ℓZ .		
	3	0.3.2 – Convergence in LZ versus uniform convergence.		
	4	0.4 – Schwarz Inequality		
	5	0.4 - Triangle Inequality		
	6	0.5 – Orthogonality 0.5.1 – Definitions and examples.		
	7	0.5.2 – Orthogonal Projections – up to and including example 0.23		
II		**Inner Product Spaces – contd.**	**12**	
	8	0.5.2 – Orthogonal Projections – rest of the section		
	9	0.5.3 – Gram – Schmidt Orthogonalization.		
	10	0.6 – Linear Operators and their Adjoints 0.6.1- Linear Operators		
	11	0.6.2 – Adjoints - (up to and including Example 0.31)		
	12	0.6.2 – Adjoints – rest of the section.		

III	**Fourier Series**		**12**	
	13	1.1 – Introduction (1.1.1 to 1.1.3)		
	14	1.2 – Computation of Fourier Series 1.2.1 – On the interval [-π , +π] – with examples		
	15	1.2.2 – Other intervals – with examples		
	16	1.2.3 – Cosine and Sine expansions with examples		
	17	1.2.5 – The complex form of Fourier Series		
	Modules III and IV are presented only for motivations and examples for the theory. All the proofs of theorems in these modules are optional to study and exempted from external examination.			
IV	**Fourier Transforms**		**12**	
	18	2.1 – Informal development of the Fourier transform 2.1.1 – Fourier Inversion Theorem		
	19	2.2.2 – Fourier Transform of a convolution		
	20	2.2.3 – Adjoint of the Fourier Transform		
	21	2.2.4 – Plancherel Theorem		
	22	More problems from the above sections		
V (Open Ended)	**Fourier Analysis**		**12**	
	After having the above basics of Fourier Analysis, one can look at the discrete versions of Fourier Analysis and can enter into Wavelets theory (for instance refer sections 4.1 and 4.2 of text book). The Haar wavelet analysis with its decomposition and reconstruction theorems open the window to signal theory which is an active area of research for both pure and applied Mathematicians			

References

1. Ten lectures on Wavelets, Daubechies, Philadelphia, SIAM, 1992.
2. Fourier Analysis and its Applications, Gerald B Folland, Wadsworth and Brooks/Cole Advanced Books and Software, Pacific Grove, California.
3. Introduction to Fourier Analysis on Euclidean Spaces, Elias M Stein and Guido -Weiss, Princeton University Press.
4. How to make Wavelets, Robert S. Strichartz, The American Mathematical Monthly.

Note: 1) Optional topics are exempted for end semester examination.
2) 70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	3	2	1	3	1	3	1	3	0	1
CO 2	3	3	2	1	3	1	3	1	3	0	1
CO 3	3	3	2	1	3	1	3	1	3	0	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT8EJ401			
Course Title	**ADVANCED TOPOLOGY**			
Type of Course	**Elective**			
Semester	VIII			
Academic Level	400-499			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	4	0	60
Pre-requisites	1. Topology I			
Course Summary	The advanced topology course extends Topology I by introducing further concepts and tools. It starts with the product topology and explores its properties. Embeddings, including the Tychonoff embedding theorem, are discussed. Urysohn's Lemma from the previous course is used to prove the Urysohn Metrisation Theorem. Nets and filters are introduced to address sequence limitations. Various forms of compactness and compactifications are examined, with a focus on their relation to completeness in metric spaces. The course concludes with important results such as the Baire category theorems.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Learn basic structures and constructions in Topology	U	F	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Analyse and apply the concepts of Nets, Filters, and Convergence in the context of Topological Spaces	An	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	To develop the student's ability to handle abstract ideas of mathematics and mathematical proofs	Ap	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Text Book	Introduction to General Topology, 2nd Edition, K. D. Joshi, New Age International Publishers, 1983.			
Module	**Unit**	**Content**	**Hrs (48+12)**	**External Marks (70)**
I		**Chapter 8: Products & Coproducts**	**10**	
	1	Cartesian Products of Families of Sets – 8.1		
	2	The Product Topology – 8.2		
	3	Productive Properties – Separation Axioms 8.3		
	4	Productive Properties – Connectedness – 8.3		
	5	Countably Productive Properties –Metrisability– 8.4		
	6	Countably Productive Properties –Countability– 8.4		
	7	The Case of Separability – 8.4		
II		**Chapter 9: Embedding & Metrisation**	**10**	
	8	Evaluation Functions into Products – 9.1		
	9	Embedding Lemma – 9.2		
	10	Tychonoff Embedding – 9.2		
	11	The Urysohn Metrisation Theorem – 9.3		
III		**Chapter 10: Nets & Filters**	**12**	
	12	Definition & Convergence of Nets – 10.1		
	13	Topology & Convergence of Nets – 10.2		
	14	Nets & Compactness – 10.2		
	15	Filters & Their Convergence – 10.3		
	16	Topology & Filters – 10.3		
	17	Ultrafilters and Compactness – 10.4		
IV		**Chap 11,12: Compactness & Complete Metric Spaces**	**16**	

	18	Variations of Compactness – 11.1		
	19	The Alexander Sub-base Theorem – 11.2		
	20	Local Compactness – 11.3		
	21	Compactifications – 11.4 (Wallman Compactification 11.15 to 11.20 may be relegated to Practicum)		
	22	Complete Metrics – 12.1		
	23	Consequences of Completeness – 12.2		
	24	Completions of a Metric – 12.4		
V	**Practicum:**		**12**	
	1	Wallman Compactification: 11.15 to 11.20		
	2	12.3: Some Applications (of Completeness)		
	3	Chapter 13: Category Theory		
	4	Chapter 14: Uniform Spaces		
	5	Chapter 15 Section 2: Paracompactness		
	6	Chapter 15 Section 3: Use of Ordinal Numbers		
	7	Nagata-Smirnov Metrisation Theorem		

References

1. Topology, J. R. Munkres, Prentice Hall of India, 2000.
2. General Topology, S. Willard, Addison Wesley Pub. Company, 1976.
3. General Topology, J. L. Kelley, D. van Nostrand, 1955.
4. Introduction to Topology and Modern Analysis; G. F. Simmons, McGraw-Hill, 1963.
5. Topology, James Dugundji, Prentice Hall of India, 1975.

Note: 70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	3	1	3	1	2	1	3	0	1
CO 2	3	3	2	1	3	1	3	1	3	0	1
CO 3	3	3	3	3	2	1	2	1	2	0	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours				
Course Code	MAT8EJ402				
Course Title	**PARTIAL DIFFERENTIAL EQUATIONS**				
Type of Course	**Elective**				
Semester	VIII				
Academic Level	400-499				
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours	
	4	4	-	60	
Pre-requisites	1. Real Analysis 2. Basic Concepts of Vector functions 2. Ordinary Differential Equations				
Course Summary	This introductory Partial Differential Equations (PDEs) course equips students with the mathematical tools and problem-solving skills necessary to analyse and solve real-world phenomena governed by PDEs. The syllabus focuses on analytical methods for solving first and second-order PDEs, laying the foundation for further exploration of advanced PDEs and their applications.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understanding of basic concepts, definitions, and mathematical problems related to first-order quasilinear equations.	U	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Analyse and evaluate the classification of second-order linear equations, including the Cauchy problem and wave equations.	An	E	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Evaluate solutions for boundary value problems and apply them in solving PDEs.	E	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Text: Linear Partial Differential Equations for Scientists and Engineers, Fourth Edition, Tyn Myint-U, Lokenath Debnath, Birkhauser(2007), ISBN : 978-81-8489-079-2.

Module	Unit	Content	Hrs (48 +12)	Ext. Marks (70
I		**First Order Quasilinear Equations and Method of Characteristics**	9	
	1	Basic Concepts, definitions and mathematical problems		
	2	Classification of first order equations		
	3	Construction of a first order equation		
	4	Geometrical Interpretation of a First- Order Equation		
	5	Method of characteristics and General solutions		
		Sections from Text: 1.2, 1.3, 2.1, 2.2,2.3, 2.4, 2.5.		
II		**Classification of Second Order Linear Equations, The Cauchy Problem and Wave Equations**	21	
	6	Second order equations in two independent variables		
	7	Canonical Forms		
	8	Equations with constant coefficients		
	9	General Solutions		
	10	The Cauchy Problem		
	11	Homogeneous Wave Equations		
	12	Initial Boundary-Value Problems		
	13	Equations with Nonhomogeneous Boundary Conditions		
	14	Vibration of Finite String with Fixed Ends		
	15	Nonhomogeneous Wave Equations		
	16	The Riemann Method		

	Sections from Text: 4.1 - 4.4, 5.1, 5.3-5.8			
III	**Method of Separation of Variables**		**13**	
	17	Introduction		
	18	Separation of Variables		
	19	The Vibrating String Problem		
	20	Existence and Uniqueness of Solution of the Vibrating String Problem		
	21	The Heat Conduction Problem		
	22	Existence and Uniqueness of Solution of the Heat Conduction Problem		
	23	The Laplace and Beam Equations		
	24	Nonhomogeneous Problems		
	Sections from Text: 7.1-7.8			
IV	**Boundary Value Problems and Applications**		**7**	
	25	Boundary Value Problems		
	26	Maximum and Minimum Principles		
	27	Uniqueness and Continuity Theorems		
	28	Dirichlet Problem for a circle		
	29	Neumann Problem for a circle		
	30	Dirichlet Problem for a rectangle		
	31	The Neumann Problem for a Rectangle		
	Sections from Text: 9.1-9.4, 9.6, 9.7, 9.8,9.9			
V (Open Ended)	**Green's Functions, Boundary Value Problems and Nonlinear Equations**		**12**	
		Green's Functions for Ordinary Differential Equations, Construction of Green's Functions, The Dirac Delta Function, Properties of Green's Functions, Method of Green's Functions (only for Laplace operator) Nonlinear PDEs -brief overview from any text		

References:

1. Partial Differential Equations -An Introduction, Second Edition, Walter A. Strauss, John Wiley and Sons Limited.

2. Partial Differential Equations-Classical Theory with a Modern Touch, A.K. Nandakumaran, P.S. Datti, Cambridge-IISc Series.

3. Elements of Partial Differential Equations, I.N. Sneddon, McGraw-Hill, New York (1972).

Note: 70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	2	1	3	1	2	1	3	0	1
CO 2	3	3	2	1	3	1	3	1	3	0	1
CO 3	2	3	2	1	3	1	3	1	3	0	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT8EJ403			
Course Title	**RINGS AND MODULES**			
Type of Course	**Elective**			
Semester	VIII			
Academic Level	400-499			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites	Elementary number theory, algebra combinatorics, basic linear algebra			
Course Summary	This course is a self-contained elementary introduction to Rings and Modules. The course will cover basic topics of Ring Theory and Module Theory which is a core course in Algebra			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Define and differentiate between various types of rings, including rings of continuous functions, matrix rings and polynomial rings	U	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Analyse and apply the concepts of ideals within rings, including definitions, maximal ideals, generators for subrings and ideals.	An	Ap	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Evaluate and synthesize the concepts of homomorphisms of rings, including quotient rings, ideals in quotient rings, endomorphism rings and field of fractions.	E	M	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Text book	Introduction to Rings and Modules, C. Musili, Narosa Publishing House, 2001.			
Module	**Unit**	**Content**	**Hrs (48 +12)**	**Ext. Marks (70**
I		**Rings**	**12**	
	1	Chapter 1 – Section 1.1: Terminology		
	2	Chapter 1 – Section 1.2: Rings of Continuous functions		
	3	Chapter 1 – Section 1.3 to 1.5: Matrix Rings, Polynomial Rings and Power series rings		
	4	Chapter 1 – Section 1.8 to 1.9: Some Special Rings and Direct Products		
	5	Chapter 1 – Section 1.10 to 1.12: Several Variables, Opposite rings, Characteristic of a ring		
II		**Ideals**	**12**	
	6	Chapter 2 – Section 2.1 to 2.2 : Definitions, Maximal Ideals		
	7	Chapter 2 – Section 2.3: Generators for subrings and Ideals		
	8	Chapter 2 – Section 2.4: Basic Properties of Ideals		
	9	Chapter 2 – Section 2.5: Algebra of Ideals		
III		**Homomorphisms of Rings**	**12**	
	10	Chapter 2 – Section 2.6 & 2.7 : Quotient rings and Ideals in Quotient rings		
	11	Chapter 3 – Section 3.1: Definition and Basic Properties		
	12	Chapter 3 – Section 3.2 : Fundamental Theorems of Homomorphisms		
	13	Chapter 3 – Section 3.3: Endomorphism Rings		
	14	Chapter 3 – Section 3.4: Field of Fractions		
	15	Chapter 3 – Section 3.5: Prime Fields		
IV		**Modules**	**12**	
	16	Chapter 5: Modules: Section 5.1: Definition and Examples		
	17	Chapter 5: Section 5.2 to 5.4: Direct sums, Free Modules and Vector spaces		
	18	Chapter 5: Section 5.4 to 5.3: Direct sums and Free Modules		
	19	Chapter 5: Section 5.6: Quotient Modules		
	20	Chapter 5: Section 5.7: Homomorphisms		
	21	Chapter 5: Section 5.8: Simple Modules		
V		**Open Ended**	**12**	
		Artinian Modules and Rings, Noetherian Modules and Rings, Nil Radical, Jacobson Radical		
References	1. John B. Fraleigh, A First Course in Abstract Algebra, 7th Edition, 2002 2. M. Artin: Algebra, Prentice Hall, 1991 3. Thomas W. Hungerford, Algebra, Springer, 2003 4. Joseph Gallian, Contemporary Abstract Algebra, 7th Edition, Cengage Learning, 2009. 5. D.M. Burton, A First Course in rings and ideals, Addison- Wesley, 1970.			

Note: 70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	2	1	3	1	2	1	3	0	1
CO 2	2	3	2	1	3	1	3	1	3	0	1
CO 3	2	2	2	1	3	1	3	1	3	0	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT8EJ404			
Course Title	**CODING THEORY**			
Type of Course	**Elective**			
Semester	VIII			
Academic Level	400-499			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	4	-	60
Pre-requisites	Linear Algebra, Algebra			
Course Summary	The course helps the student to understand various algebraic codes, - their encoding and decoding methods and the mathematical tools used in their design.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Construct the parity check/generator atrix of a linear code.	Ap	C	Internal xam/Assignment/ eminar/ Viva / End em Exam
CO2	Calculate bounds on rate and istance of a given linear code using arious bounds.	An	P	Internal xam/Assignment/ eminar/ Viva / End em Exam
CO3	Design cyclic codes of a given rate nd distance parameters and decode t using various standard decoding rocedures.	Ap	P	Internal xam/Assignment/ eminar/ Viva / End em Exam
- Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive nowledge (M)				

Detailed Syllabus:

Text	Huffman, W. Cary, and Vera Pless. Fundamentals of error-correcting codes. Cambridge university press, 2010.			
Module	**Unit**	**Content**	**Hrs (48+12)**	**External Marks (70)**
I	**Linear Codes** Text Sections: 1.1, 1.2, 1.4, 1.5.1 to 1.5.3, 1.8, 1.10, 1.11.2		**12**	
	1	Binary and Prime Fields		
	2	Linear Codes - Generator and Parity Check Matrix		
	3	Weights and Distances		
	4	Punchuring, Shortening and Extension		
	5	Hamming Codes		
	6	Reed Muller Codes		
	7	Encoding Linear Codes		
II	**Bounds on Linear Codes** **Text Sections: 2.2, 2.4, 2.8**		**5**	
	8	Plotkin Bound		
	9	Singleton Bound and MDS codes		
	10	Gilbert - Varshamov Lower Bound		
	11	Asymptotic Singleton and Plotkin Bounds		
III	**Finite Fields and Cyclic Codes** **Text Sections: 3.1 to 3.7 and 4.1, 4.2, 4.5.**		**15**	
	12	Finite fields and elementary properties		
	13	Polynomials and Euclid's Algorithm		
	14	Primitive Elements		
	15	Construction of Finite fields		

	16	Cyclotomic Polynomials		
	17	Basic Theory of Cyclic Codes		
	18	BCH Bound.		
IV	**BCH and Reed Solomon Codes** **Text Sections: 5.1, 5.2, 5.3, 5.4.1 to 5.4.3**		**16**	
	18	BCH Codes		
	19	Reed Solomon Codes and their generalization.		
	20	Peterson–Gorenstein–Zierler Decoding Algorithm		
	21	Berlekamp Massey Decoding Algorithm		
	22	Sugiyama Decoding Algorithm (Euclid's Algorithm)		
V	**OPEN ENDED**		**12**	**-**
	1	List decoding and Guruswami Sudan Algorithm		
	2	Weight Distributions of Codes and McWilliams Identities		
	3	Self-dual codes.		
	4	Codes on Projective Planes		
	5	Codes over Z4		
	6	Convolutional Codes		
References	1. E. F. Assmus, Jr. and J. D. Key, Designs and Their Codes. London: Cambridge University Press, 1993. 2. R. E. Blahut, Theory and Practice of Error Control Codes. Reading, MA: Addison-Wesley, 1983.			

Note: 70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	2	0	3	1	2	1	3	0	1
CO 2	3	2	2	0	3	1	3	1	3	0	1
CO 3	3	3	2	0	3	1	3	1	3	0	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours
Course Code	MAT8EJ405
Course Title	**FOUNDATIONS OF MATHEMATICS**
Type of Course	**Elective**
Semester	VIII
Academic Level	400-499

Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60

Pre-requisites	Nil
Course Summary	The course goes into the philosophy of mathematics, modern axiom methods, controversies in set theory around axiom of choice, its implications and various philosophical alternative approaches to the foundations of mathematics.

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Analyse Axiomatic Systems and Logical Deductions	An	C	Internal Exam/Assignment / Seminar/ Viva / End Sem Exam
CO2	Explore Axioms and their Interpretation of Mathematical Structures	Ap	C	Internal Exam/Assignment / Seminar/ Viva / End Sem Exam
CO3	Investigate Properties of standard sets in Mathematics and obtain their axiomatic constructions	E	P	Internal Exam/Assignment / Seminar/ Viva / End Sem Exam

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

TEXT: R. Wilder, Introduction to the Foundations of Mathematics (2/e), John Wiley & Sons, 1967				
Module	**Unit**	**Content**	**Hrs (60)**	**Ext. Marks (70)**
I	**Axiomatic Method** (Up to Chapter 3 Section 5 of Text Book)		**12**	
	1	Description - undefined terms, axioms, logical deductions and proofs. Case study with axioms of points and lines.		
	2	Axioms and Interpretation (models): consistency (satisfiability), completeness, categorically and independence.		
	3	Case Study with axioms of order and equivalence.		
	4	Sets and Russal's Paradox.		
	5	Finite and Infinite Sets,		
	6	Review of Mathematical Induction.		
II	**Set Theory: Cardinals** (Chapter 3, Section 6 to Chapter 4 of Text Book)		12	
	7	Infinite Sets - Ordinary and Dedekind Infinity and their equivalence		
	8	Axiom of Choice		
	9	Countable Sets and their properties		
	10	Diagonalization and Uncountable Sets, Irrational Numbers		
	11	Cardinal Numbers and Bernstein's Equivalence Theorem		
	12	Well Ordered Sets and Transfinite Induction		
III	**Set Theory: Ordering (**Chapter 5)		**12**	
	13	Well Ordering Theorem		
	14	Ordinals and Burali-Forti Paradox		
	15	Properties of Ordinals and Continuum Hypothesis		
	16	Equivalence of Axiom of Choice, Well Ordering Theorem.		
	17	Zorn's Lemma and Equivalence with Axiom of Choice		

IV	**Real Numbers** (Chapter 6 of Text Book)		**12**	
	18	Ordering and Separability of Reals, and Dedekind Cuts.		
	19	Axiomatization of Real Numbers: Constituency, Independence and		
	20	Categoricalness of Real Number Axioms.		
	21	Definition of Real numbers from Peano's Axioms		
	22	Complex Numbers.		
V	**Discussions in Mathematical Philosophy**			
	1	Abstractions: Groups/Rings/Fields/Vector Spaces		
	2	Zermelo Fraenkel Axiomatization of Set Theory		
	3	Frege-Russell Thesis Set Theory using Predicate Calculus		
	4	Brower's Intuitionist Theory		
	5	Formal Deductions and Godel's Theorems.		

References:

1. I. M. Copi, Symbolic Logic (5/e), Pearson, 2015.
2. U. C. Merzbach and C. B. Boyer, A History of Mathematics, (3/e), 2011.
3. I. Stewart and D. Tall, The foundations of Mathematics, (2/e), Oxford University Press 2015.

Note: 70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	3	2	1	3	3	3	3	0	0	3
CO 2	3	3	2	1	3	3	3	3	0	0	3
CO 3	3	3	2	1	3	3	3	3	0	0	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours				
Course Code	MAT8EJ406				
Course Title	**OPERATIONS RESEARCH**				
Type of Course	**Major**				
Semester	VIII				
Academic Level	400-499				
Course Details	Credit	Lecture/Tutorial per week	**Practical per week**	**Total Hours**	
	4	4	**-**	**60**	
Pre-requisites	Basic Mathematical and Statistical knowledge.				
Course Summary	This paper on Operation Research introduces the concepts like minimum path problem in network analysis, integer linear programming problem and dynamic programming problem. Kuhn Tucker condition to solve nonlinear programming problem is also discussed.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Solve Minimum Path Problem, Maximum flow problem	Ap	C	Internal Exam/ Assignment / Seminar/ Viva / End Sem Exam
CO2	Understand and solve ILP and MILP	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Apply Kuhn-Tucker Conditions to solve nonlinear programming problem	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Text: Optimization Methods in Operation Research and System Analysis (4th edition), KV Mittal, C Mohan, New Age International (P) Limited (2016)				
Module	**Unit**	**Content**	**Hrs (48 +12)**	**Ext. Marks (70)**
I		**Flow and Potential in Networks**	**14**	
	1	5.1,5.2 - Graphs Definitions and Notation		
	2	5.3- Minimum Path Problem		
	3	5.4- Spanning tree of minimum length		
	4	5.5- Problem of Potential Difference		
	5	5.6- Scheduling of sequential activities		
	6	5.7 Maximum flow problem		
	7	Generalized Problem of Maximum flow		
II		**Integer Programming**	**10**	
	8	6.1, 6.2-Introduction, ILP in two dimensional space		
	10	6.3-General ILP and MILP problems		
	11	6.4- Examples of ILP in two dimensional space		
	12	6.5,6.6, 6.7- Cutting planes, Example, Remarks on Cutting plane method		
III		**Kuhn-Tucker Theory and Nonlinear Programming**	**11**	
	14	8.1, 8.2-Introduction , Lagrangian Function: Saddle Point,		
	15	8.3- Relation between Saddle Point of F(X,Y) and Minimal point of f(X)		
	16	8.4- Kuhn-Tucker Conditions		
	17	8.5- Primal and Dual Problems		
	18	8.6-Quadratic Programming		
IV		**Dynamic Programming**	**13**	
	19	10.1,10.2- Introduction, Problem 1: A Minimum Path Problem		

	20	10.3-Problem II: Single Additive Constraint, Additively Separable Return		
	21	10.4, 10.5-Problem III: Single Multiplicative Constraint, Additively Separable Return, Problem IV: Single Additive Constraint, Multiplicatively Separable Return		
	22	10.6,10.7-Computational Economy in DP, Serial Multistage Model		
	23	10.8, 10.9-Examples of Failure, Decomposition		
	24	10.10-Backward and Forward Recursion		
V	**Open Ended**		**12**	
	Sensitivity Analysis, Changes in b_i, c_j, and a_{ij}, Introduction of new variable, Introduction of new constraint, Deletion of variables, Deletion of constraints, Parametric linear programming, goal programming			

References:

1. G. Hadley: Linear Programming Addison-Wesley Pub Co Reading, Mass (1975)
2. G. Hadley : Non-linear and Dynamic Programming Wiley Eastern Pub Co. Reading, Mass (1964)
3. S.S. Rao : Optimization – Theory and Applications (2nd Edn.) Wiley Eastern (P) Ltd. New Delhi.
4. Russel L Ackoff and : Fundamentals of Operation Research Maurice W.Sasioni Wiley Eastern Ltd. New Delhi. (1991)

Note: 70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	2	1	2	1	1	1	2	0	1
CO 2	3	3	1	1	2	1	1	1	2	0	1
CO 3	2	3	2	1	2	1	1	1	2	0	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT8EJ407			
Course Title	**CRYPTOGRAPHY**			
Type of Course	**Elective**			
Semester	VIII			
Academic Level	400-499			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites	Elementary number theory, algebra, combinatorics, basic linear algebra			
Course Summary	Cryptography is a fundamental aspect of information security that involves creating secure communication by encoding messages to make them unintelligible to unauthorised users and Cryptography relies heavily on mathematical concepts. This course covers a wide range of topics, starting with Classical Cryptography, which includes simple cryptosystems. It also delves into cryptanalysis of these systems. Moreover, the course includes a section on Cryptographic Hash Functions, focusing on their role in ensuring data integrity. Students gain a comprehensive understanding of these concepts and techniques, equipping them with the knowledge and skills needed to analyze and implement secure cryptographic systems.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Construct the parity check/generator matrix of a linear code. Design cyclic codes of a given rate and distance parameters.	Ap	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Calculate bounds on rate and distance of a given linear code using various bounds.	An	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Decode a cyclic code using various standard decoding procedures.	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Textbook	Cryptography Theory and Practice 3rd Edition, Douglas R. Stinson, , Chapman & Hall,			
Module	**Unit**	**Content**	**Hrs (48 +12)**	**Ext. Marks (70)**
I		**Classical Cryptography**	**12**	**Min.15**
	1	Chapter 1: Section 1.1-1.1.1: Some SimpleCryptosystems, Shift Cipher		
	2	Chapter 1: Sections 1.1.2 & 1.1.3: The SubstitutionCipher, Affine Cipher		
	3	Chapter 1: Sections 1.1.4 & 1.1.5: The VigenereCipher, The Hill Cipher		
	4	Chapter 1: Sections 1.1.6 : The Permutation Cipher		
	5	Chapter 1: Sections 1.1.7 : Stream Ciphers		
II		**Cryptanalysis**	**12**	**Min.15**
	6	Chapter 1: Section 1.2 & 1.2.1 : Cryptanalysis:Cryptanalysis of the Affine Cipher		
	7	Chapter 1: Section 1.2.2 : Cryptanalysis of theSubstitution Cipher		
	8	Chapter 1: Section 1.2.3 : Cryptanalysis of theVigenere Cipher		
	9	Chapter 1: Section 1.2.4 : A known plain textattack on the Hill Cipher		
	10	Chapter 1: Section 1.2.5 : Cryptanalysis of theLFSR-based Stream Cipher.		
III		**Shannon's Theory**	**10**	**Min.15**
	11	Chapter 2 : Sections 2.1, 2.2 : Introduction,Elementary Probability Theory		
	12	Chapter 2 : Sections 2.3: Perfect Secrecy		
	13	Chapter 2 : Sections 2.4: Entropy, HuffmanEncodings		
	14	Chapter 2 : Sections 2.5: Properties of Entropy		
	15	Chapter 2 : Sections 2.6: Spurious Keys andUnicity Distance		
	16	Chapter 2 : Sections 2.7: Product Cryptosystems		
IV		**Block Ciphers and Advanced Encryption Standard**	**14**	**Min.15**
	17	Chapter 3: Sections 3.1 and 3.2 : Introduction,Substitution - Permutation Networks		
	18	Chapter 3: Sections 3.3 (3.3.1 to 3.3.3): LinearCryptanalysis		
	19	Chapter 3: Sections 3.4 : Differential Cryptanalysis		
	20	Chapter 3: Sections 3.5 (3.5.1,3.5.2) : Data Encryption Standard (DES), Description of DES,Analysis of DES		
V		**Open Ended**	**12**	
		Cryptographic Hash Functions		
References	**1.** Jeffrey Hoffstein: Jill Pipher, Joseph H. Silverman, An Introduction to Mathematical Cryptography, Springer International Edition. **2.** Koblitz, N. (1994) A course in Number Theory and Cryptography, (SecondEd.), Springer- Verlag **3.** Yan, S. Y. (2003) Primality Testing and Integer Factorization in Public-Key Cryptography, Springer **4.** H. Deffs & H. Knebl: Introduction to Cryptography, Springer Verlag, 2002 **5.** Alfred J. Menezes, Paul C. van Oorschot and Scott A. Vanstone: Handbook of Applied Cryptography, CRC Press, 1996. **6.** William Stallings: Cryptography and Network Security Principles and			

Practice, Third Edition, Prentice-hall India, 2003.
7. D. Boneh and V. Shoup: A Graduate Course in Applied Cryptography (V 0.5)
8. J. Katz and Y. Lindell. *Introduction to Modern Cryptography* (2nd edition)

Note: 70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	2	1	3	3	3	3	0	0	3
CO 2	3	3	1	1	3	3	3	3	0	0	3
CO 3	2	3	2	1	3	3	3	3	0	0	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours				
Course Code	MAT8EJ408				
Course Title	**INTRODUCTION TO FRACTALS**				
Type of Course	**Elective**				
Semester	VIII				
Academic Level	400 - 499				
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours	
	4	4	0	60	
Pre-requisites	1. Calculus 2. Geometry				
Course Summary	This course equips students with a thorough understanding of metric spaces and the mathematical foundations of fractal geometry, blending theoretical insights with practical applications.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the basic concepts to build fractals	U	C	Internal Examination/ Assignment/ End Sem examination
CO2	Interpret the dimension of fractals	An	P	Internal Examination/Seminar/ Assignment/ Report/ End Sem examination
CO3	To understand how to construct fractals and apply them	Ap	M	Internal Examination/Seminar/ Report/ End Sem examination
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Text Book	Fractals Everywhere, (2/e), Michael F Barnsley, Dover Publications, 2012			
Module	**Unit**	**Content**	**Hrs (48+12)**	**External Marks(70)**
I		**Metric spaces**	**15**	**18**
	1	Chapter II, Section 2:- Metric spaces		
	2	Section 3: - Cauchy Sequences, Limit Points, Closed Sets, Perfect Sets, and Complete Metric Spaces		
	3	Section 4: - Compact Sets, Bounded Sets, Open Sets, and Boundaries		
	4	Section 5: - Connected Sets, Disconnected Sets, and Pathwise-Connected Sets		
II		**Space of Fractals**	**15**	**17**
	5	Section 6: - The Metric Space (H(X), h): The Space Where Fractals Live		
	6	Section 7: - The Completeness of the Space of Fractals – up to Theorem 7.1		
	7	Section 7: - The Completeness of the Space of Fractals – From Theorem 7.1 onwards.		
	8	Chapter III, Section 1 – Transformations on the Real line – up to definition 1.3		
	9	Section 1: – Transformations on the Real line – from definition 1.3 onwards.		
	10	Section 2: – Affine Transformations in the Euclidean Plane		
	11	Section 6: – The Contraction Mapping Theorem		
III		**Fractal Dimension**	**8**	**18**
	12: - Section 7: - Contraction Mappings on the Space of Fractals - up to definition 7.1			
	13: - Section 7: – Contraction Mappings on the Space of Fractals – from definition 7.1 onwards			
	14: - Section 8: – Two Algorithms for Computing Fractals from Iterated Function Systems			
	15: - Section 10: – How to Make Fractal Models with the Help of the Collage Theorem.			
	16: - Chapter V, Section 1: – Fractal Dimension – up to Theorem 1.2			
	17: - Chapter V, Section 1: – Fractal Dimension – from Theorem 1.2 onwards.			
IV		**Determination of Dimensions**	**10**	**17**
	18	Section 2: – The Theoretical Determination of the Fractal Dimension – up to Theorem 2.1(including)		
	19	Section 2: – The Theoretical Determination of the Fractal Dimension – rest of the section.		
	20	Section 3: – The Experimental Determination of the Fractal Dimension.		
	21	Section 4: – The Hausdorff-Besicovitch Fractal Dimension – up to and including Theorem 4.2		

	22	Section 4: – The Hausdorff-Besicovitch Fractal Dimension – rest of the section		
V	**OPEN ENDED**		**12**	
	Applications of Fractal functions, Fractal interpolation functions, Space filling curves, Construction of Iterated function systems, Applications of Fractals in medical imaging			
References	1. The Fractal Geometry of Nature, Benoît B. Mandelbrot, W.H. Freeman and Company, 1982. 2. Chaos and Fractals: New Frontiers of Science, (2/e), Heinz-Otto Peitgen, Hartmut Jürgens, Dietmar Saupe, Springer, 2004 3. Fractals: Form, Chance, and Dimension, Benoît B. Mandelbrot, W.H. Freeman and Company,1977. 4. Fractals Everywhere, (2/e), Michael F. Barnsley, Academic Press, 1993. 5. An Introduction to Fractals and Chaos, Michael F. Barnsley, Cambridge University Press, 2021.			

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	2	1	2	1	2	2	2	1	1
CO 2	3	3	1	1	2	1	2	2	2	1	1
CO 3	3	2	2	1	2	1	2	2	2	1	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

RESEARCH METHODOLOGY

Programme	B. Sc. Mathematics Honours			
Course Code	MAT8CJ489			
Course Title	**RESEARCH METHODOLOGY IN MATHEMATICS**			
Type of Course	**Major**			
Semester	VII			
Academic Level	400 – 499			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	4	-	60
Pre-requisites	1. Mathematical Logic and necessary exposure to set theory. 2. Research Aptitude			
Course Summary	MAT8CJ489, "Research Methodology in Mathematics," is designed to equip students with the essential skills and knowledge required for conducting research in mathematics effectively. This course focuses on various aspects of mathematical research, including axiomatic set theory, writing mathematics, researching and presenting findings, and using LaTeX for mathematical typesetting. Additionally, students explore open-ended research topics, allowing them to delve into specific areas of interest within mathematics. Throughout the course, students engage with key texts and resources, enabling them to develop a comprehensive understanding of research methodologies in mathematics.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Set Theory and Mathematical Writing: Students will demonstrate proficiency in axiomatic set theory, including concepts such as relations, functions, and Peano axioms. Students will exhibit competence in mathematical writing.			Internal Examination/ Assignment/ End Sem examination
CO2	Research Skills and Presentation Techniques: Students will acquire research skills, including identifying research topics. Students will develop effective presentation techniques, giving talks.			Internal examination/ Seminar/ Assignment/ End Sem examination
CO3	Mathematical typesetting: to use LaTeX to create and typeset documents. Beamer Presentations and PSTricks also included.			Internal Examination/Seminar/ Assignment/End Sem examination

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Text Book	(1) : Naive set theory: Paul R. Halmos, Courier Dover Publications, 2017. (2) : A student's guide to the study, practice, and tools of modern mathematics, Donald Bindner and Martin Erickson. CRC Press, ISBN: 978•1•4398•4606•3			
Module	**Unit**	**Content**	**Hrs (48+12)**	**External Marks (70)**
I		**Axiomatic Set Theory**	**12**	
		(Sections 1 to 12 from the Text 1.) 1: The axiom of extension 2: The axiom of specification 3: Unordered pairs 4: Unions and intersections 5: Complements and powers 6: Ordered pairs 7: Relations 8: Functions 9: Families 10: Inverses and composites 11: Numbers 12: The Peano axioms		
II		**Writing Mathematics (Text 2)**	**12**	
		Chapter 1: How to Learn Mathematics (A quick review – not part of evaluation)		
		Chapter 2: How to Write Mathematics • 2.1 : What is the goal of mathematical writing? 2.2 : General principles of mathematical writing 2.3 : Writing mathematical sentences 2.4 : Avoiding error		

		2.5 : Writing mathematical solutions and proofs 2.6 : Writing longer mathematical works 2.7 : The revision process		
III	**Researching and Presenting** **(Text 2)**		**12**	
		Chapter 3: How to Research Mathematics • 3.1 : What is mathematical research? 3.2 : Finding a research topic 3.3 : General advice 3.4 : Taking basic steps 3.5 : Fixing common problems 3.6 : Using computer resources 3.7 : Practicing goodmathematical judgment Chapter 4: How to Present Mathematics • 4.1 : Why give a presentation of mathematics? 4.2 : Preparing your talk 4.3 : DOs and DON'Ts 4.4 : Using technology 4.5 : Answering questions 4.6 : Publishing your research		
IV	**LATEX** **(Text 2)**		**12**	
		LaTeX 9.4 How to create and typeset a simple LATEX document 9.5 How to add basic information to your document 9.6 How to do elementary mathematical typesetting 9.7 How to do advanced mathematical typesetting 9.8 How to use graphics		
		PsTricks		

		10.1 What is PSTricks? 10.2 How to make simple pictures 10.3 How to plot functions 10.4 How to make pictures with nodes		
		Beamer 11.1 What is Beamer? 11.2 How to think in terms of frames 11.3 How to set up a Beamer document 11.4 How to enhance a Beamer presentation		
V	**OPEN ENDED** **(General Mathematical Research)**		**12**	
	Lecturer's choices from the following Reference 1 (Princeton Companion), Section 1.4: General Goals of Mathematical Research, p.48 to 78. 1. Solving Equations 2. Classifying 3. Generalizing 4. Discovering Patterns 5. Explaining Apparent Coincidences 6. Counting and Measuring 7. Determining Whether Different Mathematical Properties are Compatible 8. Working with Arguments that are not Fully Rigorous 9. Finding Explicit Proofs and Algorithms 10. What do you find in a Mathematical Paper? Reference 2 (Math Unlimited), any chapters of the lecturer's choices. Reference 3 (Krantz, Mathematical Writing), any topics of lecturer's choice.			

MULTI-DISCIPLINARY COURSES

(MDC)

Programme	B. Sc. Mathematics Honours				
Course Code	MAT1FM105(1)				
Course Title	**MATRICES AND BASICS OF PROBABILITY THEORY**				
Type of Course	**MDC**				
Semester	I				
Academic Level	100 - 199				
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours	
	3	3	-	45	
Pre-requisites	Basic Arithmetic and Computational Skill.				
Course Summary	The course "Matrices and Basics of Probability Theory" provides students with a comprehensive understanding of two fundamental mathematical concepts: matrices and probability. The syllabus begins with a focus on the algebra of matrices, covering operations such as addition, subtraction, multiplication, determinants, and inverses, followed by applications in solving systems of equations. Transitioning to probability theory, students delve into basic concepts, conditional probability, the addition and multiplication rules, and various counting methods. Additionally, the course introduces basic statistics, including frequency distributions, measures of central tendency and variation, and measures of position.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the concepts of matrices and determinants.	U	C	Internal Exam/Assignment / Seminar/ Viva / End Sem Exam
CO2	Apply matrix theory to solve systems of equations.	Ap	P	Internal Exam/Assignment / Seminar/ Viva / End Sem Exam
CO3	Understand concepts like measures of central tendency, measures of variation, measures of position and probability.	U	C	Internal Exam/Assignment / Seminar/ Viva / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (36+ 9)	Ext. Marks (50)
Texts: 1. John Bird, Bird's Higher Engineering Mathematics 9/e, Routledge, ISBN: 978-0-367-64373-7, 2021. 2. Ron Larson & Betsy Farber, Elementary Statistics, Picturing the World 6/e, Pearson Education, ISBN: 978-0-321-91121-6, 2015.				
I		**Algebra of Matrices (from text 1)**	9	Min 10
	1	Section 20.1 - Matrix notation		
	2	Section 20.2 - Addition, subtraction and multiplication of matrices		
	3	Section 20.3 to 20.4 - The unit matrix, The determinant of a 2 by 2 matrix.		
	4	Section 20.5 - The inverse or reciprocal of a 2 by 2 matrix.		
	5	Section 20.6 - The determinant of a 3 by 3 matrix		
	6	Section 20.7 - The inverse or reciprocal of a 3 by 3 matrix		
II		**System of Equations From Text 1**	9	Min 10
	7	Section 21.1 - Solution of simultaneous equations by matrices		
	8	Section 21.2 - Solution of simultaneous equations by determinants		
	9	Section 21.3 - Solution of simultaneous equations using Cramer's rule		
	10	Section 21.4 - Solution of simultaneous equations using the Gaussian elimination method.		
III		**Basic Statistics From Text 2**		
	11	Section 1.1 to 1.2 - An Overview of Statistics, Data Classification		

	12	Section 2.1 - Frequency Distributions and their Graphs	**9**	**Min 10**
	13	Section 2.3 - Measures of Central Tendency		
	14	Section 2.4 - Measures of Variation		
	15	Section 2.5 - Measures of Position		
IV		**Basics of Probability (from text 2)**	**9**	**Min 10**
	16	Section 3.1 - Basic Concepts of Probability and Counting.		
	17	Section 3.2 - Conditional Probability and the Multiplication Rule.		
	18	Section 3.3 - The Addition Rule.		
	19	Section 3.4 - Additional topics in probability and counting.		
V		**Open Ended**	**9**	
		Data Collection and Experimental Design, More Graphs and Displays (for instance refer sections from Text 2: 1.3 and 2.2)		

References:

1. Advanced engineering mathematics, 10/e, Erwin Kreyszig, Wiley, 2011.

2. Introduction to Linear Algebra with Applications, Jim DeFranza and Daniel Gagliardi, Waveland Press, 2015.

3. Elementary Statistics, 13/e, Mario F. Triola, Pearson Education, 2018.

4. Elementary Statistics, 8/e, Neil A. Weiss, Pearson Education, 2012.

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	0	3	1	3	2	2	1	2
CO 2	3	0	3	1	3	2	3	1	2
CO 3	3	0	3	1	2	2	3	1	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours
Course Code	MAT2FM106(1)
Course Title	**GRAPH THEORY AND LPP.**
Type of Course	**MDC**
Semester	II
Academic Level	100 - 199

Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	3	3	-	45

Pre-requisites	Basic Arithmetic and Geometry.
Course Summary	The course "Graph Theory and Linear Programming" introduces fundamental concepts in graph theory focusing initially on graph definitions, properties, and structures such as vertex degrees, subgraphs, paths, and cycles. The discussion extends to trees, bridges, spanning trees, cut vertices, and connectivity, emphasizing essential properties and theorems while providing proofs for brevity. Transitioning to linear programming, the course employs graphical methods for solving linear inequalities and optimization problems, progressing to the simplex method for more complex maximization and minimization problems, including duality and nonstandard scenarios. Additionally, the syllabus offers open-ended exploration into graph modellingmixture, matrix representations, and connector problems.

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand and apply the fundamental concepts in graph theory.	U	C	Internal Exam/Assignment / Seminar/ Viva / End Sem Exam
CO2	Analyse properties of graphs and trees.	An	P	Internal Exam/Assignment / Seminar/ Viva / End Sem Exam
CO3	Solve linear programming problems by geometrically and Simplex method.	Ap	C	Internal Exam/Assignment / Seminar/ Viva / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Texts:

1. John Clark & Derek Allan Holton, A First Look at Graph Theory: Allied Publishers, First Indian Reprint 1995.
2. Margaret L. Lial, Raymond N, Finite Mathematics and Calculus with Applications 9/e, Greenwell & Nathan P. Ritchey Pearson Education, Inc, ISBN 0-321-74908-1, 2012.

Module	Unit	Content	Hrs (36 +9)	Ext. Marks (50)
I		**Basics of Graph Theory (from text 1)**	9	Min 10
	1	Section 1.1 - Definition of a graph.		
	2	Section 1.3 - More definitions.		
	3	Section 1.4 - Vertex degrees.		
	4	Section 1.5 - Sub Graphs.		
	5	Section 1.6 - Paths and Cycles (Theorem 1.4 statement only).		
II		**Basics of Graph Theory From Text 1**	9	Min 10
	6	Section 2.1 - Definitions and Simple Properties of trees (Proof of Theorem 2.1, 2.2 and 2.4 omitted).		
	7	Section 2.2 - Bridges: up to and including Theorem 2.8 (Theorem 2.6 and 2.7 are statement only).		
	8	Section 2.2 - Bridges (Theorem 2.9 statement only) contd.		
	9	Section 2.3 - Spanning trees (Theorem 2.12 statement only).		
	10	Section 2.6 - Cut Vertices and Connectivity (Theorem 2.20 and Theorem 2.21 are statements only).		
III		**Linear Programming - The Graphical Method From Text 2**	9	Min 10
	11	Section 3.1 - Graphing Linear Inequalities.		
	12	Section 3.2 - Solving Linear Programming Problems Graphically; up to and including Example 2.		
	13	Section 3.2 - Solving Linear Programming Problems Graphically contd.		

	14	Section 3.3 - Applications of Linear Programming; up to and including Example 2.		
	15	Section 3.3 - Applications of Linear Programming contd.		
IV		**Linear Programming - The Simplex Method** (from text 2)	**9**	**Min 10**
	16	Section 4.1- Slack Variables and the Pivot.		
	17	Section 4.2- Maximization Problems.		
	18	Section 4.3- Minimization Problems; Duality.		
	19	Section 4.4- Nonstandard Problems.		
V		**Open Ended**	**9**	
		Graphs as models, Matrix representation of graphs, Connector problems (for instance refer sections from 1.2, 1.7 and 2.4 of Text 1).		

References:

1. Introduction to Graph Theory, 4th ed., R.J. Wilson, LPE, Pearson Education, 1996.
2. Graph Theory with Applications, J .A. Bondy & U.S.R. Murty, North-Holland,1982
3. Linear Programming: Foundations and Extensions, 2/e, Robert J. Vanderbei, Springer Science+Business Media LLC, 2001.
4. An Introduction to Linear Programming and Game Theory (3/e), Paul R. Thie and G. E. Keough, John Wiley and Sons, 2008.

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	3	1	3	2	3	1	2
CO 2	3	2	3	1	3	2	3	1	2
CO 3	3	2	3	2	3	2	3	1	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours				
Course Code	MAT1FM105(2)				
Course Title	**MATHEMATICS FOR COMPETITIVE EXAMINATIONS - PART I**				
Type of Course	**MDC**				
Semester	I				
Academic Level	100 - 199				
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours	
	3	3	-	45	
Pre-requisites	Basic Arithmetic and Computational Skill				
Course Summary	The course is designed to equip students with essential arithmetic and problem-solving skills required for competitive exams. It covers topics ranging from fundamental arithmetic operations such as number systems, fractions, and roots to more advanced concepts like financial mathematics, time-speed-distance calculations, and problem-solving techniques..				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Apply mathematical methods to solve problems	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Apply numerical skills in competitive examinations	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Manage time in competitive examinations.	C	M	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (36+ 9)	Ext. Marks (50)
I		**Fundamentals of Arithmetic**	9	Min 10
	1	Number System		
	2	Number Series		
	3	Simple and Decimal Fractions		
	4	HCF and LCM		
	5	Square root and Cube root		
II		**Basic Arithmetic Operations**	9	Min 10
	6	Simplification		
	7	Average		
	8	Ratio and Proportion		
	9	Problems based on ages		
	10	Percentage		
III		**Financial Mathematics**	9	Min 10
	11	Profit and Loss		
	12	Discount		
	13	Simple Interest		
	14	Compound Interest		
	15	Work and Time		
IV		**Time, Speed, and Distance**	9	Min 10
	16	Speed, Time and Distance		
	17	Problems based on trains		
	18	Boats and Streams		
	19	Clock and Calendar		

V	**Open Ended**	**9**	
	Mixture or Allegation, Partnership, Pipes and Cisterns		
References: 1. Fast Track Objective Arithmetic, Rajesh Verma, Arihant Publications India limited, 2018 (Primary Reference). 2. Objective Arithmetic for Competitive Examinations, Dinesh Khattar, Pearson Education, 2020. 3. Quicker Objective Arithmetic, Dr Lal, Jain, Upkar's publication, 2010.			

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	0	3	2	3	2	3	1	2
CO 2	2	0	3	1	3	2	3	1	2
CO 3	2	0	2	2	2	2	2	1	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours				
Course Code	MAT2FM106(2)				
Course Title	**MATHEMATICS FOR COMPETITIVE EXAMINATIONS - PART II**				
Type of Course	**MDC**				
Semester	II				
Academic Level	100 - 199				
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours	
	3	3	-	45	
Pre-requisites	Basic Arithmetic and Computational Skill				
Course Summary	The course "Mathematics for Competitive Examinations - Part II" is designed to prepare students for competitive exams by focusing on various reasoning and problem-solving skills. It covers a range of topics including non-verbal reasoning, verbal reasoning, spatial reasoning, and abstract reasoning, each module addressing different aspects of these skill sets.				

Course Outcomes (CO):

CO	**CO Statement**	**Cognitive Level***	**Knowledge Category#**	**Evaluation Tools used**
CO1	Apply mathematical methods to solve problems	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Understand the basic concepts of logical reasoning Skills	U	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Manage time in competitive examinations	C	M	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (36+ 9)	Ex Marks (50)
		Non-Verbal Reasoning	**9**	**Min 10**
I	1	Similarity of Pairs		
	2	What come Next		
	3	Odd One out		
	4	Coding and Decoding		
	5	Ranking Test		
II		**Reasoning Contd.**	**9**	**Min 10**
	6	Blood relations		
	7	Blood relations Contd.		
	8	Direction Sense Test		
	9	Direction Sense Test contd.		
	10	Logical Venn Diagram		
III		**Spatial Reasoning**	**9**	**Min 10**
	11	Figure analogy		
	12	Figure series		
	13	Figure Classification		
	14	Mirror and Water Images		
	15	Counting of figures		
IV		**Abstract Reasoning**	**9**	**Min 10**
	16	Cube and Dice		
	17	Logical and Analytical Reasoning		
	18	Geometry mensuration		
	19	Data Interpretation		
V		**Open Ended**		

	Alphabet and Number Sequence Test, Paper folding and paper cutting	**9**	

References:

1. A Fast Track Course in MENTAL ABILITY, Amogh Goel, Arihant Publications India limited, 2016. (Primary Reference).
2. The Mental Ability, Logical Reasoning & Problem-Solving Compendium for IAS Prelims General Studies Paper 2 & State PSC Exams, Disha Experts, Disha Publications, 2018.
3. The Pearson Guide to Verbal Ability and Logical Reasoning for the CAT, Nishit K. Sinha, Pearson Education, 2014.

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	1	2	1	2	0	1	1	0
CO 2	2	0	2	1	2	0	1	1	0
CO 3	0	1	2	1	2	0	1	1	0

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

SKILL ENHANCEMENT COURSES

(SEC)

Programme	B. Sc. Mathematics Honours				
Course Title	**MATHEMATICAL TYPE SETTING SYSTEM - LATEX**				
Course Code	MAT5FS112				
Type of Course	**SEC**				
Semester	V				
Academic Level	300-399				
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours	
	3	3	-	45	
Pre-requisites	1. Fundamental Mathematics Concepts				
Course Summary	The course will cover topics such as document formatting, mathematical typesetting, graphics and tables, bibliography management, beamer presentation and understanding the Indian language transliteration package for typesetting Sanskrit or Hindi or Malayalam using LaTeX.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Preparing a LaTex document with title page including contents, references and index	Ap	C	Internal Exam/ Assignment/ Seminar/ Viva / End Sem Exam
CO2	To Display documents with bullets, numbering and aligning or ordering and adding rows and tables	Ap	C	Internal Exam/ Assignment/ Seminar/ Viva / End Sem Exam
CO3	Use mathematical typesetting and equation environments to create professional looking equations and mathematical notation	U	F	Internal Exam/ Assignment/ Seminar/ Viva / End Sem Exam

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

<table>
<tr><td>Textbook</td><td colspan="4">Text 1: LATEX TUTORIAL, A PRIMER by Indian TEX Users Group, Edited by E. Krishnan, 2003.
Text 2: George Gratzer, More Math Into LaTeX-Springer 2016 (5th Edition),</td></tr>
<tr><td>Module</td><td>Unit</td><td>Content</td><td>Hrs (36+ 9)</td><td>Ex. Marks (50)</td></tr>
<tr><td rowspan="5">I</td><td colspan="2">Getting Started with LaTeX (Text-1)</td><td rowspan="5">8</td><td rowspan="5">Min 10</td></tr>
<tr><td>1</td><td>The basics- Tutorial I</td></tr>
<tr><td>2</td><td>The documents – Tutorial II</td></tr>
<tr><td>3</td><td>Bibliographic Database- Tutorial III & IV</td></tr>
<tr><td>4</td><td>Table of contents and Index- Tutorial V(Omit glossary)</td></tr>
<tr><td rowspan="4">II</td><td colspan="2">Styling Pages</td><td rowspan="4">6</td><td rowspan="4">Min 10</td></tr>
<tr><td>5</td><td>Displayed Text – Tutorial VI</td></tr>
<tr><td>6</td><td>Rows and columns – Tutorial VII</td></tr>
<tr><td>7</td><td>Tables – Tutorial VII .2</td></tr>
<tr><td rowspan="5">III</td><td colspan="2">Typesetting Mathematics</td><td rowspan="5">10</td><td rowspan="5">Min 10</td></tr>
<tr><td>8</td><td>Basic Mathematical equation- Tutorial VIII.1, VIII.2</td></tr>
<tr><td>9</td><td>Groups of Equations and numbering – Tutorial VIII.3</td></tr>
<tr><td>10</td><td>Matrices, dots, delimiters and affixing symbols- Tutorial VIII.4</td></tr>
<tr><td>11</td><td>Operators, Equations, Symbols, notations, Greek letters etc. Tutorial VIII.5, VIII.6, VIII.7, VIII.8(In VIII.8 focus only on usual symbols, Greek letters, operations etc. commonly used in mathematics)</td></tr>
<tr><td rowspan="4">IV</td><td colspan="2">Theorems, figures, Cross references and Presentation(Text-1 and 2)</td><td rowspan="4">12</td><td rowspan="4">Min 10</td></tr>
<tr><td>12</td><td>Theorem in Latex – Tutorial IX.1</td></tr>
<tr><td>13</td><td>The AMS theorem package- Tutorial IX.2 (Omit IX.2.2 , IX.2.3)</td></tr>
<tr><td>14</td><td>Boxes – Tutorial X (Section X.1 , X.2 Only)</td></tr>
</table>

	15	Floating Images- Tutorial XI (Section XI.I.I , XI.I.2 and XI.I.5 Only)		
	16	Cross Reference – Tutorial XII (Section XII.1, XII.2 Only)		
	17	Footnotes- Tutorial XIII (Section XIII.1 Only)		
	18	Presentation – Text 2, Section 12.1 to 12.2.4		
	19	Presentation – Text 2, Section 12.2.6 to 12.2.9 (Omit 12.2.5 and 12.2.7)		
V	**Open Ended**		**9**	
	1	Installation of LaTeX		
	2	Familiarising Overleaf Platform		
	3	Write a chapter in a book that you are studying in any semester having mathematical symbol theorems and figures.		
	4	Create Slides with beamers and posters		
	5	Transliteration symbols with Illustrative examples of the Indian Languages, such as Sanskrit, Hindi (Devanagari) and Malayalam.		

References:

1) Tobias Oetiker, Hubert Partl, Irene Hyna and Elisabeth Schlegl, The Not So Short Introduction to LATEX 2ε (Online Link:- The Not So Short Introduction to LaTeX (oetiker.ch))
2) Harvey J. Greenberg, A simplified introduction to LaTeX (Online version)
3) Leslie Lamport (second edition. Addison Wiley,1994)- LaTeX, a Document Preparation System.
4) Donald Knuth (Addison-Wesley, 1984), The TeX book
5) Frank Mittelbach and Michel Goossens (second edition), Addison-Wesley, 2004).

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	1	0	1	1	2	2	1	0	2	3	0
CO 2	2	3	1	0	1	1	1	3	1	0	2	3	0
CO 3	3	2	1	0	1	1	2	1	1	0	2	2	0

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours				
Course Code	MAT6FS113				
Course Title	**DATA SCIENCE WITH PYTHON**				
Type of Course	**SEC**				
Semester	VI				
Academic Level	300 - 399				
Course Details	Credit	Lecture perweek	Tutorial per week	Practical per week	Total Hours
	3	3	-	0	60
Pre-requisites	A basic course in Python programming with the understanding of using looping, conditionals, creating variables, writing functions, and importing modules.				
Course Summary	This course is an advanced course for those who have learned the basics of Python. It will enable the students to learn more features of Python with a specific focus on how to use them to analyse data and arrive at conclusions in practical situations with the help of a reasonable knowledge of statistics.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Learn to rearrange and manipulate various data structures in Python to make it more meaningful	U	F	Internal Exam/ Assignments / End Semester Examination
CO2	Understand fundamentals of Statistics from a real life point of view	U	F	Internal Exam/ Assignments / Quiz / End Semester Examination
CO3	Learn how to visualise data for clearer understanding of practical situations	Ap	C	Internal Exam / Quiz / End Semester Examination
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Note : Python IDLE (with necessary modules like pandas, scipy), Anaconda/Spyder package, Jupyter notebook interface or Google colab (free to use) interface, Pydroid 3 for android (along with Pydroid repository plugin) can be used for training purposes. Python version 3.10 or above should be used to avoid errors with some of the functionalities we discuss in the course.

Textbook	1 Mastering Python for Data Science, Samir Madhavan, PACKT Publishing, 2015 2 Data Science from Scratch, Second Edition ,Joel Grus, O'Reilly, 2019			
Module	**Unit**	**Content**	**Hrs (36+ 9)**	**Ext. Marks (50)**
I		**Python Tools for Handling and Manipulating Data (Text 2, Chapter 2)**	**8**	**Min 10**
	1	Exceptions, Lists.		
	2	Tuples, Dictionaries.		
	3	Counters, Sets, List Comprehensions,		
	4	Truthiness, Automated Testing and assert Iterables and Generators		
	5	Randomness, Regular Expressions, zip and Argument Unpacking		
II		**More Tools for Data Handling – Numpy and Pandas (Text 1, Chapter 1)**	**8**	**Min 10**
	6	NumPy: Mathematical operations, Array subtraction, squaring an array, A trigonometric function performed on the array, Conditional operations.		
	7	NumPy : Matrix multiplication, Indexing and slicing, Shape manipulation.		

	8	Pandas : Inserting and exporting data, CSV, Data cleansing, Checking the missing data.		
	9	Pandas : Filling the missing data, String operations, Merging data		
	10	Data operations: Aggregation operations, Joins, The inner join		
	11	Data operations: The left outer join, The full outer join, The groupby function		
III	**Inferential Statistics (Text 1, Chapter 2)**		12	Min 10
	12	Various forms of distribution, A normal distribution, A normal distribution from a binomial distribution.		
	13	A Poisson distribution, A Bernoulli distribution.		
	14	A z-score, A p-value, One-tailed and two-tailed tests.		
	15	Type 1 and Type 2 errors, confidence interval.		
	16	Correlation, Z-test vs T-test, The F distribution.		
	17	The chi-square distribution, Chi-square for the goodness of fit, The chi-square test of independence, ANOVA.		
IV	**Applying the Theory to Problems (Text 1, Chapter 3)**		8	Min 10
	18	What is data mining? Presenting an analysis.		
	19	Studying the Titanic – with all the required analysis		
V	**Open Ended Visualizing Data (Text 1, Chapter 4)**		10	
	1	Making Sense of Data through Advanced Visualization - Controlling the line properties of a chart		

	2	Using keyword arguments, Using the setter methods, Using the setp() command.		
	3	Creating multiple plots, Playing with text, Styling your plots.		
	4	Box plots, Heatmaps, Scatter plots with histograms.		
	5	A scatter plot matrix, Area plots.		
References	1 Thomas Nield, Essential Math for Data Science - Take Control of Your Data with Fundamental Linear Algebra, Probability, and Statistics, O'Reilly Media, 2022 2 Wes McKinney, Python for Data Analysis_ Data Wrangling with pandas, NumPy, and Jupyter-O'Reilly Media, Third Edition, 2022 3 Fabio Nelli, Python Data Analytics- With Pandas, NumPy, and Matplotlib, Apress, Second Edition, 2018 4 https://www.kaggle.com/datasets/yasserh/titanic-dataset 5 https://www.w3schools.com/datascience/ds_python.asp 6 https://realpython.com/python-for-data-analysis/ 7 https://www.geeksforgeeks.org/data-science-with-python-tutorial/ 8 https://learn.microsoft.com/en-us/training/modules/explore-analyze-data-with-python/1-introduction 9 https://onlinecourses.nptel.ac.in/noc24_cs54/preview 10 https://onlinecourses.nptel.ac.in/noc20_cs46/preview			

Note: For detailed understanding of the topics given in Module II, additional reference 1 can also be used, though it is not very essential.

Roadmap:

Being a practice-oriented course, the teachers may introduce the students to more problems so as to familiarize them with the tools in which they have been trained through this course. Many good examples on how to use these in real life situations can be found in Chapter 13 of additional reference 2 and the URLs provided in the additional references section.

Mapping of COs with PSOs and POs :

	PSO 1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	3	3	1	3	2	3	3	1	1	1
CO 2	3	2	3	2	3	2	1	1	1	1	1
CO 3	3	2	2	1	3	1	3	3	1	-	1

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Quiz	End Semester Examinations
CO 1	√	√		√
CO 2	√	√	√	√
CO 3	√		√	√

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Internal Exam
- Assignment
- Quiz
- End Semester Examinations

VALUE-ADDED COURSES

(VAC)

Programme	B. Sc. Mathematics Honours			
Course Code	MAT3FV109(1)			
Course Title	**HISTORY OF MATHEMATICS**			
Type of Course	**VAC**			
Semester	III			
Academic Level	200 - 299			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	3	3	-	45
Pre-requisites	Aptitude for Mathematics and its History.			
Course Summary	The course goes into the philosophy of mathematics, modern axiom methods, controversies in set theory around axiom of choice, its implications and various philosophical alternative approaches to the foundations of mathematics.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Analyse Key Mathematical Theorems and Concepts from Ancient to Early Modern Times	An	C	Internal Exam/ Assignment/ Seminar/ Viva / End Sem Exam
CO2	Evaluate and Compare Methods of Addressing Infinity and Large Cardinal Numbers	E	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Ensure students gain a comprehensive understanding of the historical development and foundational concepts of mathematics	An	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Textbook	Mathematics & Its History, 3rd Edition, John Stillwell, Springer (2010) ISBN: 978-1-4419-6052-8.			
Module	**Unit**	**Content**	**Hrs (36+9)**	**Ext. Marks (50)**
I	**Ancient Origins & Foundations**		**9**	**Min 10**
	Quick Review of Ancient Mathematics			
	1	Chapter 1: Pythagoras Theorem		
	2	Chapter 2: Greek Geometry		
	3	Chapter 3: Greek Number Theory		
	Infinity in Greek Mathematics – Chapter 4			
	4	Section 4.1, 4.2-Fear of Infinity, Eudoxus' Theory of Proportions		
	5	Section – 4.3, 4.4-The Method of Exhaustion, Area of a Parabolic Segment		
	Sets & Logic – Chapter 24			
	6	Sections 24.1, 24.2, 24.4- Sets, Ordinals, Axiom of Choice & Large Cardinals		
	7	Section 24.3- Measure		
	8	Section 24.5-The Diagonal Argument		
	Biographical Notes: Pythagoras, Euclid, Diophantus, Archimedes			
II	**Calculus – Chapter 9**		**9**	**Min 10**
	9	Section 9.1, 9.2-What is Calculus, Early Results on Areas & Volumes		
	10	Section 9.3-Maxima, Minima & Tangents		
	11	Section 9.4-The *Arithemetica Infinitorum* of Wallis		
	12	Section 9.5-Newton's Calculus of Series		
	13	Section 9.6-The Calculus of Leibnitz		

	Biographical Notes: Wallis, Newton & Leibnitz			
III	**Algebraic Equations & Numbers**		**9**	**Min 10**
	Polynomial Equations – Chapter 6			
	14	Section 6.1, 6.2- Algebra, Linear Equations & Elimination		
	15	Section 6.3, 6.4 Quadratic Equations, Quadratic Irrationals		
	16	Section 6.5-The Solution of the Cubic		
	17	Section 6.6-Angle Division		
	18	Section 6.7-Higher Degree Equations		
	Biographical Notes: Tartaglia, Cardano & Viete			
	Complex Numbers – Chapter 14			
	19	Section 14.1, 14.2, 14.3- Impossible Numbers, Quadratic & Cubic Equations		
	20	Section 14.4- Wallis' Attempt at Geometric Representation		
	21	Section 14.5, 14.6- The Fundamental Theorem of Algebra, The Proofs of d'Alembert & Gauss		
	Biographical Notes: d'Alembert			
IV	**Topology – Chapter 22**		**10**	**Min 10**
	22	Section 22.1, 22.2- Geometry & Topology, Polyhedron Formulas of Descartes & Euler		
	23	Section 22.3-The Classification of Surfaces		
	24	Section 22.4- Descartes & Gauss-Bonnet		
	25	Section Euler 22.5-Characteristic & Curvature		
	26	Section 22.7, 22.8- The Fundamental Group, The Poincare Conjecture		
	Biographical Notes: Poincare			
V	**Open Ended Module**		**9**	
	1	Hypercomplex Numbers – Chapter 20		

	2	Number Theory in Asia – Chapter 5		
	3	Mechanics – Chapter 13		
	4	Complex Numbers & Functions – Chapter 16		
	5	Non-Euclidean Geometry – Chapter 18		
	6	Group Theory – Chapter 19		

References:

1. Mathematics, The Queen & Handmaiden of Sciences, E. T. Bell, McGraw Hill.
2. Men of Mathematics, E. T. Bell, Simon & Schuster, 1986.
3. What is Mathematics?, Richard Courant & Herbert Robbins,
4. History of Mathematics, 7^{th} Edition, David M. Burton, McGraw Hill.
5. Mathematics In India, Kim Plofker, Princeton University Press, 2009.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	2	1	0	3	2	2	0	3	2	1
CO 2	3	2	1	0	2	1	2	0	2	1	0
CO 3	1	1	0	0	3	2	2	0	3	2	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours				
Course Code	MAT3FV109(2)				
Course Title	**COMPUTATIONAL LOGIC**				
Type of Course	**VAC**				
Semester	III				
Academic Level	200-299				
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours	
	3	3	-	45	
Pre-requisites	Nil				
Course Summary	The course will cover the basics of propositional and predicate logic, Compactness, and the Resolution Theory.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Determine the Satisfiability of a Propositional Formula Set.	Ap	C	Internal Exam/Assignment / Seminar/ Viva / End Sem Exam
CO2	Analyse Theorems of Propositional Logic	Ap	C	Internal Exam/Assignment / Seminar/ Viva / End Sem Exam
CO5	Remember Proofs of Major Theorems of Logic	An	M	Internal Exam/Assignment / Seminar/ Viva / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Text book	Logic for Computer Scientists, U. Schoning, Birkhauser, 2008 (Reprint).			
Module	**Unit**	**Content**	**Hrs (45 = 36 +9)**	**Ext. Marks (50)**
I	**Propositional Logic (Chapter 1 of Text Book).**		**10**	**Min 10**
	1	Syntax and Semantics, Truth Tables, Satisfiability and Validity.		
	2	Equivalence and Normal Forms, Substitution Theorem		
	3	DNF and CNF forms		
	4	Horn Formulas,		
	5	Compactness Theorem for Propositional Calculus		
	6	Resolution Theorem and Resolution Algorithm		
II	**Introduction to Predicate Logic: Section 2.1, 2.2,** Subsection on Mathematical Theories of Section 2.3		**9**	**Min 10**
	7	Syntax of Predicate Logic		
	8	Semantics - Structures and Models, Satisfiability and Validity		
	9	Equivalence of formulas - Substitution, Variable Renaming.		
	10	Skolem Normal Form		
	11	Mathematical Theories - Axioms and Models.		
III	**Herbrand Theory for Predicate Logic: Section 2.4**		**9**	**Min 10**
	12	Herbrand Universe and Structures		
	13	Herbrand Model and Satisfiability Theorem		
	14	Skolem Lowenheim Theorem		
	15	Herbrand Expansion and Godel-Herbrand-Skolem Theorem		
	16	Compactness and Herbrand's Theorem		
IV	**Resolution for Predicate Logic: Section 2.5**			

	17	Ground Resolution and Resolvants	**8**	**Min 10**
	18	Ground Resolution Theorem		
	19	Robinson's Unification Theorem and Algorithm		
	20	Lifting Lemma		
	21	Resolution Theorem for Predicate Logic		
V	**Logic Programming**		**9**	
	1	Unsolvability of Predicate Logic (Section 2.3 on Text Book)		
	2	SLD Resolution (Section 2.6 of Text Book)		
	3	Introduction to Logic Programming		
	4	Horn Clause Programs		
	5	Evaluation Strategies for Horn Clause Programs.		

References:

1. J. H. Gallier, Logic for Computer Science - Foundations of Automatic Theorem Proving, Dower, 2015.
2. S. Reeves, M Clarke, Logic for Computer Science, Addition Wesley, 1990. coding

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	2	1	0	3	2	2	0	3	2	1
CO 2	3	2	1	0	2	1	2	0	2	1	0
CO 3	1	1	0	0	3	2	2	0	3	2	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours				
Course Code	MAT4FV110(1)				
Course Title	**STATISTICS AND MATHEMATICS WITH R**				
Type of Course	**VAC**				
Semester	IV				
Academic Level	200-299				
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours	
	3	3	-	45	
Pre-requisites	1. Basic School (+2) Level Statistics 2. Basic Programming Experience				
Course Summary	The "Statistics and Mathematics with R" course is designed to provide an understanding of R programming for statistical analysis and mathematical computation. The curriculum begins with an introduction to R, covering basic features, data storage, and manipulation techniques. Subsequent modules explore graphical visualization, programming constructs such as flow control and functions, and computational linear algebra. Each unit offers hands-on exercises and references to relevant sections in the textbook by Braun and Murdoch, supplemented by further reading materials for deeper exploration. This course helps students with practical skills in utilizing R for statistical analysis and mathematical modeling.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Demonstrate Proficiency in Basic and Intermediate R Programming	Ap	P	Internal Exam/ Seminar/Assignment / End Sem Exam
CO2	Create and Interpret Various Types of Graphs Using R	C	C	Internal Exam/ Seminar/Assignment / End Sem Exam
CO3	Apply Advanced Mathematical and Statistical Functions in R	Ap	P	Internal Exam/ Seminar/Assignment / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Textbook	A First Course in Statistical Programming with R, , W. John Braun and Duncan J. Murdoch, Cambridge University Press, 3rd Ed., 2021, ISBN 978-1-108-99514-6.			
Module	**Unit**	**Content**	**Hrs (36+9)**	**External Marks (50)**
I		**Introduction to R**	**12**	**Min 10**
	1	R Studio. R Command Line. R as calculator. Named Storage. Quitting R.		
	2	Basic Features of R.		
	3	Vectors in R.		
	4	Data Storage in R. Packages,		
	5	Libraries and Repositories.		
	6	Getting Help. Useful Features of R.		
	7	Data Frames, tibbles, and lists		
	8	Data Input and Output		
	Reference: Chapter 2, Sections 1 to 10			
II		**Graphics with R**	**4**	**Min 10**
	9	Bar Charts and Dot Charts. Pie Charts.		
	10	Histograms. Box Plots. Scatter Plots.		
	11	Plotting from Data Frames. Quantiles. QQ Plots.		
	Reference: Section 3.1.			
III		**Programming in R**	**13**	**Min 10**
	12	Flow Control. For Loop. Examples 4.1 to 4.4.		
	13	If Statement. Examples.		
	14	Eratosthenes Sieve.		
	15	While Loop. Examples. Newton's Method.		

	16	Repeat loop. Break and Next Statements. Examples and Exercises.		
	17	Functions.		
	18	General Programming Guidelines		
	Reference: Chapter 4, Sections 1-4.			
IV	**Computational Linear Algebra**		**7**	**Min 10**
	21	Vectors and Matrices in R		
	12	Matrix Multiplication and Inversion		
	19	Eigenvalues and Eigenvectors		
	20	Singular Value Decomposition		
	Reference: Sections 7.1, 7.2, 7.3, 7.4.1.			
V	**OPEN ENDED**		**9**	
	Suggestions: Section 3.2 - 3.4: Higher Level Graphics with ggplot Section 4.6: Debugging and Maintenance Section 4.7: Efficient Algorithms. Section 6.1: Monte Carlo, 6.2: Pseudo-Random Numbers Appendix A: Overview of Random Variables and Distributions Section 6.3: Simulation of Random Variables Section 8.3: Newton-Raphson Section 8.5: Linear Programming			
Reference	1. Roger D. Peng, R Programming for Data Science, LeanPub, 2022, ISBN 9781365056826. https://bookdown.org/rdpeng/rprogdatascience/ 2. Garrett Grolemund, Hands-On Programming with R, O'Reilly, 2014, ISBN 1449359019. https://rstudio-education.github.io/hopr/ 3. Ruriko Yoshida, Linear Algebra and its Applications in R, Chapman and Hall, 2021, ISBN 9780367486846			

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	2	1	2	2	2	2	2	2	1
CO 2	2	3	1	0	2	2	2	2	2	1	1
CO 3	1	1	3	2	2	2	2	2	2	1	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT4FV110(2)			
Course Title	**THE MATHEMATICAL PRACTICES OF MEDIEVAL KERALA**			
Type of Course	**VAC**			
Semester	IV			
Academic Level	200 - 299			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	3	3	-	45
Pre-requisites	1. Fundamental Mathematics Concepts: Number system,Basic Mathematical operations, Plane Geometry. 2. Convergence of series of numbers and functions.			
Course Summary	This course familiarises students with the traditional Indian Mathematics practised in the Medieval Kerala School of Astronomy and Mathematics.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Uncover the underlying fundamental principles of the traditional mathematics practised in medieval Kerala.	U	C	Seminar Presentation/ Group Tutorials
CO2	Appreciate the role of thought process and working rules in mathematics.	U	C	Seminar Presentation/ Group Tutorials
CO3	Appreciate the usage of infinite series in mathematical analysis.	U	C	Seminar Presentation/ Group Tutorials
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Text Book	1. **Lilavati of Bhaskaracarya** Translated by K.S.Patwardhan, S.A.Naimpally and S.L.Singh, Motilal Banarsidass Publishers, Delhi. 2006. 2. **Ganita Yukti Bhasa of Jyesthadeva**. Volume I. English Translation by K.V.Sarma with explanatory notes by K.Ramasubramanian, M.D.Srinivas and M.S.Sriram. Hindustan Book Company, 2008.		

Module	Unit	Content	Hours (36 + 9)	Ext. Marks (50)
I	**Measurement of sides and areas of triangles, quadrilaterals and circles.**		9	14
	1	Computation of sides of a right triangle when one side is given.		
	2	Computation of area of triangles and quadrilaterals.		
	3	Computation of the perpendicular below the intersection of diagonals.		
	4	Approximating the surface area and volume of spheres.		
	5	Computation of sides of polygons inscribed in a circle.		
	6	Computation of the arcs and chords of circles.		
	Chapter 28 from Text I (Treatment based on English translations of Sanskrit verses in Lilavati).			
II	**Rules concerned with Solids, Shadow of Gnomon and Pulverizer.**		9	12
	7	Volume of Solids		
	8	Volume of a heap of Grain		
	9	Shadows of Gnomon.		
	10	Pulverization		
	Chapters 29, 30, 31, 32 and 33 from Text I (Treatment based on English translations of Sanskrit verses in Lilavati).			
III	**Circle and Circumference as in Yuktibhasa.**		10	14
	11	Circumference of a circle approximated by regular polygons.		
	12	Circumference of a circle without calculating square roots.		
	13	Circumference of a circle in terms of the hypotenuses.		
	14	Summation of Series.		
	15	Calculation of circumference.		
	16	Conversion of the Rsine to Arc.		
	Sections 6.1 to 6.6 of Chapter 6 from Text II.			
IV	**Sine and Cosine series as in Yuktibhasa.**		8	10
	17	Some technical terms and derivation of Rsines.		
	18	Computation of Rsines.		
	19	Computation of Jya and Sara by sankalita and accurate circumference.		
	Sections 7.1 to 7.6 of Chapter 7 from Text II.			
V (Open Ended)	**From Ancient Mathematical Rules to Modern Computer Algorithms.**		9	
	20	Decoding of important Sanskrit verses discussed in Modules I and II from Lilavati (Text I).		

	21	Decoding of important Sanskrit verses discussed in Modules III and IV from Yuktibhasa (Text II).		
	22	Conversion of selected Rules discussed in Modules I to IV into Computer Algorithms.		
	Relevant Topics from Text I, Text II and References.			

References:

1. The Mathematics of India - Concepts, Methods, Connections. P.P.Divakaran, Hindustan Book Agency, New Delhi, 2018.
2. A Passage to Infinity - Medieval Indian Mathematics from Kerala and its Impact. George Ghevarghese Joseph, Sage Publications, New Delhi, 2009.
3. On an Untapped Source of Medieval Keralese Mathematics. C.T.Rajagopal and M.S.Rangachari, Archive for the History of Exact Sciences, 35 (2), (1986), 91 - 99.
4. Yukthibhasha. Rama Varma Maru Thampuran and A.R.Akhileswara Iyer (Editors)}, Mangalodayam Press, Trichur 1948.
5. Tantrasangraha of Nilakantha Somayaji with Yuktidipika and Laghuvivrti of Sankara. K.V.Sarma, Vishveshvaranand Visva Bandhu Institute of Sanskrit and Indological Studies, Punjab University, Hoshiarpur 1977.
6. Colebrook's translation of the Lilavati with Notes by Haran Chandra Banerji. The Book Company, Calcutta, 1927.
7. Mathematical Treasures – Lilavati of Bhaskara. Frank J.Swetz and Victor J.Katz. Loci. 2011.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	1	1	3	2	1	0	2	3	0
CO 2	2	3	1	2	2	3	1	0	2	3	0
CO 3	2	2	2	2	2	1	1	0	2	2	0

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

VOCATIONAL MINORS

Programme	B. Sc. Mathematics Honours			
Course Code	MAT1VN101			
Course Title	**PYTHON PROGRAMMING**			
Type of Course	**Vocational Minor – Data Analytics**			
Semester	I			
Academic Level	100-199			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	3	2	75
Pre-requisites	Nil			
Course Summary	Course aims to provide basic programming skills in Python and Python libraries like NumPy etc.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Understand the basics of Python Data structures and Programming constructs	U	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Understand the basics of Python Programming constructs	U	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Apply Python Libraries for Data Science and Machine Learning	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam

- Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
- Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45+ 30)	Ext. Marks (70)
1		**Data Types and Data Structures**	10	Min.15
	1	Introduction to Python: - using the Python interpreter, Overview of programming in Python		
	2	Expressions and Variables-String Operations.		
	3	Python Data Structures: lists & Tuple –Sets - Dictionaries		
	4	Programming Fundamentals: Conditions and Branching- Loops		
	5	Functions: formal arguments, variable-length arguments		
II		**Classes, files and modules**	12	Min.15
	6	Introduction to Classes and Objects: -classes, class attributes, instances, instance attributes		
	7	Binding and method invocation, inheritance, polymorphism,		
	8	Built-in functions for classes and instances.		
	9	Files and input/output, reading and writing files		
	10	Methods of file objects, using standard library functions		
	11	Exception Handling		
III		**Introduction to Data Science using Python**	12	Min.15
	12	Python libraries: Numpy- Scikit- Pandas.		
	13	Importing Datasets: Importing and Exporting Data in Python, Basic Insights from Datasets		
	14	Data cleansing and pre-processing: Identify and Handle Missing Values		
	15	Descriptive Statistics		
	16	ANOVA Correlation		

	17	Dealing with Outliers		
IV		**Data Visualization Packages - Matplotlib and Seaborn**	**11**	**Min.15**
	18	Overview of data visualization concepts		
	19	Introduction to Matplotlib and Seaborn		
	20	Basic Plotting and Customization with Matplotlib		
	21	Basic Plotting and Statistical Visualization with Seaborn		
	22	Other Visualization Libraries – Case Studies		
		Practical's	**30**	
	1	a) Write a program to calculate compound interest when principal, rate and number of periods are given b) Read name, address, email and phone number of a person through keyboard and print the details		
	2	Write a program to check whether the given input is digit or lowercase character or uppercase character or a special character (use 'if-else-if' ladder)		
	3	a) Print the below triangle using for loop. 5 4 4 3 3 3 2 2 2 2 1 1 1 1 1 b) Python Program to Print the Fibonacci sequence using while loop		
	4	Python program to print all prime numbers in a given interval (use break)		
	5	Write a function called GCD that takes parameters a and b and returns their greatest common divisor		

	6	Write a function called palindrome that takes a string argument and returns True if it is a palindrome and False otherwise. Remember that you can use the built-in function len to check the length of a string		
	7	Define a new class called Circle with appropriate attributes and instantiate a few Circle objects. Write a function called draw_circle that draws circles on the canvas		
	8	Write a python program that defines a matrix and prints		
	9	Write a python program to perform addition of two square matrices		
	10	Python program to perform read and write operations on a file.		
	11	Use the structure of exception handling all general-purpose exceptions		
	12	Write a Python program that calculates basic statistics measures using NumPy		
	13	Create a CSV file named sales_data.csv, which contains sales data for a company. The file has the following columns: Date, Product, Units Sold, and Revenue. Write a Python program using Pandas to perform the following tasks: a) Read the data from the CSV file into a DataFrame. b) Calculate the total revenue generated by each product. c) Determine the total units sold for each product. d) Find the date with the highest revenue. e) Plot a bar chart showing the total revenue generated by each product.		

	14	Create a CSV file named student_grades.csv, which contains the grades of students in different subjects. The file has the following columns: Student_ID, Maths, Science, English, and History. Write a Python program using Matplotlib to perform the following tasks: a) Read the data from the CSV file into a DataFrame. b) Calculate the average score for each subject. c) Plot a bar chart showing the average scores for each subject. d) Plot a histogram showing the distribution of scores in Maths.		
	15	Visualizing Titanic Dataset You are given a dataset containing information about passengers on the Titanic, including their survival status, age, sex, class, and fare. Write a Python program using Seaborn to perform the following tasks: a) Load the Titanic dataset into a DataFrame. b) Plot a count plot to visualize the number of passengers in each class. c) Plot a bar plot to visualize the survival rate of passengers based on their class and sex. d) Plot a heatmap to visualize the correlation matrix of numerical features (e.g., age, fare, and survival status).		

References:

1. Core Python Programming by Wesley J. Chun, 2nd Edition , Pearson Education.
2. An Introduction to Python by Guido Van Russom, Fred L.Drake, Network Theory Limited.
3. Python for Data Science, Dr. Mohd. Abdul Hameed, Wiley Publications - 1st Ed. 2021
4. Python Programming: A Modern Approach, Vamsi Kurama, Pearson
5. Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython ,2nd edition, Wes McKinney, O’Reilly Media (2017)

Note: Proofs of all the results are exempted for the end semester exam.

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	1	3	1	3	3	2	1	2
CO 2	2	1	3	1	3	3	2	1	2
CO 3	3	2	3	2	3	3	3	1	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	BSc Mathematics Honours			
Course Code	MAT2VN101			
Course Title	**LINEAR ALGEBRA FOR MACHINE LEARNING**			
Type of Course	**Vocational Minor – Data Analytics**			
Semester	II			
Academic Level	100-199			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	3	2	75
Pre-requisites	Foundations in Mathematics			
Course Summary	Course aims to provide basics of linear algebra which is useful in understanding machine learning problems			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Solve system of linear quations	Ap	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Apply vector spaces and its properties	Ap	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Understand basics of matrix algebra and its applications	U	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Textbook	Introduction to Linear Algebra" by Gilbert Strang, Wellesley-Cambridge Press, 2016, ISBN: 978-0980232776			
Module	**Unit**	**Content**	**Hrs (45+ 30)**	**Marks (70)**
I		**Solving Linear Equations**	**12**	**Min.15**
	1	Vectors and Linear Equation		
	2	The Idea of Elimination		
	3	Elimination Using Matrices		
	4	Rules for Matrix Operations		
	5	Inverse Matrices		
	6	Elimination = Factorization: A = L U		
	7	Transposes and Permutations		
II		**Vector Spaces and Subspaces**	**12**	**Min.15**
	8	Spaces of Vectors		
	9	The Nullspace of A: Solving Ax = 0		
	10	The Rank and the Row Reduced Form		
	11	The Complete Solution to Ax = b		
	12	Independence, Basis and Dimension		
	13	Dimensions of the Four Subspaces		
III		**Orthogonality**	**8**	**Min.15**
	14	Orthogonality of the Four Subspaces		
	15	Projections		
	16	Least Squares Approximations		
	17	Orthogonal Bases and Gram-Schmidt		
IV		**Eigenvalues and Eigenvectors**	**13**	**Min.15**
	18	Introduction to Eigenvalues		
	19	Diagonalizing a Matrix		
	20	Symmetric Matrices		

	21	Positive Definite Matrices		
	22	Similar Matrices		
	23	Singular Value Decomposition (SVD)		
		Practical using Python	**30**	
	1	Write Python function for vector operations: addition, scalar multiplication, norm,		
	2	Write Python function for matrix operations: addition, multiplication, inverse, transpose		
	3	Implement a Python function to solve a system of linear equations using NumPy's linear algebra module.		
	4	Implement matrix factorization techniques such as LU decomposition in Python using NumPy		
	5	Write a Python function to check if a set of vectors forms a vector space. And to determine if a set of vectors forms a subspace of a given vector space.		
	6	Write a Python function to find the basis of the column space, null space of a matrix, to calculate the rank, dimension of a matrix using NumPy,		
	7	Write a function to determine if a set of vectors is linearly independent, to find the span of a set of vectors. and to check if a set of vectors forms a basis for a given vector space.		
	8	Create a function to determine if two given vectors are orthogonal to each other and to calculate the projection of one vector onto another vector.		
	9	Use orthogonalization to find the least squares approximation of a vector that does not lie in the span of a given set of vectors.		
	10	Implement the Gram-Schmidt process in Python to orthogonalize a given set of vectors and to orthogonalize columns of a given matrix		
	11	Implement a function to perform a change of basis operation on a given vector.		
	12	Write a Python script to verify the rank-nullity theorem by computing the rank and nullity of a matrix and		

		comparing with the dimensions of its domain and codomain.		
	13	Write a Python function to compute the eigenvalues and eigenvectors of a square matrix using SciPy.		
	14	Write a Python function to check if a given square matrix is diagonalizable, to diagonalize a matrix using its eigenvectors and eigenvalues.		
	15	Write a Python function to compute the singular value decomposition of a matrix using NumPy, Use Singular Value Decomposition (SVD) to find the rank and dimension of a matrix, and discuss how it can be used for dimensionality reduction.		
		Reference		
	1	"Linear Algebra and Its Applications" by David C. Lay, Steven R. Lay, and Judi J. McDonald, Pearson, 2020,ISBN: 978-0134860244		
	2	Linear Algebra: Concepts and Applications" by Charles R. Johnson and Dean E. Riess, Wiley, 2017,ISBN: 978-1118612596		
	3	Linear Algebra: A Modern Introduction" by David Poole, Cengage Learning, 2016, ISBN: 978-1305658004		
	4	Linear Algebra for Machine Learning" by Jason Brownlee, Machine Learning Mastery, 2021		
	5	Numerical Python: Scientific Computing and Data Science Applications with Numpy, SciPy, and Matplotlib" by Robert Johansson, Apress, 2018, ISBN: 978-1484242452		

Note: Proofs of all the results are exempted for the end semester exam.

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	3	1	2	2	3	1	1
CO 2	3	2	3	1	2	2	3	1	1
CO 3	3	3	3	1	2	2	3	1	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	BSc Mathematics Honours				
Course Code	MAT3VN201				
Course Title	**INTRODUCTION TO MACHINE LEARNING**				
Type of Course	**Vocational Minor – Data Analytics**				
Semester	III				
Academic Level	200-299				
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours	
	4	3	2	75	
Pre-requisites	Minor 1, Minor 2 (Code)				
Course Summary	Course aims to provide basic concepts of machine learning including paradigms of supervised, unsupervised and reinforcement learning.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Machine Learning concepts and basic parameter estimation methods.	U	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Distinguish between Supervised, Unsupervised and semi supervised learning and evaluate the performance measures	U	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Apply the algorithms identifying problem situations	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Ext. Marks (70)
I		**Introduction to Machine Learning**	10	Min.15
	1	Introduction: Machine Learning - Machine Learning Foundations		
	2	Machine Learning Paradigms- Supervised, Unsupervised, Reinforcement		
	3	Applications of Machine Learning, Case studies		
	4	Basics of parameter estimation - maximum likelihood estimation (MLE) and maximum a posteriori Estimation (MAP).		
	5	Introduction to Bayesian formulation.		
II		**Supervised Learning & SVM**	14	Min.15
	6	Regression – Simple Linear regression and Multiple Linear Regression		
	7	Gradient Descent algorithm and Matrix method, Overfitting in regression.		
	8	Methods for Classification- Logistic regression, Naive Bayes, Decision tree algorithm- ID3		
	9	SVM - Introduction, Maximum Margin Classification, Mathematics behind Maximum Margin Classification		
	10	Maximum Margin linear separators, soft margin SVM classifier, non-linear SVM		
	11	Kernels for learning non-linear functions, polynomial kernel, Radial Basis Function (RBF)		
		Performance Measures & Unsupervised Learning		
	12	Regression Evaluation Metrics – Mean Absolute Error (MAE), Mean Squared Error (MSE), Root Mean Squared Error (RMSE), R-squared (Coefficient of Determination)		

III	13	Classification Evaluation Metrics - Precision, Recall, Accuracy, F-Measure, Receiver Operating Characteristic Curve (ROC), Area Under Curve (AUC)	11	Min.15
	14	Bootstrapping, Cross Validation, Ensemble methods, Bias-Variance decomposition.		
	15	Clustering - Similarity measures, Hierarchical Agglomerative Clustering, K-means partitional clustering		
	16	Expectation maximization (EM) for soft clustering		
	17	Dimensionality reduction –Principal Component Analysis, t-Distributed Stochastic Neighbour Embedding (t-SNE)		
IV		**Introduction to Advanced Machine Learning**	10	Min.15
	18	Introduction to Reinforcement Learning, Learning Task		
	19	Learning Models for Reinforcement – (Markov Decision process, Q Learning - Q Learning function, Q Learning Algorithm), Application of Reinforcement Learning		
	20	Introduction to Neural Network, Perceptron, Multilayer feed forward network,		
	21	Activation functions (Sigmoid, ReLU, Tanh), Back - propagation algorithm.		
	22	Case Study: Applying Reinforcement Learning in Autonomous Vehicle Navigation Case Study: Predicting Customer Churn in Telecommunications Industry using Neural Networks		
		Practical’s	30	
	1	Create a dataset containing measurements of the heights of students in a class. Estimate the parameters of a normal distribution that best describes the distribution of heights using Maximum Likelihood Estimation (MLE)		

	2	The probability that it is Friday and that a student is absent is 3 %. Since there are 5 school days in a week, the probability that it is Friday is 20 %. What is the probability that a student is absent given that today is Friday? Apply Baye's rule in python to get the result		
	3	Implement Simple Linear regression using python		
	4	Implement Multiple Linear regression using python		
	5	Implement the Logistic regression algorithm		
	6	Write a program to implement the naïve Bayesian classifier for a sample training data set stored as a .CSV file. Compute the accuracy of the classifier, considering few test data sets		
	7	Write a program to demonstrate the working of the decision tree based ID3 algorithm. Use an appropriate data set for building the decision tree and apply this knowledge to classify a new sample.		
	8	Create a dataset containing information about the prices of houses in a certain city. The dataset includes various features such as the size of the house, number of bedrooms, location, and age of the house, as well as the corresponding sale prices. Your task is to build a regression model to predict the sale price of houses based on their features and evaluate the model's performance using appropriate evaluation metrics (MAE, MSE, RMSE, R-squared)		
	9	Implement the support vector machine algorithm		
	10	Create a dataset containing information aboutcustomers of a telecommunications company. The dataset includes features such as customer demographics, service usage, and contract details, as well as a binary target variable indicating whether eachcustomer churned (1) or not (0). Your task is to build aclassification model to predict customer churn based onthe available features. Evaluate the trained model's performance on the testing data using the following evaluation metrics: Accuracy, Precision, Recall, F1-score and ROC Curve. Use SVM Classification		
	11	Program to implement K-Means clustering Algorithm		

	12	Create dataset containing information about customers of a retail store, including features such as age, income, and spending score. Your task is to perform clustering on the dataset to identify distinct groups of customers based on their purchasing behaviour. Use K-means Algorithm		
	13	Implement Dimensionality reduction using Principal Component Analysis (PCA) method		
	14	Implementing a simple reinforcement learning algorithm		
	15	Create a dataset containing information about patients with diabetes, including features such as age, BMI, blood pressure, and glucose levels, as well as an indication of whether each patient has diabetes or not. Your task is to build a simple neural network classifier to predict whether a patient has diabetes based on their features		
		References		
	1.	M. Gopal, "Applied Machine Learning", McGraw Hill Education		
	2.	Tom M Mitchell, —Machine Learning, First Edition, McGraw Hill Education, 2013		
	3.	Machine Learning: A Probabilistic Perspective by Kevin P. Murphy		
	4.	Ethem Alpaydin, Introduction to Machine Learning, 2nd edition, MIT Press 2010.		

Note: Proofs of all the results are exempted for the end semester exam.

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	3	2	3	2	3	1	2
CO 2	2	3	3	2	3	2	3	1	2
CO 3	2	3	3	2	3	2	3	1	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	BSc Mathematics Honours			
Course Code	MAT8VN401			
Course Title	**INTRODUCTION TO ARTIFICIAL INTELLIGENCE**			
Type of Course	**Vocational Minor – Data Analytics**			
Semester	VIII			
Academic Level	400-499			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	3	2	75
Pre-requisites	Python Programming, Foundation of Mathematics, Machine Learning			
Course Summary	This course on "Introduction to Artificial Intelligence" offers a thorough exploration of AI fundamentals and techniques. Covering topics like representation, search algorithms, and intelligent agents, students' progress to advanced concepts including knowledge representation, neural networks, and practical implementations. With hands-on sessions focusing on algorithm implementation and machine learning models, students gain both theoretical understanding and practical skills essential for AI development.			

Course Outcome

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand foundation principles, mathematical tools and program paradigms of AI and Apply problem solving through search for AI applications	U	C	Internal exam/ Assignment/ Seminar/ External/ Practical Assessment
CO2	Understand formal methods of knowledge representation and Apply logic and reasoning techniques to AI applications	U	P	Internal exam/ Assignment/ Seminar/ External/ Practical Assessment
CO3	Apply intelligent agents for Artificial Intelligence programming techniques	Ap	P	Internal exam/ Assignment/ Seminar/ External/ Practical Assessment
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Module	Unit	Content	Hrs (45 +30)	Ext. Marks (70)
I		**Introduction to Artificial Intelligence**	10	Min.15
	1	Introduction to AI, History and Evolution of AI, Applications		
	2	Introduction to representation and search		
	3	The Propositional calculus, Predicate Calculus, Calculus expressions and Applications		
	4	State Space Search, Production Systems, Problem Characteristics, types of production systems, Graph theory		
	5	Intelligent Agents: Agents and Environments, The nature of environments, The structure of agents. concept of rationality, the nature of environments, structure of agents, problem solving agents, problem formulation		
II		**Search Strategies**	14	Min.15
	6	Uninformed Search Strategies - Breadth First Search, Depth First Search, Depth Limited Search, Iterative Deepening Depth First Search		
	7	Bidirectional Search, Comparison of Uninformed search Strategies, Searching with partial information		
	8	Sensor-less problems, Contingency problems		
	9	Informed Search Strategies - Generate& test, Hill Climbing, Best First Search		
	10	A* and AO* Algorithm, Constraint satisfaction, Backtracking Search		
	11	Game playing: Minimax Search, Alpha-Beta Cutoffs		
	12	Optimal Decisions in Games, Stochastic Games		
III		**Knowledge Representation**	13	Min.15
	13	Knowledge Representation -Knowledge based agents, Wumpus world		
	14	Knowledge Representation -issues, The frame problem.		
	15	First order Logic: Representation, Inference, Reasoning Patterns, Resolution, Forward and Backward Chaining		

	16	Propositional Logic: Representation, Inference, Reasoning Patterns, Resolution, Forward and Backward Chaining		
	17	Agent based and distributed problem solving		
	18	Introduction to Expert System Technology, Bayes Rule,Bayesian Network, Hidden Markov Model, Decision Network		
IV		**Introduction to ANN**	8	Min.15
	19	Introduction ANN, biological neuron, Artificial neuron		
	20	Perceptron Learning		
	21	Back Propagation algorithm		
	22	Introduction to Natural Language Processing, Pattern recognition Case study - Enhancing Customer Service with AI-Powered Chatbots		
		Practical's	30	
	1	Write a program to implement depth first search algorithm.		
	2	Write a program to implement breadth first search algorithm.		
	3	Write a program to simulate 4-Queen / N-Queen problem.		
	4	Write a program to solve tower of Hanoi problem.		
	5	Write a program to implement alpha beta search.		
	6	Write a program for Hill climbing problem.		
	7	Write a program to implement A*algorithm		
	8	Write a program to implement AO*algorithm		
	9	Design the simulation of tic–tac–toe game using min-max algorithm		
	10	Write a program to shuffle Deck of cards		
	11	Write a program to derive the predicate.		
	12	Solve constraint satisfaction problem (a) Derive the expressions based on Associative law		

		(b)Derive the expressions based on Distributive law.		
	13	Develop a simple text-based game using Python that simulates a classic "Guess the Number" game. The game should generate a random number between 1 and 100 and prompt the player to guess the number. After each guess, the game should provide feedback to the player (e.g., "Too high", "Too low", or "Correct!") and keep track of the number of attempts it takes for the player to guess the correct number. Once the player guesses the correct number, the game should display the number of attempts and ask if the player wants to play again		
	14	Train a simple machine learning model, such as a linear regression or logistic regression classifier, using a dataset of your choice and evaluate its performance using appropriate metrics.		
	15	Implement a decision tree classifier from scratch and apply it to a classification task with a real-world dataset		
		References		
	1	S. Russel and p. Norvig, Artificial intelligence – A Modern Approach, 3rdEdn, Pearson		
	2	Artificial Intelligence: Elaine Rich, Kevin Knight, Mc-GrawHill		
	3	Artificial Intelligence by Luger (Pearson Education)		
	4	D W Patterson, introduction to Artificial Intelligence and Expert Systems, PHI, 1990		
	5	Deep Learning by Ian Goodfellow, Yoshua Bengio, and Aaron Courville:		

Note: Proofs of all the results are exempted for the end semester exam.

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	1	3	2	3	2	3	1	2
CO 2	3	2	3	2	3	2	3	1	2
CO 3	2	3	3	2	3	2	3	1	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	BSc Mathematics Honours			
Course Code	MAT1VN102			
Course Title	**STATISTICS FOR DATA SCIENCE**			
Type of Course	**Vocational Minor – Data Analytics**			
Semester	I			
Academic Level	100-199			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	3	2	75
Pre-requisites	Foundations in mathematics			
Course Summary	Course aims to provide basic concepts such as central tendency, probability, sampling and testing			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand measures of central tendency , dispersion, regression	U	C	Internal exam/ Assignment/ Seminar/ External/ Practical Assessment
CO2	Distinguish discrete and ontinuous distributions and its properties	U	C	Internal exam/ Assignment/ Seminar/ External/ Practical Assessment
CO3	Analyse data using testing hypothesis	An	C	Internal exam/ Assignment/ Seminar/ External/ Practical Assessment
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Ext. Marks (70)
I		**Descriptive statistics**	**11**	**Min.15**
	1	Measures of central tendency: - mean, median, mode		
	2	Measures of dispersion: Range, Mean deviation, Quartile deviation and Standard deviation		
	3	Moments, Skewness and Kurtosis,		
	4	Correlation - Linear correlation		
	5	Karl Pearson's coefficient of Correlation, Rank correlation		
	6	Linear regression- Simple and Multiple		
II		**Probability**	**7**	Min.15
	7	Sample space, Events, Different approaches to probability		
	8	Addition and multiplication theorems on probability		
	9	Independent events, Conditional probability		
	10	Bayes Theorem		
III		**Probability Distributions**	**12**	Min.15
	11	Random variables, Probability density functions and distribution functions		
	12	Marginal density functions, Joint density functions		
	12	Mathematical expectations		
	14	Moments and moment generating functions		
	15	Discrete probability distributions – Binomial, Poisson distribution		
	16	Continuous probability distributions- uniform distribution and normal distribution.		
III		**Sampling and Testing**		
	17	Theory of Sampling: - Population and sample, Types of sampling Theory of Estimation: - Introduction, point estimation		

	18	methods of point estimation-Maximum Likelihood estimation and method of moments, Central Limit Theorem(Statement only)	**15**	Min.15
	19	Null and alternative hypothesis, types of errors, level of significance, critical region		
	20	Large sample tests – Testing of hypothesis concerning mean of a population and equality of means of two populations		
	21	Small sample tests – t Test for single mean, difference of means. Paired t-test		
	22	Chi-square test (Concept of test statistic ns2/σ2), F test - test for equality of two population variances		
	23	ANOVA – one-way & two-way classification		
		Practical using MS Excel	**30**	
	1. Calculate the mean, median, and mode of a dataset. 2. Calculate the range of a dataset. 3. Calculate the mean deviation of a dataset. 4. Calculate the quartile deviation of a dataset. 5. Calculate the standard deviation of a dataset. 6. Calculate skewness and kurtosis of a dataset. 7. Compute the Karl Pearson's coefficient of correlation between two variables. 8. Calculate rank correlation (e.g., Spearman's rank correlation) between two variables. 9. Perform simple linear regression analysis. 10. Perform multiple linear regression analysis. 11. Calculate probabilities of events using different approaches (e.g., classical, relative frequency, subjective). 12. Apply addition and multiplication theorems of probability to solve problems. 13. Calculate conditional probabilities and use Bayes' Theorem. 14. Generate random samples from various probability distributions (e.g., binomial, Poisson, normal) and calculate relevant statistics. 15. Conduct hypothesis testing using Excel functions for large sample tests (e.g., z-test, t-test), small sample tests (e.g., t-test for single mean, paired t-test), chi-square test, F-test, and ANOVA.			
		References		
	1	Fundamentals of statistics: S. C. Gupta, 6th Revised and enlarged edition April 2004, Himalaya Publications		

	2	Fundamentals of Mathematical Statistics- S. C. Gupta,V. K. Kapoor. Sultan Chand Publications		
	3	Introduction to Mathematical Statistics - Robert V. Hogg & Allen T. Craig. Pearson education		
	3	Probability and Statistics for Engineering and the Sciences, Jay L. Devore, Cengage Learning, January 2022, ISBN for the 10th Edition: 978-1305251809		

Note: Proofs of all the results are exempted for the end semester exam.

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	1	3	1	3	3	3	1	2
CO 2	2	1	3	1	3	3	3	1	2
CO 3	3	2	3	2	3	3	3	2	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	BSc Mathematics Honours				
Course Code	MAT2VN102				
Course Title	**R PROGRAMMING**				
Type of Course	**Vocational Minor – Data Analytics**				
Semester	II				
Academic Level	100-199				
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours	
	4	3	2	75	
Pre-requisites	Foundations in Mathematics, Programming Fundamentals				
Course Summary	Course aims to provide R programming fundamentals and algorithm writing				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the basic programming structure of R, visualization of models nd their inference.	U	P	Internal exam/ Assignment/ Seminar/ External/ Practical Assessment
CO2	Apply statistical functions, models and their Inferences	Ap	P	Internal exam/ Assignment/ Seminar/ External/ Practical Assessment
CO3	Design data model, visualization and inference of dataset to gain insights	C	P	Internal exam/ Assignment/ Seminar/ External/ Practical Assessment
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Ext. Marks (70)
I		**Introduction to R**	10	Min.10
	1	Introduction to R: R Studio, Basic components in R Studio.		
	2	Basic R syntax: variables, data types, operators		
	3	Working with Data structures Vectors, List, Matrices & Arrays, Factors and Data frame		
	4	Control structures (if-else statements, Loops) & Functions		
	5	Measures of Central Tendency & Dispersion		
II		**Data Manipulation and Visualization with R**	13	Min.20
	6	Importing and exporting data in R (CSV, Excel, Xml, Json, databases)		
	7	Data Cleaning: Exploring raw data, Missing values, Zeros and NAs – Separating, Uniting Columns, String Manipulation, Filling Missing values		
	8	Data manipulation with dplyr: filtering, selecting, mutating, summarizing		
	9	Basic Charts: Pie, Bar, Histogram, Boxplot and Scatterplot		
	10	Data visualization with ggplot2: creating plots (scatter plots, bar plots, line plots)		
	11	Customizing plots and Introduction to other Visualization Packages (ggplot2 extensions, plotly)		
III		**Statistical Analysis with R**	9	Min.15
	12	Overview of statistical analysis in R		
	13	Descriptive statistics: mean, median, standard deviation, variance		
	14	Probability distributions and random variables		
	15	Hypothesis testing: t-tests, chi-square tests, ANOVA		

	16	Linear regression analysis: simple and multiple regression		
	17	Introduction to statistical modelling with R		
IV		**Introduction to Machine Learning with R**	**13**	**Min.15**
	18	Introduction to machine learning concepts and algorithms		
	19	Supervised learning techniques: classification and regression		
	20	Unsupervised learning techniques: clustering and dimensionality reduction		
	21	Case study – Explore Diamond dataset for prize prediction		
	22	Applied Analytics – HR, Finance & Marketing, Case studies		
		Practical's	**30**	
	1	Write a R program to take input from user (name, age, occupation, salary) and display the values with datatypes. Also print version of R installation.		
	2	Write a R program to calculate the sum of numbers from 1 to 10.		
	3	Write a R Program to create a list containing a vector, a matrix and a list and write a code for the following. 1) Give names to the elements in the list 2) Add element at the end of the list 3) Remove the second element		

	4	R program to create a data frame of student with four given vectors and write a code 1) to get the structure of a given data frame. 2) to get the statistical summary and nature of the data of a given data frame. 3) to extract specific column from a data frame using column name. 4) to extract first two rows from a given data frame. 5) to extract 3rd and 5th rows with 1st and 3rd columns from a given data frame. 6) to add a new column in a given data frame. 7) to add new row(s) to an existing data frame. 8) to drop column(s) by name from a given data frame. 9) to drop row(s) by number from a given data frame. a) 10) to extract the records whose grade is greater than 9
	5	Write a R program to find biggest of 3 number (if -else)
	6	Write a R program to find sum of elements of vector and to find minimum and maximum elements of vector (loop)
	7	Write a R program to Import a CSV file named 'data.csv' into a data frame named 'data_df'. a) Display the structure of the 'data_df' data frame using the 'str()' function. b) Print the first few rows of the data frame to inspect the data using the 'head()' function. c) Calculate summary statistics (mean, median, min, max) for numerical variables in the data frame using the 'summary()' function.

	8	Write a Program in R for Missing value imputation 1) Load the 'iris' dataset into a data frame named 'iris_df'. 2) Introduce missing values into the 'iris_df' dataset by randomly replacing a certain percentage of values with NA. 3) Display the summary of missing values in the dataset using the 'is.na()' and 'colSums()' functions. 4) Impute missing values in the dataset using a simple technique (e.g., replacing missing values with the mean or median of the corresponding column). 5) Verify that there are no missing values remaining in the dataset after imputation. 6) Compare summary statistics (mean, median, min, max) of the dataset before and after missing value imputation.	
	9	Import a dataset from a CSV file and use dplyr to filter rows based on a condition.	
	10	Write a R Program to print data in different graph formats (Histogram, Pie, Bar, Boxplot, Scatterplot)	
	11	Write a R program to visualize different plot using ggplot 1) Load the 'iris' dataset into a data frame named 'iris_df'. 2) Create a scatter plot of 'Sepal.Length' against 'Sepal.Width' with points colored by 'Species'. 3) Generate a box plot of 'Petal.Length' for each 'Species'. 4) Create a histogram of 'Sepal.Length' with customized bin widths and colors. 5) Generate a density plot of 'Petal.Width' for each 'Species' overlaid on the same plot. 6) Create a bar plot showing the count of each 'Species' in the dataset. 7) Generate a violin plot of 'Petal.Length' for each 'Species' with custom fill colors. 8) Create a line plot showing the trend of 'Sepal.Length' over 'Petal.Length' for each 'Species'. 9) Combine multiple plots into a single visualization using facets based on 'Species'. 10) Customize the appearance of the plots by adding titles, axis labels, legends, and adjusting plot aesthetics (e.g., colors, transparency).	
	12	Write a Program to find mean, median, standard deviation and variance	

	13	The heights of 6 randomly chosen sailors are 63,65,68,69,71,72 inches. Those of 10 randomly chosen soldiers are 61,62,65,66,69,69,70,71,72,73 inches. Discuss whether this data gives a suggestion that the sailors are taller than soldiers. Aim: To test the claim that sailors are taller than soldiers (t-test)		
	14	Write a R Program to Apply Simple Linear Regression and Multiple Linear Regression		
	15	Write a R Program to Apply K-means clustering algorithm to the data and visualize the clusters.		
		References		
	1	Hands-On Programming with R by Garrett Grolemund		
	2	R Cookbook by Winston Chang, Paul Teetor, and Joseph Adler		
	3	Beginning R: The Statistical Programming Language by Mark Gardener		
	4	The Art of R Programming by Norman Matloff		
	5	Advanced R by Hadley Wickham		

Note: Proofs of all the results are exempted for the end semester exam.

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	3	3	2	3	3	3	2	2
CO 2	3	3	3	2	3	3	3	2	2
CO 3	3	3	3	2	3	3	3	2	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	BSc Mathematics Honours				
Course Code	MAT3VN202				
Course Title	**DATA MINING**				
Type of Course	**Vocational Minor – Data Analytics**				
Semester	III				
Academic Level	200-299				
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours	
	4	3	2	75	
Pre-requisites	Basic Knowledge in MS Excel				
Course Summary	Course aims to provide basic data mining techniques using Weka tool				

Course Outcome:

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the fundamental concepts and principles of data mining	U	C	Internal exam/ Assignment/ Seminar/ External/ Practical Assessment
CO2	Understand the mining techniques like association, classifications and clustering on datasets	U	P	Internal exam/ Assignment/ Seminar/ External/ Practical Assessment
CO3	Apply data mining techniques to real-world datasets	Ap	P	Internal exam/ Assignment/ Seminar/ External/ Practical Assessment
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Ext. Marks (70)
I		**Introduction to Data Mining**	**8**	**Min 15**
	1	Data Warehousing - Data warehousing architecture, Warehouse Schema, Data warehouse backend process, Multidimensional Data Model		
	2	OLAP Operations, Introduction to KDD process, Data mining		
	3	Data mining Functionalities, Classification of Data Mining Systems.		
	4	Data Warehousing Case Study: Government, Tourism and Industry		
	5	Data Preprocessing - Data Cleaning, Data Integration and Transformation, Data Reduction, Data discretization		
II		**Association Analysis**	**7**	**Min 15**
	6	Association Analysis - Basic Concepts, Frequent Item set Mining Methods: Apriori Algorithm, generating association Rules from Frequent Item sets, Improving the Efficiency of Apriori.		
	7	Evaluation of Association Patterns, Visualization, Partition algorithm A Case Study on Association using Orange Tool		
	8	Dynamic Item set Counting algorithm- FP-tree growth algorithm-Incremental Algorithm-Border algorithm		
III		**Classification & Prediction**	**14**	**Min 15**
	9	Classification Technique: Introduction, Decision Trees: Tree Construction Principle – Attribute Selection measure – Tree Pruning - Decision Tree construction Algorithm – CART – ID3		
	10	Bayesian Classification: Bayes' theorem, Naïve Bayesian Classification		
	11	K- Nearest Neighbour Classifiers, Support Vector Machine. Evaluating the performance of a Classifier, Methods for comparing classifiers, Visualization		
	12	Case Study of Classification using Orange Tool		

	13	Linear Regression, Nonlinear Regression, Other Regression-Based Methods		
IV		**Clustering**	16	**Min 15**
	14	Clustering techniques: Data Attribute Types – Data Similarity and Dissimilarity		
	15	Partitioning Methods: k-Means and k- Medoids, CLARANS		
	16	Hierarchical Method: Agglomerative and Divisive Hierarchical Clustering		
	17	Density-based Clustering - DBSCAN, Grid based clustering-STING		
	18	Evaluation of Clustering Method		
	19	Case Study of Clustering using Orange Tool		
	20	Introduction to Web Mining - Basic concepts, Web content mining, Web structure mining, Web usage mining		
	21	Introduction to Text mining, Text Preprocessing, Text clustering		
	22	Case Study – Web Mining: Analysing User Behaviour on E-commerce Website Case Study - Sentiment Analysis of Customer Reviews		
		Practical's	**30**	
	1	Installation of WEKA Tool		
	2	Creating new Arff File		
	3	Pre-Processes Techniques on Data Set		
	4	Pre-process a given dataset based on Handling Missing Values		
	5	Generate Association Rules using the Apriori Algorithm		
	6	Generating association rules using FP growth algorithm		
	7	Build a Decision Tree by using ID3 algorithm		
	8	Build a Naïve Bayesian Classifier		
	9	Build a K- Nearest Neighbour Classifiers		
	10	Build a Support Vector Machine		

	11	Build a Linear Regression		
	12	Build K-Means Algorithm		
	13	Build K-Medoids Algorithm		
	14	Build Hierarchical Clustering Algorithms		
	15	Create Student. ariff file to suggest better college using Decision tree		
		References		
	1	Arun K Pujari, "Data Mining Techniques", Universities Press. 2012		
	2	Pang-Ning Tan, Michael Steinbach, Vipin Kumar, 'Introduction to Data Mining'		
	3	G. K. Gupta, "Introduction to Data Mining with Case Studies", Easter Economy Edition, Prentice Hall of India, 2006.		
	4	Data Mining: Practical Machine Learning Tools and Techniques" by Ian H. Witten, Eibe Frank, Mark A. Hall, and Christopher J. Pal:		
	5	Data Mining: Concepts and Techniques" by Jiawei Han, Micheline Kamber, and Jian Pei:		

Note: Proofs of all the results are exempted for the end semester exam.

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	3	2	3	2	3	1	2
CO 2	2	3	3	2	3	2	3	1	2
CO 3	2	3	3	2	3	2	3	1	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	BSc Mathematics Honours				
Course Code	MAT8VN402				
Course Title	**DATA VISUALIZATION**				
Type of Course	**Vocational Minor – Data Analytics**				
Semester	VIII				
Academic Level	400-499				
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours	
	4	3	2	75	
Pre-requisites	Minor 1 and minor 2				
Course Summary	Course aims to provide data visualization techniques using R programming and interactive chart building				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the methods for visualizing data	U	C	Internal exam/ Assignment/ Seminar/ External/ Practical Assessment
CO2	Apply Visualization methods for different data domains	Ap	P	Internal exam/ Assignment/ Seminar/ External/ Practical Assessment
CO3	Design an Interactive data visualization story board for data	C	C	Internal exam/ Assignment/ Seminar/ External/ Practical Assessment

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Ext. Marks (70)
I		**Introduction to Data Visualization**	**8**	**Min.10**
	1	Definition, Methodology, Data Visualization and Theory, Visualization Design objectives		
	2	Key Factors – Purpose, visualization function and tone, visualization design options – Data representation, Data Presentation		
	3	Seven stages of data visualization, widgets, and introduction to different data visualization tools		
	4	Computational Statistics and Data Visualization, Presentation and Exploratory Graphics		
	5	Graphics and Computing, Statistical Historiography		
II		**Visualizing Data Methods**	**13**	**Min.15**
	6	Mapping, Time series, Connections and correlations - Scatter plot maps		
	7	Hierarchies and Recursion – introduction to Networks and Graphs, Info graphics		
	8	Complete Plots, Customization of plots -Parameters, Arranging Plots, Annotation,		
	9	Extensibility-Building Blocks, Combining Graphical Elements, 3-D Plots, Data Handling		
	10	Data and Graphs, Graph Layout Techniques, Graph Drawing		
	11	Bipartite Graphs, Hierarchical Trees, Spanning Trees, Networks, Directed Graphs, Tree maps		
III		**Data visualization using R**	**12**	**Min.20**
	12	Environment setup - R and RStudio, Basic plotting functions in R		
	13	Creating scatter plots, histograms, pie chat, bar charts, Boxplot, violin plot, line chart, heatmap, Customizing plot appearance,		
	14	Introduction to ggplot2, Grammar of graphics, creating static plots with ggplot2, Customizing plots with themes and scales		

	15	Introduction to plotly for interactive plotting, Creating interactive scatter plots, line plots, and bar charts, Adding interactivity with tooltips, zooming, and brushing		
	16	Designing interactive dashboards with Shiny and plotly, Other Visualization Pacakges		
IV		**Introduction to Tableau**	**12**	**Min.15**
	17	Environment Setup, Design flow, Data Types, File Types		
	18	Data Source - Custom Data View, Extracting Data, Field operations, Metadata, Data Joining and Blending		
	19	Worksheets- Adding, renaming, reordering Worksheet, Workbook Calculations		
	20	Sort and Filters- Sorting, Quick filtering, Context filtering, Condition filtering, Filter operations		
	21	Tableau Charts ─ Bar Chart, Line Chart, Multiple Measure Line Chart, Pie Chart		
	22	Scatter Plot, Bubble Chart, Bullet Graph, Box Plot, Dashboard – Formatting – Forecasting – Trend Lines		
		Practical's using R	**30**	
	1	Exploring Data with Basic Plots · Load a dataset (e.g., Iris dataset) into R. · Create scatter plots, histograms, and box plots to explore the distribution of variables. · Label axes, add titles, and customize colors and styles		
	2	Visualizing Relationships · Choose a dataset with multiple variables. · Create scatter plots to visualize relationships between pairs of variables. · Use color or shape to represent categorical variables. · Analyze patterns and correlations in the data		

	3	Time Series Visualization · Load a time series dataset (e.g., stock prices, weather data) into R. · Create line plots to visualize trends and fluctuations over time. · Use different line styles or colors to represent multiple time series. · Add labels, titles, and annotations to the plot		
	4	Bar and Pie Charts: · Load a dataset with categorical variables (e.g., survey responses, product categories). · Create bar charts and pie charts to visualize the distribution of categories. · Customize the appearance of the charts (e.g., colors, labels, legends).		
	5	Heatmaps and Correlation Plots: · Load a dataset with numerical variables (e.g., correlation matrix). · Create heatmaps to visualize correlations between variables. · Customize the color scheme and add annotations to the heatmap. · Interpret the patterns of correlation in the data		
	6	Box Plots and Violin Plots: · Load a dataset with numerical and categorical variables (e.g., Iris dataset). · Create box plots and violin plots to visualize the distribution of numerical variables across different categories. · Compare the use of box plots and violin plots for data visualization		

	7	Interactive Visualizations with ggplot2 and Shiny: · Create interactive plots using ggplot2 and Shiny. · Design a Shiny app with interactive controls (e.g., sliders, checkboxes) to explore different aspects of the data.		
	8	Geospatial Visualization: · Load a dataset with geographical information (e.g., map coordinates, regions). · Create maps using packages like ggmap, leaflet, or tmap to visualize spatial data. · Add layers, markers, and tooltips to the map to provide additional information		
	9	Faceted Plots: · Load a dataset with multiple groups or categories. · Create faceted plots using ggplot2 to display subsets of the data in separate panels. · Customize the appearance of each panel (e.g., axis limits, labels, titles		
	10	Network Visualization: · Load a dataset representing a network or graph (e.g., social network, co-authorship network). · Create network visualizations using packages like igraph or networkD3. · Customize the layout, node colors, and edge weights to convey information about the network structure.		
	11	Word Clouds and Text Visualization: · Load a dataset containing text data (e.g., tweets, reviews). · Create word clouds to visualize word frequency and importance. · Customize the appearance of the word cloud (e.g., colors, fonts, word sizes).		

	12	Dashboards with Plotly and Shiny: · Design an interactive dashboard using Plotly and Shiny. · Incorporate interactive plots, tables, and controls to explore and analyze data dynamically.		
	13	Dynamic Visualizations · Load a dataset with time-varying data (e.g., stock prices, sensor readings). · Create animated plots using package plotly. · Customize the animation settings (e.g., frame rate, transition effects) to enhance datavisualization.		
	14	Visualizing Hierarchical Data · Load a dataset with hierarchical or nested structure (e.g., organizational hierarchy, file directories). · Create tree maps, dendrograms, or sunburst plots to visualize hierarchical data structures. · Customize the appearance of the plots to highlight different levels of hierarchy.		
	15	Dashboard Design · Design a dashboard layout with multiple visualizations and interactive components. · Arrange the visualizations in a coherent and informative manner. · Add text annotations, titles, and summaries to provide context and insights.		
		References		
	1	Ben Fry, “Visualizing Data”, O‟Reilly Media, Inc., 2007.		
	2	Scott Murray, “Interactive data visualization for the web”, O‟Reilly Media, Inc., 2nd edition, 2017		
	3	Fundamentals of Data Visualization" by Claus O. Wilke		
	4	Data Visualization: A Practical Introduction" by Kieran Healy		
	5	Learning tableau by Joshua N. Milligan		

Note: Proofs of all the results are exempted for the end semester exam.

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	1	3	2	3	2	3	1	2
CO 2	3	2	3	2	3	2	3	1	2
CO 3	2	3	3	2	3	2	3	1	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

MINOR COURSES

Programme	B. Sc. Mathematics Honours				
Course Code	MAT1MN101				
Course Title	**CALCULUS**				
Type of Course	**Minor**				
Semester	I				
Academic Level	100 – 199				
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours	
	4	4	-	60	
Pre-requisites	Basic Idea of Functions, Limits and Continuity				
Course Summary	This course covers fundamental concepts in calculus: It begins with introducing the idea of tangent lines, rates of change, and the derivative, illustrating their application in describing motion and finding instantaneous rates of change. Basic rules of differentiation, including the product, quotient, and power rules, as well as techniques for finding higher-order derivatives are discussed. It also covers related rates, differentials, extrema of functions, the mean value theorem, concavity, inflection points, curve sketching, indefinite and definite integrals, integration by substitution, and the geometric interpretation of the definite integral. These sections explore various calculus techniques for analysing functions, determining areas under curves, and solving real-world problems.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Demonstrate proficiency in finding derivatives using various differentiation techniques and apply them to describe motion, rates of change, and related rates problems.	Ap	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Analyse functions to determine extrema, concavity, and inflection points using the Mean Value Theorem, First and Second Derivative Tests, leading to effective curve sketching.	An	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Apply integration techniques to compute areas between curves, volumes of solids of revolution, arc lengths, and surface areas, culminating in understanding the Fundamental Theorem of Calculus and its applications.	Ap	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

<table>
<tr><td colspan="2">Text Book</td><td colspan="3">Calculus, Soo T. Tan, Brooks/Cole Cengage Learning (2010) ISBN-13: 978-0-534-46579-7.</td></tr>
<tr><td>Module</td><td>Unit</td><td>Content</td><td>Hrs (48 +12)</td><td>Ext. Marks (70)</td></tr>
<tr><td rowspan="9">I</td><td colspan="2">Introduction to Differentiation</td><td rowspan="9">14</td><td rowspan="9">Min 15</td></tr>
<tr><td>1</td><td>A Quick Review of Functions, Limits, and Continuity (This unit is optional)</td></tr>
<tr><td>2</td><td>Section 1.5: Tangent Lines and Rates of Change -
An intuitive Look, Defining a Tangent Line, Tangent lines, Secant lines and Rates of Change.</td></tr>
<tr><td>3</td><td>Section 2.1: The Derivative -
The Derivative, Using the Derivative to Describe the Motion of the Maglev, Differentiation, Finding the Derivative of a Function, Differentiability, Differentiability and Continuity</td></tr>
<tr><td>4</td><td>Section 2.2: Basic Rules of Differentiation -
Some Basic Rules</td></tr>
<tr><td>5</td><td>Section 2.3: The Product and Quotient Rules -
The Product and Quotient Rules(Example 6 is optional), Extending the Power Rule, Higher- Order Derivatives</td></tr>
<tr><td>6</td><td>Section 2.6: The Chain Rule – Composite Functions, The Chain Rule, Applying The Chain Rule</td></tr>
<tr><td>7</td><td>Section 2.7 : Implicit Differentiation – Implicit Functions, Implicit Differentiation</td></tr>
<tr><td>8</td><td>Section 2.8: Related Rates -
Related Rates Problems, Solving Related Rates Problems.</td></tr>
<tr><td rowspan="6">II</td><td colspan="2">Applications of Differentiation</td><td rowspan="6">12</td><td rowspan="6">Min 15</td></tr>
<tr><td>9</td><td>Section 2.9: Differentials and Linear Approximations -
Increments, Differentials, Linear Approximations</td></tr>
<tr><td>10</td><td>Section 3.1: Extrema of Functions -
Absolute Extrema of Functions, Relative Extrema of Functions, Finding the Extreme Values of a Continuous Function on a Closed Interval</td></tr>
<tr><td>11</td><td>Section 3.2: The Mean Value Theorem -
Rolle’s Theorem, Some Consequences of the Mean Value Theorem, Determining the Number of Zeros of a Function.</td></tr>
<tr><td>12</td><td>Section 3.3: Increasing and Decreasing Functions and the First Derivative Test -
Increasing and Decreasing Functions, Finding the Relative Extrema of a Function</td></tr>
<tr><td>13</td><td>Section 3.4: Concavity and Inflection Points -
Concavity, Inflection Points(Example 6 is optional), The Second Derivative Test, The roles of $f\,'$and f'' in Determining the Shape of a Graph.</td></tr>
<tr><td rowspan="2">III</td><td colspan="2">Introduction to Integration</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>14</td><td>Section 3.6: Curve Sketching -</td></tr>
</table>

		The Graph of a Function, Guide to Curve Sketching(Up to and including Example 2)	**10**	**Min 15**
	15	Section 4.1: Indefinite Integrals - Antiderivatives, The indefinite Integral, Basic Rules of Integration.		
	16	Section 4.2: Integration by Substitution - How the method of Substitution Works, The Technique of Integration by Substitution (Example 8 is optional)		
	17	Section 4.3: Area - An Intuitive Look, Sigma Notation, Summation Formulas, Defining the Area of The Region Under the Graph of a Function (Example 9 is optional)		
	18	Section 4.4: The Definite Integral - Definition of the Definite Integral (Examples 2,3, and 4 are optional), Geometric Interpretation of the Definite Integral, The Definite Integral and Displacement, Properties of the Definite Integral.		
IV	**The Main Theorem and Applications of Integration**		**12**	**Min 15**
	19	Section 4.5: The Fundamental Theorem of Calculus - The Mean Value Theorem for Definite Integrals, The Fundamental Theorem of Calculus - Part 1, Fundamental Theorem of Calculus - Part 2, Evaluating Definite Integrals using Substitution, Definite Integrals of Odd and Even Functions		
	20	Section 5.1**:** Areas Between Curves - A Real- Life Interpretation, The Area Between Two Curves, Integrating with Respect to □		
	21	Section 5.2: Volumes: Disks, Washers, and Cross Sections - Solids of Revolution, The Disk Method, The Method of Cross Sections.		
	22	Section 5.4: Arc Length and Areas of Surfaces of Revolution - Definition of Arc Length, Length of a Smooth Curve, Surfaces of Revolution		
V	**Open Ended**		**12**	
	1	Limits Involving Infinity; Asymptotes		
	2	Derivatives of Trigonometric Functions		
	3	The General Power Rule and using the Chain Rule		
	4	Volumes Using Cylindrical Shells		
	5	Work , Moments and Centre of Mass		
	6	Taylor & Maclaurin's Series		
	7	Approximation by Taylor Series		
	8	Transcendental Functions		
	9	Improper Integrals		
	10	Numerical Integration		

References:

1. Calculus & Analytic Geometry, 9th Edition, George B. Thomas & Ross L. Finney, Pearson Publications.
2. Thomas' Calculus, 14th Edition, Maurice D. Weir, Christopher Heil, & Joel Hass, Pearson Publications.

3. Calculus, 7th Edition, Howard Anton, Biven, & Stephen Davis, Wiley India.
4. Advanced Engineering Mathematics, 10th Ed, Erwin Kreyszig, John Wiley & Sons.
5. Calculus, 4th Edition, Robert T Smith and Roland B Minton, McGraw-Hill Companies
6. Calculus, 9th Edition, Soo T Tan, Brooks/Cole Pub Co.
7. Calculus, Vol 1, Tom M. Apostol, John Wiley & Sons.
8. Michael Van Biezen Calculus Lectures: https://youtu.be/YZYxPclo2rg?si=qKCt6ty8m5dBR4DG

Note: 1) Optional topics are exempted for end semester examination.
2) Proofs of all the results are also exempted for the end semester exam.

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	1	3	1	2	1	3	1	1
CO 2	2	1	3	1	3	1	3	1	2
CO 3	3	2	3	1	3	1	3	1	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT2MN101			
Course Title	**DIFFERENTIAL EQUATIONS AND MATRIX THEORY**			
Type of Course	**Minor**			
Semester	II			
Academic Level	100 –199			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites	Basic Calculus			
Course Summary	This course covers a range of topics. It starts with introducing fundamental terminology and methods for solving differential equations, including separable equations, linear equations, exact equations, and equations with constant coefficients. Then it proceeds into more specialized topics such as homogeneous linear equations with constant coefficients and Cauchy-Euler equations, providing methods for their solution. Laplace transforms, including their definition, properties, and applications in solving differential equations and transforming derivatives are explored. The course concludes with an introduction to vector spaces matrix theory the eigenvalue problem, Fourier series, and separable partial differential equations, providing a comprehensive foundation in advanced calculus and its applications to engineering and physics.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Solve basic ordinary differential equations using separation of variables, linear methods, and Laplace transforms.	Ap	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Apply concepts from linear algebra, including matrices, determinants, and eigenvalues, to solve systems of equations and analyse linear systems.	Ap	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Analyse periodic functions using Fourier series and solve separable partial differential equation	An	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Text	Advanced Engineering Mathematics, 6th Edition, Dennis G. Zill, Jones & Bartlett Learning LLC (2018) ISBN: 978-1-284-10590-2			
Module		**Content**	**Hrs (48 +12)**	**Ext. Marks (70)**
		Differential Equations		
I	1	Introduction to Differential Equations - Section 1.1: Definitions and Terminology - A Definition, Classification by Type, Notation, Classification by Order , Classification by Linearity, Solution.	**11**	Min 15
	2	Section 2.2: Separable Equations - Introduction, A Definition, Method of Solution.		
	3	Section 2.3: Linear Equations - Introduction, A Definition, Standard Form, Method of Solution, An Initial Value Problem (Examples 4 & 5, ref section 1.1)		
	4	Section 2.4: Exact Equations - Introduction, Differential of a Function of Two Variables, Method of Solution.		
	5	Section 3.3: Homogeneous Linear Equations with Constant Coefficients - Introduction, Auxiliary Equation.		
	6	Section 3.6: Cauchy-Euler Equations - Cauchy-Euler Equation (Second Order Only), Method of Solution.		
		Laplace Transforms		
II	7	Section 4.1: Definition of the Laplace Transform - Basic Definition (Definition 4.1.1 onwards)	**14**	Min 15
	8	Section 4.1: Definition of the Laplace Transform - □is a Linear Transform.		
	9	Section 4.2: The Inverse Transform and Transforms of Derivatives - Inverse Transforms		
	10	Section 4.2:The Inverse Transform and Transforms of Derivatives - Transforms of Derivatives		
	11	Section 7.6: Vector Spaces - Vector Space (Example 2 is optional), Subspace.		
	12	Section 7.6: Vector Spaces - Basis, Standard Bases, Dimension, Span		
		Matrix Theory	**13**	Min 15
III	13	Section 8.2: Systems of Linear Algebraic Equations - Introduction, General Form, Solution, Augmented Matrix, Elementary Row Operations, Elimination Methods.		
	14	Section 8.2: Systems of Linear Algebraic Equations - Homogeneous Systems, Notation		
	15	Section 8.3: Rank of a Matrix -		

		Introduction, A Definition, Row Space, Rank by Row Reduction, Rank and Linear Systems.		
	16	Section 8.4: Determinants - Introduction, A Definition (Topics up to and including Example 2).		
	17	Section 8.8: The Eigenvalue Problem - Introduction, A Definition (Topics up to and Including Example 2)		
	18	Section 8.8: The Eigenvalue Problem - A Definition (Topics from Example 3 onwards), Eigenvalues and Eigenvectors of A^{-1}.		
IV		**Fourier Series and PDE**	**10**	Min 15
	19	Section 12.2: Fourier Series - Trigonometric Series (Definition 12.2.1 onwards), Convergence of a Fourier Series.		
	20	Section 12.3: Fourier Cosine and Sine Series - Introduction, Even and Odd Functions, Properties, Cosine and Sine Series (Definition 12.3.1 onwards).		
	21	Section 13.1: Separable Partial Differential Equations - Introduction, Linear Partial Differential Equation, Solution of a PDE, Separation of Variables.		
	22	Section 13.1: Separable Partial Differential Equations - Classification of Equations.		
		Open Ended		
	1	Initial-Value Problems	**12**	
	2	Differential Equations as Mathematical Models		
	3	Second Order Non-Homogeneous Equations-Method of Undetermined Coefficients, Variation of Parameters.		
	4	Linear Models – IVP		
	5	Linear Models - BVP		
	6	Non-linear Models		
	7	Half- Range Fourier Series		
	8	Classical PDEs and Boundary- Value Problems		

	1	Advanced Engineering Mathematics, Erwin Kreyszig, 10th Edition, Wiley India.
	2	Calculus & Analytic Geometry, 9th Edition, George B. Thomas & Ross L. Finney, Pearson Publications.
	3	Calculus, 7th Edition, Howard Anton, Biven, & Stephen Davis, Wiley India.

Note: 1) Optional topics are exempted for end semester examination.

2) Proofs of all the results are also exempted for the end semester exam.

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	1	3	1	3	3	3	1	2
CO 2	2	1	3	1	3	3	3	1	2
CO 3	3	2	3	2	3	3	3	2	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT3MN201			
Course Title	**CALCULUS OF SEVERAL VARIABLES**			
Type of Course	**Minor**			
Semester	III			
Academic Level	200 - 299			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites	Calculus of Single Variable			
Course Summary	This course provides a comprehensive study of advanced calculus topics, including partial derivatives, limits, continuity, the chain rule, and vector-valued functions. Students will explore directional derivatives, tangent planes, and extrema of functions of multiple variables, as well as integral calculus techniques such as line integrals, double integrals (including those in polar coordinates), surface integrals, and the applications of these concepts in vector calculus and field theory			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Apply Multivariable Calculus Concepts to Vector Valued Functions	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Apply Techniques of Multivariable Integration	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Apply Advanced Theorems in Multivariable Calculus	E	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Textbook	Calculus, Soo T. Tan, Brooks/Cole Cengage Learning (2010) ISBN-13: 978-0-534-46579-7			
Module	Unit	Content	Hrs (48 +12)	**Ext. Marks (70)**
I		**Partial Derivatives**	14	Min 15
	1	12.1: Vector Valued Functions & Space Curves		
	2	12.2: Differentiation & Integration of Vector Valued Functions		
	3	13.1: Functions of Two or More Variables		
	4	13.2: Limits & Continuity		
	5	13.3: Partial Derivatives		
	6	13.4: Differentials		
	7	13.5: The Chain Rule		
	8	13.6: Directional Derivatives		
	9	13.7: Tangent Planes & Normal Lines		
	10	13.8: Extrema of Functions of Two Variables		
II		**Vector Derivatives – Calculus of Scalar & Vector Fields**	11	Min 15
	11	13.6: Gradient Vector of a Scalar Field		
	12	15.1, 15.2: Divergence & Curl of Vector Fields		
	13	15.3: Line Integrals		
	14	15.4: Path Independence & Conservative Vector Fields		
		(Fundamental Theorem of Line Integration- Gradients)		
III		**Multiple Integration**	14	Min 15
	15	14.1: Double Integrals		
	16	14.2: Iterated Integrals		
	17	14.3: Double Integrals in Polar Coordinates		
	18	14.4: Applications of Double Integrals		
	19	14.5: Surface Area		

	20	14.6: Triple Integrals		
	21	14.7: Triple Integrals in Cylindrical & Spherical Coordinates		
	22	14.8: Change of Variables in Multiple Integrals		
IV	**Integral Calculus of Fields & Fundamental Theorems**		11	Min 15
	23	15.5: Green’s Theorem		
	24	15.6: Parametric Surfaces		
	25	15.7: Surface Integrals		
	26	15.8: Divergence Theorem		
	27	15.9: Stoke’s Theorem		
V	Open Ended Module – Complex Analysis		12	
	1	Algebra of Complex Numbers, Complex Functions, Complex Differentiation		
	2	Cauchy-Riemann Equations, Analytic Functions		
	3	Complex Line Integrals		
	4	Cauchy’s & Cauchy-Goursat Theorems		
	5	Cauchy’s Integral Formula, Derivative Formula		
	6	Morera’s & Liouville’s Theorem, Fundamental Theorem of Algebra		
	7	12.3: Arc Length & Curvature		
	8	12.4: Velocity & Acceleration		
	9	12.5: Tangential & Normal Components		
	10	13.9: Lagrange Multipliers		

. References:

1. Advanced Engineering Mathematics, Erwin Kreyzsig, 10th Edition, Wiley India.

2. Advanced Engineering Mathematics, 6th Edition, Dennis G. Zill, Jones & Bartlett Learning LLC (2018) ISBN: 978-1-284-10590-2.

3. Calculus & Analytic Geometry, 9th Edition, George B. Thomas & Ross L. Finney, Pearson Publications.

4. Thomas' Calculus, 14th Edition, Maurice D. Weir, Christopher Heil, & Joel Hass, Pearson Publications.

5. Calculus, 7th Edition, Howard Anton, Biven, & Stephen Davis, Wiley India.

. **Note: 1) Optional topics are exempted for end semester examination.**
2) Proofs of all the results are also exempted for the end semester exam.

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	3	2	3	3	3	1	2
CO 2	3	0	3	2	3	3	3	1	2
CO 3	3	2	3	2	3	3	3	1	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT1MN102			
Course Title	**DIFFERENTIAL CALCULUS**			
Type of Course	**MINOR**			
Semester	I			
Academic Level	100-199			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	4	-	60
Pre-requisites	Set theory along with an understanding of the real number system.			
Course Summary	This course provides a foundational understanding of calculus concepts: From the beginning sections students learn about limits (including one-sided limits and limits at infinity), continuity (definitions and properties), and the intermediate value theorem. Modules II and III cover differentiation techniques, including tangent lines, the definition of derivatives, rules of differentiation (product, quotient, chain), implicit differentiation, and advanced topics like L'Hopital's Rule for indeterminate forms. Module IV focuses on the analysis of functions, discussing concepts such as increasing/decreasing functions, concavity, inflection points, and techniques for identifying relative extrema and graphing polynomials.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Analyse limit, continuity and differentiability of a function	An	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Apply rules and techniques of differentiation to solve problems, also find limit in indeterminate forms involving transcendental functions	Ap	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Draw a polynomial function by analysing monotonicity, concavity and point of inflection using derivatives test	An	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Text book	Anton, Howard, Irl C. Bivens, and Stephen Davis. *Calculus: early transcendentals*. 10th Edition, John Wiley & Sons, 2021.			
Module	**Unit**	**Content**	**Hrs 60**	**External Marks (70)**
I		**Fundamentals of Limits and Continuity**	14	Min.15
	1	Section 1.1: Limits (An Intuitive Approach) - Limits, One-Sided Limits, The Relationship Between One-Sided and Two Sided Limits		
	2	Section 1.2: Computing Limits - Some Basic Limits, Limits of Polynomials and Rational Functions as $x \to a$		
	3	Section 1.2: Computing Limits - Limits involving Radicals, Limits of Piecewise-Defined Functions		
	4	Section 1.3: Limits at Infinity; End Behaviour of a Function Limits of Rational Functions as $x \to \pm\infty$ - A Quick Method for Finding Limits of Rational Functions as $x \to +\infty$ or $x \to -\infty$		
	5	Section 1.5: Continuity - Definition of Continuity, Continuity on an interval, Some Properties of Continuous Functions,		
	6	Section 1.5: Continuity - Continuity of Polynomials and Rational Functions, Continuity of Compositions, The Intermediate- Value Theorem.		
II		**Differentiation**	14	Min.15
	7	Section 2.1: Tangent Lines and Rates of Change - Tangent lines, Slopes and Rate of Change		
	8	Section 2.2: The Derivative Function - Definition of the Derivative Function-Topics up to and including Example 2.		
	9	Section 2.3: Introduction to Techniques of Differentiation - Derivative of a Constant, Derivative of Power Functions, Derivative of a Constant Times a Function, Derivatives of Sums and Differences, Higher Derivatives		
	10	Section 2.4: The Product and Quotient Rules - Derivative of a Product, Derivative of a Quotient, Summary of Differentiation Rules.		
	11	Section 2.5: Derivatives of Trigonometric Functions - Example 4 and Example 5 are optional		
	12	Section 2.6: The Chain Rule Derivatives of Compositions, An Alternate Version of the Chain Rule, Generalized Derivative Formulas		
		Differentiation contd :	10	
	13	Section 3.1: Implicit Differentiation - Implicit Differentiation (sub section)		

III	14	Section 3.2: Derivatives of Logarithmic Functions - Derivative of Logarithmic Functions (sub section) Logarithmic Differentiation, Derivatives of Real Powers of x.		Min.15
	15	Section 3.3: Derivatives of Exponential and Inverse Trigonometric Functions - Derivatives of Exponential Functions		
	16	Section 3.3: Derivatives of Exponential and Inverse Trigonometric Functions - Derivatives of the Inverse Trigonometric Functions		
	17	Section 3.6: L'Hopital's Rule; Indeterminate Forms - Inderminate Forms of Type 0/0, Indeterminate Forms of Type ∞/∞		
	18	Section 3.6: L'Hopital's Rule; Indeterminate Forms - Inderminate Forms of Type $0 \cdot \infty$, Indeterminate Forms of Type $\infty - \infty$		
IV		**Applications of Differentiation**	10	Min 15
	19	Section 4.1: Analysis of Functions I: Increase, Decrease, and Concavity - Increasing and Decreasing Functions		
	20	Section 4.1: Analysis of Functions I: Increase, Decrease, and Concavity - Concavity, Inflection Points		
	21	Section 4.2: Analysis of Functions II: Relative Extrema; Graphing Polynomials - Relative Maxima and Minima, First Derivative Test, Second Derivative Test		
	22	Section 4.2: Analysis of Functions II: Relative Extrema; Graphing Polynomials Geometric Implications of Multiplicity, Analysis of Polynomials		
V	**Module V (Open Ended)**		12	
		Infinite Limits		
		Differentiability, Relation between Derivative and Continuity		
		Parametric Equations, Parametric Curves		
		Inverse Trigonometric Functions and their derivatives		
		Taylor series expansion of functions		
		Maclaurin series of sin x, cos x, tan x, log(1+x), log(1-x) etc		
		Binomial expansion of $\frac{1}{(1+x)}$, $\frac{1}{(1-x)}$, $\frac{1}{\sqrt{1+x}}$, $\frac{1}{\sqrt{1-x}}$ etc		
		Different coordinate systems: - Cartesian, Spherical, and Cylindrical coordinates		
		Conic sections with vertex other than the origin		
		Indeterminate Forms of Type $0^0, \infty^0, 1^\infty$		
		Graphing Rational Functions		
References				
	1	Calculus and Analytic Geometry, 9 th Edition, George B. Thomas Jr and Ross L. Finney, Pearson Publications.		

	2	Calculus, Soo T. Tan, Brooks/Cole Cengage Learning (2010) ISBN-13: 978-0-534-46579-7.
	3	Marsden, Jerrold, and Alan Weinstein. *Calculus I*. Springer Science & Business Media, 1985.
	4	Stein, Sherman K. *Calculus in the first three dimensions*. Courier Dover Publications, 2016.

Note: 1) Optional topics are exempted for end semester examination. 2) Proofs of all the results are also exempted for the end semester exam. (3) 70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	1	3	1	2	1	3	1	2
CO 2	3	1	3	1	2	1	3	1	2
CO 3	2	1	3	2	3	2	3	1	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT2MN102			
Course Title	**CALCULUS AND MATRIX ALGEBRA**			
Type of Course	**MINOR**			
Semester	II			
Academic Level	100-199			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	4	-	60
Pre-requisites	Basic Calculus			
Course Summary	Students learn about antiderivatives, the indefinite and definite integrals, Riemann sums, and the Fundamental Theorem of Calculus. Course explores the average value of functions, evaluating definite integrals by substitution, calculating areas between curves, and finding the length of plane curves. Next it introduces functions of multiple variables, including notation, graphs, limits, continuity, and partial derivatives for functions of two or more variables. Course also focuses on matrix algebra, determinants, eigenvalue problems (including complex eigenvalues) and orthogonal matrices and their properties.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Demonstrate proficiency in applying calculus techniques to solve analytical and geometrical problems involving indefinite and definite integrals, substitution methods, and integration by parts.	Ap	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Apply multivariable calculus concepts, including functions of multiple variables, limits, continuity, and partial derivatives, to model and analyse real-world phenomena and mathematical problems.	Ap	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Apply linear algebra principles, such as matrix operations, determinants, and eigenvalue problems, to analyze and solve systems of equations and geometric problems.	Ap	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Text Book	1. Howard Anton, Bivens and Stephen Davis, Calculus• Early Transcendentals (10th Edition). 2. Advanced Engineering Mathematics(6/e): Dennis G Zill Jones & Bartlett, Learning, LLC (2018) ISBN: 9781284105902

Module	Unit	Content	Hrs 60	External Marks (70)
I		**Indefinite and Definite Integrals**	**12**	**Min 15**
	1	Section 5.2: The Indefinite Integral - Antiderivatives, The Indefinite Integral, Integration Formulas, Properties of the Indefinite Integral, Integral Curves		
	2	Section 5.3: Integration by Substitution - u-Substitution, Easy to Recognize Substitutions, Less Apparent Substitutions		
	3	Section 5.5: The Definite Integral - Riemann Sums and the Definite Integral, Properties of the Definite Integral.		
	4	Section 5.6: The Fundamental Theorem of Calculus - The Fundamental Theorem of Calculus (sub section), The Relationship Between Definite and Indefinite Integrals.		
II		**Techniques and Applications**	**13**	**Min 15**
	5	Section 5.8: Average Value of a Function and its Applications - Average Value of a Continuous Function (up to and including Example 2 only)		
	6	Section 5.9: Evaluating Definite Integrals by Substitution - Two Methods for Making Substitutions in Definite Integrals		
	7	Section 6.1: Area Between Two Curves - Area Between □= □(□) and □= □(□), Reversing the Roles of □and □		
	8	Section 6.4: Length of a Plane Curve - Arc Length		
	9	Section 7.2: Integration by Parts - The Product rule and Integration by Parts, Guidelines for Integration by Parts, Repeated Integration by Parts		
	10	Section 7.5: Integrating Rational Functions by Partial Fractions - Partial Fractions, Finding the form of a Partial Fraction Decomposition, Linear Factors, Quadratic Factors (Example 4 is optional), Integrating Improper Rational Functions.		
III		**Multivariable Calculus**	**10**	**Min 15**
	11	Section 13.1: Functions of Two or More Variables: Notation and Terminology, Graphs of Functions of Two Variables.		
	12	Section 13.1: Functions of Two or More Variables: Level Curves, Level Surfaces.		
	13	Section 13.2: Limits and Continuity - Limit along Curves		
	14	Section 13.2: Limits Continuity - Continuity		
	15	Section 13.3: Partial Derivatives -		

		Partial Derivatives of Functions of Two Variables, The Partial Derivative Function, Partial Derivative Notation, Implicit Partial Differentiation, Partial Derivatives and Continuity		
	16	Section 13.3: Partial Derivatives Partial Derivatives of Functions with more than Two Variables, Higher order Partial Derivatives, Equality of Mixed Partials.		
IV		**Linear Algebra Essentials**	**13**	**Min 15**
	17	Section 8.1: Matrix Algebra		
	18	Section 8.2: Systems of Linear Algebraic Equations		
	19	Section 8.8: The Eigenvalue Problem - Topics up to and including Example 4		
	20	Section 8.8: The Eigenvalue Problem - Topics from Complex Eigenvalues onwards		
	21	Section 8.10: Orthogonal Matrices - Topics up to and including Theorem 8.10.3		
	22	Section 8.10: Orthogonal Matrices - Topics from Constructing an Orthogonal Matrix onwards		
V		**Module V (Open Ended)**	**12**	
		Fundamental theorems in Vector Calculus such as Green's theorem, divergence theorem, and the Stokes' theorem.		
		Trigonometric Substitutions		
		Integrating Trigonometric Functions		
		Volume of Solids of Revolution, Area of Surfaces of Revolution		
		The Chain Rule in Partial Differentiation		
		Directional Derivatives and Gradients, Tangent Planes and Normal Vectors		
		Basics of Vector Calculus including the differential operators such as gradient, divergence and curl.		
		Simpsons Rule, Trapezoidal rule in Numerical Integration		
		Algebra of Complex Numbers		

References		
	1	Calculus and Analytic Geometry, 9 th Edition, George B. Thomas Jr and Ross L. Finney, Pearson Publications.
	2	Calculus, Soo T. Tan, Brooks/Cole Cengage Learning (2010) ISBN-13: 978-0-534-46579-7.
	3	Marsden, Jerrold, and Alan Weinstein. *Calculus I*. Springer Science & Business Media, 1985.
	4	Stein, Sherman K. *Calculus in the first three dimensions*. Courier Dover Publications, 2016.
	5	Kreyszig, Erwin. *Advanced Engineering Mathematics 9th Edition with Wiley Plus Set*. Vol. 334. US: John Wiley & Sons, 2007.
	6	Elementary Linear Algebra, Applications version, 9 th edition, Howard Anton and Chriss Rorres

Note: 1) Optional topics are exempted for end semester examination. 2) Proofs of all the results are also exempted for the end semester exam.

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	1	3	1	1	1	3	0	0
CO 2	2	1	2	1	2	1	2	0	0
CO 3	2	1	2	1	2	1	2	0	0

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT3MN202			
Course Title	**DIFFERENTIAL EQUATIONS AND FOURIER SERIES**			
Type of Course	**Minor**			
Semester	III			
Academic Level	200-299			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	4	-	60
Pre-requisites	Basic Calculus and familiarity with Real Numbers			
Course Summary	In Module I students are introduced to various types of differential equations, including linear, separable, exact equations, and Bernoulli's equation. Module II delves deeper into linear equations, both homogeneous and nonhomogeneous. Module III introduces Fourier series, including trigonometric series, Fourier cosine and sine series, and half-range expansions. Module IV transitions into algebra of complex numbers, , and functions of complex variables, including analytic functions and the Cauchy•Riemann equations, which are fundamental in complex analysis.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Apply various methods, such as separation of variables, linear, and exact equations, integrating factors, and substitution, to solve differential equations, including those with constant coefficients and Cauchy-Euler equations.	Ap	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Analyse and solve partial differential equations, including separable ones, and comprehend Fourier series and their applications in solving differential equations and understanding periodic function	An	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Apply complex number theory, including arithmetic operations, polar forms, powers, roots, sets in the complex plane, functions of a complex variable, and Cauchy-Riemann equations, to analyze and solve real-world problems in various fields.	Ap	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs 60	External Marks (70)
Text Book	Advanced Engineering Mathematics(6/e) : Dennis G Zill, Jones & Bartlett, Learning, LLC(2018)ISBN: 978-1-284-10590-2			
I		**Foundations of Differential Equations**	10	Min 15
	1	Introduction to Differential Equations Section 1.1: Definitions and Terminology Introduction, A Definition, Classification by Type, Notation, Classification by Order Classification by Linearity, Solution.		
	2	Section 2.2: Separable Equations Introduction, A Definition, Method of Solution.		
	3	Section 2.3: Linear Equations Introduction, A Definition, Standard Form, Method of Solution, An Initial Value Problem		
	4	Section 2.4: Exact Equations Introduction, Differential of a Function of Two Variables (Definition 2.4.1 and Theorem 2.4.1 only), Method of Solution.		
	5	Section 2.4: Exact Equations Integrating Factors		
	6	Section 2.5: Solutions by Substitutions Bernoulli's Equation		
II		**Linear Differential Equations**	11	Min 15
	7	Section 3.1: Theory of Linear Equations 3.1.2 Homogenous Equations, Linear Dependence and Independence, Solutions of Differential Equations,		
	8	Section 3.1: Theory of Linear Equations 3.1.3 Nonhomogeneous Equations, Complementary Function		
	9	Section 3.3: Homogeneous Linear Equations with Constant Coefficients Introduction, Auxiliary Equation.		
	10	Section 3.4: Undetermined Coefficients Introduction, Method of Undetermined Coefficients (Topics up to and including Example 4.)		
	11	Section 3.6: Cauchy-Euler Equations Cauchy-Euler Equation (Second Order Only), Method of Solution.		
III		**Fourier Series**	13	Min 15
	12	Section 12.2: Fourier Series Trigonometric Series (Definition 12.2.1 onwards), Convergence of a Fourier Series, Periodic Extension		
	13	Section 12.3: Fourier Cosine and Sine Series Introduction, Even and Odd Functions, Properties, Cosine and Sine Series (Definition 12.3.1 onwards).		
	14	Section 12.3: Fourier Cosine and Sine Series Half-Range Expansions.		

	15	Section 13.1: Separable Partial Differential Equations Introduction, Linear Partial Differential Equation, Solution of a PDE, Separation of Variables.		
	16	Section 13.1: Separable Partial Differential Equations Classification of Equations.		
IV		**Introduction to Complex Analysis**		**Min 15**
	17	Section 17.1: Complex Numbers Introduction, A definition, Terminology, Arithmetic Operations, Conjugate, Geometric Interpretation	**14**	
	18	Section 17.2: Powers and Roots Introduction, Polar Form, Multiplication and Division, Integer Powers of z.		
	19	Section 17.2: Powers and Roots DeMoivre's Formula, Roots.		
	20	Section 17.3: Sets in the Complex Plane Introduction, Terminology.		
	21	Section 17.4: Functions of a Complex Variable Introduction, Functions of a Complex Variable, Limits and Continuity, Derivative, Analytic Functions.		
	22	Section 17.5: Cauchy- Riemann Equations Introduction, A Necessary Condition for Analyticity, Harmonic Functions, Harmonic- Conjugate Functions.		
V		**Module V (Open Ended)**	**12**	
		Initial Value Problems		
		Differential Equations as Mathematical Models		
		Method of Variation of Parameters in solving DE		
		Solving DE with the Runge-Kutte Method		
		Interpolation, Extrapolation		
		Classical PDEs and Boundary Value Problems		
		Heat Equation		
		Wave Equation		
		Fourier Transform		
References				
	1	Advanced Engineering Mathematics, Erwin Kreyszig, 8^{th} Edition, Wiley Student Edition.		
	2	Mathematics For Engineers and Scientist, Alan Jeffrey, Sixth Edition		
	3	Complex Analysis A First Course with Applications (3/e), Dennis Zill & Patric Shanahan Jones and Bartlett, Learning (2015) ISBN 1-4496-9461-6		

Note: Proofs of all the results are also exempted for the end semester exam.

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	1	3	2	3	3	3	1	2
CO 2	3	1	3	2	3	3	3	1	2
CO 3	3	2	3	2	3	3	3	1	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT1MN103			
Course Title	**BASIC CALCULUS**			
Type of Course	**Minor**			
Semester	I			
Academic Level	100 – 199			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	4	-	60
Pre-requisites	Basic Set Theory including functions and their algebraic operations .			
Course Summary	This course provides a comprehensive exploration of calculus and its applications: It begins with fundamental concepts of graphs, linear models, inverse functions, laying the groundwork for calculus. Modules II and III delve into differentiation techniques, including product and quotient rules, implicit differentiation, derivatives of inverse functions, and applications like extrema, theorems (such as Rolle's and Mean Value Theorems), and curve sketching. Module IV explores integral calculus, covering the fundamental theorem of calculus, numerical integration techniques (like the Trapezoidal Rule and Simpson's Rule), and introduces hyperbolic functions and their derivatives and integrals.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Apply graphical analysis skills to mathematical models:	Ap	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Evaluate and solve calculus problems involving limits and continuity	E	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Apply differentiation and integration techniques to analyse functions:	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Text Book	Calculus: Early Transcendental Functions (6edn), Ron Larson and Bruce Edwards Cengage Learning ISBN-13: 978-1-285-77477-0.			
Module	**Unit**	**Content**	**Hrs (48 +12)**	**Ext. Marks (70)**
I		**Foundations of Calculus: Graphs, Functions, and Limits**		
	1	A quick review of sections 1.1 and 1.2 (not for external exam) Section 1.3 – Functions and their Graphs	**13**	**Min 15**
	2	Section 1.5: Inverse Functions - Inverse Functions, Existence of an Inverse Function		
	3	Section 1.6: Exponential and Logarithmic Functions - Exponential Functions, The Number e, The Natural Logarithmic Function		
	4	Section 2.2: Finding Limits Graphically and Numerically - An Introduction to Limits, Limits That Fail to Exist, A Formal Definition of Limit (examples are optional topics)		
	5	Section 2.3: Evaluating Limits Analytically - Properties of Limits, A Strategy for Finding Limits,		
	6	Section 2.3: Evaluating Limits Analytically - Dividing Out Technique, Rationalizing Technique, The Squeeze Theorem		
II		**Continuity, Derivatives, and Differentiation Rules**		
	7	Section 2.4: Continuity and One-Sided Limits - Continuity at a Point and on an Open Interval, Properties of Continuity, The Intermediate Value Theorem.	**12**	**Mn 15**
	8	Section 3.1: The Derivative and the Tangent Line Problem - The Derivative of a Function, Differentiability and Continuity		
	9	Section 3.2: Basic Differentiation Rules and Rates of Change – The Constant Rule, The Power Rule, The Constant Multiple Rule, The Sum and Difference Rules		
	10	Section 3.2 : Basic Differentiation Rules – rest of the section.		
	11	Section 3.3: Product and Quotient Rules and Higher Order Derivatives - The Product Rule, The Quotient rule, Higher- Order Derivatives		
	12	Section 3.4 The Chain Rule.		
	13	Section 3.5: Implicit Differentiation Implicit and Explicit Functions, Implicit Differentiation, Logarithmic Differentiation		
III		**Applications of Derivatives: Extrema, Concavity, and Curve Sketching**		
	14	Section 4.1: Extrema on an Interval - Extrema of a Function, Relative Extrema and Critical Numbers, Finding Extrema on a Closed Interval	**12**	**Min 15**
	15	Section 4.2: Rolle's Theorem and The Mean Value Theorem - Rolle's Theorem, The Mean Value Theorem		
	16	Section 4.3: Increasing and Decreasing Functions and The First Derivative Test - Increasing and Decreasing Functions, The First Derivative Test		
	17	Section 4.4: Concavity and the Second Derivative Test -		

		Concavity, Points of Inflection, The Second Derivative Test		
	18	Section 4.6: A summary of Curve Sketching - Analyzing the Graph of a Function		
IV		**Integral Calculus: Fundamental Theorems and Applications"**		
	19	Section 5.1: Antiderivatives and Indefinite Integration – Antiderivatives, Basic Integration Rules, Initial Conditions and Particular Solutions.	11	**Min 15**
	20	Section 5.3: Reimann Sums and Definite Integrals – Reimann Sums, Definite Integrals, Properties of Definite Integrals.		
	21	Section 5.4: The Fundamental Theorem of Calculus - The Fundamental Theorem of Calculus, The Mean Value Theorem for Integrals.		
	22	Section 5.4: The Fundamental Theorem of Calculus - Average Value of a Function, The Second Fundamental Theorem of Calculus, Net Change Theorem		
V		**Open Ended**		
		One Sided Limits and Discontinuity, Derivatives of Inverse Functions, Derivatives of Trigonometric functions, Limits at Infinity and Horizontal Asymptotes, Numerical Integration, Area problems using Riemann Sums, Hyperbolic Functions.	**12**	

References:

1. Calculus, Soo T. Tan, First Edition, Brooks/Cole, Cengage Learning, 2011.
2. Calculus & Analytic Geometry, (9/e), George B. Thomas & Ross L. Finney, Pearson Publications
3. Calculus, (7/e), Howard Anton, Biven, & Stephen Davis, Wiley India
4. Calculus, (7/e)., Howard Anton, Biven, & Stephen Davis, Wiley India.
5. Calculus: Early Transcendentals, (4/e), Dennis G. Zill and Warren S. Wright

Note: 1) Optional topics are exempted for end semester examination.
2) Proofs of all the results are also exempted for the end semester exam.,

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	1	3	2	3	2	3	1	2
CO 2	3	1	3	1	3	1	3	1	2
CO 3	2	1	3	1	3	2	3	1	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B.Sc. Mathematics Honours			
Course Code	MAT2MN103			
Course Title	**ANALYSIS AND SOME COUNTING PRINCIPLES**			
Type of Course	**Minor**			
Semester	II			
Academic Level	100 – 219			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	4	-	60
Pre-requisites	Basic Calculus and familiarity with Real Number system.			
Course Summary	This course covers fundamental topics in calculus and complex analysis, beginning with sequences and series in Module I, exploring convergence tests like the nth-term test, comparison tests, and alternating series. Module II delves into complex numbers and functions, discussing the arithmetic and geometric properties of complex numbers, along with polar and exponential forms. In Module III, the focus shifts to limits, continuity, and differentiability of complex functions, including the Cauchy-Riemann equations and harmonic functions. Finally, Module IV introduces counting principles, including permutations, combinations, the pigeonhole principle, and basic elements of probability.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Describe and apply convergence tests for sequences and series.	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Demonstrate proficiency in manipulating complex numbers and functions.	Ap	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Evaluate limits, continuity, and differentiability of real and complex functions.	E	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Text Book		1. Calculus: Early Transcendental Functions (6/e), Ron Larson and Bruce Edwards, Cengage Learning ISBN 13: 978-1-285-77477-0. 2. Complex Analysis A First Course with Applications (3/e), Dennis Zill & Patric Shanahan Jones and Bartlett, Learning (2015) ISBN 1-4496-9461-6 3. Discrete Mathematical Structures (6/e), Bernard Kolman, Robert Busby, Sharon C. Ross, Pearson ISBN 978-93-325-4959-3		
Module	**Unit**	**Content**	**Hrs (48 +12)**	**Ext. Marks (70)**
I		**Sequences and Series (Text 1)**		
	1	Section 9.1: Sequences - Sequences (sub section), Limit of a Sequence, Monotonic Sequences and Bounded Sequences.	13	Min 15
	2	Section 9.1: Sequences Monotonic Sequences and Bounded Sequences		
	3	Section 9.2: Series and Convergence - Infinite Series, Geometric Series, nth-Term Test for Divergence		
	4	Section 9.3: The Integral Test and p-Series - The Integral Test, p-series and Harmonic Series		
	5	Section 9.4: Comparisons of Series - Direct Comparison Test, Limit Comparison Test		
	6	Section 9.5: Alternating Series - Alternating Series (sub section), Alternating Series Remainder, Absolute and conditional Convergence		
II		**Complex Numbers (Text 2)**		
	7	Section 1.1: Complex numbers and their Properties - The Imaginary Unit, Terminology, Arithmetic Operations, Zero and Unity, Conjugate, Inverses	13	Min 15
	8	Section 1.2: Complex Plane - Complex Plane, Vectors, Properties, Distance Again, Inequalities		
	9	Section 1.3: Polar Form of Complex Numbers - Polar Form, Principal Argument, Multiplication and Division, Integer Powers of z, de Moivre's Formula		
	10	Section 1.4: Powers and Roots - Roots, Principal nth Root		
	11	Section 1.5: Sets of Points in the Complex Plane - Circles, Disks and Neighborhoods, Open Sets, Annulus, Domain, Regions, Bounded Sets		
	12	Section 2.1: Complex Functions - Introduction, Function, Real and Imaginary Parts of a Complex Function, Exponential Function		
III		**Complex Analysis (Text 2)**		
	13	Section 3.1: Limits and Continuity - Introduction, Real Limits, Complex Limits (definition only), Real Multivariable Limits (Example 2 and Problems Using Epsilon Delta Definition are optional)		
	14	Section 3.1: Limits and Continuity -		

		Continuity of Real Functions, Continuity of Complex Functions (Example 6 is optional), Properties of Continuous Functions.	**12**	Min 15
	15	Section 3.2: Differentiability and Analyticity - Introduction, The Derivative, Rules of Differentiation		
	16	Section 3.2: Differentiability and Analyticity - Analytic Functions, Entire Functions, Singular Points, An Alternate Definition of $f'(z)$.		
	17	Section 3.3: Cauchy -Riemann Equations - Introduction, A Necessary Condition for Analyticity, A Sufficient Condition for Analyticity		
	18	Section 3.4: Harmonic Functions Introduction, Harmonic Functions, Harmonic Conjugate Functions		
IV	**Introduction to Counting and Probability Theory (Text 3)**			
	19	Chapter 3: Counting Section 3.1 - Permutations	**10**	Min 15
	20	Chapter 3: Counting Section 3.2 - Combinations		
	21	Chapter 3: Counting Section 3.3 – Pigeonhole Principle		
	22	Chapter 3: Counting Section 3.4 – Elements of Probability		
V	**Open Ended**			
	Pattern Recognition for Sequences, Rearrangement of Series, The Ratio Test, The Root Test, Taylor Polynomials and Approximations, Power Series, Taylor Series, Maclaurin Series, Complex Functions as Mappings, Linear Mappings, Special Power Functions, Relations and Di Graphs.		**12**	

References:

1. Calculus, Soo T. Tan, First Edition, Brooks/Cole, Cengage Learning, 2011.
2. Calculus & Analytic Geometry, (9/e)., George B. Thomas & Ross L. Finney, Pearson Publications.
3. Calculus, (7/e), Howard Anton, Biven, & Stephen Davis, Wiley India.
4. Calculus: Early Transcendentals, (4/e)., Dennis G. Zill and Warren S. Wright.
5. Advanced Engineering Mathematics, (10/e), Erwin Kreyszig, John Wiley and Sons.
6. Complex Variables and Applications, (8/e), James Brown and Ruel Churchill, McGraw-Hill International (UK) Ltd
7. Discrete Mathematics, (6/e), Richard Johnsonbaugh, Pearson

Note: 1) Optional topics are exempted for end semester examination.

2) Proofs of all the results are also exempted for the end semester exam.

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	1	3	1	1	1	3	0	0
CO 2	2	1	2	1	1	1	2	0	0
CO 3	2	1	2	1	1	1	3	0	0

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	BSc Mathematics Honours				
Course Title	**MATRIX ALGEBRA AND VECTOR CALCULUS**				
Course Code	**MAT3MN203**				
Type of Course	**Minor**				
Semester	III				
Academic Level	200 – 299				
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours	
	4	4	-	60	
Pre-requisites	Basic Calculus and familiarity with Euclidian Geometry.				
Course Summary	This course covers fundamental concepts in vectors, vector calculus, and matrices. Students will explore vectors in 2-space and 3-space, including dot and cross products, as well as lines and planes in 3-space. The vector calculus portion includes vector functions, partial and directional derivatives, tangent planes, normal lines, curl, divergence, line integrals, double integrals, surface integrals, and triple integrals. Additionally, the course delves into matrix algebra, systems of linear equations, matrix rank, and the eigenvalue problem.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Discuss the geometry of Vectors in two- and three-dimensional spaces	U	C	Internal Exam/ Assignment/ Seminar/ Viva / End Sem Exam
CO2	Discuss the basic concepts of matrices, and evaluate the solutions of system of linear equations using matrices.	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Describe the idea of eigen values and eigen vectors.	U	C	Internal Exam/ Assignment/ Seminar/ Viva / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (60)	Ext. Marks (70)
Text: Advanced Engineering Mathematics, 6th Edition, Dennis G. Zill, Jones & Bartlett Learning LLC (2018) ISBN: 978-1-284-10590-2.				
I		**Vectors**	**11**	**Min. 15**
	1	Section 7.1-Vectors in 2 -Space (quick review)		
	2	Section 7.2-Vectors in 3-Space (quick review)		
	3	Section 7.3- Dot Product up to and including Example 5		
	4	Section 7.4- Cross Product up to and including Example 3		
	5	Section 7.5- Lines and Planes in 3-space- upto and including Example 6		
	6	Section 7.5- Lines and Planes in 3-space- From Planes: Vector Equation onwards		
II		**Vector Calculus**	**15**	**Min. 15**
	7	Section 9.1 – Vector Functions		
	8	Section 9.4 – Partial Derivatives		
	9	Section 9.5 – Directional Derivative – upto and including Example 4.		
	10	Section 9.5 – Functions of Three Variables onwards.		
	11	Section 9.6 – Tangent Planes and Normal Lines – upto and including Example 4		
	12	Section 9.6 – Topics from Normal Line onwards		
	13	Section 9.7 – Curl and Divergence -		
III		**Vector Calculus – contd.**		**Min. 15**
	14	Section 9.8 – Line Integrals – upto and including Example 5.		

	15	Section 9.10 – Double Integrals – upto and including Example 2	**12**	
	16	Section 9.13 – Surface Integrals – upto and including Example 4		
	17	Section 9.15 – Tripple Integrals (Examples 5 and 7 areoptional)		
IV		**Matrices**	**10**	**Min. 15**
	18	Section 8.1- Matrix Algebra.		
	19	Section 8.2-Systems of Linear Algebraic Equations. Up to and including Example 7		
	20	Section 8.2-Systems of Linear Algebraic Equations. From Homogeneous Systems onwards till end omit chemical equations		
	21	Section 8.3 -Rank of a Matrix.		
	22	Section 8.8-The Eigenvalue Problem.-Up to and including Example 4		
V		**Open Ended**	**12**	
		Vector Spaces, Gram- Schmidt Orthogonalization (for instance, refer sections 7.6 and 7.7) Green's Theorem, Stocke's Theorem and Divergence Theorem (for instance, refer sections 9.12, 9.14 and 9.16) Complex Eigen Values Eigen Values and Singular Matrices. Eigen Values and Eigen Vectors of inverse of A Improper Integrals, Beta and Gama Functions		
		References: **1.** Calculus and Analytic Geometry (9th Edn), George B Thomas, Jr. and Ross L Finney, Addison -Wesley Publishing Company. **2.** A Freshman Honors Course in Calculus and Analytic Geometry, Emil Artin (Author), Marvin J Greenberg (Foreword).		

		3. Advanced Engineering Mathematics (10th Edn), Erwin Kreyszig, John Wiley and Sons. 4. Improper Riemann Integrals: Ioannis M. Roussos CRC Press by Taylor & Francis Group, LLC(2014) ISBN: 978-1-4665-8808-0 (ebook -pdf)		

Note: 1) Optional topics are exempted for end semester examination. 2) Proofs of all the results are also exempted for the end semester exam.

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	1	3	2	3	2	3	1	2
CO 2	3	1	3	2	3	3	3	1	2
CO 3	3	2	3	2	3	2	3	1	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B.Sc Mathematics Honours			
Course Code	MAT1MN104			
Course Title	**MATHEMATICAL LOGIC, SET THEORY AND COMBINATORICS**			
Type of Course	**Minor**			
Semester	I			
Academic Level	100 - 199			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites	Higher Secondary Mathematics.			
Course Summary	This course explores mathematical logic, set theory, and combinatorics, covering fundamental ideas like propositions, logical equivalences, and quantifiers. It introduces set theory concepts such as sets, operations with sets, and cardinality. Additionally, it delves into functions and matrices, along with topics like permutations, combinations, and discrete probability in combinatorics.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Analyse propositional logic and equivalences	An	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Apply set theory and operations	Ap	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Implement functions, matrices, and combinatorics	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Ext. Marks (70)
		Text: Discrete Mathematics with Applications, (1/e), Thomas Koshy, Academic Press (2003), ISBN: 978-0124211803.		
I		**Mathematical Logic**	15	Min. 15
	1	1.1 Propositions: Conjunction, Disjunction.		
	2	1.1 Propositions: Converse, Inverse and Contrapositive.		
	3	1.1 Propositions: Biconditional Statement, Order of Precedence, Tautology, Contradiction and Contingency (Switching network and Example 1.16 are optional).		
	4	1.2 Logical Equivalences (Equivalent Switching Networks, Example 1.23, Fuzzy Logic and Fuzzy Decisions are optional)		
	5	1.3 Quantifiers (Example 1.28, De Morgan's Laws and example 1.29 are optional)		
	6	1.4 Arguments: Valid and Invalid arguments, (Example 1.33 is optional)		
II		**Set Theory**	12	
	7	2.1 The Concept of a Set - up to and including example 2.7 (Example 2.6 is optional).		Min. 15
	8	2.1 The Concept of a Set - finite and infinite sets (Topics from the Hilbert Hotel paradoxes onwards are optional).		
	9	2.2 Operations with Sets – up to and including example 2.21.		
	10	2.2 Operations with Sets – Cartesian product (Fuzzy sets, Fuzzy subsets and operations on fuzzy sets are optional).		
	11	2.4 The Cardinality of a Set (Theorem 2.2 and Algorithm subsets are optional).		
III		**Functions and Matrices**		

	12	3.1. The Concept of Functions - up to and including example 3.2	10	Min. 15
	13	3.1. The Concept of Functions – Piecewise definition, sum and product (Example 3.7 is optional).		
	14	3.2 Special Functions – up to and including example 3.13 (Proof of Theorems 3.1 and 3.2 are optional).		
	15	3.2 Special Functions- Characteristic function, Mod and Div functions (Theorem 3.3, Code dealing and The two Queens Puzzle are optional).		
	16	3.7 Matrices (Proof of theorem 3.12, algorithm product are optional).		
IV	**Combinatorics and Discrete Probability**		**11**	**Min. 15**
	17	6.1 The Fundamental Counting Principles (Example 6.7 is optional)		
	18	6.2 Permutations - up to and including example 6.13 (Proof of theorem 6.4 is optional)		
	19	6.2 Permutations - Cyclic permutations (Theorem 6.7 and Fibonacci numbers revisited are optional)		
	20	6.4 Combinations (Proof of theorem 6.10, example 6.22, theorem 6.12 and example 6.26 are optional)		
	21	6.8 Discrete Probability- up to and including example 6.49 (Examples 6.45 and 6.47 are optional)		
	22	6.8 Discrete Probability- Mutually exclusive events (Proof of theorem 6.20 is optional)		
V	**Open Ended**		**12**	
	1. Basic calculus concepts such as limits, continuity, differentiation and integration. Relations and Digraphs, Conditional Probability, Multiplication theorem of Probability, Dependent and Independent Events, Probability Distributions, Correlation and Regression, Bisection Method, Regula-Falsie Method, Gauss-Jordan Method.			

References:

1. Discrete Mathematics and Its Applications (7/e), Kenneth H. Rosen, McGraw-Hill, NY (2007).
2. Discrete Mathematics with Applications(4/e), Susanna S Epp, Brooks/ Cole Cengage Learning (2011).
3. Discrete Mathematics, Gary Chartrand, Ping Zhang, Waveland Press (2011).

Note: 1) Optional topics are exempted for end semester examination. 2) Proofs of all the results are also exempted for the end semester exam.

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	3	1	3	2	3	1	2
CO 2	3	2	3	2	3	2	3	1	2
CO 3	2	1	3	2	3	2	3	1	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B.Sc Mathematics Honours			
Course Code	MAT2MN104			
Course Title	**GRAPH THEORY AND AUTOMATA**			
Type of Course	**Minor**			
Semester	II			
Academic Level	100 - 199			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites	Higher Secondary Mathematics			
Course Summary	This course introduces students to Graph Theory and Automata, covering topics such as graphs, adjacency matrices, and isomorphic graphs in Module I. In Module II, it explores Eulerian and Hamiltonian graphs, including paths, cycles, and connected graphs. Module III focuses on Planar Graphs, Graph Coloring, Trees, and Spanning Trees. Finally, Module IV delves into Automata, covering concepts like formal languages, grammars, and finite state automata.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Analyse Graph Structures and Properties	E	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Apply Algorithms to Eulerian and Hamiltonian Graphs	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Explore Formal Languages and Finite State Automata	E	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Text: Discrete Mathematics with Applications, Thomas Koshy, Academic Press (2003), ISBN: 978-0124211803.				
Module	**Unit**	**Content**	**Hrs (48 +12)**	**Ext. Marks (70)**
I		**Graphs**	**14**	**Min. 15**
	1	8.1 Graphs - Graph, Simple Graph (Example 8.3 is optional).		
	2	8.1 Graphs - Adjacency and Incidence, Degree of a Vertex, Adjacency Matrix (Example 8.5 and proof of Theorem 8.2 are optional).		
	3	8.1 Graphs – Subgraph of a Graph.		
	4	8.1 Graphs - Complete Graph, Cycle and Wheel Graphs (Fibonacci and Paraffins, Lucas and Cycloparaffins are optional).		
	5	8.1 Graphs - Bipartite graph, Complete Bipartite Graph, Weighted Graph (Graphs and Telecommunications, Graphs and Local Area Networks and A Generalised Handshake Problem are optional).		
	6	8.3 Isomorphic Graphs.		
II		**Eulerian and Hamiltonian graphs**	**10**	**Min. 15**
	7	8.4 Paths, Cycles and Circuits – Path, Independent Subsets of the Vertex set, Cycle and Circuit (Proof of theorem 8.3, 8.5, example 8.20 and example 8.21 are optional).		
	8	8.4 Paths, Cycles and Circuits – Connected Graphs (Proof of theorem 8.3, 8.5, example 8.20 and example 8.21 are optional).		
	9	8.5 Eulerian and Hamiltonian graphs- Eulerian Graph (Proof of theorem 8.7, example 8.26, Algorithm Eulerian graph, example 8.27, Algorithm Eulerian circuit, proof of theorem 8.8, example 8.31).		

	10	8.5 Eulerian and Hamiltonian graphs- Hamiltonian Graph (Knight's tour problem, example 8.34, Travelling Salesperson Problem, Example 8.35 are optional)		
III	**Planar Graphs and Trees**		**11**	**Min. 15**
	11	8.6 Planar Graphs- Planar Graph (Proofs of theorems 8.11 and 8.12 are optional).		
	12	8.6 Planar Graphs- Degree of a Rregion, Homeomorphic Graphs.		
	13	8.7 Graph Coloring- Graph Coloring, Chromatic Number, The Four-Color Problem (Example 8.27 is optional).		
	14	9.1 Trees- Trees (Proof of theorem 9.1 and 9.2 are optional).		
	15	9.2 Spanning Trees - Spanning Trees, Kruskal's Algorithm for a Spanning Tree.		
IV	**Automata**		**13**	**Min. 15**
	16	2.1 The Concept of Sets – Alphabet, Length of a Word, Language, Concatenation.		
	17	11.1 Formal Languages - Equality of Words, Concatenation of Languages (Examples 11.2, 11.3, 11.5 and Proof of Theorem 11.1 are optional).		
	18	11.1 Formal Languages – Kleene Closure.		
	19	11.2 Grammars – Grammars, Phase Structure Grammar.		
	20	11.2 Grammars – Derivation and Language.		
	21	11.3 Finite State Automata – up to and including Example 11.30 (Example 11.27 is optional).		
	22	11.3 Finite State Automata – Equivalent Finite State Automata up to and including example 11.35.		
V	**Open Ended Module**		**12**	
	Computer representation of graphs, minimal spanning trees, rooted trees, Digraphs and Finite state machines			

References:

1. Discrete Mathematics and Its Applications (7/e), Kenneth H. Rosen, McGraw-Hill, NY (2007).

2. Discrete Mathematics with Applications (4/e), Susanna S Epp, Brooks/ Cole Cengage Learning (2011).

3. A First Look at Graph Theory, John Clark and Allan Holton, Allied Publishers (1991).

Note: 1) Optional topics are exempted for end semester examination. 2) Proofs of all the results are also exempted for the end semester exam.

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	1	2	1	1	0	3	0	0
CO 2	2	1	2	0	1	1	2	0	0
CO 3	2	1	2	0	1	1	3	0	0

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours
Course Code	MAT3MN204
Course Title	**BOOLEAN ALGEBRA AND SYSTEM OF EQUATIONS**
Type of Course	**Minor**
Semester	III
Academic Level	200-299

Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60

Pre-requisites	MAT1MN203 and MAT2MN203
Course Summary	This course comprises four main modules: Lattice, Boolean Algebra, System of Equations, and Eigenvalue and Eigenvectors. Module I introduce concepts like ordered sets and lattices, while Module II explores Boolean Algebra and its applications. Module III covers linear systems of equations, including Gauss elimination and determinants. Finally, Module IV delves into Eigenvalue and Eigenvectors, offering insights into matrix properties and applications.

Course Outcome

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Analyse Lattices and Boolean Algebra	E	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Apply Matrix Operations and Linear Systems	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Investigate Eigenvalue and Eigenvector Problems	An	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Textbook	1. Theory and Problems of Discrete mathematics (3/e), Seymour Lipschutz, Marc Lipson, Schaum's Outline Series. 2. Advanced Engineering Mathematics (10/e), Erwin Kreyzsig, Wiley India.			
Module	**Unit**	**Content**	Hrs (48 +12)	**Ext. Marks (70)**
I		**Lattice (Text 1)**	12	Min 15
	1	14.2 Ordered set		
	2	14.3 Hasse diagrams of partially ordered sets		
	3	14.5 Supremum and Infimum		
	4	14.8 Lattices		
	5	14.9 Bounded lattices, 14.10 Distributive lattices		
	6	14.11 Complements, Complemented lattices		
II		**Boolean Algebra (Text 1)**	10	Min 15
	7	15.2 Basic definitions		
	8	15.3 Duality		
	9	15.4 Basic theorems		
	10	15.5 Boolean algebra as lattices		
	11	15.8 Sum and Product form for Boolean algebras		
	12	15.8 Sum and Product form for Boolean algebras - Complete Sum and Product forms		
III		**System of Equations (Text 2)**	14	Min 15
	13	7.1 Matrices, Vectors: Addition and Scalar Multiplication		
	14	7.2 Matrix Multiplication (Example 13 is optional)		
	15	7.3 Linear System of Equations- Gauss Elimination		
	16	7.4 Linear Independence- Rank of a matrix- Vector Space (Proof Theorem 3 is optional)		

	17	7.5 Solutions of Linear Systems- Existence, Uniqueness (Proof of Theorem 1, Theorem 2 and Theorem 4 are optional)		
IV	**Eigen Value and Eigen Vectors (Text 2)**		12	Min 15
	18	7.6 Second and Third Order Determinants- up to and including Example 1		
	19	7.6 Second and Third Order Determinants- Third order determinants		
	20	7.7 Determinants- Cramer's Rule (Proof of Theorem 1, Theorem 2, Theorem 3 and Theorem 4 are optional)		
	21	7.8 Inverse of a Matrix- Gauss- Jordan Elimination (Proof Theorem 1, Theorem 2, Theorem 3 and Theorem 4 are optional)		
	22	8.1 The Matrix Eigenvalue Problem- Determining Eigenvalues and Eigenvectors (Proof of Theorem 1 and Theorem 2 are optional)		
V	Open Ended Module		12	
	Relation on a set, Equivalence relation and partition, Isomorphic ordered sets, Well-ordered sets, Representation theorem of Boolean algebra, Logic gates, Symmetric, Skew-symmetric and Orthogonal matrices, Linear Transformation.			

References:

1. Howard Anton & Chris Rorres, Elementary Linear Algebra: Application (11/e) : Wiley

2. Ron Larson, Edwards, David C Falvo : Elementary Linear Algebra (6/e), Houghton Mi_in

Harcourt Publishing Company (2009)

3. Thomas Koshy - Discrete Mathematics with Applications-Academic Press (2003)

4. George Gratzer, Lattice theory: First concepts and distributive lattices. Courier Corporation (2009)

Note: 1) Optional topics are exempted for end semester examination. 2) Proofs of all the results are also exempted for the end semester exam.

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	1	3	2	3	1	3	1	2
CO 2	3	2	3	2	3	2	3	1	2
CO 3	3	2	3	2	3	2	3	1	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours				
Course Title	**MATRIX THEORY**				
Course Code	MAT1MN105				
Type of Course	**Minor**				
Semester	I				
Academic Level	100 – 199				
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours	
	4	4	-	60	
Pre-requisites	Higher Secondary Algebra				
Course Summary	This course provides a comprehensive introduction to linear algebra, focusing on systems of linear equations, matrix algebra, determinants, and Euclidean vector spaces. Through a blend of theoretical concepts and practical applications, students will develop a strong foundation in linear algebra techniques and their uses in various fields.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the fundamental operations and concepts of systems of linear equations, including Gaussian elimination and elementary row operations, leading to an understanding of matrix algebra	U	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Apply the properties of determinants to evaluate them using cofactor expansions and row reduction techniques, and comprehend the relationships between matrices and determinants.	Ap	P	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO3	Explore the geometry and properties of Euclidean vector spaces, including norms, dot products, distances, orthogonality, and the cross product.	An	C	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Text : Howard Anton and Chriss Rorres, Elementary Linear Algebra (11/e), Applications version, Wiley

Module	Unit	Content	Hrs (48 +12)	Ext. Marks (70)
I		**System Of Linear Equations**	12	
	1	Section 1.1: -Introduction to systems of linear equations – up to and including Example 5		
	2	Section 1.1: - Rest of the section.		
	3	1.2 :- Gaussian Elimination – up to Example 5		
	4	Section 1.2; - From Example 5 onwards.		
	5	Section 1.3: - Matrices and Matrix Operations – up to and including Example 7.		
	6	Section 1.3; - Rest of the section.		
II		**Matrix Algebra**	12	
	7	Section 1.4: - Inverses; Algebraic Properties of Matrices - up to and including Example 6.		
	8	Section 1.4; - Properties of inverses onwards – up to and including Example 12.		
	9	Section 1.4: - Rest of the section.		
	10	Section 1.5; - Elementary matrices and a method for finding inverse (Proof of Theorem 1.5.3 is optional)		
	11	Section 1.6: - More on Linear systems and Invertible Matrices (Proofs of all the theorems are optional)		
	12	Section 1.7; - Diagonal, Triangular and Symmetric Matrices (Proof of theorem 1.7.1 is optional)		
III		**Determinants**	12	
	13	Section 2.1 :- Determinants by Cofactor expansions		
	14	Section 2.2; - Evaluating determinants by row reduction		
	15	Section 2.3: - Properties of determinants; Cramer's Rule – up to and including Theorem 3.2.5 (proofs of all the results are optional).		
	16	Section 2.3;- up to and including Example 7.		
	17	Section 2.3;- rest of the section.(proofs of all the results are optional)		
IV		**Euclidean Vector Spaces**	12	
	18	Section 3.1:- Vectors in 2-space, 3-space and n-space		
	19	Section 3.2:- Norm , dot product and distance in R^n (proofs of all the results are optional).		
	20	Section 3.3: - Orthogonality (proofs of all the results are optional).		
	21	Section 3.4:-The geometry of linear systems.		
	22	Section 3.5:-Cross product (Proof of Theorem 3.5.4 is optional)		
V		**Open Ended Module**	12	
		Matrix Transformations, Combinatorial approach to determinants, Rank of Matrix (From reference 1) Orthogonal Matrices (from reference 1)		

References:

1. Advanced Engineering Mathematics, 6th Edition, Dennis G. Zill, Jones & Bartlett Learning LLC (2018) ISBN: 978•1•284•10590•2.
2. Advanced Engineering Mathematics, Erwin Kreyzsig, 10th Edition, Wiley India.
3. Linear Algebra and its Applications: 3rd Edition, David C. Lay, Pearson Publications

Note: 1) Optional topics are exempted for end semester examination. (2) Proofs of all the results are exempted for external exam. (3) 70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	3	1	2	2	3	1	2
CO 2	3	2	3	1	2	2	3	1	2
CO 3	2	1	3	1	3	2	3	1	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT2MN105			
Course Title	**VECTOR SPACES AND LINEAR TRANSFORMATIONS**			
Type of Course	**Minor**			
Semester	II			
Academic Level	100 – 199			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites	Linear Algebra Course in Semester 1 - Vectors and Matrices			
Course Summary	This course delves into advanced concepts in linear algebra, focusing on general vector spaces, basis and dimension, matrix transformations, and eigenvalues and diagonalization. The course builds on foundational linear algebra principles and explores their applications in higher-dimensional spaces and complex transformations.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Define and apply concepts related to vector spaces, including understanding vector space axioms, subspaces, and the solution space of homogeneous systems.	U	C	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO2	Explore the concepts of linear independence, coordinates, basis, and dimension within vector spaces, including computing basis vectors and understanding coordinate systems relative to a basis.	Ap	P	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO3	Analyse and apply matrix transformations, including basic transformations in R2R2 and R3R3, understanding properties of these transformations, and exploring concepts related to eigenvalues, eigenvectors, and diagonalization of Amatrices.	An	C	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Text: Howard Anton and Chriss Rorres, Elementary Linear Algebra (11/e), Applications version, Wiley

Module	Unit	Content	Hrs (60)	Ext. Marks (70)
I		**General Vector Spaces**	12	
	1	Section 4.1: -Real vector spaces – up to and including Example 8.		
	2	Section 4.1:- Rest of the section.		
	3	Section 4.2: - Subspaces (examples 7, 8 are optional) – up to and Example 10.		
	4	Section 4.2: - From Example 10 to Example 15 (proof of theorem .4.2.3 is optional)		
	5	Section 4.2: - Rest of the section (Linear transformation view point is optional)		
II		**Basis And Dimension**	12	
	6	Section 4.3: - Linear independence – up to and including Theorem 4.3.3		
	7	Section 4.3: - Rest of the section (proofs of all the results are optional).		
	8	Section 4.4:- Coordinates and Basis -up to and including Example 5		
	9	Section 4.4: - rest of the section from Theorem 4.4.1.		
	10	Section 4.5:-Dimension – up to and including Example 3.		
	11	Section 4.5: - Rest of the section from Example 3 (proofs of all the theorems are optional).		
III		**Matrix Transformations**	12	
	12	Section 4.9: - Basic matrix transformations in R^2 and R^{3}- Reflection operators, Projection operators		
	13	Section 4.9:- Rotation Operators – Rotation in R^3		
	14	Section 4.9:- Rest of the section.		
	15	Section 4.10: - Properties of Matrix Transformations – up to and including Example 4.		
	16	Section 4.10:- rest of the section (proofs of theorems are optional)		
	17	Section 4.11: - Geometry of Matrix Operators on R^2 (proof of Theorem 4.11.2 is optional)		
IV		**Eigen Values and Diagonalization**	12	
	18	Section 5.1:- Eigen values and eigen vectors – up to Theorem 5.1.3		
	19	Section 5.1; -From Theorem 5.1.3 to Example 7 (including)		
	20	Section 5.1: - Rest of the section (Eigen values of general linear transformation is optional)		
	21	Section 5.2: - Diagonalization – up to and including Example 4 (proofs of theorems are optional)		
	22	Section 5.2; - Rest of the section (Geometric and algebraic multiplicity are optional)		
V		**OPEN ENDED**	12	
		Rank space, Null space and Rank- Nullity theorem, General Linear transformations and Matrix representation, Eigen values of general linear transformation, Geometric and algebraic multiplicity.		

References:

1 Advanced Engineering Mathematics, 6th Edition, Dennis G. Zill, Jones & Bartlett Learning LLC (2018) ISBN: 978-1-284-10590-2.
2. Advanced Engineering Mathematics, Erwin Kreyzsig, 10th Edition, Wiley India.
3. Linear Algebra and its Applications: 3rd Edition, David C. Lay, Pearson Publications

Note: 1) Optional topics are exempted for end semester examination. (2) Proofs of all the results are exempted for external exam. (3) 70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	1	3	1	1	1	3	0	0
CO 2	2	1	2	1	1	1	2	0	0
CO 3	2	1	3	1	1	1	3	0	0

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT3MN205			
Course Title	**OPTIMIZATION TECHNIQUES**			
Type of Course	**Minor**			
Semester	III			
Academic Level	200 - 299			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites	Basic understanding of linear algebra and introductory optimization concepts.			
Course Summary	This course provides a comprehensive exploration of linear programming and optimization techniques, focusing on graphical methods, the simplex method, and specialized problems like transportation and assignment. Students will gain practical skills in formulating, solving, and analyzing linear programming models, with applications in various optimization scenarios.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Describe the fundamental properties and types of linear programming models, distinguishing between maximization and minimization models, and explain various methods used for solving linear programming problems including graphical methods.	U	C	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO2	Apply the simplex method to solve both maximization and minimization linear programming problems, compare the graphical method with the simplex method in terms of efficiency and applicability, and demonstrate problem-solving skills through worked-out examples.	Ap	P	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO3	Evaluate and solve transportation and assignment problems using specific techniques such as the North-West corner method, Least Cost cell method, Vogel's approximation method, and the Hungarian method, while also comparing the transportation model with general linear programming models.	An	C	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam

Detailed Syllabus:

Text book	Operations Research (2/e), P Rama Murthy ,New Age International Publishers

Module	Unit	Content	Hrs (48 +12)	Ext. Marks (70)
I		**Linear Programming Models: (Graphical Method)**	**10**	**Min 15**
	1	Section 2.1- Introduction, 2.2- Properties of Linear Programming Model		
	2	Section 2.3-Maximization Models		
	3	Section 2.4- Minimization Models		
	4	Section 2.5- Methods for the Solution of a Linear Programming Problem (up to Problem 2.9)		
	5	Section 2.5- Methods for the Solution of a Linear Programming Problem (From Problem 2.9)		
II		**Linear Programming Models: (Simplex Method)**	**13**	**Min 15**
	6	Section 3.1- Introduction, 3.2- Comparison Between Graphical and Simplex Methods		
	7	Section 3.3- Maximisation Case		
	8	Section 3.4- Minimisation Case		
	9	Section 3.5- Worked Out Problems- Maximization		
	10	Section 3.7- Minimisation Problems		
III		**Linear Programming Models: (Two Phase Simplex Method and Transportation Problem)**	**11**	**Min 15**
	11	Section 3.8- Mixed Problems		
	12	Section 3.10- Artificial Variable Method or Two Phase Method		
	13	Section 3.11- Degeneracy in Linear Programming Problems		
	14	Section 4.1 , 4.2 Transportation model		
	15	Section 4.3 – Comparison between Transportation model and general linear programming model, 4.4- Approach to solution to a transportation problem by Transportation Algorithm.		
IV		**Linear Programming Models: (Transportation Problem and Assignment Problem)**	**14**	
	16	Section 4.4.3- Basic feasible solution by North -West corner method		**Min 15**
	18	Section 4.4.4- Solution by Least Cost cell method		
	19	Section 4.4.5- Solution by Vogel's approximation method		
	20	Section 4.4.6- Optimality test- Stepping stone method (Modified distribution method is in open ended module)		
	21	Section 5.1, 5.2 – Assignment model,		
	22	Section 5.4- Approach to solution-Hungarian method(Other methods of solution are optional)		
V		**Open Ended Module**	**12**	
	Simplex method special Cases- Alternate solution. Unbound Solutions ,Problem with Unrestricted Variables Transportation model- Modified distribution method Game theory			

References :

1. KV Mittal and C Mohan, Optimization methods in Operations research and system analysis(3/e)

2. Kanti Swarup, PK Gupta and Manmohan, Operations Research(20/e)

Note: 1) Optional topics are exempted for end semester examination. (2) Proofs of all the results are exempted for external exam. (3) 70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	1	3	2	3	2	3	1	2
CO 2	3	2	3	2	3	2	3	1	2
CO 3	3	2	3	2	3	2	3	1	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT1MN106			
Course Title	**PRINCIPLES OF MICRO ECONOMICS**			
Type of Course	**Minor**			
Semester	I			
Academic Level	100 - 199			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites	Higher Secondary Mathematics			
Course Summary	Explore market behaviour in Demand and Supply Analysis, focusing on utility, the law of demand, supply, and elasticity, and delve into Cost and Revenue Functions to understand cost structures, revenue functions, and their relation to demand elasticity. Explore the Theory of Consumer Behaviour to comprehend utility maximization and rational consumer choices, then apply economic optimization techniques using derivatives in Economic Applications to optimize functions and solve constrained optimization problems efficiently.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Analyse the factors affecting demand and supply and determine market equilibrium.	An	C	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO2	Apply the concepts of cost and revenue functions to analyze short-run and long-run production decisions.	Ap	P	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO3	Evaluate economic functions and optimize using derivatives and Lagrange multipliers.	E	C	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Text Book		1. Principles Of Microeconomics, 15^{th} revised edition H.L.Ahuja, S.Chand 2. Introduction to Mathematical Economics, 3^{rd} edition, Edward.T.Dowling, Schaum's Outline series, TMH		
Module	**Unit**	**Content**	**Hrs (48 +12)**	**Ext. Marks (70)**
I		**Demand and Supply Analysis Text(1) (Relevant sections of chapter 5 and 7)**	**13**	
	1	Utility and demand, the meaning of demand and quantity demanded		
	2	The law of demand- demand curve- market demand curve		
	3	Reasons for the law of demand- slope of a demand curve		
	4	Shift in demand- demand function and demand curve		
	5	The meaning of supply- supply function- law of supply		
	6	Slope of a supply curve- shift in supply- market equilibrium		
	7	Price elasticity if demand- measurement of price elasticity- arc elasticity of demand- cross elasticity of demand		
II		**Cost and Revenue Functions Text (2) (Relevant sections of chapter 19and 2)**	**12**	
	8	Cost function- Average Cost(AC) and Marginal Cost(MC)		
	9	Short run costs: Total Fixed and Variable Cost- Short Run average cost curve- Average Variable Cost(AVC)- Relationship between AVC and Average product- Average Total Cost- Marginal Cost		
	10	Long run costs: Long Run Average Cost Curve- relationship of Long run Average Cost Curve(LAC) and Long run Marginal Cost Curve(LMC) with SAC and SMC		
	11	Revenue function, Marginal Revenue(MR) and Average Revenue(AR)		
	12	Relation between MR, AR and elasticity of demand		
III		**Theory Of Consumer Behaviour Text(1) (Relevant sections of chapter 9 and 11)**	**10**	
	13	Cardinal utility analysis- the law of diminishing marginal utility- illustration of law of diminishing marginal utility		
	14	The law of equi-marginal Utility		
	15	Indifference curves- ordinal utility		
	16	Marginal rate of substitution- properties of indifference curves		
IV		**Economic Applications of Derivatives Text (2) (Chap-4:sec.4.7&4.8 ,Chap 5,Chap6:sec.6.1-6.6)**	**13**	
	17	Economic application of derivatives- marginal, average, total concepts		

	18	Optimizing economic function		
	19	Functions of several variables and partial derivatives		
	20	Second order partial derivatives, optimization of multivariable function		
	21	Constrained optimization with Lagrange multipliers		
	22	Significance of Lagrange multipliers, total differential		
V		**Open Ended**	**1**	
	Derivative of a function, first order derivative, second order derivative, local maxima, local minima, optimization			

References:

1. RGD Allen, Mathematical analysis for economists Macmillan
2. Geoff Renshaw: Maths for Economics(3/e) Oxford University Press, N.Y. (2012) ISBN 978•0•19•96212•4

Note: 1) Proofs of all the results are exempted for external exam. (2) 70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	3	2	3	2	3	1	2
CO 2	2	1	3	2	3	2	3	1	2
CO 3	3	2	3	1	3	2	3	1	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours				
Course Code	MAT2MN106				
Course Title	**OPTIMIZATION TECHNIQUES IN ECONOMICS**				
Type of Course	**Minor**				
Semester	II				
Academic Level	100 - 199				
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours	
	4	4	-	60	
Pre-requisites	Higher Secondary Mathematics				
Course Summary	This course examines the causes, effects, and measures of income inequality, including its measurement using tools like the Lorenz curve and Gini ratio. It explores calculus of several variables, focusing on directional derivatives, gradients, and optimization techniques, both constrained and unconstrained, with applications in economic contexts such as profit maximization and monopolistic practices. Additionally, the course covers input-output analysis, introducing technological coefficient matrices and models to analyse economic equilibrium and production functions.				

Course Outcomes (CO):

CO	**CO Statement**	**Cognitive Level***	**Knowledge Category#**	**Evaluation Tools used**
CO1	Analyse the causes and effects of income inequality and evaluate the measures used to reduce it.	An	C	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO2	Apply the principles of calculus to optimize economic functions without constraints.	Ap	P	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO3	Evaluate constrained optimization problems using appropriate mathematical techniques.	E	P	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Text book:		1. M.L.Jhingan: Micro Economic Theory(6/e), Vrinda publications 2. Carl.P.Simon, Lawrence Blume: Mathematics for Economists W.W. Nortan& Company, Inc(1994) ISBN 0•393•95733•O 3. Mehta• Madnani: Mathematics for Economics Revised Edn S. Chand.		
Module	**Unit**	**Content**	**Hrs (48 +12)**	**Ext. Marks (70)**
I		**Inequalities in Income Text (1)(Chapter 47)**	**10**	
	1	Inequalities in Income- Causes of inequality		
	2	Effects of inequality – measures to reduce inequality		
	3	Measurement of inequality of income- Lorenz curve Gini ratio		
II		**Calculus of Several Variables and Unconstrained Optimization Text(2)(Chap:14:sec.14.6,14.7,14.8,Chap 17: sec.17.1-17.5)**	**14**	
	4	Directional derivatives and gradients, the gradient vector		
	5	Approximation by differential Jacobian derivative		
	6	The chain rule, higher order derivative		
	7	Second order derivatives and Hessians		
	8	Young's theorem, economical applications		
	9	Unconstrained optimization: definitions, first order conditions, second order conditions		
	10	Global maxima and minima, global maxima of concave functions		
	11	Economic applications- profit maximising firm- discriminating Monopolist		
	12	Least square analysis		
III		**Constrained Optimization Text (2) (Chap 18: sec.18.1-18.7)**	**12**	
	13	First order conditions: objective function, constraint functions, examples		
	14	Equality constraints, two variables and one equality constraints, several equality constraints		
	15	Ineuality constraints, one inequality constraints, several inequality constraints		

	16	Mixed constraints, constrained minimization problems		
	17	Kuhn-Tucker formulation, examples and applications		
IV		**Input output analysis Text(3) (Chap 19 :sec.19.1-19.7,19.9,19.11,19.13)**	**12**	
	18	Introduction- assumption- technological coefficient matrix		
	19	Closed and open input output model- coefficient matrix and open model		
	20	The Hawkins- Simon conditions- solution for two industries		
	21	Determination of equilibrium of prices- coefficient matrix and closed model		
	22	The Leontief production function- limitation of input output analysis		
V		**Open Ended Module**	**12**	
	The total derivative,The chain rule,Level curves and their tangents,Concave and Convex Functions			

References:

1. R G D Allen: Mathematical analysis for economists Macmillain
2. A C Chiang& K Wainwright: Fundamentals of Mathematical Economics(4/e) McGraw Hill
3. Michael D Intriligator: Mathematical Optimization and Economic Theory Classics in Applied Mathematics, SIAM(2002)

Note: 1) Proofs of all the results are exempted for external exam. (2) 70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	2	3	2	2	1	3	2	1
CO 2	3	2	3	1	2	1	3	1	1
CO 3	2	2	3	1	2	1	3	1	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT3MN206			
Course Title	**APPLIED MATHEMATICS FOR ECONOMIC ANALYSIS**			
Type of Course	**Minor**			
Semester	III			
Academic Level	200 - 299			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites	Higher Secondary Mathematics			
Course Summary	This course covers differential and difference equations and their economic applications. It explores production functions, including the law of variable proportions, isoquants, and optimization of Cobb-Douglas and CES functions. Additionally, it introduces econometrics, focusing on regression analysis and econometric methodology.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Apply differential and difference equations to model and solve economic problems.	Ap	P	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO2	Analyse production functions to understand the relationship between inputs and outputs, including optimization techniques.	An	C	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO3	Evaluate econometric models to interpret statistical relationships and economic variables.	E	C	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Text Books	1. Edward.T.Dowling: Introduction to mathematical Economics, Schaum's Outline series, 3rd edition TMH 2. SPsingh, AP Parashar, HP singh: Econometrics and Mathematical Economics, S.Chand 3. Damodar N Gujarati and Sangeeta: Basic Economics(4/e) TMH Indian Reprint, 2008			
Module	**Unit**	**Content**	**Hrs (48 +12)**	**Ext. Marks (70)**
I		**Differential and Difference Equations Text(1) (Chapter 16, 17)**	**12**	
	1	Differential Equation: definition and concepts		
	2	First order linear differential equation, exact differential equations, integrating factors		
	3	Separation of variables, Economic applications		
	4	Difference equations: definitions and concepts		
	5	First order linear difference equations, Economic applications		
	6	The Cobweb Model, the Harrod model		
II		**The Production Function Text (2) (Chapter 14: sec 14.1-14.9)**	**10**	
	7	Meaning and nature of production function, the Law of Variable Proportions		
	8	Isoquants, Marginal Rate of Technical Substitution(MRTS)		
	9	Producers' equilibrium, expansion of path.		
	10	The elasticity of substitution, ridge lines and Economic region of production		
III		**The Production Function(contd.) and Euler's theorem Text(1&2) (Chapter 14: sec 14.10-14.3 of text 2, Chap 6: sec 6.9 &6.10 of text 1)**	**14**	
	11	Euler's theorem(Statement only), Euler's theorem and homogenous production function		
	12	Cobb Douglas production function, properties, limitations		
	13	CES production function, properties, advantages, limitations		
	14	Returns to scale, Cobb Web theorem		
	15	Optimization of Cobb Douglas, Optimization of CES production Function		
IV		**Econometrics Text(3) (Pages 1 to 59)**	**12**	
	16	Introduction to econometrics		
	17	Statistical v/s deterministic relationships, regression v/s correlation		
	18	Types of data, Measurements of Economic variables		
	19	Methodology of Econometrices		
	20	Two variable regression analysis		
	21	Population regression function (PRF), Stochastic specification of PRF		
	22	Sample regression function (SRF)		

V	Open Ended Module	12	
	Matrix solution of Simultaneous Differential and Difference equations,Differentiation of Exponential and Logarithamic functions		

References:
1. RGD Allen Mathematical Analysis for Economists MacMillan
2. AC Chiang & K Wainwright: Fundamentals of Mathematical Economics (4/e,) McGraw Hill
3. Jeffrey.M. Wooldridge: Introductory Econometrics: A modern Approach (6/e), Cengage learning 2016

Note: 1) Proofs of all the results are exempted for external exam. (2) 70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.

Mapping of COs with PSOs and POs :

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	1	3	2	3	2	3	1	2
CO 2	3	1	3	2	3	2	3	1	2
CO 3	2	3	3	2	3	2	3	1	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

DOUBLE MAJOR COURSES

(Courses other than listed in the pathways 1 – 4)

Programme	B. Sc. Mathematics Honours				
Course Title	**ELEMENTARY LINEAR ALGEBRA**				
Type of Course	**Double Major**				
Semester	IV				
Academic Level	200 – 299				
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours	
	4	3	2	75	
Pre-requisites	1. Mathematical Logic and necessary exposure to set theory. 2. Basic Calculus				
Course Summary	After introducing the basic notions in set theory, the course develops into the construction of the Real number system. Thereafter Real functions are introduced and the notion of limit is developed in a rigorous way..				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Analyse the properties and relationships within vector spaces, eigenvalues, eigenvectors, and orthogonality, demonstrating proficiency in identifying subspaces, bases, eigen decomposition, and orthogonal sets.	An	C	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO2	Apply techniques such as finding null spaces, column spaces, solving characteristic equations, diagonalizing matrices, and performing QR factorization.	Ap	P	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO3	Evaluate the significance and utility of results such as Spectral theorem and singular value decomposition in various applications	E	M	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Text	Linear Algebra and its Applications, Third Edition, David .C. Lay, Pearson Publications.			
Module	**Unit**	**Content**	**Hrs (45+30)**	**External Marks (70)**
I		**Vector Spaces**	**14**	**20**
	1	Section 4.1 – Vector Spaces and Subspaces		
	2	Section 4.2 – Null Spaces, Column Spaces and Linear Transformations.		
	3	Section 4.2 – The Column Space of a Matrix.		
	4	Section 4.2 – Kernel and Range of a Linear Transformation.		
	5	Section 4.3 – Linearly Independent; Bases.		
	6	Section 4.3 – Bases for Nul A and Col A.		
		Continue the study of sections 4.5 to 4.6 in the practicum mode as instructed.		
II		**Eigen Values and Eigen Vectors**	**11**	**20**
	7	Section 5.1 – Eigen Vectors and Eigen Values.		
	8	Section 5.2 – The Characteristic Equation.		
	9	Section 5.2 – Similarity of Matrices.		
	10	Section 5.3 - Diagonalization		
	11	Section 5.3 – Diagonalizing Matrices		
III		**Orthogonality**	**10**	**15**
	12	Section 6.1 – Inner Product, Length and orthogonality.		
	13	Section 6.1 – Orthogonal Vectors (Orthogonality)		
	14	Section 6.2 – Orthogonal Sets.		
	15	Section 6.2 – Orthonormal sets.		
	16	Section 6.4 – The Gram – Schmidt Process – Orthonormal Bases		
	17	Section 6.4 – QR Factorization of Matrices		
IV		**Singular Value Decomposition**	**10**	**15**
	18	Section 7.1 – Diagonalization of Symmetric Matrices.		
	19	Section 7.1 – The Spectral Theorem.		
	20	Section 7.2 - Quadratic Forms - Change of Variable and Geometric View of Principal Axes omitted.		
	21	Section 7.2 – Quadratic Forms – Classifying Quadratic Forms.		
	22	Section 7.4 - The Singular Value Decomposition – (applications are omitted for exam)		
V		Practicum: The goal is for the students to learn the following selected topics via self-study and group activities. The lecturer may assist by running and overseeing group discussions and class seminars and referring library books for self-study and note preparations.	**30**	**-**

		Chapters 1 to 3 of the textfor giving an introduction and motivation to the concepts of vector spaces, subspaces, Linear dependence and independence, Linear Transformations and theirrelations with matrices.		
		Section 4.4 – Coordinate Systems.		
		Section 4.4 – The Coordinate Mapping.		
		Section 4.5 – The Dimension of a Vector Space.		
		Section 4.5 – Subspaces of a Finite Dimensional Space.		
		Section 4.6 – Rank.		
		Section 4.6 – The Rank Theorem.		

References

1. Elementary Linear Algebra: Application Version,11/e, Howard Anton & Chris Rorres Wiley
2. Algebra Done Right, 3/e, Sheldon Axler, Springer Nature,2015.
3. Introduction to Linear Algebra, 6/e, Gilbert Strang, Wellesley•Cambridge Press.
4. Basic Linear Algebra, 2/e, T. S. Blyth and E.F. Robertson, Springer, 2002.
5. Linear Algebra, 2/e, Hoffman K and Kunze R, Prentice Hall of India,1991.
6. Bretscher, Otto. *Linear algebra with applications*. Vol. 52. Eaglewood Cliffs, NJ: Prentice Hall, 1997.
7. Blyth, Thomas Scott, and Edmund F. Robertson. *Basic linear algebra*. Springer Science & Business Media, 2013.

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Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	2	2	3	1	3	2	3	1	2
CO 2	3	3	3	2	3	1	3	2	3	1	2
CO 3	3	3	2	3	3	1	3	2	3	1	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours				
Course Title	**REAL ANALYSIS**				
Type of Course	**Double Major**				
Semester	IV				
Academic Level	200 – 299				
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours	
	4	3	2	75	
Pre-requisites	1. Mathematical Logic and necessary exposure to set theory. 2. Basic Calculus				
Course Summary	After introducing the basic notions in set theory, the course develops into the construction of the Real number system. Thereafter Real functions are introduced and the notions of limit and continuity are developed.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Analyse sequences and their limits, apply limit theorems, and demonstrate understanding of monotone sequences and apply the Bolzano Wierstrass theorem and its implications on sub sequences.	An	C	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO2	To apply the concepts of continuous functions, including combinations of continuous functions and their behaviour on intervals. Also demonstrate proficiency in determining uniform continuity and its applications.	Ap	P	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO3	To evaluate Riemann integrals, identify Riemann integrable functions, and apply the Fundamental Theorem of Calculus. Demonstrate proficiency in solving problems related to L'Hospital's Rule, Taylor's Theorem, Pointwise and Uniform Convergence, and Interchange of Limits.	E	P	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Text	Introduction to Real Analysis, 4/e, Robert G Bartle, Donald R Sherbert John Wiley & Sons (2011)				
Module	**Unit**	**Content**	**Hrs (45+30)**	**External Marks (70)**	**Internal Marks**
I		**Sequences and Limits**	**12**	**20**	**10**
	1	Section 3.1 – Sequences and their limits.	3		
	2	Section 3.2 – Limit theorems.	3		
	3	Section 3.3 – Monotone sequences – Euler's number introduction only.	2		
	4	Section 3.4 – Sub sequences and the Bolzano Wierstrass theorem – 3.4.1 to 3.4.9 (second proof of Theorem 3.4.8 is optional)	2		
	5	Section 4.1- Limit of functions (Proofs included in Practicum).	1		
	6	Section 4.2: Limit theorems (Proofs included in Practicum).	1		
II		**Continuous Functions**	**10**	**20**	
	7	Section 5.1 – Continuous functions.	2		
	8	Section 5.2 – Combinations of continuous functions.	2		
	9	Section 5.3 – Continuous functions on Intervals • 5.3.1 to 5.3.5	2		
	10	Section 5.3 – from 5.3.7 to 5.3.10	2		
	11	Section 5.4 – Uniform Continuity - 5.1.1 to 5.4.8	2		
III		**Differentiation**	**10**	**20**	
	12	Section 6.1 – The Derivative – 6.1.1 to 6.1.4	2		
	13	Section 6.1 – from 6.1.5 to 6.1.7	2		
	14	Section 6.2- The Mean Value Theorem - 6.2.1 to 6.2.4	2		
	15	Section 6.2- from 6.2.5 to 6.2.9	2		
	16	Section 6.2- from 6.2.10 to 6.2.13	2		
IV		**The Riemann Integral**	**13**	**15**	
	17	Section 7.1 –Riemann Integral –7.1.1 to 7.1.4 (a)	2		
	18	Section 7.1 – from 7.1.5 to 7.1.7	2		
	19	Section 7.2 – Riemann Integrable functions – 7.2.1 to 7.2.5 (example 7.2.6 is optional)	2		
	20	Section 7.2 – from 7.2.7 to 7.2.13	2		
	21	Section 7.3 – The Fundamental Theorem – 7.3.1 to 7.3.9	3		
	22	Section 7.3 – The Fundamental Theorem – 7.3.10 to 7.3.18	2		

V	**Practicum:** The goal is for the students to learn the following selected topics in 15 practicum sessions of two hours each via self-study and group activities. The lecturer may assist by running group discussions and supervising class seminars and referring library books for self-study and note preparations.	**30**	**-**	**20**
	Session 1: Sets and Functions – Section 1.1			
	Session 2: Mathematical Induction – Section 1.2			
	Session 3: Finite and Infinite Sets – Section 1.3			
	Session 4: The Algebraic and Order Properties of R-Section 2.1			
	Session 5: Absolute Value and the Real Line - Section 2.2			
	Session 6: The Completeness property of R- Section 2.3			
	Session 7: Intervals - Section 2.5			
	Session 8: The Cauchy Criterion – Section 3.5			
	Session 9: Introduction to Infinite Series - Section 3.7			
	Session 10: Section 4.1 – proofs as in Module I			
	Session 11: Section 4.2 - proofs as in Module I			
	Session 12: L'Hospital's Rules - Section 6.1			
	Session 13: Taylor's Theorem - Section 6.4			
	Session 14: Pointwise and Uniform Convergence -Section 8.1			
	Session 15: Interchange of Limits - Section 8.2			
References	1. Tom.M.Apostol, Calculus I, Wiley & Sons. 2. Tom.M.Apostol, Mathematical Analysis, 2/e, Addison•Wesley. 3. Richard R Goldberg, Methods of Real Analysis, 2/e, Wiley 4. Raymond L Wilder, Introduction to the Foundations of Mathematics,2/e, John Wiley & Sons			

Note: 1) Optional topics are exempted for end semester examination (2) 70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	3	2	2	3	1	3	2	3	1	2
CO 2	3	3	2	3	3	1	3	2	3	1	2
CO 3	3	3	3	3	3	1	3	2	3	1	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Title	**COMPLEX ANALYSIS**			
Type of Course	**Double Major**			
Semesters	5/6			
Academic Level	300 - 399			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	3	2	75
Pre-requisites	Basic algebra of numbers, basic Calculus and basic proof techniques.			
Course Summary	This course discusses the concepts of complex numbers. Module-I discusses complex numbers and their properties, complex plane, polar form of complex numbers, powers and roots and sets points in the complex plane. Module-II discusses the complex functions, special power functions such as z^n and $z^{1/n}$. The third module includes the concepts of limits and continuity, Differentiability and analyticity, Cauchy Riemann equations and Harmonic conjugates. Module-IV discusses elementary functions such as Exponential functions, Logarithmic functions, Trigonometric and hyperbolic functions. Final module is an open ended part that includes linear mappings, reciprocal functions, Branch cuts and points, etc...			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understanding the concepts of Complex numbers and their properties.	Ap	C	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO2	To gain a thorough understanding of the algebraic, geometric, and topological aspects of the complex number system, as well as complex variable functions, their limits and continuity.	Ap	C	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO3	To understand harmonic functions and their relationship with analytic functions. Also to understand a few simple analytic functions of complex analysis and their properties.	Ap	C	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Text	Complex Analysis (Third Edition): Dennis G. Zill & Patric D. Shanahan			
Module	**Unit**	**Content**	**Hrs (75)**	**External Marks (70)**
I		**Module I**	**11**	**15**
	1	Section 1.1 Complex Numbers and Their Properties		
	2	Section 1.2 Complex Plane		
	3	Section 1.3 Polar Form of Complex Numbers-up to and including Example 2.		
	4	Section 1.3 Polar Form of Complex Numbers- All the topics after Example 2.		
	5	Section 1.5 Sets of Points in Complex Plane- up to and including Example 2.		
	6	Section 1.5 Sets of Points in Complex Plane -All the topics after Example 2.		
II		**Module II**	**12**	**15**
	7	Section 2.1 Complex Functions		
	8	Section 2.2 Complex Functions as Mappings- up to and including Example 4.		
	9	Section 3.1 Limits and Continuity-Limits (All the topics in 3.1.1)		
	10	Section 3.1 Limits and Continuity-Continuity (Topics in 3.1.2, up to Example 7.)		
	11	Section 3.1 Limits and Continuity-Continuity (Theorem 3.1.4 to up to and including a bounding property.		
III		**Module III**	**10**	**20**
	12	Section 3.2 Differentiability and Analyticity- up to and including Example 2.		
	13	Section 3.2 Differentiability and Analyticity- All the topics after Example 2.		
	14	Section 3.3 Cauchy-Riemann Equations-up to and including Theorem 3.3.2		
	15	Section 3.3 Cauchy Riemann Equations:-All the topics after Theorem 3.3.2.		
	16	Section 3.4 Harmonic Functions		
IV		**Module IV**	**12**	**20**
	17	Section 5.2 Complex Integrals-up to and including Example 2		
	18	Section 5.2 Complex Integrals- All the topics after Example 2		
	19	Section 5.3 Cauchy- Goursat Theorem-up to and including Example 4.		
	20	Section 5.3 Cauchy- Goursat Theorem-All the topics after Example 4.		
	21	Section 5.4 Independence of Path- up to and including Example 1.		
	22	Section 5.4 Independence of Path- All the topics after Example 1.		
V		**Practicum**	**30**	
	Section 5.5 Cauchy's Integral Formulas and Their Consequences- Cauchy's Two Integral Formulas (All the topics in 5.5.1)			
	Section 5.5 Cauchy's Integral Formulas and Their Consequences- Some Consequences of the Integral Formulas (All the topics in 5.5.2)			

	Section 6.1 Sequences and Series- up to and including Example 4.		
	Section 6.1 Sequences and Series- All the topics after Example 4.		
	Section 6.2 Taylor Series-up to and Excluding Theorem 6.2.4.		
	Section 6.2 Taylor Series-From Theorem 6.2.4 to Example 3.		
	Section 6.3 Laurent Series-up to and including Example 1.		
	Section 6.3 Laurent Series- All the topics after Example 1.		
	Section 6.4 Zeros and Poles- Proofs of Theorem 6.4.1, Theorem 6.4.2, Theorem 6.4.3 are omitted.		
	Section 6.5 Residues and Residue Theorem-up to and including Example 3.		
	Section 6.5 Residues and Residue Theorem-All the topics after Example 3.		
	Section 6.6 Some Consequences of the Residue Theorem- Evaluation of Real Trigonometric Functions (up to and including example1 of 6.6.1)		
	Section 6.6 Some Consequences of the Residue Theorem- Evaluation of Real Improper Integrals(up to and including Example 2)		
	Section 6.6 Some Consequences of the Residue Theorem- Theorem 6.6.1 and Example 3.		
	Section 6.6 Some Consequences of the Residue Theorem- Theorem 6.6.2 and Example 4.		

References		
	1	Brown, James Ward, and Ruel V. Churchill. Complex variables and applications. McGraw-Hill,, 2009.
	2	Stein, Elias M., and Rami Shakarchi. Complex analysis. Vol. 2. Princeton University Press, 2010.
	3	Burckel, Robert B. An Introduction to Classical Complex Analysis: Vol. 1. Vol. 64. Birkhäuser, 2012.
	4	Hormander, Lars. An introduction to complex analysis in several variables. Elsevier, 1973.
	5	Priestley, Hilary A. Introduction to complex analysis. OUP Oxford, 2003.
	6	Silverman, Richard A. Introductory complex analysis. Courier Corporation, 2013.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	1	2	3	1	3	2	3	1	2
CO 2	3	3	2	3	3	1	3	2	3	1	2
CO 3	3	3	2	3	3	1	3	2	3	1	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	BSc Mathematics Honours			
Course Title	**INTRODUCTION TO PYTHON AND SCIENTIFIC COMPUTING**			
Type of Course	**SEC – Double Major**			
Semester	IV			
Academic Level	200-299			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	3	2	75
Pre-requisites	(1) Basic knowledge to start a desktop/laptop computer. (2) A basic course in calculus with an understanding of differential and integral calculus. (3) A basic course in matrix algebra (higher secondary level)			
Course Summary	This course introduces the fundamentals of Python with a focus towards mathematical programming. Getting started with Python, Various Interfaces, Variables, Modules, Loops, Lists, Tuples, Functions, Branching, Input and Output, Arrays and Plotting, Dictionaries and Strings and finally Classes and Object-Oriented Programming are introduced. Using the Python programming structure, an introduction to the advanced mathematics software SageMath is given in the last part of the course. Various practical problems making use of concepts from calculus and linear algebra are to be solved using the SageMath software in the open-ended practical part so that the students will come to know how to apply software to answer and compute typical problems from these subjects.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand Basics of Python Programming.	U	C	Internal Exam/ Assignment/ Practical Assessment / Viva/ End Sem Exam
CO2	Intermediate Level Concepts such as Object-Oriented Programming.	An	P	Internal Exam/ Assignment/ Practical Assessment / Viva/ End Sem Exam
CO3	Scientific Computation using SageMath.	E	P	Internal Exam/ Assignment/ Practical Assessment / Viva/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Textbook				
	1. Introduction to Scientific Programming with Python, Joakim Sundnes, Simula SpringerBriefs on Computing, 2020, ISBN: 978-3-030-50356-7. Open Access: https://link.springer.com/book/10.1007/978-3-030-50356-7 2. Sage for Undergraduates, 2nd Ed., Gregory V. Bard, 2022, American Mathematical Society, 2022. ISBN: 978-1470411114. 2014 Online Ed: http://www.people.vcu.edu/~clarson/bard-sage-for-undergraduates-2014.pdf			
Module	**Unit**	**Content**	**Hrs** **(36+ 9)**	**Marks** **Ext: 50**
I		**Python Basics** (Text 1, Ch. 1, 2, 3, 4.)	**8**	**Min.10**
	1	Getting Started (Ch 1). Programming Simple Mathematics (Sec 2.1). Variables and Variable Types (Sec 2.2).		
	2	Formatting Text Output. Importing Modules. (Sec 2.3, 2.4).		
	3	Loops and Lists. Loops for Automating Repeated Tasks. Using Lists to Store Sequences of Data. (Sec 3.1, 3.2, 3.3).		
	4	Iterating over a List with a for Loop.. Nested Lists and List Slicing. (Sec 3.4, 3.5).		
	5	Tuples. (Sec 3.6)		
II		**Functions, Branching, I/O, Modules.**	**8**	Min 10
	6	Programming with Functions.. Function Arguments and Local Variables. Default Arguments and Doc Strings. (Sec 4.1, 4.2, 4.3)		
	7	If Tests for Branching the Program Flow. Functions as arguments to Functions. (Sec 4.4, 4.5)		
	8	Solving Equations with Python Functions. (Sec 4.6)		
	9	Writing Test Functions to Verify Programs (Sec 4.7).		
	10	User Input and Error Handling. Reading Input User Data. Reading Data from Files. Writing Data to Files. (Sections 5.1, 5.3, 5.4. Section 5.2 omitted).		
	11	Handling Errors in Programs. (Sec 5.5)		
	12	Making Modules. (Sec 5.6)		
III		**More Data Structures, Plotting**		

	(Text 1, Ch. 6, 7).			
	13	Arrays and Plotting. Numpy and Array Computing. Plotting Curves with Matplotlib. (Sec 6.1, 6.2)	7	**Min 10**
	14	Plotting Discontinuous and Piecewise Defined Functions. (Sec 6.3).		
	15	Dictionaries and Strings. Examples: A Dictionary for Polynomials, Reading File Data to a Dictionary. (Sec 7.1 7.2, 7.3),		
	16	String Manipulation (Sec 7.4).		
IV	**Classes and Object-Oriented Programming.** (Text 1, Ch. 9, 10.)		7	**Min 10**
	17	Basics of Classes. (Sec 8.1)		
	18	Protected Class Attributes, Special Methods. Example: Automatic Differentiation of Functions. (Sec 8.2, 8.3, 8.4).		
	19	Test Functions for Classes. Example: A Polynomial Class. (Sec 8.5, 8.6).		
	20	Class Hierarchies and Inheritance. Example: Classes for Numerical Differentiation, Integration. (Sec 9.1, 9.2, 9.3).		

V	**Practical (Open-Ended)** Lecturer's selections of 15 sessions of 2 hours each from below. **Miscellaneous Python Exercises** 1. Pitfalls of Programming, Text 1, Section 2.5. 2. Familiarize various Python runtime environments and IDEs like IDLE, Spyder, VS Code, Virtual Environments, Jupyter Notebook, Google Colab, Anaconda/Miniconda/Mamba, Replit. 3. Familiarize various documentation websites and how to refer to the syntax and implementation of a Python concept or Package. 4. Case studies from Reference 2:, Income Tax Calculator (page 38), Investment Report (p. 73), Approximating Square Roots. (p. 92), Text Analysis (p. 126), Generating Sentences (p. 150). **Sagemath** 1. Getting and installing sagemath in Windows, Ubuntu OS Using sagemath using cocalc (online). 2. Using Sage as a Calculator, Using Sage with Common Functions, Using Sage for Trigonometry (Text 2, sections 1.1, 1.2, 1.3). 3. Using Sage to Manipulate Polynomials (Text 2, section 1.7) 4. Matrices and Sage-A First Taste of Matrices, Doing the RREF in Sage (Text 2, section 1.5) 5. Using Sage for 2-D graphs (Text 2, section 1.4) 6. The Derivative, Slope of Tangent, Higher-Order Derivatives (Text 2, section 1.11)) 7. Antiderivatives (Indefinite Integral), Definite Integrals, Improper Integrals (Text 2, sec 1.12, upto sec 1.12.6)) **Sympy (Reference 3).** 1. Sympy Introductory Tutorial. 2. Solve an equation algebraically. 3. Solve a system of equations algebraically. 4. Solve one or a system of equations numerically. 5. Find the roots of a polynomial symbolically or numerically. 6. Solve a matrix equation algebraically. 7. Solve a Diophantine equation algebraically. 8. Solve an ODE algebraically. **More Numpy and Data Visualization** (Reference 1: Chapter 3, 4) 1. Numpy Functions: arange, linspace, zeros, ones, random.random, reshaping. (Sec 3.1.1 to 3.1.6). Copying, Saving and Restoring, Slicing, Arithmetic Operations. (Sec 3.1.7 to 3.1.10). 2. Matplotlib Module: 2D Plots, Polar Plots, Pie Charts, Multiple Plots. (Sec 4.1) 3. Sine function and friends, Circle, Parametric Plots, Error Bars. (Sec 4.2)

4. Simple 2D Animation (Reference 1, Section 4.4), Making a movie of a Plot (Text 1, Section 4.4)
5. Famous Curves: Astroids, Ellipse, Spirals of Archimedes and Fermat (Reference 1, Sec 4.5)
6. 2D Plots and Fractals (Reference 1, Section 4.6)
7. 3D Plots (Reference 1, Section 4.7)

Numerical methods using SageMath (Reference 5: Chapter 7)(7.1 - 7.10, 7.12)

1) Evaluate a Taylor series numerically.
2) Interpolate a function using
   a) Newton's forward interpolation.
   b) Newton's backward interpolation.
   c) Lagrange's Interpolation.
   d) Newton's General Interpolation.
3) Find integral of function using
   a. Trapezoidal Rule
   b. Simpson's 1/3-rule
4) Find derivative of function numerically.
5) Solve first order differential equations numerically.
   a) Euler method
   b) Fourth order Runge-Kutta method
6) Solve algebraic equations numerically.
   a) The Bisection method
   b) Regula Falsi Method

References

1. Python for Education, Ajith Kumar B. P., 2023 https://scischool.in/python/pythonForEducation.pdf
2. Fundamentals of Python First Programs, Kenneth A Lambert, 2 Ed., Cengage, 2018.
3. Sympy Tutorial: https://docs.sympy.org/latest/tutorials/intro-tutorial/index.html
   Solving Equations: https://docs.sympy.org/latest/guides/solving/index.html
4. Computational Mathematics with SageMath, Paul Zimmermann, Alexandre Casamayou, https://www.sagemath.org/sagebook/english.html
5. SageMath Advice For Calculus, Tuan A. Le and Hieu D. Nguyen, https://users.rowan.edu/~nguyen/sage/SageMathAdviceforCalculus.pdf
6. Sagemath Reference: https://doc.sagemath.org/

Programming Resources

1. Python official website: https://www.python.org
   Documentation: https://docs.python.org/
2. Spyder official website and documentation, https://www.spyder-ide.org/
3. MIT Courseware, Getting Started: Python and IDLE, https://web.mit.edu/6.s189/www/handouts/GettingStarted.html
4. Jupyter Notebook, https://jupyter.org/
5. Google Colaboratory (colab), https://colab.google/
6. Visual Studio Code: https://code.visualstudio.com,
   Documentation: https://code.visualstudio.com/docs
   VS Code for Web: https://vscode.dev/
7. Replit, https://replit.com/
8. Python Virtual Environments: https://docs.python.org/3/tutorial/venv.html
9. Anaconda, Miniconda and Mamba.
   Anaconda: https://docs.anaconda.com/free/anaconda/
   Miniconda: https://docs.anaconda.com/free/minicoda
   Mamba: https://mamba.readthedocs.io/en/latest/
10. SageMathCloud at Cocalc: https://cocalc.com
    Documentation: https://doc.cocalc.com/

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	3	2	1	3	2	3	3	2	1	2
CO 2	3	3	2	2	3	2	3	3	2	1	2
CO 3	3	3	3	3	3	1	3	3	3	1	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

ONLINE EQUIVALENT COURSES

(These courses are currently available on the government portal SWAYAM. If they are removed in the future, the board will update the course listings accordingly)

<u>The course in brackets, including its course code, is equivalent to the online course specified against it.</u>

1. (MAT8EJ401 Advanced Topology)

   https://onlinecourses.nptel.ac.in/noc24_ma74/preview

   An Introduction to Point•Set•Topology Part•II
   By Prof. Anant R. Shastri | IIT Bombay

2. (MAT8EJ402 PARTIAL DIFFERENTIAL EQUATIONS)

   https://onlinecourses.nptel.ac.in/noc24_ma73/preview

   Partial Differential Equations
   By Prof. Sivaji Ganesh | IIT Bombay

3. (MAT8EJ403 RINGS AND MODULES)

   https://onlinecourses.nptel.ac.in/noc24_cs72/preview

   Modern Algebra
   By Prof. Manindra Agrawal | IIT Kanpur

4. (MAT8EJ405 FOUNDATIONS OF MATHEMATICS)

   https://onlinecourses.nptel.ac.in/noc24_ma42/preview

   Set Theory and Mathematical Logic
   By Prof. Amit Kuber | IIT Kanpur

5. (MAT8EJ406 OPERATIONS RESEARCH)

   https://onlinecourses.swayam2.ac.in/cec24_ma05/preview

   Operations Research
   By Professor Bibhas C. Giri | Jadavpur University

6. (MAT1CJ101 Differential Calculus + MAT2CJ101 Integral Calculus)

   https://onlinecourses.nptel.ac.in/noc24_ma47/preview

   Calculus of One Real Variable
   By Prof. Joydeep Dutta | IIT Kanpur

7. (MAT3CJ201 MULTIVARIABLE CALCULUS)

   https://onlinecourses.nptel.ac.in/noc24_ma52/preview

   Calculus of Several Real Variables
   By Prof. Joydeep Dutta | IIT Kanpur

8. (MAT4CJ203 REAL ANALYSIS I)

   https://onlinecourses.swayam2.ac.in/cec24_ma01/preview

   Real Analysis
   By Prof. Surajit Borkotokey | Dibrugarh University

9. (MAT5CJ302 ABSTRACT ALGEBRA I)

   https://onlinecourses.nptel.ac.in/noc24_ma50/preview

   Introduction to Abstract Group Theory
   By Prof. Krishna Hanumanthu | Chennai Mathematical Institute

10. (MAT5CJ303 COMPLEX ANALYSIS I + MAT6CJ304 COMPLEX ANALYSIS II)

    https://onlinecourses.nptel.ac.in/noc24_ma60/preview

    Complex Analysis
    By Prof. Pranav Haridas | Kerala School of Mathematics

No.PWC/GA/BoS/MAT/001/2024 Dated: 27/05/2024

NOTIFICATION

It is hereby notified that the following members have been nominated to the Board of Studies in Mathematics of Providence Women's College (Autonomous) Kozhikode as per the sub section 68 H Amendment of Calicut University Act 5 of 1975. The nominated members shall hold the office for a period of three years from the date of this notification. Their appointments are ratified by the Governing Body meeting held on 22/05/2024.

	Name and Designation	**Institution**
1.	Aiswarya Paul Assistant Professor, Department of Mathematics. Chairman, Head of the Department.	Providence Women's College, Calicut.
2.	(i) Dr. Sunil Mathew Associate Professor, Department of Mathematics. External expert. (ii) Dr. Vani Lakshmi R Assistant Professor, Department of Data Science. External expert.	NIT, Calicut. Prasanna School of Public Health, Manipal Academy of Higher Education.
3.	Dr. Aswin VS Associate Professor, Industry Expert.	School of Digital Sciences, Thiruvananthapuram.
4.	Dr. Vineesh KP Assistant Professor, Department of Mathematics. Member. Ms. Reshmi KM Assistant Professor, Department of Mathematics. Member.	Sree Narayana Guru College, Chelannur, Kozhikode. Govt. Arts and Science College, Kozhikode.

PROVIDENCE WOMEN'S COLLEGE

B.Sc. STATISTICS HONOURS

(MAJOR, MINOR AND GENERAL FOUNDATION COURSES)

SYLLABUS & MODEL QUESTION PAPERS

w.e.f. 2024 admission onwards

(PWC FYUGP Regulations 2024)

CONTENTS

B.Sc. STATISTICS HONOURS

(MAJOR, MINOR AND GENERAL FOUNDATION COURSES)

SYLLABUS

PROGRAMME OUTCOMES (PO):

At the end of the graduate programme at PROVIDENCE WOMEN'S COLLEGE, a student would:

PO1	Knowledge Acquisition: Demonstrate a profound understanding of knowledge trends and their impact on the chosen discipline of study.
PO2	Communication, Collaboration, Inclusiveness, and Leadership: Become a team player who drives positive change through effective communication, collaborative acumen, transformative leadership, and a dedication to inclusivity.
PO3	Professional Skills: Demonstrate professional skills to navigate diverse career paths with confidence and adaptability.
PO4	Digital Intelligence: Demonstrate proficiency in varied digital and technological tools to understand and interact with the digital world, thus effectively processing complex information.
PO5	Scientific Awareness and Critical Thinking: Emerge as an innovative problem-solver and impactful mediator, applying scientific understanding and critical thinking to address challenges and advance sustainable solutions.
PO6	Human Values, Professional Ethics, and Societal and Environmental Responsibility: Become a responsible leader, characterized by an unwavering commitment to human values, ethical conduct, and a fervent dedication to the well-being of society and the environment.
PO7	Research, Innovation, and Entrepreneurship: Emerge as a researcher and entrepreneurial leader, forging collaborative partnerships with industry, academia, and communities to contribute enduring solutions for local, regional, and global development.

PROGRAMME SPECIFIC OUTCOMES (PSO):

At the end of the BSc Statistics (Honours) programme at PROVIDENCE WOMEN'S COLLEGE, a student would:

PSO1	Acquire comprehensive understanding of concepts, principles, and theories of Statistics.
PSO2	Apply fundamental concepts of descriptive and inferential Statistics- exploratory data analysis
PSO3	Master skills in using Statistical Software’s to meet the challenges of Employability, Research and Development.
PSO4	Identify the potential area of applications of Statistical theories.
PSO5	Construct Statistical models for real world problems and obtain solutions
PSO6	Continue to acquire relevant knowledge and skills appropriate to professional activities and demonstrate highest standards of ethical issues in Statistical Science

MINIMUM CREDIT REQUIREMENTS OF THE DIFFERENT PATHWAYS IN THE THREE-YEAR PROGRAMME IN PWC FYUGP

Sl. No.	Academic Pathway	Major	Minor/ Other Disciplines	Foundation Courses AEC: 4 MDC: 3 SEC: 3 VAC: 3	Intern -ship	Total Credits	Example
		Each course has 4 credits		Each course has 3 credits			
1	Single Major (A)	68 (17 courses)	24 (6 courses)	39 (13 courses)	2	133	Major: Statistics + six courses in different disciplines in different combinations
2	Major (A) with Multiple Disciplines (B, C)	68 (17 courses)	12 + 12 (3 + 3 = 6 courses)	39 (13 courses)	2	133	Major: Statistics+ Mathematics and Chemistry
3	Major (A) with Minor (B)	68 (17 courses)	24 (6 courses)	39 (13 courses)	2	133	Major: Statistics Minor: Mathematics
Exit with UG Degree / Proceed to Fourth Year with 133 Credits							

B.Sc. STATISTICS (HONOURS) PROGRAMME

COURSE STRUCTURE FOR PATHWAYS 1 – 3

1. Single Major
2. Major with Multiple Disciplines
3. Major with Minor

Semester	Course Code	Course Title	Total Hours	Hours / Week	Credits	Marks		
						Internal	External	Total
1	STA1CJ101/ STA1MN100	Core Course 1 in Major **Univariate Data Analysis**	75	5	4	30	70	100
		Minor Course 1	60/ 75	4/ 5	4	30	70	100
		Minor Course 2	60/ 75	4/ 5	4	30	70	100
		Ability Enhancement Course 1– English	60	4	3	25	50	75
		Ability Enhancement Course 2 – Additional Language	45	3	3	25	50	75
		Multi-Disciplinary Course 1 – Other than Major	45	3	3	25	50	75
		Total		**23/ 25**	**21**			**525**
2	STA2CJ101/ STA2MN100	Core Course 2 in Major **Bivariate Data Analysis**	75	5	4	30	70	100
		Minor Course 3	60/ 75	4/ 5	4	30	70	100
		Minor Course 4	60/ 75	4/ 5	4	30	70	100
		Ability Enhancement Course 3– English	60	4	3	25	50	75
		Ability Enhancement Course 4 – Additional Language	45	3	3	25	50	75
		Multi-Disciplinary Course 2 – Other than Major	45	3	3	25	50	75
		Total		**23/ 25**	**21**			**525**
3	STA3CJ201	Core Course 3 in Major **Mathematical Methods for Statistics I**	60	4	4	30	70	100
	STA3CJ202/ STA3MN200	Core Course 4 in Major **Probability and Random Variables**	75	5	4	30	70	100
		Minor Course 5	60/ 75	4/ 5	4	30	70	100
		Minor Course 6	60/ 75	4/ 5	4	30	70	100
		Multi-Disciplinary Course 3 – Kerala Knowledge System	45	3	3	25	50	75
		Value-Added Course 1 – English	45	3	3	25	50	75
		Total		**23/ 25**	**22**			**550**

4	STA4CJ201	Core Course 5 in Major **Probability Distributions**	75	5	4	30	70	100
	STA4CJ202	Core Course 6 in Major **Bivariate Random Variables and Limit Theorems**	75	5	4	30	70	100
	STA4CJ203	Core Course 7 in Major **Applied Statistics Time Series, Index Numbers & Official Statistics**	75	5	4	30	70	100
		Value-Added Course 2 – English	45	3	3	25	50	75
		Value-Added Course 3 – Additional Language	45	3	3	25	50	75
		Skill Enhancement Course 1 – English	60	4	3	25	50	75
		Total		**25**	**21**			**525**
5	STA5CJ301	Core Course 8 in Major **Estimation**	60	4	4	30	70	100
	STA5CJ302	Core Course 9 in Major **Sampling Methods**	75	5	4	30	70	100
	STA5CJ303	Core Course 10 in Major **Testing of Hypothesis**	75	5	4	30	70	100
		Elective Course 1 in Major	60	4	4	30	70	100
		Elective Course 2 in Major	60	4	4	30	70	100
	STA5FS101	Skill Enhancement Course 2 **Statistical analysis using Python**	45	3	3	25	50	75
		Total		**25**	**23**			**575**
6	STA6CJ301/ STA8MN301	Core Course 11 in Major **Linear Regression Analysis**	75	5	4	30	70	100
	STA6CJ302/ STA8MN302	Core Course 12 in Major **Design and Analysis of Experiments**	75	5	4	30	70	100
	STA6CJ303/ STA8MN303	Core Course 13 in Major **Stochastic Processes**	60	4	4	30	70	100
		Elective Course 3 in Major	60	4	4	30	70	100
		Elective Course 4 in Major	60	4	4	30	70	100
	STA6FS102	Skill Enhancement Course 3 **Basic research methodology**	45	3	3	25	50	75
	STA6CJ349	Internship in Major (Credit for internship to be awarded only at the end of Semester 6)	60		2	50	-	50

		Total		**25**	**25**			**625**
Total Credits for Three Years					**133**			**3325**
7	STA7CJ401	Core Course 14 in Major **Advanced Analytical Tools**	75	5	4	30	70	100
	STA7CJ402	Core Course 15 in Major **Probability Theory**	75	5	4	30	70	100
	STA7CJ403	Core Course 16 in Major **Distribution Theory**	75	5	4	30	70	100
	STA7CJ404	Core Course 17 in Major **Advanced Sampling Methods & Design of Experiments**	75	5	4	30	70	100
	STA7CJ405	Core Course 18 in Major **Advanced Statistical Inference**	75	5	4	30	70	100
		Total		**25**	**20**			**500**
8	STA8CJ406/ STA8MN406	Core Course 19 in Major **Applied Stochastic Processes and Time Series Analysis**	75	5	4	30	70	100
	STA8CJ407/ STA8MN407	Core Course 20 in Major **Applied Multivariate Techniques**	60	4	4	30	70	100
	STA8CJ408/ STA8MN408	Core Course 21 in Major **Generalized Linear Models**	60	4	4	30	70	100
	OR (instead of Core Courses 19-21 in Major)							
	STA8CJ449	Project (in Honours programme)	360*	13*	12	90	210	300
	STA8CJ499	Research Project (in Honours with Research programme)	360*	13*	12	90	210	300
		Elective Course 5 in Major / Minor Course 7	60	4	4	30	70	100
		Elective Course 6 in Major / Minor Course 8	60	4	4	30	70	100
		Elective Course 7 in Major / Minor Course 9 / Major Course in any Other Discipline	60	4	4	30	70	100
	OR (instead of Elective Course 7 in Major, in the case of Honours with Research Programme)							
	STA8CJ489	Research Methodology	60	4	4	30	70	100
		Total		**25**	**24**			**600**
Total Credits for Four Years					**177**			**4425**

*The teacher should have 13 hrs/week of engagement (the hours corresponding to the three core courses) in the guidance of the Project(s) in Honours programme and Honours with Research programme, while each student should have 24 hrs/week of engagement in the Project work. Total hours are given based on the student’s engagement.

CREDIT DISTRIBUTION FOR PATHWAYS 1 – 3

1. Single Major
2. Major with Multiple Disciplines
3. Major with Minor

Semester	**Major Courses**	**Minor Courses**	**General Foundation Courses**	**Internship/ Project**	**Total**
1	4	4 + 4	3 + 3 + 3	-	21
2	4	4 + 4	3 + 3 + 3	-	21
3	4 + 4	4 + 4	3 + 3	-	22
4	4 + 4 + 4	-	3 + 3 + 3	-	21
5	4 + 4 + 4 + 4 + 4	-	3	-	23
6	4 + 4 + 4 + 4 + 4	-	3	2	25
Total for Three Years	**68**	**24**	**39**	**2**	**133**
7	4 + 4 + 4 + 4 + 4	-	-	-	20
8	4 + 4 + 4	4 + 4 + 4	-	12* / 12*	24
* instead of three Major courses					
Total for Four Years	**88 + 12 = 100**	**36**	**39**	**2**	**177**

DISTRIBUTION OF MAJOR COURSES IN STATISTICS FOR PATHWAYS 1 – 3

1. Single Major
2. Major with Multiple Disciplines
3. Major with Minor

Semester	Course Code	Course Title	Hours/ Week	Credits
1	STA1CJ101/ STA1MN100	Core Course 1 in Major **Univariate Data Analysis**	5	4
2	STA2CJ101/ STA2MN100	Core Course 2 in Major **Bivariate Data Analysis**	5	4
3	STA3CJ201	Core Course 3 in Major **Mathematical Methods for Statistics I**	4	4
	STA3CJ202/ STA3MN200	Core Course 4 in Major **Probability and Random Variables**	5	4
4	STA4CJ201	Core Course 5 in Major **Probability Distributions**	5	4
	STA4CJ202	Core Course 6 in Major **Bivariate Random Variables and Limit Theorems**	5	4
	STA4CJ203	Core Course 7 in Major **Applied Statistics Time Series, Index Numbers & Official Statistics**	5	4
5	STA5CJ301	Core Course 8 in Major **Estimation**	4	4
	STA5CJ302	Core Course 9 in Major **Sampling Methods**	5	4
	STA5CJ303	Core Course 10 in Major **Testing of Hypothesis**	5	4
		Elective Course 1 in Major	4	4
		Elective Course 2 in Major	4	4

6	STA6CJ304 / STA8MN304	Core Course 11 in Major **Linear Regression Analysis**	5	4
	STA6CJ305 / STA8MN305	Core Course 12 in Major **Design and Analysis of Experiments**	5	4
	STA6CJ306 / STA8MN306	Core Course 13 in Major **Stochastic Processes**	4	4
		Elective Course 3 in Major	4	4
		Elective Course 4 in Major	4	4
	STA6CJ349	Internship in Major	-	2
Total for the Three Years				**70**
7	STA7CJ401	Core Course 14 in Major **Advanced Analytical Tools**	5	4
	STA7CJ402	Core Course 15 in Major **Probability Theory**	5	4
	STA7CJ403	Core Course 16 in Major **Distribution Theory**	5	4
	STA7CJ404	Core Course 17 in Major **Advanced Sampling Methods & Design of Experiments**	5	4
	STA7CJ405	Core Course 18 in Major **Advanced Statistical Inference**	5	4
8	STA8CJ406/ STA8MN406	Core Course 19 in Major **Applied Stochastic Processes and Time Series Analysis**	5	4
	STA8CJ407/ STA8MN407	Core Course 20 in Major **Applied Multivariate Techniques**	4	4
	STA8CJ408/ STA8MN408	Core Course 21 in Major **Generalized Linear Models**	4	4
	OR (instead of Core Courses 19 – 21 in Major)			
	STA8CJ449	Project (in Honours programme)	13	12
	STA8CJ499	Research Project (in Honours with Research programme)	13	12
		Elective Course 5 in Major	4	4
		Elective Course 6 in Major	4	4
		Elective Course 7 in Major	4	4
	OR (instead of Elective course 7 in Major, in Honours with Research programme)			
	STA8CJ489	Research Methodology	4	4

Total for the Four Years		114

ELECTIVE COURSES IN STATISTICS

Sl. No.	Course Code	Title	Semester	Total Hrs	Hrs/ Week	Credits	Marks		
							Internal	External	Total
1	STA5EJ301	**Statistical Quality Control**	5	60	4	4	30	70	100
2	STA5EJ302	**Optimization Techniques**	5	60	4	4	30	70	100
3	STA5EJ303	**Biostatistics**	5	60	4	4	30	70	100
4	STA5EJ304	**Econometrics**	5	60	4	4	30	70	100
5	STA5EJ305	**Official Statistics**	5	60	4	4	30	70	100
6	STA5EJ306	**Longitudinal Data Analysis**	5	60	4	4	30	70	100
7	STA6EJ301	**Simulation Techniques**	6	60	4	4	30	70	100
8	STA6EJ302	**Reliability Theory**	6	60	4	4	30	70	100
9	STA6EJ303	**Life Time Data Analysis**	6	60	4	4	30	70	100
10	STA6EJ304	**Demography**	6	60	4	4	30	70	100
11	STA6EJ305	**Actuarial Statistics**	6	60	4	4	30	70	100
12	STA8EJ411	**Statistical Methods for Machine Learning**	8	60	4	4	30	70	100
13	STA8EJ412	**Operations Research**	8	60	4	4	30	70	100
14	STA8EJ413	**Queueing Models**	8	60	4	4	30	70	100
15	STA8EJ414	**Statistical Decision Theory**	8	60	4	4	30	70	100
16	STA8EJ415	**Analysis of Clinical Trials**	8	60	4	4	30	70	100
17	STA8EJ416	**Applied Algorithms and Big Data Techniques**	8	60	4	4	30	70	100
18	STA8EJ417	**Advanced Trends in Statistics**	8	60	4	4	30	70	100

DISTRIBUTION OF MINOR COURSES IN STATISTICS

The minor courses given below should not be offered to the students who have taken statistics as the major discipline. They should be offered to students from other major discipline only.

Sl. No :	**Semester**	**Course Code**	**Title**	**Semester**	**Total Hrs**	**Hrs/ Week**	**Credits**	**Marks**		
								Internal	**External**	**Total**
1		(Preferable for Mathematics, Physics, Chemistry and Biochemistry students)								
	1	STA1MN101	**Descriptive Statistics for Data Science**	1	75	5	4	30	70	100
	2	STA2MN101	**Probability theory I**	2	75	5	4	30	70	100
	3	STA3MN201	**Statistical inference using R**	3	75	5	4	30	70	100
2		(Preferable for Computer Science and Electronics students)								
	1	STA1MN103	**Introductory statistics with R**	1	75	5	4	30	70	100
	2	STA2MN103	**Regression and probability theory**	2	75	5	4	30	70	100
	3	STA3MN203	**Random variables and CART**	3	75	5	4	30	70	100
3		(Preferable for Psychology students)								
	1	STA1MN105	**Descriptive statistics**	1	75	5	4	30	70	100
	2	STA2MN105	**Introduction to probability**	2	75	5	4	30	70	100
	3	STA3MN205	**Inferential Statistics**	3	75	5	4	30	70	100

4		(Preferable for Life Science students)								
	1	STA1MN107	**Basic statistics**	1	75	5	4	30	70	100
	2	STA2MN107	**Statistical inference I**	2	75	5	4	30	70	100
	3	STA3MN207	**Statistical inference II**	3	75	5	4	30	70	100
5		(Preferable for Social Science students)								
	1	STA1MN108	**Statistics for critical thinking I**	1	75	5	4	30	70	100
	2	STA2MN108	**Statistics for critical thinking II**	2	75	5	4	30	70	100
	3	STA3MN208	**Statistics for critical thinking III**	3	75	5	4	30	70	100
6		(Preferable for Geography students)								
	1	STA1MN109	**Elementary statistics**	1	75	5	4	30	70	100
	2	STA2MN109	**Theory of Probability**	2	75	5	4	30	70	100
	3	STA3MN209	**Statistical inference**	3	75	5	4	30	70	100
7		(Preferable for Economics students)								
	1	STA1MN110	**Basic statistics and data visualization**	1	75	5	4	30	70	100
	2	STA2MN110	**Data analysis foundations in statistics**	2	75	5	4	30	70	100
	3	STA3MN210	**Probability theory and sampling techniques**	3	75	5	4	30	70	100
8		(Preferable for Commerce and Business Administration students)								
	1	STA1MN111	**Fundamentals of data analysis**	1	75	5	4	30	70	100
	2	STA2MN111	**Statistical modeling and sampling techniques**	2	75	5	4	30	70	100

	3	STA3MN211	**Probability theory and statistical distributions**	3	75	5	4	30	70	100

SINGLE MINOR - SIX COURSES IN STATISTICS

Sl. No :	Semester	Course Code	Title	Semester	Total Hrs	Hrs/ Week	Credits	Marks		
								Internal	External	Total
		(Preferable for Mathematics, Physics, Chemistry and Biochemistry students)								
1	1	STA1MN101	**Descriptive Statistics for Data Science**	1	75	5	4	30	70	100
		STA1MN102	**Applied statistics using R**	1	75	5	4	30	70	100
	2	STA2MN101	**Probability theory I**	2	75	5	4	30	70	100
		STA2MN102	**Probability theory II**	2	75	5	4	30	70	100
	3	STA3MN201	**Statistical inference using R**	3	75	5	4	30	70	100
		STA3MN202	**Statistical inference for Data Science**	3	75	5	4	30	70	100
		(Preferable for Computer Science and Electronics students)								
2	1	STA1MN103	**Introductory statistics with R**	1	75	5	4	30	70	100
		STA1MN104	**Applied statistics**	1	75	5	4	30	70	100
	2	STA2MN103	**Regression and probability theory**	2	75	5	4	30	70	100
		STA2MN104	**Regression using JASP software**	2	75	5	4	30	70	100
	3	STA3MN203	**Random variables and CART**	3	75	5	4	30	70	100
		STA3MN204	**Tests of hypothesis and SVM**	3	75	5	4	30	70	100

		(Preferable for Psychology students)								
3	1	STA1MN105	**Descriptive statistics**	1	75	5	4	30	70	100
		STA1MN106	**Introductory statistics with JASP**	1	75	5	4	30	70	100
	2	STA2MN105	**Introduction to probability**	2	75	5	4	30	70	100
		STA2MN106	**Correlation and regression**	2	75	5	4	30	70	100
	3	STA3MN205	**Inferential Statistics**	3	75	5	4	30	70	100
		STA3MN206	**Tests of hypothesis with JASP software**	3	75	5	4	30	70	100

DISTRIBUTION OF MINOR COURSES IN ACTUARIAL SCIENCE

Sl. No:	Semester	Course Code	Title	Semester	Total Hrs	Hrs/ Week	Credits	Marks		
								Internal	External	Total
		(Preferable for Mathematics, Statistics, Commerce and Economics students)								
1	1	ACT1MN101	**Actuarial mathematics I**	1	75	5	4	30	70	100
	2	ACT2MN101	**Actuarial mathematics II**	2	75	5	4	30	70	100
	3	ACT3MN201	**Risk modeling and survival analysis**	3	75	5	4	30	70	100

SINGLE MINOR - SIX COURSES IN ACTUARIAL SCIENCE

Sl. No:	Semester	Course Code	Title	Semester	Total Hrs	Hrs/ Week	Credits	Marks		
								Internal	External	Total
		(Preferable for Mathematics, Statistics, Commerce and Economics students)								
1	1	ACT1MN101	**Actuarial mathematics I**	1	75	5	4	30	70	100
		ACT1MN102	**Financial Mathematics**	1	75	5	4	30	70	100
	2	ACT2MN101	**Actuarial mathematics II**	2	75	5	4	30	70	100
		ACT2MN102	**Actuarial economics**	2	75	5	4	30	70	100
	3	ACT3MN201	**Risk modeling and survival analysis**	3	75	5	4	30	70	100
		ACT3MN202	**Life contingencies**	3	75	5	4	30	70	100

DISTRIBUTION OF GENERAL FOUNDATION COURSES IN STATISTICS

Semester	Course Code	Course Title	Total Hours	Hours/ Week	Credits	Marks		
						Internal	External	Total
1	STA1FM101 STA1FM102	Multi-Disciplinary Course 1 **Quality Control** **Fundamentals of statistics**	45	3	3	25	50	75
2	STA2FM103 STA2FM104	Multi-Disciplinary Course 2 – **Managerial Decision Making** **Statistical sampling and probability theory**	45	3	3	25	50	75
5	STA5FS101	Skill Enhancement Course 2 **Statistical analysis using Python**	45	3	3	25	50	75
6	STA6FS102	Skill Enhancement Course 3 **Basic research methodology**	45	3	3	25	50	75

EVALUATION SCHEME

1. The evaluation scheme for each course contains two parts: internal evaluation (about 30%) and external evaluation (about 70%). Each of the Major and Minor courses is of 4-credits. It is evaluated for 100 marks, out of which 30 marks is from internal evaluation and 70 marks, from external evaluation. Each of the General Foundation course is of 3-credits. It is evaluated for 75 marks, out of which 25 marks is from internal evaluation and 50 marks, from external evaluation.

2. The 4-credit courses (Major and Minor courses) are of two types: (i) courses with only theory and (ii) courses with 3-credit theory and 1-credit practical.

- In 4-credit courses with only theory component, out of the total 5 modules of the syllabus, one open-ended module with 20% content is designed by the faculty member teaching that course, and it is internally evaluated for 10 marks. The internal evaluation of the remaining 4 theory modules is for 20 marks.
- In 4-credit courses with 3-credit theory and 1-credit practical components, out of the total 5 modules of the syllabus, 4 modules are for theory and the fifth module is for practical. The practical component is internally evaluated for 20 marks. The internal evaluation of the 4 theory modules is for 10 marks.

3. All the 3-credit courses (General Foundational Courses) in Statistics are with only theory component. Out of the total 5 modules of the syllabus, one open-ended module with 20% content is designed by the faculty member teaching that course, and it is internally evaluated for 5 marks. The internal evaluation of the remaining 4 theory modules is for 20 marks.

<table>
<tr><th rowspan="2">Sl. No.</th><th colspan="2" rowspan="2">Nature of the Course</th><th colspan="2">Internal Evaluation in Marks (about 30% of the total)</th><th rowspan="2">External Exam on 4 modules (Marks)</th><th rowspan="2">Total Marks</th></tr>
<tr><th>Open-ended module / Practicum</th><th>On the other 4 modules</th></tr>
<tr><td>1</td><td>4-credit course</td><td>only theory (5 modules)</td><td>10</td><td>20</td><td>70</td><td>100</td></tr>
<tr><td>2</td><td>4-credit course</td><td>Theory (4 modules) + Practical</td><td>20</td><td>10</td><td>70</td><td>100</td></tr>
<tr><td>3</td><td>3-credit course</td><td>only theory (5 modules)</td><td>5</td><td>20</td><td>50</td><td>75</td></tr>
</table>

1. MAJOR AND MINOR COURSES

1.1. INTERNAL EVALUATION OF THEORY COMPONENT

Sl. No.	Components of Internal Evaluation of Theory Part of a Major / Minor Course	Internal Marks for the Theory Part of a Major / Minor Course of 4-credits			
		Theory Only		Theory + Practical	
		4 Theory Modules	Open-ended Module	4 Theory Modules	Practical
1	Test paper/ Mid-semester Exam	10	4	5	-
2	Seminar/ Viva/ Quiz	6	4	3	-
3	Assignment	4	2	2	-
		20	10	10	20*
	Total	30		30	

* Refer the table in section 1.2 for the evaluation of practical component

1.2. EVALUATION OF PRACTICAUM COMPONENT

The evaluation of practicum component in Major and Minor courses is completely by internal evaluation.

- Continuous evaluation of practicum by the teacher-in-charge shall carry a weightage of 50%.
- The end-semester practicum examination and viva-voce, and the evaluation of practicum records shall be conducted by the teacher in-charge and an internal examiner appointed by the Department Council.
- The process of continuous evaluation of practicum courses shall be completed before 10 days from the commencement of the end-semester examination.
- Those who passed in continuous evaluation alone will be permitted to appear for the end-semester examination and viva-voce.

The scheme of continuous evaluation and the end-semester examination and viva- voce of practicum component shall be as given below:

Sl. No.	Evaluation of Practicum Component of in a Major / Minor Course	Marks for Practical	Weightage
1	Continuous evaluation of practicum/ exercise performed in practicum classes by the students	10	50%

2	End-semester examination and viva-voce to be conducted by teacher-in-charge along with an additional examiner arranged internally by the Department Council	7	35%
3	Evaluation of the Practicum records submitted for the end semester viva–voce examination by the teacher-in-charge and additional examiner	3	15%
	Total Marks	20	

1.3. EXTERNAL EVALUATION OF THEORY COMPONENT

External evaluation carries 70% marks. Examinations will be conducted at the end of each semester. Individual questions are evaluated in marks and the total marks are converted into grades by the College based on 10-point grading system (refer section 5).

PATTERN OF QUESTION PAPER FOR MAJOR AND MINOR COURSES

Duration	Type	Total No. of Questions	No. of Questions to be Answered	Marks for Each Question	Ceiling of Marks
2 Hours	Short Answer	10	8 – 10	3	24
	Paragraph/ Problem	8	6 – 8	6	36
	Essay	2	1	10	10
				Total Marks	70

2. INTERNSHIP

- All students should undergo Internship of 2-credits during the first six semesters in a firm/industry / organization, or training in labs with faculty and researchers of their own institution or other Higher Educational Institutions (HEIs) or research institutions.
- Internship can be for enhancing the employability of the student or for developing the research aptitude.
- Internship can involve hands-on training on a particular skill/ equipment/ software. It can be a short project on a specific problem or area. Attending seminars or workshops related to an area of learning or skill can be a component of Internship.

- A faculty member/ scientist/ instructor of the respective institution, where the student does the Internship, should be the supervisor of the Internship.

2.1. GUIDELINES FOR INTERNSHIP

1. Internship can be in Statistics or allied Disciplines.
2. There should be minimum 60 hrs. of engagement from the student in the Internship.
3. Summer vacations and other holidays can be used for completing the Internship. BSc. Statistics (Honours) Programme, Institute/ Industry visit or study tour is a requirement for the completion of Internship. Visit to minimum one research institute, research laboratory and place of Statistical data anyalysis importance should be part of the study tour. A brief report of the study tour has to be submitted with photos and analysis.
4. The students should make regular and detailed entries in to a personal log book through the period of Internship. The log book will be a record of the progress of the Internship and the time spent on the work, and it will be useful in writing the final report. It may contain experimental conditions and results, ideas, mathematical expressions, rough work and calculation, computer file names etc. All entries should be dated. The Internship supervisor should periodically examine and countersign the log book.
5. The log book and the typed report must be submitted at the end of the Internship.
6. The Institution at which the Internship will be carried out should be prior-approved by the Department Council of the College where the student has enrolled for the UG (Honours) Programme.

2.2. EVALUATION OF INTERNSHIP

- The evaluation of Internship shall be done internally through Continuous Assessment mode by a committee internally constituted by the Department Council of the College where the student has enrolled for the UG (Honours) Programme.

- The credits and marks for the Internship will be awarded only at the end of semester 6.
- The scheme of continuous evaluation and the end-semester viva-voce examination based on the submitted report shall be as given below:

Sl. No.	Components of Evaluation of Internship		Marks for Internship 2 Credits	Weightage
1	Continuous evaluation of internship through interim presentations and reports by the committee internally constituted by the Department Council	Acquisition of skill set	10	40%
2		Interim Presentation and Viva-voce	5	
3		Punctuality and Log Book	5	
4	Report of Institute Visit/ Study Tour		5	10%
5	End-semester viva-voce examination to be conducted by the committee internally constituted by the Department Council	Quality of the work	6	35%
6		Presentation of the work	5	
7		Viva-voce	6	
8	Evaluation of the day-to-day records, the report of internship supervisor, and final report submitted for the end semester viva–voce examination before the committee internally constituted by the Department Council		8	15%
	Total Marks		50	

3. PROJECT

3.1. PROJECT IN HONOURS PROGRAMME

• In Honours programme, the student has the option to do a Project of 12-credits instead of three Core Courses in Major in semester 8.

• The Project can be done in the same institution/ any other higher educational institution (HEI)/ research Centre/ training Centre.

• The Project in Honours programme can be a short research work or an extended internship or a skill-based training programme.

• A faculty member of the respective institution, where the student does the Project, should be the supervisor of the Project.

3.2. PROJECT IN HONOURS WITH RESEARCH PROGRAMME

- A relaxation of 5% in marks (equivalently, a relaxation of 0.5 grade in CGPA) is allowed for those belonging to SC/ ST/ OBC (non-creamy layer)/ Differently-Abled/ Economically Weaker Section (EWS)/ other categories of candidates as per the decision of the UGC from time to time.
- In Honours with Research programme, the student has to do a mandatory Research Project of 12-credits instead of three Core Courses in Major in semester 8.
- The approved research centres of PROVIDENCE WOMEN'S COLLEGE or any other HEI can offer the Honours with Research programme. The departments in the affiliated colleges under PROVIDENCE WOMEN'S COLLEGE, which are not the approved research centres of the University, should get prior approval from the University to offer the Honours with Research programme. Such departments should have minimum two faculty member with Ph.D., and they should also have the necessary infrastructure to offer Honours with Research programme.
- A faculty member of the College with a Ph.D. degree can supervisethe research project of the students who have enrolled for Honours with Research. One such faculty member can supervise maximum five students in Honours with Research stream.
- The maximum intake of the department for Honours with Research programme is fixed by the department based on the number of faculty members eligible for project supervision, and other academic, research, and infrastructural facilities available.
- If a greater number of eligible students are opting for the Honours with Research programme than the number of available seats, then the allotment shall be based on the existing rules of reservations and merits.

3.3. GUIDELINES FOR THE PROJECT IN HONOURS PROGRAMME AND HONOURS WITH RESEARCH PROGRAMME

1. Project can be in Statistics or allied disciplines.

2. Project should be done individually.
3. Project work can be of experimental/ theoretical/ computational in nature.
4. There should be minimum 300 hrs. of engagement from the student in the Project work in Honours programme as well as in Honours with Research programme.
5. There should be minimum 13 hrs./week of engagement (the hours corresponding to the three core courses in Major in semester 8) from the teacher in the guidance of the Project(s) in Honours programme and Honours with Research programme.
6. The various steps in project works are the following:
   - Wide review of a topic.
   - Investigation on a problem in systematic way using appropriate techniques.
   - Systematic recording of the work.
   - Reporting the results with interpretation in a standard documented form.
   - Presenting the results before the examiners.
7. During the Project the students should make regular and detailed entries in to a personal log book through the period of investigation. The log book will be a record of the progress of the Project and the time spent on the work, and it will be useful in writing the final report. It may contain experimental conditions and results, ideas, mathematical expressions, rough work and calculation, computer file names etc. All entries should be dated. The Project supervisor should periodically examine and countersign the log book.
8. The log book and the typed report must be submitted at the end of the Project. A copy of the report should be kept for reference at the department. A soft copy of the report too should be submitted, to be sent to the external examiner in advance.
9. It is desirable, but not mandatory, to publish the results of the Project in a peer reviewed journal.
10. The project report shall have an undertaking from the student and a certificate from the research supervisor for originality of the work, stating that there is no plagiarism, and that the work has not been submitted for the award of any other degree/ diploma in the same institution or any other institution.

11. The project proposal, institution at which the project is being carried out, and the project supervisor should be prior-approved by the Department Council of the college where the student has enrolled for the UG (Honours) programme.

3.4. EVALUATION OF PROJECT

- The evaluation of Project will be conducted at the end of the eighth semester by both internal and external modes.
- The Project in Honours programme as well as that in Honours with Research programme will be evaluated for 300 marks. Out of this, 90 marks is from internal evaluation and 210 marks, from external evaluation.
- The internal evaluation of the Project work shall be done through continuous assessment mode by a committee internally constituted by the Department Council of the college where the student has enrolled for the UG (Honours) programme. 30% of the weightage shall be given through this mode.
- The remaining 70% shall be awarded by the external examiner appointed by the Providence Women's College.
- The scheme of continuous evaluation and the end-semester viva-voce of the Project shall be as given below:

Components of Evaluation of Project	Marks for the Project (Honours/ Honours with Research)	Weightage
Continuous evaluation of project work through interim presentations and reports by the committee internally constituted by the Department Council	90	30%
End-semester viva-voce examination to be conducted by the external examiner appointed by the college	150	50%
Evaluation of the day-to-day records andproject report submitted for the end-semester viva–voce examination conducted by the external examiner	60	20%
Total Marks	300	

INTERNAL EVALUATION OF PROJECT

Sl. No	Components of Evaluation of Project	Marks for the Project (Honours / Honours with Research)
1	Skill in doing project work	30
2	Interim Presentation and Viva-Voce	20
3	Punctuality and Log book	20
4	Scheme/ Organization of Project Report	20
	Total Marks	90

EXTERNAL EVALUATION OF PROJECT

Sl. No	Components of Evaluation of Project	Marks for the Project (Honours / Honours with Research) 12 credits
1	Content and relevance of the Project, Methodology, Quality of analysis, and Innovations of Research	50
2	Presentation of the Project	50
3	Project Report (typed copy), Log Book and References	60
4	Viva-Voce	50
	Total Marks	210

4. GENERAL FOUNDATION COURSES

- All the General Foundation Courses (3-credits) in Statistics are with only theory component.

4.1. INTERNAL EVALUATION

Sl. No.	Components of Internal Evaluation of a General Foundation Course in Statistics	Internal Marks of a General Foundation Course of 3-credits in Statistics	
		4 Theory Modules	Open-ended Module
1	Test paper/ Mid-semester Exam	10	2
2	Seminar/ Viva/ Quiz	6	2
3	Assignment	4	1
	Total	20	5
		25	

4.2. EXTERNAL EVALUATION

External evaluation carries about 70% marks. Examinations will be conducted at the end of each semester. Individual questions are evaluated in marks and the total marks are converted into grades by the College based on 10-point grading system (refer section 5).

PATTERN OF QUESTION PAPER FOR GENERAL FOUNDATION COURSES

Duration	Type	Total No. of Questions	No. of Questions to be Answered	Marks for Each Question	Ceiling of Marks
1.5 Hours	Short Answer	10	8 – 10	2	16
	Paragraph/ Problem	5	4 – 5	6	24
	Essay	2	1	10	10
				Total Marks	50

5. LETTER GRADES AND GRADE POINTS

- Mark system is followed for evaluating each question.
- For each course in the semester letter grade and grade point are introduced in 10-point indirect grading system as per guidelines given below.
- The Semester Grade Point Average (SGPA) is computed from the grades as a measure of the student's performance in a given semester.
- The Cumulative GPA (CGPA) is based on the grades in all courses taken after joining the programme of study.
- Only the weighted grade point based on marks obtained shall be displayed on the grade card issued to the students.

LETTER GRADES AND GRADE POINTS

Sl. No.	Percentage of Marks (Internal & External Put Together)	Description	Letter Grade	Grade Point	Range of Grade Points	Class
1	95% and above	Outstanding	O	10	9.50 – 10	First Class with Distinction
2	Above 85% and below 95%	Excellent	A+	9	8.50 – 9. 49	
3	75% to below 85%	Very Good	A	8	7.50 – 8.49	
4	65% to below 75%	Good	B+	7	6.50 – 7.49	First Class
5	55% to below 65%	Above Average	B	6	5.50 – 6.49	
6	45% to below 55%	Average	C	5	4.50 – 5.49	Second Class
7	35% to below 45% aggregate (internal and external put together) with a minimum of 30% in external valuation	Pass	P	4	3.50 – 4.49	Third Class
8	Below an aggregate of 35% or below 30% in external evaluation	Fail	F	0	0 – 3.49	Fail
9	Not attending the examination	Absent	Ab	0	0	Fail

- When students take audit courses, they will be given Pass (P) or Fail (F) grade without any credits.
- The successful completion of all the courses and capstone components prescribed for the three-year or four-year programme with 'P' grade shall be the minimum requirement for the award of UG Degree or UG Degree (Honours) or UG Degree (Honours with Research), as the case may be.

5.1. COMPUTATION OF SGPA AND CGPA

- The following method shall be used to compute the Semester Grade Point Average (SGPA):

  The SGPA equals the product of the number of credits (Ci) with the grade points (Gi) scored by a student in each course in a semester, summed over all the courses taken by a student in the semester, and then divided by the total number of credits of all the courses taken by the student in the semester,

  i.e. SGPA (Si) = $\Sigma_i (C_i \times G_i) / \Sigma_i (C_i)$

where Ci is the number of credits of the ith course and Gi is the grade point scored by the student in the ith course in the given semester. Credit Point of a course is the value obtained by multiplying the credit (Ci) of the course by the grade point (Gi) of the course.

$$\text{SGPA} = \frac{\text{Sum of the credit points of all the courses in a semester}}{\text{Total credits in that semester}}$$

ILLUSTRATION – COMPUTATION OF SGPA

Semester	**Course**	**Credit**	**Letter Grade**	**Grade point**	**Credit Point** (Credit x Grade)
I	Course 1	3	A	8	3 x 8 = 24
I	Course 2	4	B+	7	4 x 7 = 28
I	Course 3	3	B	6	3 x 6 = 18
I	Course 4	3	O	10	3 x 10 = 30
I	Course 5	3	C	5	3 x 5 = 15
I	Course 6	4	B	6	4 x 6 = 24
	Total	20			139
	SGPA				139/20 = 6.950

- The Cumulative Grade Point Average (CGPA) of the student shall be calculated at the end of a programme. The CGPA of a student determines the overall academic level of the student in a programme and is the criterion for ranking the students.

  CGPA for the three-year programme in PWC FYUGP shall be calculated by the following formula.

$$\text{CGPA} = \frac{\text{Sum of the credit points of all the courses in six semesters}}{\text{Total credits in six semesters (133)}}$$

  CGPA for the four-year programme in PWC FYUGP shall be calculated by the following formula.

$$\text{CGPA} = \frac{\text{Sum of the credit points of all the courses in eight semesters}}{\text{Total credits in eight semesters (177)}}$$

- The SGPA and CGPA shall be rounded off to three decimal points and reported in the transcripts.

- Based on the above letter grades, grade points, SGPA and CGPA, the College shall issue the transcript for each semester and a consolidated transcript indicating the performance in all semesters.

* * * * * * *

B.Sc. STATISTICS HONOURS

(MAJOR, MINOR AND GENERAL FOUNDATION COURSES)

SYLLABUS

PROVIDENCE WOMEN'S COLLEGE
FOUR- YEAR UNDERGRADUATE PROGRAMME
(PWC FYUGP)
BSc STATISTICS MAJOR COURSES

SEMESTER I

Programme	B. Sc. Statistics				
Course Code	STA1CJ101(P)/STA1MN100 (P)				
Course Title	**Univariate Data Analysis**				
Type of Course	**Major**				
Semester	I				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	HSE level Mathematics/Statistics courses				
Course Summary Objective	To make the student describe, visualize, distinguish, illustrate single variable data				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Describe types of data To understand the various types of data and emphasize the relevance of big data in statistical analysis.	U	C	Instructor-created exams / Quiz
CO2	Illustrate (numerical data) To understand and apply measures of central tendency to describe the centre of a data se	U	F	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO3	Visualize To analyse the spread or variability within a univariate data set using measures of dispersion	U	C	Seminar Presentation / Group Tutorial Work/ Instructor-created

				exams
CO4	Illustrate (software) To provide hands-on experience applying the concepts learned in the previous modules.	U	C	Instructor-created exams / Home Assignments
CO5	To equip students with skills in effectively presenting univariate data using tables and diagrams.	Ap	P	One Minute Reflection Writing assignments/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I	Introduction to Statistics		**10**	**10**
	1	Understanding Types of Data- Categorical, Numerical Data (Discrete and Continuous)		
	2	Time Series Data, Cross-Sectional Data, Nominal and Ordinal Data		
	3	Primary and Secondary data, Design a questionnaire.		
	4	Data Sources in the Digital Age, Challenges and Opportunities in Analysing Modern Data		
	Sections from References:			
II	Measures of Central tendency		**10**	**20**
	5	Arithmetic Mean, Simple and Weighted Mean		
	6	Median, and Mode(Calculation and Interpretation).		
	7	Geometric Mean, Harmonic Mean (Calculation and Interpretation).		
	8	Comparison of Measures of Central Tendency- Scenarios for Applying Mean, Median, and Mode- Robustness of Measures, Partition values		
	Sections from References:			
III	Measures of Dispersion		**15**	**25**
	9	Absolute and relative measures of dispersion		
	10	Range, Quartile Deviation		
	11	Mean Deviation		
	12	Standard Deviation		
	13	Coefficient of Variation		
	14	Moments- Central and non-Central Moments,		
	15	Measures of Skewness based on Quartiles and Moments		
	16	Kurtosis based on Moments,		
	17	Box plot		
	Sections from References:			

IV		Introduction to R	**10**	**15**
	18	R as a calculator, R preliminaries,		
	19	Getting help, data inputting methods(direct and importing from other spread sheet applications like Excel),		
	20	Statistical software and a programming language,		
	21	Data accessing, and indexing, Graphics in R, built in functions,		
	22	Saving, Storing and Retrieving work.		
	Sections from References:			
V		**Open Ended Module:** **Practical Applications, Case Study and Group Assignments**	**30**	
	1	Practical exercises Hands-on using Software R: Graphical Presentation of Data, Measures of central tendency and dispersion. Case study using primary data in the form of Group Assignments and Discussions. Prepare record of at least 10 questions from Module III and IV using R Package		
	Sections from References:			

Books and References:

Textbooks :

1. S.C. Gupta and V. K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand and Sons
2. Michale J. Crawley, THE R BOOK, John Wiley & Sons, England (2009)

References

1. V. K. Rohatgi, An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.
2. Sudha G. Purohitet.al., Statistics Using R, Narosa Publishing House, , India(2008)
3. A.M. Mood, F.A. Graybill and D C Bose, Introduction to Theory of Statistics, McGraw Hill
4. John E Freund, Mathematical Statistics (6th edn), Pearson Edn, NewDelhi.

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	3	1	2	-	-	2	-	2	-	-	-
CO 2	3	3	-	2	1	-	3	1	2	3	-	-
CO 3	1	2	-	2	-	-	2	-	2	-	-	-
CO 4	3	2	-	1	-	-	3	-	2	2	-	-
CO	3	2	-	-	-	-	3	-	2	-	-	-

5												
CO 6	1	1	2	-	3	3	2	2	1	-	3	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

SEMESTER II

Programme	B. Sc. Statistics
Course Code	STA2CJ101(P)/STA2MN100(P)
Course Title	**Bivariate Data Analysis**
Type of Course	**Major**
Semester	II
Academic Level	100-199

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75

Pre-requisites	HSE level Mathematics/Statistics courses
Course Summary Objective	To make the student analyze Bi variate data and Examine agreement / strength of variables

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Describe and interpret bivariate data	U	C	Instructor-created exams / Quiz
CO2	Understand the concept of correlation and interpret their magnitude and direction	U	F	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO3	Perform simple linear regression analysis to model the relationship beteen variables	U	C	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Identify patterns and trends in bivariate data	U	C	Instructor-created exams / Home Assignments
CO5	Apply effectively in real life situations and do analysis using R software and communicate the results.	Ap	P	One Minute Reflection Writing assignments/ Instructor-created exams

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45	Marks (70)

			+30)	
I		**Concept of Bivaraite Data**	**10**	**15**
	1	Bivariate Data: Definition, Scatter Diagram.		
	2	Contingency tables for discrete data, joint, marginal.		
	3	Curve fitting: Principle of least squares		
	4	fitting of straight line, exponential and power curves using the principle of least squares		
	Sections from References:			
II		**Correlation**	**10**	**20**
	5	Concept, types of Correlation,		
	6	Karl Pearson’s Coefficient of Correlation for grouped and ungrouped data and its properties.		
	7	Spearman’s Rank Correlation		
	8	measures using Discordant and Concordant pairs		
	9	Point Bi serial correlation interpretation of correlation coefficient		
	Sections from References:			
III		**Regression**	**15**	**20**
	10	Concept of Regression		
	11	Distinction between Correlation and Regression		
	12	Linear and Non Linear Regression		
	13	Lines of Regression		
	14	Need of Two lines of Regression		
	15	Regression coefficients		
	16	Properties of Regression Coefficients		
	17	Angle of Regression lines and interpretation		
	Sections from References:			
IV		**Partial and Multiple Correlation**	**10**	**15**
	18	Concepts of Partial and Multiple Correlation Coefficients (three variable cases only).		
	19	Computation of Multiple and Partial Correlation Coefficients		
	20	Properties of Multiple and Partial Correlation Coefficients		
	21	Analysis of Categorical Data: Contingency table,		
	22	Independence & association of attributes.		
	Sections from References:			
V		**Open Ended Module:** **Practical Applications, Case Study and Group Assignments**	**30**	
	1	Practical exercises Hands-on using Software R: Graphical Presentations, Correlation and regression Case study using primary data in the form of Group Assignments and Discussions. Prepare record of at least 10 questions from Module I, II, III and IV using R Package		
	Sections from References:			

Books and References:

1. Christian Heumann, Michael Schomaker, Shalabh., Introduction to Statistics and Data Analysis, Springer Publications,2016
2. S.C.Gupta and V.K.Kapoor., Fundamentals of Applied Statistics, Sultan Chand and Sons

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	3	-	-	-	2	3	2	-	-	-	-
CO 2	-	-	-	-	-	3	3	2	-	-	-	-
CO 3	-	-	-	-	-	2	2	3	-	-	-	-
CO 4	-	-	-	-	-	-	3	3	-	-	1	1
CO 5	-	2	-	3	2	-	2	-	1	-	2	-
CO 6	2	-	2	-	-	3	2	3	-	3	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6	✓			✓

SEMESTER III

Programme	B. Sc. Statistics
Course Code	STA3CJ201
Course Title	**Mathematical Methods for Statistics I**

Type of Course	**Major**				
Semester	III				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	HSE level Mathematics course				
Course Summary Objective	Make students aware of fundamental concepts of Mathematical Analysis,				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Explain the concepts of Real line	U	C	Instructor-created exams / Quiz
CO2	Determine limits of Sequence and series	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Understand Convergence and Divergence	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Explain Continuity and Uniform Continuity	U	C	Instructor-created exams / Home Assignments
CO5	Derivative of functions	Ap	P	One Minute Reflection Writing assignments
CO6	visualize Theory of Integration	Ap	P	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)

I		**Real Line**	**16**	**20**
	1	The Order Properties of R		
	2	Absolute Value and the Real Line		
	3	The Completeness Property of R		
	4	Archimedean Property		
	5	The Existence of $\sqrt{2}$		
	6	The Density Theorem		
	7	Nested Intervals Property		
	8	Uncountability of R		
	Sections from References:			
II		**Sequences and Series**	**12**	**15**
	9	Sequence, Limit of a Sequence,		
	10	Limit Theorems, Monotone Convergence Theorem (statement only), Subsequence,		
	11	Bolzano- Weierstrass Theorem		
	12	The Cauchy Criterion, Introduction to Infinite Series,		
	13	Convergence criteria, common convergence tests.		
	Sections from References:			
III		**Function**	**10**	**20**
	14	Limit of functions		
	15	On-sided Limits,		
	16	Continuous Functions,		
	17	Bolzano's Intermediate Value Theorem,		
	18	Uniform Continuity,		
	19	Monotone and Inverse Functions		
	Sections from References:			
IV			**10**	**15**
	20	Derivative		
	21	Chain Rule		
	22	The Mean Value Theorem		
	23	Riemann Integral, Riemann Integrable Functions,		
	24	Fundamental Theorem of Calculus		
	Sections from References:			
V		**Open Ended Module:**	**12**	
	1	Sets and Functions, Finite and Infinite Sets Algebraic Properties of R, Rational and Irrational Numbers,		
	Sections from References:			

Books and References:

1. Bartle R. G. and Sherbert D. R. (2000). Introduction to Real Analysis, 3rd edition, John Wiley & Sons
2. Rudin, W. (1976) Principles of Mathematical Analysis, McGraw-Hill, New York.
3. Royden, H. L. and Fitzpatrick, P. M. (2010). Real Analysis. Prentice Hall.

Programme	B. Sc. Statistics
Course Code	STA3CJ202(P)/STA3MN200 (P)

Course Title	**Probability and Random Variables**				
Type of Course	**Major**				
Semester	III				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	HSE level Mathematics/Statistics courses				
Course Summary Objective	Make the students recall set theory, define, classify, illustrate probability theory. Discuss use of math. Expectation in variable properties				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Define and comprehend the fundamental concepts of probability and apply basic probability rules.	U	C	Instructor-created exams / Quiz
CO2	Define random variables, compute their probabilities, and consequently develop probability and cumulative probability distributions.	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Recognize and interpret moments of a distribution through mathematical expectation	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Develop proficiency in handling probability problems using statistical software and analyzing probability distributions.	U	C	Instructor-created exams / Home Assignments
CO5	Communicate the solutions to probability problems effectively and enhance the ability to present information clearly and concisely	Ap	P	One Minute Reflection Writing assignments
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive				

Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**Basics of Set Theory**	**12**	**18**
	1	Permutations and Combinations		
	2	Random experiment, Sample space, Events,		
	3	Classical definition of probability		
	4	Statistical regularity		
	5	Statistical Definition of Probability		
	6	Field, Sigma field		
	7	Axiomatic definition of probability and simple properties		
	8	Addition theorem (two and three events)		
	Sections from References:			
II		**Conditional probability**	**10**	**15**
	9	Definition of Conditional probability		
	10	Multiplication theorem		
	11	Independence of events- Pair wise and Mutual		
	12	Bayes theorem and its applications.		
	Sections from References:			
III		**Random variables**	**13**	**20**
	13	Discrete and Continuous Random variables		
	14	Probability mass function (pmf) properties and examples		
	15	Probability density function (pdf)-properties and examples		
	16	Cumulative distribution function		
	17	Properties of Distribution Function		
	18	Plotting step function/Ladder function		
	19	Change (transformation) of variables		
	20	Derivative method		
	21	Distribution function method		
	Sections from References:			
IV		**Mathematical Expectation**	**10**	**17**
	22	Expected values of Random Variables		
	23	Raw and Central Moments (definition and relationships)		
	24	Moment generation function (MGF)		
	25	Properties of MGF		
	26	Characteristic function (definition and use only),		
	27	Moment measures of Skewness and kurtosis.		
	Sections from References:			
V		**Open Ended Module: Practical Applications Probability and Distributions**	**30**	
	1	Handling problems related to probability		

		Verification of function as pmf/pdf, Evaluation of moments, MGF and characteristic function (R / Mathematica-wolframcloud /sage…) Case Study Observing a random phenomenon, construction of empirical probability distribution.		
	Sections from References:			
	Books and References 1. S.C. Gupta and V. K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand and Sons 2. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn., (Reprint), Tata McGraw-Hill Pub. Co. Ltd. 3. Christian Heumann, Michael Schomaker and Shalabh (2016): Introduction to Statistics and Data Analysis with Exercises, Solutions and Applications in R., Springer International Publishing Switzerland 4. John E Freund (2014): Mathematical Statistics, Pearson Edn, New Delhi 5. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2ndEdn. (Reprint) John Wiley and Sons.			

SEMESTER IV

Programme	B. Sc. Statistics
Course Code	STA4CJ201(P)
Course Title	**Probability Distributions**
Type of Course	**Major**
Semester	IV
Academic Level	200-299

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75

Pre-requisites	HSE level Mathematics/Statistics courses
Course Summary Objective	To understand random variables, their probability distributions (discrete and continuous cases separately). To analyse their characterization & properties of the distribution. To gain proficiency in transformation of random variables. To analyse their characterization & properties of the real data set.

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Apply probability concepts to model. .	U	C	Instructor-created exams / Quiz
CO2	Analyze random phenomena Analyze the corresponding distribution and its characterization.	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Gain thorough idea about theoretical and practical aspects of Probability distribution	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Apply transformation of random variables to obtain new distributions.	U	C	Instructor-created exams / Home Assignments
CO5	Uses of moments, cumulates, and characteristic functions.	Ap	P	One Minute Reflection Writing assignments
CO6	Analyze the distributional properties of data using moments, skewness, and kurtosis.	Ap	P	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive				

Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**Standard Distributions Discrete**	**10**	**16**
	1	Degenerate distribution		
	2	Bernoulli distribution (definition).		
	3	Binomial distribution (definition, properties and application).		
	4	Poisson distribution (definition, properties and application).		
	5	Relationship between Binomial and Poisson Distributions		
	Sections from References:			
II		**Standard Distributions Discrete**	**10**	**16**
	6	Discrete Uniform distribution (definition and basic properties).		
	7	Geometric distribution (definition and basic properties).		
	8	Lack of memory property of Geometric Distribution		
	9	Negative Binomial distribution (definition and basic properties).		
	10	Hyper-geometric distribution (definition and basic properties).		
	Sections from References:			
III		Standard distributions Continuous	**10**	**18**
	9	Rectangular (definition, mean, variance and mgf)		
	10	Exponential (definition, mean, variance and mgf)		
	11	Memoryless property of Exponential distribution		
	12	Gamma (definition, mean, variance and mgf)		
	13	Beta (definition, mean, variance and mgf)		
	14	Relationship between Gamma, Beta first and second distributions		
	Sections from References:			
IV		Normal distribution	**15**	**20**
	15	Definition		
	16	Derivation of Mean and Variance		
	17	Derivation of Median and Mode Mean Deviation		
	18	Derivation of MGF		
	19	Derivation of General Central Moment		
	20	Standard Normal Distribution		
	21	Normal distribution- additive property		
	22	Area properties of Normal Distribution		
	24	Computing area under standard Normal Curve		
	25	Quartile Deviation		
	26	Lognormal, Pareto Distributions (definition only).		
	27	Cauchy, Weibull and Laplace Distributions (definition only).		
	Sections from References:			
V		**Open Ended Module: Practical Applications**	**30**	
	1	Fitting of standard distributions		

		Random number generation using software		
	Sections from References:			

Books and References:

1. S.C. Gupta and V.K. Kapoor : Fundamentals of Mathematical Statistics, Sultan Chand and sons
2. V.K. Rohatgi: An introduction to Probability theory and Mathematical Statistics, Wiley Eastern.
3. Mood A.M., Graybill. F.A and Boes D.C. : Introduction to Theory of Statistics McGraw Hill
4. Johnson, N.L., Kemp, A.W., and Kotz, S.. (2005): Univariate Discrete Distributions, 5th edition, Wiley Interscience, John Wiley & Sons
5. Johnson, N.L., Kotz, S., and Balakrishnan, N. (2002): Continuous Univariate Distributions, Vol. 1, John Wiley
6. Johnson, N.L., Kotz, S., and Balakrishnan, N. (2002): Continuous Univariate Distributions, Vol. 2, John Wiley
7. Hogg, R. V., Craig, A., and Mckean, J.W. (2019): Introduction to Mathematical STATistics, 8th edition , Pearson
8. John E Freund : Mathematical Statistics (Sixth Edition), Pearson Education (India),New Delhi.

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Programme	B. Sc. Statistics
Course Code	STA4CJ202(P)

Course Title	**Bivariate Random Variables and Limit Theorems**				
Type of Course	**Major**				
Semester	IV				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	HSE level Mathematics/Statistics courses				
Course Summary Objective	Make students to aware bivariate distributions and understanding BVN. Apply LLN for computing asymptotic probability				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Calculate Marginal & Conditional Probability	U	C	Instructor-created exams / Quiz
CO2	Examine Independence of two Random Variables	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Examine properties of Bivariate Normal Distribution	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Compute upper and lower bound of Probability	U	C	Instructor-created exams / Home Assignments
CO5	Discriminate sequences of Random Variables satisfying Law of Large Numbers	Ap	P	One Minute Reflection Writing assignments
CO6	Asymptotic behavior of Random Variables	Ap	P	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45	Marks (70)

			+30)	
I		**Bivariate Random Variable**	**10**	**18**
	1	Joint probability mass function		
	2	Joint Probability density function		
	3	Marginal Probability functions		
	4	Conditional Probability functions		
	5	Joint Probability Distribution function		
	6	Properties of Joint Probability Distribution function		
	7	Independence of Random Variables.		
	Sections from References:			
II		Bivariate Expectation	**11**	**18**
	8	Mathematical expectation of Bivariate Random Variables,		
	9	Addition theorem of Expectation		
	10	Multiplication theorem of Expectation,		
	11	Covariance, Cauchy-Schwartz Inequality		
	12	Conditional Expectation and Conditional Variance		
	Sections from References:			
III		Bivariate Normal Distribution (BVN)	**10**	**14**
	13	Probability density function of BVN, properties of BVN		
	14	Marginal Probability density function of BVN		
	15	Conditional Probability density function of BVN		
	16	Standard bivariate normal distribution		
	Sections from References:			
IV		**Limit Theorems**	**14**	**20**
	17	Convergence in probability		
	18	Convergence in distribution		
	19	Chebyshev's Inequality		
	20	Weak Law of Large Numbers (iid case)		
	21	Bernoulli's Law of Large Numbers.		
	22	Central Limit Theorem (Lindberg levy-iid case),		
	23	Applications of CLT		
	24	Computation of sample size using Chebeshev's Inequality and CLT		
	Sections from References:			
V		**Open Ended Module:** **Practical Applications**	**30**	
	1	Hands-on in R: joint probability law, marginal and conditional probability functions, conditional expectation and variance, Chebyshev's inequality, WLLN, BVN		
	Sections from References:			

Books and References:
1. S. C. Gupta and V. K. Kapoor. Fundamentals of Mathematical Statistics. Sultan Chand and Sons.
2. Samuel Kotz, N. Balakrishnan, Norman L. Johnson. Continuous Multivariate Distributions: Models and Applications. Wiley Series in Probability and Statistics

Programme	B. Sc. Statistics				
Course Code	STA4CJ203(P)				
Course Title	Applied Statistics Time Series, Index Numbers & official statistics				
Type of Course	**Major**				
Semester	IV				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	HSE level Mathematics/Statistics courses				
Course Summary Objective	Make students to apply statistical models in time series data. Importance of various indices and vital rates.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Describing TS components forces affecting data.	U	C	Instructor-created exams / Quiz
CO2	Interpreting and computing trend and SI	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Relate IN for economic policy formulation	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Computation of various IN	U	C	Instructor-created exams / Home Assignments
CO5	Summarise Fertility mortality rates	Ap	P	One Minute Reflection Writing assignments
CO6	Construct Life tables	Ap	P	Viva Voce

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**Time Series**	**10**	**20**
	1	Time series definition and Components of time series.		
	2	Additive and Multiplicative models		
	3	Measurement of secular trend Free Hand/Graphical method		
	4	Method of Semi Averages		
	5	Method of moving averages		
	6	Method of least squares (linear, quadratic and exponential).		
	Sections from References:			
II		**Measurement of Seasonal Variation**	**10**	**15**
	7	Simple average method.		
	8	Ratio to trend Method		
	9	Ratio to moving average		
	10	Method-Link relative method		
	Sections from References:			
III		**Index Numbers**	**14**	**20**
	11	Classification of Index Numbers		
	12	Methods of constructing Index Numbers		
	13	Unweighted Index Numbers, Weighted Index Numbers		
	14	Laspeyre's, Paasche's, Marshal-Edgeworth, Fisher's, Dorbish Bowleys, Kellys)-		
	15	Quantity Index Numbers-Fixed base and chain base Index. Numbers		
	16	Different tests of a good Index numbers: - Unit test, Time Reversal Test-Factor Reversal Test- Circular test.		
	17	Fishers Ideal Index Number		
	18	Cost of Living Index Numbers-Consumer Price Index Numbers-		
	19	Family Budget enquiry		
	Sections from References:			
IV		**Vital Statistics**	**11**	**15**
	20	Sources of Vital Statistics (SRS, CRS),		
	21	Fertility rate- CBR, ASFR, TFR, GFR,		
	22	Mortality rate- CDR, ASDR, SDR, IMR,		
	23	Population growth- NRR and GRR (definitions only).		
	24	Construction of simple life tables		
	Sections from References:			
V		**Open Ended Module:** **Practical Applications, Case Study**	**30**	
	1	Visit of Government Organizations NSSO, DES Case study using secondary data available from government publications of Module I, II, III & IV Presentation of collected data.		
	Sections from References:			
Books and References:				

1. SC Gupta and VK Kapoor: Fundamentals of Applied Statistics. Sulthan Chand and sons, New Delhi.
2. Parimal Mukhopadhyay: Applied Statistics. Books and Allied (P) Ltd.
3. Box GE and Jenkins G M, Time series Analysis, Holden day

SEMESTER V

Programme	B. Sc. Statistics				
Course Code	STA5CJ301				
Course Title	**Estimation**				
Type of Course	**Major**				
Semester	V				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites					
Course Summary Objective	Make students to understand standard sampling distr. Calculate point estimate and its properties construction of interval estimates				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	construct various sampling distribution To understand sampling distributions and its applications	U	C	Instructor-created exams / Quiz
CO2	interpret point estimation and its properties, interval estimation The student will be able to know various methods of estimation and applying them in practical cases.	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	solve parameters using various methods of estimation	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	construct confidence intervals The students understand the concept of interval estimation and its applications	U	C	Instructor-created exams / Home Assignments
CO5	apply using software	Ap	P	One Minute

				Reflection Writing assignments
CO6	The student will be able to know point estimation and apply it in real life situations.	Ap	P	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I		**Sampling Distributions**	**10**	**20**
	1	Definitions of parameter, statistic and standard error		
	2	Exact sampling distribution Chi square distribution (derivations of distributions not required).		
	3	Mean, Variance, MGF		
	4	Mode, Additive property		
	5	Students t distribution (derivations of distributions not required)		
	6	Mean, Variance, Moments		
	7	Snedecor's F distribution: (derivations of distributions not required)		
	8	mean, variance, mode		
	9	Relationship between z, t, F and Chi square distributions.		
	10	Sampling distributions, - distribution of sample mean and variance.		
	Sections from References:			
II		Point Estimation	**10**	**20**
	11	Estimator, Estimate Properties of good Estimator Unbiasedness, Sufficiency, Consistency and Efficiency		
	12	Factorization theorem		
	13	Complete Statistic		
	14	Minimum Variance Unbiased Estimator (MVUE) Cramer-Rao inequality(statement only)		
	15	Completeness Rao-Blackwell theorem(statement only),		
	16	Lehman Scheffe theorem (statement only),		
	17	Smple problems. MVB Estimators and their applications		
	Sections from References:			
III		Methods of Estimation	**20**	**15**
	18	Method of Moments,		
	19	Method of Maximum Likelihood Estimation		
	20	Application of order statistics in estimation		
	Sections from References:			
IV		Interval Estimation	**8**	**15**

	21	Concept of Confidence Interval		
	22	Confidence Intervals for mean of Normal population Large & small sample		
	23	Confidence Intervals for Proportion		
	24	Confidence intervals for Variance of Normal population		
	25	Confidence Interval for the difference of means and proportion		
	Sections from References:			
V	**Open Ended Module:**		**12**	
	1	Understanding concepts and properties from modules 1 to 4 using softwares		
	Sections from References:			

Books and References:

1. Goon, A.M. Gupta, M.K., and Das Gupta, B. (1980): An outline of statistical theory, Vol.I, 6th revised ed. World Press limited, Calcutta.
2. Gupta, S.C. and Kapoor, V.K. (2014): Fundamentals of Mathematical Statistics, Sultan Chand & Sons.
1. Rohatgi, V.K. (1984) An introduction to probability theory and mathematical statistics, Wiley Eastern.
2. Wilks, S.S. (1962): Mathematical statistics - John Wiley & Sons.

Programme	B. Sc. Statistics				
Course Code	STA5CJ302(P)				
Course Title	**Sampling Methods**				
Type of Course	**Major**				
Semester	V				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites					
Course Summary Objective	Make students aware of statistical surveys types of sampling methods of sampling and comparing them based on efficiency of estimates				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Explain need and necessity of sampling	U	C	Instructor-created exams / Quiz
CO2	Distinguish between methods of sampling	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Construct sampling based on nature of population	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Examine the efficiency of estimation	U	C	Instructor-created exams / Home Assignments
CO5	Construct random samples	Ap	P	One Minute Reflection Writing assignments
CO6		Ap	P	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**Statistical Surveys**	**10**	**15**
	1	Census and Sample Surveys		
	2	Advantages of Sample survey over Census		
	3	Basic concepts in sampling &Types of sampling		
	4	Concepts of Probability Proportional to Size and Random Sampling		
	5	Principal steps in Sample Survey.		
	6	Sampling and non-Sampling errors		
	Sections from References:			
II		Simple random sampling	**12**	**20**
	7	Simple Random Sampling (SRS) Simple Random Sampling With Replacement. (SRSWR) Simple Random Sampling Without Replacement (SRSWOR)		
	8	Merits and demerits of Simple Random Sampling (SRS).		
	9	Methods of selecting SRS (Lottery method and Random Number method).		
	10	Estimation of Mean		
	11	Variance of estimated mean		
	12	Estimate of estimated variance.		
	13	Unbiased estimate of Population Mean Square		
	Sections from References:			
III		Stratified random sampling	**15**	**20**
	14	Need for stratification		
	15	Estimation of Mean and variance of estimated mean		
	16	Proportion and Optimum allocation:		
	17	Allocation of sample size under Proportional Allocation and variance of estimated mean		
	18	Allocation of sample size under Optimum Allocation and variance of estimated mean		
	19	Comparison of Stratified sampling over SRS		
	Sections from References:			
IV			**8**	**15**
	20	Systematic sampling:		
	21	Estimation of mean and variance.		
	22	Advantages of systematic sampling over SRS and stratified sampling.		
	23	Comparison of systematic sampling over SRS and stratified sampling.		
	24	Cluster sampling: Clusters with equal sizes		
	25	Estimation of the population mean and total,		
	26	Comparison with simple random sampling		
	Sections from References:			
V		**Open Ended Module: Practical Applications**	**30**	
	1	Selection of sample and determination of sample size. Estimation of		

		mean and variance under SRSWR Estimation of mean and variance under SRSWOR Estimation of mean and variance under Stratified sampling using real life problems.		
	Sections from References:			

Books and References:

1. Murthy M.N (1967): Sampling theory and Methods, Statistical Publisher Society, Calcutta.
2. Des Raj (2000): sample Survey Theory, Narosa publishing house.
3. Sampath S. (2000): Sampling theory and Methods. Narosa Publishing House.
4. Sukhatme B.V (1984): Sample Survey methods and its Applications, Indian Society of Agricultural Statistics.
5. S.C Gupta and V.K Kapoor: Fundamentals of Applied Statistics. Sultan Chand & Sons.

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Programme	B. Sc. Statistics				
Course Code	STA5CJ303(P)				
Course Title	**Testing of Hypothesis**				
Type of Course	**Major**				
Semester	V				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites					
Course Summary Objective	Objective make students aware of statistical hypotheses, framing of proper null and alternate hypothesis, selection of tests based conditions.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Describe the basic concepts and terminologies of testing of hypothesis.	U	C	Instructor-created exams / Quiz
CO2	Understand the theory behind the statistical test construction	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Understand some specific statistical tests and their application	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Describe the situations where parametric tests cannot be used.	U	C	Instructor-created exams / Home Assignments
CO5	Understand the non-parametric alternatives of parametric tests.	Ap	P	One Minute Reflection Writing assignments
CO6		Ap	P	Viva Voce

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		Statistical Hypothesis	**9**	**15**
	1	Statistical Hypothesis definition		
	2	Null and Alternative hypothesis		
	3	Simple and Composite hypothesis		
	4	Parametric and Non parametric test		
	5	Type I and Type-II errors		
	6	Critical Region		
	7	Level of significance & Size of the test		
	8	Power of the test and p- value.		
	Sections from References:			
II		Tests of hypothesis	**9**	**15**
	9	Most powerful test		
	10	Uniformly Most Powerful test		
	11	Neyman- Pearson Lemma (statement and proof of sufficiency part only)		
	12	Application of NP Lemma to construct uniformly most powerful test,		
	13	Unbiased test (definition only)		
	14	Likelihood ratio test, properties of likelihood ratio tests (without proof		
	Sections from References:			
III		Parametric Tests	**17**	**20**
	15	Large sample test concerning mean		
	16	Large sample test for equality of means,		
	17	Large sample test for proportions,		
	18	Large sample test for equality of proportions.		
	19	Small sample tests,		
	20	Independent t-test, paired t-test,		
	21	Test for the significance of population variance.		
	22	Concept of ANOVA		
	Sections from References:			
IV		Non parametric Tests	**10**	**20**
	23	Introduction and Concept		
	24	Test for randomness based on total number of runs,		
	25	Empirical distribution function, One Sample Tests: Kolmogrov – Smirnov test,		
	26	Sign test, Signed rank test (Wilcoxon)		
	27	Mann-Whitney U test. Kruskal-Wallis test.		
	28	Chi-square test of goodness of fit		
	29	Chi-square test for independence of attributes		
	Sections from References:			
V		**Open Ended Module: Practical Applications**	**30**	
	1	All statistical tests should be done to students with simple example		

		using R or Python.		
	Sections from References:			

Books and References:

Gupta, S.C. and Kapoor, V.K. (2014): Fundamentals of Mathematical Statistics, Sultan Chand & Sons.

Christian Heumann, Michael Schomaker, Shalabh., Introduction to Statistics and Data Analysis, Springer Publications, 2016

Goon, A.M., Gupta, M.K. and Dasgupta, B. (2002): Fundamentals of Statistics, Vol. I, 8th Edn. The World Press, Kolkata.

Rohatgi, V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2nd Edn. (Reprint) John Wiley and Sons

Casella, G. and Berger R.L. (2002). : Statistical Inference, 2nd Edn. Thomson Learning

Gibbons, J. D. and Chakraborty, S (2003): Nonparametric Statistical Inference. 4th Edition. Marcel Dekker, CRC.

SEMSTER VI

Programme	B. Sc. Statistics				
Course Code	STA6CJ301(P)				
Course Title	**Linear Regression Analysis**				
Type of Course	**Major**				
Semester	VI				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites					
Course Summary Objective	Objective make students to describe and assess the strength of relationships between variables, to explain them using math model, check adequacy of model				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Student will be able to understand the context of regression analysis	U	C	Instructor-created exams / Quiz
CO2	Capable for fitting a linear regression model to the given data	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Able to scrutinize the fitted model using the model adequacy checking	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Capable for forecasting the future values using the fitted model	U	C	Instructor-created exams / Home Assignments
CO5	Able to understand which type of regression model (linear or non-linear) is suitable	Ap	P	One Minute Reflection Writing assignments
CO6		Ap	P	Viva Voce

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		Simple Regression	**10**	**16**
	1	Regression Model building: Scatter Diagram,		
	2	Regressor, Response, Error, uses of Regression.		
	3	Simple Linear Regression model,.		
	4	Assumptions, least square and maximum likelihood estimation of the parameters of the model.		
	5	Properties of least square estimators,		
	6	Hypothesis testing on slope and intercept of the model		
	7	Coefficient of Determination		
	Sections from References:			
II		Multiple Regression	**10**	**16**
	8	Multiple Regression model, assumptions		
	9	least square and maximum likelihood estimation of the parameters of the model,		
	10	testing significance of regression coefficients, test on individual regression coefficient.		
	11	R^2 and adjusted R^2.		
	Sections from References:			
III			**17**	**25**
	12	Model adequacy checking		
	13	Residuals		
	14	Methods for scaling residuals,.		
	15	Residual plots,		
	16	PRESS statistic.		
	17	Detection and treatment of outliers		
	Sections from References:			
IV			**8**	**13**
	18	Transformation and weighting to correct model inadequacy- variance stabilizing transformations		
	19	Transformations to linearize the model.		
	20	Concept of Box-Cox transformation..		
	21	Concept of multicollinearity,		
	22	Sources of multicollinearity, Variance Inflation Factor		
	Sections from References:			
V		**Open Ended Module: Practical Applications**	**30**	
	1	Concept of non-linear regression, application to machine learning. Practical example of fitting a regression model using statistical software.		

	Sections from References:			

Books and References:

1. Montgomery, D. C., Peck, E. A., & Vining, G. G. (2012). Introduction to Linear Regression Analysis. Wiley.
2. D. D Joshi (1987). Linear Estimation and Design of Experiments. Wiley
3. Darlington, R. B. (1990). Linear Regression Analysis: Assumptions and Applications. Sage Publications.
4. Seber, G. A. F., & Lee, A. J. (2003). Linear Regression Analysis. Wiley
5. Weisberg, S. (2014). Applied Linear Regression. Wiley.
6. Yan, X., & Chen, M. (2007). Linear Regression Analysis: Theory and Computing. World Scientific

Programme	B. Sc. Statistics
Course Code	STA6CJ302(P)
Course Title	**Design and Analysis of Experiments**
Type of Course	**Major**
Semester	VI
Academic Level	300-399

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75

Pre-requisites	
Course Summary Objective	Objective make students aware of designing, planning conducting analysing interpreting controlled tests, analysing. Differentiating the variation from various sources

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Identify various causes of variation	U	C	Instructor-created exams / Quiz
CO2	Describe models to express the resulting observation based effects and errors	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Discuss the fundamental principles of experiments	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Summarize the total variation into sum of fixed and random causes	U	C	Instructor-created exams / Home Assignments
CO5		Ap	P	One Minute Reflection Writing assignments
CO6		Ap	P	Viva Voce

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**Theory of Linear Estimation**	**10**	**15**
	1	Estimability of linear parametric functions.		
	2	Method of least squares		
	3	Best Linear Unbiased Estimator (BLUE)		
	4	Gauss -Markov theorem		
	5	Linear hypothesis, Estimation of error variance.		
	Sections from References:			
II		**Analysis of variance**	**10**	**15**
	6	Definitions of Fixed effect model and random effect models		
	7	Definition of analysis of Variance,		
	8	Assumptions and Limitations of ANOVA		
	9	One way ANOVA with a single observation per cell		
	10	Two-way ANOVA with a single observation per cell		
	Sections from References:			
III		Analysis of covariance	**17**	**20**
	11	Model of Analysis of covariance		
	12	Analysis of covariance with a single observation per cell		
	13	Experimental Designs		
	14	Terminology Unit, Material Treatment and Experimental error.		
	15	Principles of design of Experiment		
	16	Randomization		
	17	Replication		
	18	Local Control		
	Sections from References:			
IV		**Basic Designs**	**8**	**20**
	19	Completely randomized design (CRD)		
	20	Randomized Block Design (RBD)		
	21	Latin Square Design (LSD).		
	22	Missing plot technique,		
	23	Comparison of Efficiency, Model Adequacy Checking		
	Sections from References:			
V		**Open Ended Module:** **Practical Applications**	**30**	
	1	Designing Experiments, Hands on Using R, Practical Interpretation of Results. Practical problems of ANOVA		
	Sections from References:			

Books and References:

1. S.C. Gupta & V.K. Kapoor: Fundamentals of Applied Statistics, Sultan Chand & Sons
2. M.N. Das & N. Giri: Design of Experiments, New Age International
3. Douglas C. Montgomery: Design and Analysis of Experiments, Wiley and Sons
4. John Lawson: Design, and Analysis of Experiments with R, Chapman and Hall

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Programme	B. Sc. Statistics
Course Code	STA6CJ303
Course Title	**Stochastic Processes**
Type of Course	**Major**
Semester	VI
Academic Level	300-399

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites					
Course Summary Objective	Objective make students aware of random process, behaviour stationary non stationary discrete continuous indexed process transition probabilities markovian behaviour				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the basic probability concepts including conditional probability, generating functions and Laplace transform	U	C	Instructor-created exams / Quiz
CO2	Student will define and understand the concept of stochastic processes	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	CO3 Student will be able to know and identify different types of stochastic process based on state space and time space.	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Students will analyse and model systems using discrete-time Markov chains, applying concepts such as transition probabilities, stationary distributions, and limiting behaviour	U	C	Instructor-created exams / Home Assignments
CO5	Develop proficiency in modelling systems with Poisson processes, recognizing their properties and applications across various domains	Ap	P	One Minute Reflection Writing assignments
CO6		Ap	P	Viva Voce

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I			**10**	**15**
	1	Introduction to Stochastic Processes(SP)		
	2	Definition of state space and time space		
	3	Classification of SP according to state space and time space,.		
	4	Process with independent increment		
	5	Process with stationary increment		
	Sections from References:			
II			**10**	**20**
	6	Markov property		
	7	Markov Chain		
	8	Discrete time Markov Chain(MC),		
	9	Transition probability matrix,		
	10	MC as graph.		
	11	Higher transition probabilities,		
	12	Chapman- Kolmogorov Equation.		
	13	One dimensional random walk (concept only)		
	Sections from References:			
III			**20**	**20**
	14	First passage probabilities		
	15	PGF,		
	16	Different types of states, classification of states (Recurrent, transient, ergodic)		
	17	Periodicity, mean ergodic theorem (statement only)		
	18	Class property, stationary distribution, limiting distributions,		
	19	Gambler's ruin problem (concept and construction of tpm only).		
	Sections from References:			
IV			**8**	**15**
	20	Continuous time MC,		
	21	Chapman-Kolmogorov equation (statement only),		
	22	Poisson Process		
	23	Inter-arrival time.		
	22	Relationship connecting Poisson Process and distributions (exponential, binomial, uniform and geometric)		
	Sections from References:			
V		**Open Ended Module:**	**12**	
	1	Practical problems relating to previous modules.		
	Sections from References:			

Books and References:
1. Medhi J. (2014) Stochastic Processes. Third Edition, New Age International
2. Basu A.K. (2003) Introduction to Stochastic Processes, Narosa, New-Delhi.
3. Cinlar E. (2013) Introduction to Stochastic Processes, Dover Publications, NewYork
4. Feller W. (1968) Introduction to Probability Theory and its Applications, Vols. I & II, John Wiley,

New York.
5. Karlin S. and Taylor H.M. (1975) A First Course in Stochastic Processes, Second edition, Academic Press, New-York.
6. Ross S.M. (2014) Introduction to Probability models, Eleventh edition, Academic Press

VII SEMESTER

Programme	B. Sc. STATISTICS				
Course Code	STA 7 CJ 401 (P)				
Course Title	ADVANCED ANALYTICAL TOOLS				
Type of Course	**Major**				
Semester	VII				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practicum per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic knowledge of Real analysis and Matrix theory.				
Course Summary	The main objective of this course to understand Reimann-Stieltjes integral, Uniform convergence, vector space Eigen values and Eigen vectors.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Evaluate the Riemann-Stieltjes integral and verify the conditions for the existence of the integrals.	An	C	Instructor-created exams
CO2	Demonstrate an understanding of limits and continuity of various functions	U	F	Practical Assignment
CO3	Develop skills in generalizing the concepts in univariate calculus to multivariate setup	Ap	C	Seminar Presentation
CO4	Demonstrate proficiency in understanding and applying vector space concepts	U	F	Instructor-created exams / Home Assignments
CO5	Demonstrate proficiency in applying vector space and matrix concepts	U	F	Writing assignments
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I	**Riemann – Stieltjes Integral**		**10**	**15**
	1	Definition, Linear properties- Integration by parts - Change of variable		
	2	Reduction to a Riemann integral		
	3	Step functions as integrators-Reduction to a finite sum		
	4	Monotonically increasing integrators- Riemanns conditions-Comparison theorems- Functions of bounded variations (concepts only)		
	5	Necessary & Sufficient conditions for the existence of Riemann Stieltjes integral		
	6	Mean-value theorems		
II	**Sequences and Series of Functions**		**13**	**20**
	7	Point wise convergence of sequence of functions - Examples of sequences of real valued functions		
	8	Definition of Uniform convergence - Uniform convergence and continuity		
	9	Cauchy condition for uniform convergence - Uniform convergence of infinite series of functions		
	10	Uniform convergence and Riemann-Stieltjes Integration - Uniform convergence and differentiation		
	11	Multivariable Functions- Limits and continuity of multivariable functions – Derivatives - directional derivatives		
	12	Total derivative in terms of partial derivatives		
	13	Taylor's theorem-Inverse and implicit functions.		
III	**Algebra of Vectors**		**10**	**15**
	14	Vector spaces - definition and examples		
	15	Subspaces - Linear independence - Basis and dimension- Linear equations		
	16	Vector spaces with an inner product: Properties		
	17	Gram-Schmidt orthogonalization.		
IV	**Algebra of matrices**		**12**	**20**
	18	Theory of matrices and determinants - Matrix operations-Elementary matrices and diagonal reduction of a matrix- Determinants-Transformations		
	19	Generalized inverse of a matrix		
	20	Matrix representations of vector spaces, bases, etc.		
	21	Idempotent matrices. Special products of matrices		
	22	Eigene values and reduction of matrices: Classification and transformations of quadratic forms. Roots of determinant equations. Canonical reduction of matrices.		
V	**Open Ended Module:**		**30**	
		Hands-on-activities using Python/R. Open book problem solving exercises		

Text Books

1. **Khuri, A.T. (1993).** Advanced Calculus with Applications in Statistics. John Wiley &Sons, New York.
   (Chapter7).
2. **Apostol, T.M. (1974).** Mathematical Analysis- Second Edition. Narosa Publications, New Delhi.
3. **Rao, C.R. (2002).** Linear Statistical Inference & Its Applications- Second Edition. John Wiley & Sons, New York.
4. **Rao, A.R. & Bhimasankaram, P. (1992)**. Linear Algebra. Hindustan Book Agency, New Delhi.
5. **Rao,A.R. and Bhimsankaram, P. (1992)**. Linear Algebra.Tata McGraw Hill, New Delhi.
6. **Lewis, D.W. (1996).** Matrix Theory. Allied Publishers, Bangalore.
7. **Graybill, F. A. (1983).** Matrices with Applications in Statistics. John Wiley & Sons, New York.

References:

1. **Widder, D.A. (1996).** Advanced Calculus, Second Edition, Prentice Hall, Inc., New Delhi.
2. **Malik, S.C. & Arora, S. (2006).** Mathematical Analysis- Second Edition. New Age Internati International, New Delhi.
3. **Rudin, W. (1976).** Principles of Mathematical Analysis- Third Edition. McGraw Hill, New York
4. **Biswas, S. (1997).** A text book of Linear Algebra. New Age International, New Delhi.
5. **Rao, C.R. (2002).** Linear Statistical Inference and Its Applications- Second Edition. John Wiley & Sons, New York.

Programme	B. Sc. STATISTICS				
Course Code	STA 7 CJ 402 (P)				
Course Title	PROBABILITY THEORY				
Type of Course	**Major**				
Semester	VII				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practicum per week	Total Hours
	4	3	-	3	75
Pre-requisites	Basic Probability theory, Concept of convergence				
Course Summary	Understanding expectation and various celebrated theorems in classical probability theory.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Recall sequence of sets and its convergence.	R	F	Instructor-created exams
CO2	Explain the concept of field, sigma field, Borel sigma field and monotone class.	U	C	Practical Assignment
CO3	Describe various types of measures and explain its properties.	R	C	Seminar Presentation
CO4	Explain decomposition of distribution function, characteristic function and its properties.	Ap	P	Instructor-created exams / Home Assignments
CO5	Explain the monotone convergence Theorem, Fatou's Theorem and Lebesgue dominated convergence Theorem.	Ap	P	Writing assignments
CO6	Explain the concept of convergence in probability, Convergence almost surely, Convergence in distribution, Convergence in r^{th} mean and their inter-relations.	U	F	Group Tutorial Work
CO7	Illustrate the convergence of distribution functions, Helly-Bray Lemma and Helly – Bray theorem, and Levy continuity theorem.	An	P	Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I			**10**	**20**
	1	Definition of minimal sigma field, generated sigma field and induced sigma field		
	2	Random variables, Sigma fields induced by random variables, Vector random variables, limits of sequence of random variables.		
	3	Concept of measure space, finite measure, sigma finite measure, complete measure, counting measure and signed measure (Definition and examples only).		
	4	Probability space, General Probability space.		
	5	Induced probability space.		
II			**12**	**15**
	6	Decomposition of distribution functions, Distribution function of vector random variables, Correspondence theorem.		
	7	Expectation and moments, Properties of expectations.		
	8	Moments and inequalities		
	9	Characteristic functions, Properties, Inversion theorem		
	10	Characteristic functions and moments, Bochner's theorem (No proof required)		
	11	Independence of classes of events; Independence of random variables		
	12	Kolmogorov 0-1 law; Borel 0-1 law		
III			**12**	**20**
	13	Monotone convergence Theorem.		
	14	Fatou's Theorem		
	15	Lebesgue dominated convergence Theorem		
	16	Lebesgue-Stieltjes integral and its reduction to Riemann-Stieltjes integral and Riemann integral.		
	17	Statement and applications of Lebesgue decomposition and Radon-Nykodym theorem.		
IV			**11**	**15**
	18	Convergence in probability, Convergence almost surely		
	19	Convergence in distribution, Convergence in rth mean – their inter-relations- examples and counter examples.		
	20	Weak convergence		
	21	Helly-Bray Lemma and Helly – Bray theorem		
	22	Levy continuity theorem.		
V	**Open Ended**		**30**	
		Sequences of sets, limit supremum, limit infimum and limit of sets. Monotone sequence of sets. Fields, Sigma fields, Borel sigma field and monotone class. Hands-on-activities using Python/R. Open book problem solving exercises		

Text Books

1. B.R Bhat (1999). Modern Probability Theory, Wiley Eastern
2. Laha & Rohatgi (1979). Probability theory, Wiley New York
3. De Barra, G. (2000). Measure Theory and Integration, New Age International (P) Ltd, New Delhi.

References

1. **Ash R. B (2000)**. Probability and Measure Theory, Second edition. Academic Press.

2. **Billingsley P (1985)**. Probability and Measure, Second edition, John Wiley and Sons, NewYork.

Programme	B. Sc. STATISTICS				
Course Code	STA7 CJ 403 (P)				
Course Title	DISTRIBUTION THOERY				
Type of Course	**Major**				
Semester	VII				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practicaum per week	Total Hours
	4	3	-	2	75
Pre-requisites	1. Basic knowledge of various univariate and bivariate distributions. 2. Matrix theory – Eigen Values & Eigen vectors.				
Course Summary	The main objective of this course are to understand the concepts of multivariate probability distributions. Study essential properties of multivariate distributions and apply customized probability distributions in the relevant context.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
1.	Distinguish different distributions and illustrate their role in modelling count data.	U	F	Seminar Presentation / Group Tutorial Work
2.	Describe the properties and applications of multivariate normal distribution.	U	C	Instructor-created exams
3.	Estimate the ML Estimates of the mean vector and dispersion matrix of multivariate normal.	An	P	Instructor-created exams
4.	Evaluate marginal and conditional distribution from multivariate normal distribution	An	P	Instructor-created exams / Home Assignments
5.	Describe the genesis of Wishart distribution with its properties.	U	C	Home Assignment
6.	Explain distribution function of random vectors, order statistics and their distributions.	Ap	C	Instructor-created exams / Home Assignments
7.	Compare Hotelling T^2 and	U	F	Instructor-created

	Mahalanobis D^2 statistic and able to apply them in testing problems.			exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45+30)	Marks (70)
I	**Open-End**		**30**	**20**
	1	Overview of univariate & bivariate distributions and their properties. Sampling Distributions- Central and non-central (t, F and $\chi 2$) Order statistics – their distributions and properties- Joint, marginal and conditional distribution of order statistics The distribution of sample range and sample median. Problems using R/Python		
II	**Multivariate Normal Distribution**		**12**	**20**
	1	Definition and properties of multivariate normal density function		
	2	Distribution of a linear combination of the components of a normal random vector.		
	3	Maximum Likelihood estimation of the mean vector and dispersion matrix.		
	4	The distribution of sample mean vector inference concerning the mean vector when the dispersion matrix is known for single and two populations.		
III	**Generalized Variance**		**9**	**15**
	5	Wishart Distribution		
	6	Properties of Wishart distribution		
	7	Test for covariance matrix		
	8	Test for equality of covariance matrices		
	9	Test for independence of sets of variables.		
IV	**Quadratic forms and their distributions**		**14**	**15**
	10	Jacobian of matrix transformation of Y=AXB; Y=AXA' ; X=TT'		
	11	Independence of a linear form and quadratic form		
	12	Distributions of quadratic form of a multivariate vector		
	13	Cochran's theorem		
	14	Partial and multiple correlation coefficients		
	15	Partial regression coefficients		
V	**T^2 and D^2 distributions**		**10**	
	16	Hotelling T^2 distribution and its applications		
	17	Generalized T^2 statistic and its distribution		
	18	Uses of T^2 statistic		
	19	Optimum properties of T^2 statistic		
	20	Mahalanobis D^2 statistic and its distribution		
	21	Relation between T^2 and D^2		
	22	Test based on T^2 statistic		

Text Book

1. **Anderson T W (2010)** : An Introduction to Multivariate Statistical Analysis, Wiley Eastern Ltd.
2. **Johnson, R A and Wichern D W (2003)** : Applied Multivariate Statistical Analysis, Prentice-Hall of India Private Ltd., New Delhi.

Reference

1. **Jhonson, Kotz and Balakrishna (1991)** : Continuous univariate distributions, Vol-1 2^{nd} Ed., John Wiley and Sons
2. **Johnson, Kemp and Kotz (1992)** : Univariate Discrete distributions, 2nd Ed, John Wiley and Sons
3. **Kotz, Balakrishnan, Johnson (2004)** : Continuous Multivariate Distributions, Vol 1, 2^{nd} Ed. John Wiley & Sons
4. **Mukhopadhyay P (1996)** : Mathematical Statistics, New Central Book Agency (P) Ltd. Calcutta.
5. **Srivastava, M, C G Khatri (1979)** : Introduction to Multivariate Statistics, Elsevier Science Ltd.

Programme	B. Sc. STATISTICS				
Course Code	STA 7 CJ 404 (P)				
Course Title	ADVANCED SAMPLING METHODS AND DESIGN OF EXPERIMENTS				
Type of Course	**Major**				
Semester	VII				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practicum per week	Total Hours
	4	3	-	2	75
Pre-requisites	Knowledge about sampling procedures and various sampling methods, linear estimation and analysis of variance				
Course Summary	Understand PPS sampling, ratio and regression sampling methods. Identify various factorial design experiments.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Estimate the population parameters concerning the study variables under auxiliary information (Ratio and regression methods).	An	C	Instructor-created exams
CO2	Discuss probability proportional to size (PPS) sampling strategies.	U	F	Home Assignments
CO3	Explain the concepts of ordered and unordered estimators and its properties.	Ap	C	Instructor-created exams
CO4	Discuss the multi stage and multiphase sampling.	U	F	Seminar Presentation
CO5	Apply incomplete block designs and balanced incomplete block designs.	Ap	C	Practical Assignment
CO6	Explain factorial experiments, total confounding and partial confounding.	Ap	C	Group Tutorial Work
CO7	Differentiate between strip plot and split plot designs.	An	P	Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**Open-Ended**	**30**	
		Census and Sampling-Basic concepts, probability sampling and non-probability sampling, simple random sampling with and without replacement, Systematic sampling- linear and circular systematic sampling, Stratification and stratified random sampling, Complete Block Designs. Problems using R/Python		
II	**Cluster , Ratio and Regression Sampling**		**12**	**20**
	1	Cluster sampling with equal and unequal clusters		
	2	Estimation of mean and variance, relative efficiency, optimum cluster size, varying probability cluster sampling		
	3	Ratio method of estimation-estimation of ratio, mean and total.		
	4	Bias and relative bias of ratio estimator. Mean square error of ratio estimator. Unbiased ratio type estimator		
	5	Regression methods of estimation		
	6	Comparison of ratio and regression estimators with simple mean per unit method. Ratio and regression method of estimation in stratified population		
III	**Varying probability sampling**		**10**	**15**
	7	pps sampling with and without replacements		
	8	Des- Raj ordered estimators-Murthy's unordered estimator		
	9	Horvitz-Thompson estimators, Yates and Grundy forms of variance and its estimators		
	10	Zen-Midzuno scheme of sampling, πPS sampling		
	11	Multi stage and multiphase sampling		
IV	**Incomplete Block Designs**		**11**	**20**
	12	Balanced Incomplete Block designs		
	13	Construction of BIB Designs, Analysis with recovery of inter-block information and intra-block information		
	14	Partially balanced incomplete block designs		
	15	Analysis of partially balanced incomplete block designs with two associate classes		
	16	Youden square design		
	17	Lattice designs		
V	**Factorial Designs**		**12**	**15**
	18	Basic definitions and principles - Analysis of 2^n factorial experiments		
	19	Total confounding of 2^n designs in 2^n blocks. Partial confounding in 2^n blocks		
	20	3^n factorial designs		
	21	Fractional factorial designs		
	22	Concepts of Split plot design and strip plot design		

Text Books

1. **Cochran W.G. (1992)**: Sampling Techniques, Wiley Eastern, New York.
2. **D. Singh and F.S. Chowdhary (1986)**: Theory and Analysis of Sample Survey Design, Wiley Eastern (New Age International), New Delhi.
3. **Montgomery D C (2001)**. Design and Analysis of Experiments, John Wiley.
4. **Das M N and Giri N C (1979)**. Design and Analysis of Experiments, second edition, Wiley.

References

1.**P.V.Sukhatme et.al. (1984)**: Sampling Theory of Surveys with Applications. IOWA State University Press, USA.

2. **Des Raj (1976)**: Sampling Theory. McGraw Hill

3. **Mukhopadhyay. P. (1999)**. Theory and Methods of Survey Sampling. Prentice-Hall India, New-Delhi.

4. **Chakrabarti, M.C. (1964)**. Design of experiments, ISI, Calcutta.

5. **Hinkleman and Kempthrone C (1994)**. Design and Analysis of Experiments Volume I, John Wiley.

Programme	B. Sc. STATISTICS				
Course Code	STA 7 CJ 405 (P)				
Course Title	ADVANCED STATISTICAL INFERENCE				
Type of Course	**Major**				
Semester	VII				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic knowledge of statistical estimation & testing of hypothesis				
Course Summary	Understand UMVUE and related theorems, UMP tests & SPRT				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Describe the method of finding sufficient statistics, minimum variance unbiased estimators, consistent estimators and consistent and asymptotically normal estimators	U	F	Instructor-created exams
CO2	Relate sufficient statistic and ancillary statistic using Basu's thorem	Ap	C	Instructor-created exams
CO3	Determine UMVUE using complete sufficient statistic using Rao- Blackwell, and Lehmann-Scheffe theorems	Ap	C	Seminar Presentation
CO4	Explain the concept of interval estimation- SELCI, Bayesian and Fiducial Intervals	U	F	Observation of Practical Skills
CO5	Construct most powerful tests using Neyman-Pearson lemma, one-sided and two-sided UMP tests and UMP unbiased tests	C	M	Group Tutorial Work
CO6	Describe the concept of α-similar tests and construct such tests	U	F	Practical Assignment
CO7	Develop SPRT for different problems	C	P	Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C), Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**Open-Ended**	**30**	
		Point Estimation. Desirable properties of a good estimator, unbiasedness, efficiency, Methods of Estimation - method of maximum likelihood, Bayesian estimation method. Testing of Hypotheses; concept of testing hypotheses, simple and composite hypotheses, null and alternative hypotheses, type I and type II errors, critical region, level of significance, power of test. Most powerful tests uniformly most powerful test, Neyman Pearson Lemma Problems using R/Python		
II		**Sufficient statistics and minimum variance unbiased estimators**	**12**	**15**
	1	Sufficient statistics, Factorization theorem for sufficiency, Joint sufficient statistics		
	2	Exponential family, Pitman family, Minimal sufficient statistics (MSS). Criteria to find the MSS, Ancillary statistics, Complete statistics		
	3	Basu's theorem		
	4	Unbiasedness, Best Linear Unbiased estimator(BLUE), Minimum variance unbiased estimator(MVUE)		
	5	Rao-Blackwell theorem		
	6	Lehman-Scheffe theorem		
	7	Necessary and sufficient condition for MVUE, Fisher Information, Cramer Rao inequality and its applications		
III		**Consistent asymptotically normal estimators and Interval Estimation**	**12**	**20**
	8	Consistent estimator, Invariance property of consistent estimator		
	9	Method of moments-method of percentiles to determine consistent estimators, choosing between Consistent estimators		
	10	CAN estimators		
	11	Definition of Interval estimation, Shortest expected length confidence interval-large sample confidence intervals-unbiased confidence intervals-examples		
	12	Bayesian and Fiducial intervals		
IV		**UMP tests**	**11**	**20**
	13	One-sided UMP tests, two- sided UMP tests and UMP unbiased tests		
	14	UMP tests for multi-parameter case: UMP unbiased test		
	15	α-similar tests and α-similar tests with Neyman structure, construction of α-similar tests with Neyman structure		
	16	Principle of invariance in testing of hypotheses, locally most powerful tests		
	17	Likelihood ratio tests		
	18	Bayesian tests		
V		**Sequential Tests**	**10**	**15**
	19	Some fundamental ideas of sequential sampling – Sequential Probability Ratio Test (SPRT)		
	20	Important properties, termination of SPRT – the fundamental identity		

		of SPRT		
	21	Operating Characteristic (OC) function and Average Sample Number (ASN) of SPRT		
	22	Developing SPRT for different problems		

Text Books

1. **Kale,B.K . and Muraleedharan K.(2015)** Parametric Inference : An Introduction, Alpha Science Intl Ltd.

2. **George Casella and Roger L Berger (2002)**. Statistical inference, Second Edition, Duxbury, Australia.

3. **Manojkumar Srivastava and Namita Srivastava(2009)**. Statistical Inference: Testing of Hypothesis, Eastern Economy Edition, PHI Learning Pvt. Ltd., New Delhi.

4. **Rohatgi, V.K(1976)**. An introduction to Probability Theory and Mathematical Statistics, John Wiley and sons, New York.

References

1. **Lehmann, E.L(1983)**. Theory of point estimation, John Wiley and sons, New York.

2. **Rohatgi, V.K (1984)**. Statistical Inference, John Wiley and sons, New York.

3. **Rao, C.R (2002)**. Linear Statistical Inference and its applications, Second Edition, JohnWiley and sons, New York.

4. **Lehman, E.L. and Romano, Joseph P.(2005)**. Testing Statistical Hypotheses. Third Edition, Springer, New- York.

SEMESTER VIII

Programme	B. Sc. STATISTICS				
Course Code	STA 8 CJ 406 (P)				
Course Title	APPLIED STOCHASTIC PROCESSES AND TIME SERIES ANALYSIS				
Type of Course	**Major**				
Semester	VII				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practicum per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic knowledge of Markov chain & general aspects of time series				
Course Summary	Understand queue, renewal process and Brownian process. Thorough knowledge about auto-correlation and autoregressive moving average.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
1.	Discuss the basic characteristic of a queuing system and acquire skills in analyzing queuing models	U	F	Seminar Presentation / Group Tutorial Work
2.	Analyze a network of queues	An	P	Instructor-created exams
3.	Describe the concept of renewal process and Brownian motion	U	F	Instructor-created exams
4.	Describe the basics of time series data, its auto-covariance, auto-correlation and autoregressive moving average	U	F	Instructor-created exams / Home Assignments
5.	Learn to validate a model using residual analysis	An	P	Home Assignment

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I	**Continuous time Markov chains and Queueing theory**.		**14**	**20**
	1	Continuous Time Markov Chains		
	2	Pure birth process, Yule furry process, Pure death process, Birth and Death Processes, The transition probability function, Limiting probabilities		
	3	Introduction to queueing theory, Steady state probabilities.		
	4	Exponential Models: A single server Exponential queueing system, A single server Exponential queueing system having finite capacity, Birth and Death queueing models		
	5	Network of queues: Open systems, Closed systems		
	6	Non Markovian queueing models: M/G/1 and G/M/1		
II	**Renewal process and Brownian motion**		**9**	**15**
	7	Renewal processes, renewal function and renewal density, renewal equation, stopping time		
	8	Wald's equation, limit theorems and their applications.		
	9	Brownian motion-Definition, limiting form of random walk, examples.		
	10	White noise, Gaussian process		
	11	Strictly stationary and weakly stationary processes (Definition and examples)		
	12	Branching process (Concept only)		
III	**Time series and stationary process**		**12**	**20**
	13	Time series as a discrete parameter stochastic process		
	14	Auto – Covariance, Auto- Correlation		
	15	Autoregressive, Moving Average, Autoregressive Moving Average and Autoregressive Integrated Moving Average Models		
	16	Choice of AR / MA periods		
	17	Introduction to non-linear time Series: ARCH and GARCH models		
IV	**Estimation of ARMA models**, ,.		**10**	**15**
	18	Yule – Walker estimation for AR Processes		
	19	Maximum likelihood and least squares estimation for ARMA Processes		
	20	Discussion (without proof) of estimation of mean, Auto-covariance and auto-correlation function under large samples theory		
	21	Residual analysis and diagnostic checking		
	22	Forecasting using ARIMA models		
V	**Open Ended**		**30**	
		Problems, examples and analysis of dataset using software		

Text Books

1. Ross, S.M. (2007). Introduction to Probability Models. IXth Edition, Academic Press.

2. Medhi, J. (1996). Stochastic Processes. Second Editions. New Age International

3. Box G.E.P and Jenkins G.M. (1994). Time Series Analysis, Forecasting and Control. Holden-Day

4. BrockwellP.J.and Davis R.A. (2006). Time Series: Theory and Methods, Springer – Verlag.

5. Abraham B and Ledolter J.C. (1983). Statistical Methods for Forecasting, Wiley

6. Robert H Shumway and Davis S Stoffer(2016). Time series analysis and its applications with R examples. Springer.

References

1. **Karlin, S. and Taylor, H.M. (1975)**. A First Course in Stochastic Processes, Second Edition, Academic Press.
2. **Cinlar, E. (1975)**. Introduction to Stochastic Processes. Prentice Hall. New Jersey.
3. **Basu, A.K. (2003)**. Introduction to Stochastic Processes. Narosa, New-Delhi
4. **Anderson T.W (1971)**. The Statistical Analysis of Time Series, Wiley.
5. **Fuller W.A. (1978)**. Introduction to Statistical Time Series, John Wiley
6. **William W. S. Wei (2006)**. Time Series Analysis: Univariate and Multivariate Methods. Pearson. Addison Wesley.

Programme	B. Sc. STATISTICS				
Course Code	STA 8 CJ 407				
Course Title	APPLIED MULTIVARIATE TECHNIQUES				
Type of Course	**Major**				
Semester	VIII				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	1. Good knowledge of Multivariate Normal distribution. 2. Programming skill using R.				
Course Summary	The main objective of this course are to : 1. Inculcate deep knowledge on various multivariate techniques. 2. Develop clear idea on when and where to use dependence and interdependence multivariate methods. 3. Bridge the relation between multivariate analysis using software, to strengthen statistical applications in diversified spectrum of life.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
1.	Analysing Multivariate data using reduction techniques like Principal Component Analysis, Factor Analysis and Canonical correlation.	An	P	Seminar Presentation /
2.	Formulate multivariate hypothesis tests and drawing appropriate conclusions	C	M	Instructor-created exams
3.	Discriminate multivariate normal population.	E	C	Group Tutorial Work
4.	Identify data reduction techniques	U	C	Home Assignments
5.	Analyse multivariate data using statistical software's.	An	P	Practical Skill
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (60)	Marks (70)
I	**Principle Component- Factor Analysis-Canonical correlation**		**16**	**20**
	1	Principle component		
	2	Maximum likelihood estimates of the principal components and their variance		
	3	Extraction of Principal Components and their variances		
	4	Factor Analysis – Mathematical model –Estimation of Factor Loading		
	5	Canonical correlation – Estimation of canonical correlation and variates		
	6	Structural equation models.		
II	**Classification Problems**		**15**	**20**
	7	Classification problems		
	8	Classification into one of two population (known and unknown dispersion matrix)		
	9	Classification in to one of several populations		
	10	Multivariate analysis of variance (MANOVA) – One way and two way classification		
	11	Tests independence of sets of variables		
	12	Equality of dispersion matrices and Sphericity test.		
III	**Discriminant Analysis**		**9**	**15**
	13	Discriminant Analysis		
	14	Likelihood ratio method		
	15	Bayes and min-max procedure		
	16	Discrimination between two multivariate normal population with common dispersion		
	17	Sample discriminate function		
	18	Estimation – Fisher’s method for discriminating among several populations.		
IV	**Cluster Analysis**		**8**	**15**
	19	Cluster Analysis		
	20	Proximity measures		
	21	Hierarchical clustering techniques : single, complete and average linkage algorithms.		
	22	Non-hierarchical clustering techniques : K means method.		
V	**Open –End**		**12**	
	Problems regarding Module I to IV using Statistical software			

Text Book

1. **Anderson T W (2010)** : An Introduction to Multivariate Statistical Analysis, Wiley Eastern Ltd.

2. **Johnson, R A and Wichern D W (2003)** : Applied Multivariate Statistical Analysis, Prentice-Hall of India Private Ltd., New Delhi.

Reference

1. **Morrison F (2003)** : Multivariate Statistical Methods, Brooks/Cole, 4^{th} Revised edn., McGraw Hill Book Company
2. **Seber G A (2004)** : Multivariate Observations, John Wiley.

3. **Denis, D J (2021)** : Applied Univariate, Bivariate and Multivariate Statistics : Understanding Statistics for Social and Natural Scientists, With Application in SPSS and R,John Wiley & Sons.

Programme	B. Sc. STATISTICS				
Course Code	STA 8 CJ 408				
Course Title	GENERALIZED LINEAR MODELS				
Type of Course	**Major**				
Semester	VIII				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Elementary ideas about linear estimation.				
Course Summary	Understand about generalized linear models.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
1.	Identify the general theory of GLM	U	C	Seminar Presentation /
2.	Describe the use of binary and multinomial Understand and logistic models and apply them for various data sets	R	F	Instructor-created exams
3.	Explain the concepts related to count data GLM and apply them for various count data sets.	Ap	C	Group Tutorial Work
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (60)	Marks (70)
I	**Components of a generalized linear model (GLM)**		**10**	**15**
	1	Random component		
	2	linear predictor, link function		
	3	Quantitative/qualitative explanatory variables and interpreting effects		
	4	Model matrices and model vector spaces		
	5	Identifiability and estimability		
II	**Generalized linear models**		**12**	**20**
	6	Model fitting and inference		
	7	Exponential dispersion family distributions		
	8	Likelihood and asymptotic distributions		

	9	Likelihood-ratio/Wald/Score methods of inference		
	10	Parameters, deviance, model comparison, and model checking		
	11	Goodness of fit		
III	**Binary logistic models, nominal responses**		**10**	**15**
	12	Baseline-category logit models		
	13	Ordinal responses: cumulative logit and probit models		
	14	Probit and complementary log–log models,		
	15	Multinomial response models		
IV	**Models for count data**		**16**	**20**
	16	Poisson GLMs for counts and rates		
	17	Poisson/multinomial models for contingency tables		
	18	Negative Binomial GLMS		
	19	Models for zero-inflated data		
	20	Quasi-likelihood methods		
	21	Variance inflation for over dispersed Poisson and Binomial GLMs		
	22	Beta-Binomial models and Quasi-likelihood alternatives		
	23	Quasi-likelihood and model misspecification		
V	**Open –Ended**		**12**	
	Model building and validation in practical situations using R software			

Reference

1. **Agresti, A. (2015)**. Foundations of Linear and Generalized Linear Models, Wiley
2. **Dobson, A. J. (2002)**. An Introduction to Generalized Linear Models, 2nd Ed. Chapman & Hall
3. **Jiang, J. (2007)**. Linear and Generalized Linear Mixed Models and their Applications, Springer
4. **Jong, P. and Heller, G. Z. (2008)** Generalized Linear Models for Insurance Data, Cambridge University Press.
5. **Lindsey, J. K. (1997)**. Applying Generalized Linear Models, Springer
6. **McCullagh, P. and Nelder, J. A. (1989)**. Generalized Linear Models, Chapman & Hall
7. **McCulloch, C. E. and Searle, S. R. (2001)**. Generalized, Linear and Mixed Models, Wiley
8. **Stroup, W. W. (2013)**. Generalized Linear Mixed Models, Modern Concepts, Methods and Applications, CRC Press

Programme	B. Sc. STATISTICS				
Course Code	STA 8 CJ 489				
Course Title	RESEARCH METHODOLOGY				
Type of Course	**Major**				
Semester	VIII				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Basic knowledge of typesetting & publishing				
Course Summary	To understand the concept of Research, presentation & Publication.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
1.	Identify the Concept of Research in Statistics, Selection of Topics, Perform Literature Review	U	F	Seminar Presentation /
2.	Express Scientific Word Processing with LaTeX and MS-Word	U	F	Instructor-created exams
3.	Develop Simulation.	Ap	C	Group Tutorial Work
4.	Compute Computer Oriented Numerical Methods	Ap	C	Home Assignments
5.	Describe Plagiarism	U	F	Practical Assignment
6.	Write Thesis	Ap	P	Observation of Practical Skills
* - Remember (R), Understand (U), Apply (Ap), Analyze (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (60)	Marks (70)
I	**Introduction to Research Methodology in Statistics**		**15**	**20**
	1	Meaning of Research, Objectives of Research		
	2	Types of Research- Descriptive Vs. Analytical, Applied Vs Fundamental, Quantitative Vs Qualitative, Conceptual Vs Empirical		
	3	Concept of Research in Statistics-Importance and Need for Research Ethics		
	4	Selection of Topic for Research-Research schedules, Review of Literature and its Use in Designing a Research Work-		

	5	Mode of Literature Survey-Books and Monographs, Journals, Conference Proceedings, Abstracting and Indexing Journals, E-Journals/Books and CD-ROMS-Reports etc.		
	6	Thesis Writing		
	7	Computer Application in Scientific Research-www-Searching Scientific Articles		
	8	Statistical Data Base		
II	**Scientific Word Processing with LaTeX and MS-Word**		**15**	**20**
	9	Article, Thesis Report and Slides Making		
	10	Power Point Features, Slide Preparation		
	11	Statistical Programming with R: Simple Manipulations Using Numbers and Vectors-Objects & Their Attributes		
	12	Arrays and Matrices-Lists and Data Frames-Grouping, Loops and Conditions		
	13	User Defined Functions		
	14	Probability Distributions and Statistical Models in R		
III	**Simulation**		**10**	**15**
	15	Concepts and Advantages of Simulation		
	16	Event Type Simulation		
	17	Random Variable Generation-U(0,1), Exponential, Gamma and Normal Random Variables		
	18	Monte Carlo Integration		
	19	The MCMC Principle		
	20	Algorithms and its Variants, Bootstrap Methods		
IV	Computer Oriented Numerical Methods		**8**	**15**
	21	Algorithms for Solving Algebraic and Transcendental Equations		
	22	Numerical Integration		
	23	Matrix operations		
V	**Open –Ended**		**12**	
	Solve the problems from Module I to Module IV using software and understand how to check Plagiarism			

References

1. **Anderson, J., Durston, B.H., Pooole, M. (1970)** .Thesis and Assignment Writing. Wiley Eastern. Ltd., New Delhi.4

2. **Beveridge, B. (1979)**. The Art of Scientific Investigation. W.E. Norton & Co., New York.

3. **Braun, J., Duncan, W. and Murdock, J. (2008)**. A First Course in Statistical Programming with R. Cambridge University Press, London.

4. **Chambers, J. (2008).** Software for Data Analysis: Programming with R. Springer, New York.

5. **Crewley, M.J. (2007)** The R-.Book. John Wiley, New York.

6. **Dalgaard, P.(2008)**. Introductory Statistics with R. Springer Science, New York.

7. **Kothari, C. (2005)**. Research Methodology. New Age International. Publishers, New York.

8. **Lamport, L. (1999).** LATEX: A Document Preparation System. Addison, Wesley, 2nd edition, New York

9. **Panneerselvam. (2006)**. Research Methodology. Prentice-Hall of India. Pvt.,New Delhi.

10. **Robert, C.P. and Casella, G. (2004)**. Monte Carlo Statistical Methods. Springer Science, New York.

11. **Venkataraman, M.K. (1998)** Numerical Methods in Science and Engineering. The National Publishing Company, Chennai.

12. **Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., (2002)**. An Introduction to Research Methodology, RBSA publishers.

MAJOR ELECTIVES

SEMESTER V

Programme	B. Sc. Statistics				
Course Code	STA5EJ301				
Course Title	Statistical Quality Control				
Type of Course	**Major Elective**				
Semester	V				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites					
Course Summary Objective	To make students aware of Various Quality or standards in Industrial Production, Detecting, Controlling and Maintaining Quality and Total Quality Management				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understanding notion of Quality of products	U	C	Instructor-created exams / Quiz
CO2	Assessing various meaning of Quality	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Explain causes of variation and Statistical Control	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Construction of Control Charts and OC curves	U	C	Instructor-created exams / Home

				Assignments
CO5	Distinguish Process and Product Control	Ap	P	One Minute Reflection Writing assignments
CO6	Assessing Process and Product Control	Ap	P	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I		**Control Charts theory**	**10**	**15**
	1	General theory of Control Charts.		
	2	Setting Control Limits.		
	3	Importance of 3-sigma limits		
	4	Statistical basis of Control Limits		
	5	Need of two control charts for variables		
	6	Assessing Statistical Control using Charts		
	7	Control Charts for Variables and Attributes		
	Sections from References:			
II		**Control Charts Construction**	**14**	**20**
	8	Mean Chart Theory and Construction		
	9	Dispersion (Range, Standard Deviation Chart) Chart. Theory and Construction		
	10	Proportion defective Chart Theory and Construction		
	11	Number of Defective Chart Theory and Construction		
	12	Number of Defects Chart Theory and Construction.		
	Sections from References:			
III		**Product Control**	**14**	**20**
	13	Sampling Inspection Plans (Acceptance Sampling Plans)		

	14	Single Sampling Plan		
	15	Double Sampling Plan, ,		
	16	Sequential Sampling Plan		
	17	Incoming and Outgoing Quality		
	18	AQL, RQL, LTPD, AOQ, AOQL		
	19	Errors in Sampling Inspection Plans		
	20	Power function and OC function.		
	21	Producer' and Consumers Risk		
	Sections from References:			
IV	**Characterising Sampling Plans**		**10**	**15**
	22	Constructing OC Curve of Single Sampling Plan using Hyper Geometric distribution		
	23	Constructing OC Curve of Single Sampling Plan using Binomial distribution		
	24	Constructing OC Curve of Single Sampling Plan using Poisson distribution		
	25	Constructing OC Curve of Double Sampling Plan		
	26	ASN, ATI		
	Sections from References:			
V	**Open Ended Module:**		**12**	
	1	Preliminaries of Quality Control Definition of Quality. Need of total quality Management and its uses. Causes of Variation, assessing within and between sample variation using Statistical Measures. Concept of Statistical Quality Control, Process Control and Product Control		
	Sections from References:			

Books and References:

1. **Introduction to Statistical Quality Control, 8th Edition Douglas C Montgomery**
2. **Statistical Quality Control M Mahajan Dhanpat Rai 2nd Edition**
3. **Fundamentals of Applied Statistics S C Gupta and V K Kapoor** Sultan Chand & Sons

Programme	B. Sc. Statistics				
Course Code	STA5EJ302				
Course Title	Optimization Techniques				
Type of Course	**Major Elective**				
Semester	V				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites					
Course Summary Objective	Make students to formulate, solve and implement feasible solutions of complex Industrial, Trade, Commercial problems				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understanding Basics of Operations Research.	U	C	Instructor-created exams / Quiz
CO2	Distinguishing Solution, Feasible Solution, Basic Solution and Basic Feasible Solutions	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Mathematical Formulation Real life problems	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Mastering Simplex Algorithm	U	C	Instructor-created exams / Home Assignments
CO5	Apply LPP in Transportation and Assignment Problems	Ap	P	One Minute Reflection Writing assignments
CO6	Analyse decision making under conflict Game theory	Ap	P	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)				

- Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I		**Liner Programming Problem**	**14**	**20**
	1	Graphical Solution of LPP.		
	2	Feasible Solution, Basic Feasible Solution of LPP		
	3	Simplex Algorithm without Artificial Variables.		
	4	Artificial Variable technique		
	5	Big M method		
	6	Two Phase method		
	Sections from References:			
II		Application of LPP	**10**	**15**
	7	Duality Primal and Dual LPP		
	8	Economic Interpretation of Dual		
	9	Dual Simplex Method Solution of primal using Dual.		
	10	Transportation and Assignment Problems as special case of LPP.		
	11	Balanced Transportation Problem, Balanced Assignment Problem		
	12	Initial Basic Feasible Solution using NWCR		
	13	Initial Basic Feasible Solution using LCCM		
	Sections from References:			
III		**Solving TP & AP**	**12**	**20**
	14	Solution of Transportation Problem using Vogel's Approximation Method		
	15	Optimization using MODI Method		
	16	Hungarian Method of Solving Assignment Problem		

	Sections from References:			
IV	Game Theory			
	17	Decision making under Conflict		
	18	Pay off Matrix.		
	19	MinMax MaxMin Criterions		
	20	Pure and Mixed Strategy		
	21	Value of Game and Saddle Point		
	22	Principle of Dominance, solving 2x2 games.		
	23	Graphical solution of 2xn and nx2 games		
	Sections from References:			
V	**Open Ended Module:**		**12**	**15**
	1	Origin, Development of OR. Nature & Scope of OR, Uses & Limitations of OR. Linear Programming Problem, Mathematical Formulation, General, Standard form of LPP.		
	Sections from References:			

Books and References:

1. ***Operations Research***, ***Swaroop***, ***Kanti***, ***P. K. Gupta and Man Mohan***. ***2007***. ***13th Edition***. **New Delhi:** ***Sultan Chand*** **and Sons**
2. ***Operations Research, J K Sharma, Laxmi Publications***
3. ***Operations Research V K Kapoor Sulthan Chand and Sons***

Programme	B. Sc. Statistics				
Course Code	STA5EJ303				
Course Title	Biostatistics				
Type of Course	**Major Elective**				
Semester	V				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites					
Course Summary Objective	The student will describe the need and ethics of clinical trials and designs for various phases of clinical trials.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	The student will explain Principles of Biostatistical study designs	U	C	Instructor-created exams / Quiz
CO2	The student will explain measures of morbidity.	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	The student will describe the concepts of survival time functions of important parametric models.	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	The student will explain types of censoring and estimation of parameters using censored data.	U	C	Instructor-created exams / Home Assignments
CO5	The student will explain the non-parametric methods for estimating survival function and variance of the estimator using Kaplan –Meier methods.	Ap	P	One Minute Reflection Writing assignments
CO6	The student will describe the basic biological concepts in genetics.	Ap	P	Viva Voce

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I		**Introduction**	**14**	**20**
	1	Examples of statistical problems in Biomedical Research		
	2	Types of Biological data		
	3	Principles of Biostatistical design of medical studies		
	4	study designs- observational study, experimental study-comparative experiment, cross over experiment		
	5	prospective and retrospective study		
	6	case-control and longitudinal study		
	7	Measuring the occurrence of disease, Measures of morbidity - prevalence and incidence rate, association between prevalence and incidence, uses of prevalence and incidence.		
	Sections from References:			
II		**Survival analysis**	**12**	**20**
	8	Introduction to survival analysis, concepts and definitions		
	9	Survival function		
	10	probability density function		
	11	hazard function		
	12	inter relationships,		
	13	Survival distributions- exponential distribution, Weibull distribution and lognormal distribution.		
	Sections from References:			
III		**Types of censoring**	**10**	**15**

	14	Concepts of censoring and truncation		
	15	Type I, Type II and progressive or random censoring with biological examples,		
	16	Estimation of mean survival time and variance of the estimator for type I and type II censored data with numerical examples (for exponential distribution).		
	17	Non-parametric methods for estimating survival function and variance of the estimator- Kaplan –Meier methods.		
	Sections from References:			
IV			**12**	**15**
	18	Basic biological concepts in genetics Mendel's law, Hardy- Weinberg equilibrium		
	19	Random mating, natural selection, mutation, genetic drift,		
	20	Detection and estimation of linkage in heredity		
	21	Planning and design of clinical trials, Phase I, II, and III trials.		
	22	Ethics behind randomized studies involving human subjects; randomized dose-response studies (concept only)		
	Sections from References:			
V		**Open Ended Module:**	**12**	
	1	Practical problems based on module I to IV using statistical software.		
	Sections from References:			

Books and References:

Altman, D G. (2006): Practical Statistics for Medical Research, London: Chapman and Hall.

Cox, D.R. and Oakes, D. (1984): Analysis of Survival Data, Chapman and Hall.

Daniel, W.W.(2006): Biostatistics: A Foundation for Analysis in the Health sciences, John Wiley & sons. Inc.

Dunn, G. and Everitt B. (1995): Clinical Biostatistics: An Introduction to Evidence-based Medicine. Edward Arnold.

Friedman, L.M., Furburg, C. and DeMets, D.L. (1998): Fundamentals of Clinical Trials,Springer Verlag.

Gross, A. J. and Clark V.A. (1975): Survival Distribution; Reliability Applications inBiomedical Sciences, John Wiley & Sons.

Lee, Elisa, T. (1992): Statistical Methods for Survival Data Analysis, John Wiley & Sons.

Li, C.C. (1976): First Course of Population Genetics, Boxwood Press.

Fisher, L.D. and Belle, G.V. (1993): Biostatistics: A Methodology for the Health Science, John Wiley & Sons Inc.

Lawless, J.F.(2003): Statistical Methods for Lifetime (Second Edition), John Wiley & Sons.

Rosner B. (2006): Fundamentals of Biostatistics, Edition 6.

Programme	B. Sc. Statistics				
Course Code	STA5EJ304				
Course Title	Econometrics				
Type of Course	**Major Elective**				
Semester	V				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites					
Course Summary Objective	After completing the course students should be able to interpret regression results as well as to understand the assumptions underlying theordinary least squares estimator, and judge in an educated manner whether they hold in a given problem.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	will be able to estimate and interpret linear regression models and be able to distinguish between economic and statistical importance.	U	C	Instructor-created exams / Quiz
CO2	They should be able to use a statistical/econometric computer package to estimate an econometric model	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	To understand the scope and application of econometrics to real world problems.	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	To know econometric problems and their solutions	U	C	Instructor-created exams / Home Assignments
CO5	Student also will be exposed to simple statistical packages and their use in econometric work	Ap	P	One Minute Reflection Writing

				assignments
CO6		Ap	P	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I		Introduction	10	15
	1	Purpose and scope of econometrics		
	2	Econometric model		
	3	Model building and role of econometrics.		
	4	General linear model (GLM).		
	5	Estimation under linear restrictions and properties of estimators		
	Sections from References:			
II		Heteroscedasticity	12	20
	6	Econometric problems		
	7	Heteroscedasticity		
	8	Tests for heteroscedasticity,		
	9	Consequences of heteroscedasticity and solutions		
	Sections from References:			
III		Autocorrelation	12	15
	10	Autocorrelation concept		
	11	Consequences of auto correlated disturbances,		
	12	Detection of Autocorrelation		
	13	Tests of autocorrelation.		
	14	Distributed lag models		
	15	Estimation of parameters		
	Sections from References:			

IV	Multiple regression		**14**	**20**
	16	Concept of Multiple regression		
	17	Multiple regression analysis.		
	18	Multi collinearity: Introduction and concepts,		
	19	Detection of multi collinearity,		
	20	Consequences multi collinearity		
	21	Sources multi collinearity		
	22	Tests and estimation of multi collinearity		
	Sections from References:			
V	**Open Ended Module:**		**12**	
	1	Practical Problems related to OLS/ CLR using softwares. Introduction to various Economic functions (Demand , Supply, Utility, Cost , Revenue etc.)		
	Sections from References:			

Books and References:

1. Gujarathi, D. and Sangeetha, S.(2007). Basic Econometrics, Mc Graw Hill
2. Johnston, J.(2009) Econometric Methods, 4th edition, Mc Graw Hill
3. Judge, G. J, Grifiths, W. E & et al.(1985). Theory and Practice of Econometrics, 2nd edition , John Wiley
4. Introductory Econometrics, a modern approach, 5th edition, Jeffrey M. Wooldridg
5. Maddala, G.S. and Lahiri, K. (2009): Introduction to Econometrics, 4th Wiley & Sons

Programme	B. Sc. Statistics
Course Code	STA5EJ305
Course Title	Official Statistics
Type of Course	**Major Elective**
Semester	V
Academic Level	300-399

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60

Pre-requisites	
Course Summary Objective	Aware students the role of the subject Statistics in National Policy Formulation, Planning and framing of various policies by the Governments

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Explain the roles and responsibilities of various central and state organizations.	U	C	Instructor-created exams / Quiz
CO2	Explain the methods of data collection and dissemination in the official setup	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Explain the population growth in developed and developing countries	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Explain Statistics related to Industries, foreign trade, balance of payment, cost of living, inflation, educational and other social statistics	U	C	Instructor-created exams / Home Assignments
CO5	Explain the National income estimation by various approaches.	Ap	P	One Minute Reflection Writing assignments
CO6	Describe Lorenz curve, Gini Coefficient and Theil's measure of income inequality			
CO7	Practical: Use R built in functions to solve	Ap	P	Viva Voce

	numerical problems associated with topics covered in various modules			
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I		Introduction	12	20
	1	Introduction to Indian and International Statistical systems.		
	2	Methods of collection of official statistics.		
	3	Role, function and activities of Central and State Statistical organizations.		
	4	Organization of large-scale sample surveys. Role of Ministry of Statistics & Program Implementation (MoSPI),		
	5	Central Statistical Office (CSO), National Sample Survey Office (NSSO), and National Statistical Commission.		
	6	Government of India's Principal publications containing data on the topics such as population, industry and finance.		
	7	Scope and Contents of population census of India.		
	Sections from References:			
II			12	20
	8	Population growth in developed and developing countries.		
	9	Evaluation of performance of family welfare programmes.		
	10	Projections of labour force and man power.		
	11	Statistics related to Industries, foreign trade, balance of payment		
	12	Statistics related to cost of living, inflation, educational and other social statistics		
	Sections from References:			
III			12	15
	13	Economic development		

	14	Growth in per capita income and distributive justice indices of development,		
	15	Human Development Index.		
	16	National income estimation- Product approach		
	17	National income estimation Income approach		
	18	National income estimation Expenditure approach		
IV	Measuring inequality in incomes		**12**	**15**
	19	Measuring inequality in incomes: Lorenz curve,		
	20	Gini Coefficient,		
	21	Theil's measure.		
	22	Poverty measurements: Different issues,		
	23	measures of incidence and intensity		
	Sections from References:			
V	**Open Ended Module:**		**12**	
	1	Prepare a report based on Wealth – Income distribution disparities		
	Sections from References:			

Books and References:

1. Guide to Official Statistics (CSO) 1999
2. Statistical System in India (CSO) 1995
3. Principles and Accommodation of National Population Census, UNEDCO.
4. Monthly Statistics of Foreign Trade in India, DGCIS, Calcutta and other Govt. Publications.
5. Keyfitz, N (1977): Applied Mathematical Demography- Springer Verlag.
6. Sen, A(1977): Poverty and Inequality.
7. Chubey, P.K (1995): Poverty Measurement, New Age International.

Programme	B. Sc. Statistics				
Course Code	STA5EJ306				
Course Title	Longitudinal Data Analysis				
Type of Course	**Major** Elective				
Semester	V				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites					
Course Summary Objective	Learn both how to clean longitudinal data as well as the main statistical models used to analyse it. The course will cover three fundamental frameworks for analysing longitudinal data: multilevel modelling, structural equation modelling and event history analysis.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Describe the basic concepts of Linear Model in longitudinal data analysis	U	C	Instructor-created exams / Quiz
CO2	Analyze numerical methods to solve the problems in Linear Model	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Explain the basic concepts of Generalized Linear Model	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Illustrate and study on missing data mechanism in longitudinal data analysis	U	C	Instructor-created exams / Home Assignments
CO5	Analyze longitudinal data using any statistical software	Ap	P	One Minute Reflection Writing assignments
CO6		Ap	P	Viva Voce

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I		Introduction:	12	20
	1	longitudinal studies. Design considerations		
	2	Bias, Efficiency, Sample size calculations.		
	3	Exploring longitudinal data: graphical representation of longitudinal data,.		
	4	fitting smooth curves to longitudinal data,		
	5	Exploring correlation structure.		
	6	General linear models for longitudinal data		
	Sections from References:			
II		Estimation and Analysis	12	15
	7	Weighted least-squares estimation,		
	8	Maximum likelihood estimation. Model-fitting: formulation, estimation, inference.		
	9	Analysis of Variance methods: preliminaries,		
	10	time-by-time ANOVA		
	11	derived variables, repeated measures		
	Sections from References:			
III		**Generalized Linear Model**	14	20
	12	Generalized Linear Model for Longitudinal Data:		
	13	Marginal models, for binary, ordinal, and count data:		
	14	Random effects models for binary data:		
	15	Random effects models for ordinal data		
	16	Random effects models for count data		

	17	Transition models		
	18	Likelihood-based models for categorical data		
	Sections from References:			
IV			**10**	**15**
	19	Dropouts and missing data		
	20	Classification missing data mechanism; Intermittent missing values and dropouts		
	21	Simple solutions and their limitations		
	22	last observation carried forward, complete case analysis		
	Sections from References:			
V	**Open Ended Module:**		**12**	
	1	Formatting and cleaning of longitudinal data (either in long or wide format and their interchangeability), Repeated measures and General linear model fitting, Model fitting for binary ordinal and count data (R, JAMOVI, Mathematica, Stata, SAS)		
	Sections from References:			

Books and References:

Diggle, P.J., Heagerty, P., Liang, K.Y and Zeger. S.L (2003). Analysis of Longitudinal Data- Second Edition. Oxford University Press, London.

1. Fitzmaurice,M., Laird,M. and Ware, H. Applied Longitudinal Analysis- Second Edition. John Wiley & Sons, New Jersey.

2. Crowder, M.J. and Hand, D.J. (1990). Analysis of Repeated Measures. Chapman and Hall/CRC Press, London.

3. Hand, D and Crowder, M. (1996). Practical Longitudinal Data Analysis. Chapman and Hall/CRC Press, London.

4. Lindsey, J.K. (1993) Models for Repeated Measurements. Oxford University Press, London.

5. Little, R.J.A, and Rubin, O.B. (2019). Statistical Analysis with Missing Data- Third Edition. John Wiley & Sons, New York.

6. McCullagh, P. and Nelder, J.A (1989). Generalized Linear Models- Second Edition. Chapman and Hall/CRC Press, London.

7. Weiss, R.E. (2005). Modeling Longitudinal Data. Springer, New York

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SEMESTER VI

Programme	B. Sc. Statistics				
Course Code	STA6EJ301				
Course Title	Simulation Techniques				
Type of Course	**Major Elective**				
Semester	VI				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites					
Course Summary Objective	Statistical Methods to model and analyse a variety of Random Phenomena				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Generate pseudo-random numbers using different methods.	U	C	Instructor-created exams / Quiz
CO2	Use resampling methods on real datasets.	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Apply Markov Chain Monte Carlo methods and density estimation	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Develop programs for simulation purposes.	U	C	Instructor-created exams / Home Assignments
CO5	Apply simulation skills in real-world scenarios	Ap	P	One Minute Reflection Writing assignments

CO6		Ap	P	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I			**10**	**15**
	1	Introduction to random number generation.		
	2	Methods for generating random variables - Inverse transform method		
	3	Composition method, Transformation method		
	4	Acceptance-Rejection method.		
	5	Generating from common statistical distributions Discrete and Continuous. (Rizzo (2019) and Rubinstein (2017		
	Sections from References:			
II			**12**	**20**
	6	Simulation for the multivariate normal distribution		
	7	Simple estimation based on simulated data		
	8	Monte Carlo integration and variance reduction techniques		
	9	Use of antithetic and control variables		
	10	Statistical validation of the simulated data by goodness of fit tests. (Rizzo (2019), Rubinstein (2017) and Ross (2022))		
	Sections from References:			
III			**12**	**15**
	11	Introduction to resampling,		
	12	Sampling distribution and other features of a statistic		
	13	Permutation and Randomization tests,		
	14	Theory for Jackknife, Variance estimation-consistency,		

	15	Jackknife in sample surveys,		
	16	Theory for the bootstrap and its consistency, Distribution and variance estimators (Shao & Tu (2012), Rizzo (2019))		
	Sections from References:			
IV			**14**	**20**
	17	Markov Chain Monte Carlo methods:		
	18	The Metropolis–Hasting's algorithm		
	19	Gibbs sampling.		
	20	EM algorithm.		
	21	Smoothing with kernels		
	22	density estimation (McLachlan & Krishnan (1997), Rubinstein (2017), Robert & Casella (2004) and Rizzo (2019		
	Sections from References:			
V		**Open Ended Module:**	**12**	
	1	Generate random numbers using statistical software for different distributions with its estimation and model fitting. Apply resampling methods for real life data.		
	Sections from References:			

Books and References:

1. Rizzo, M. L. (2019). Statistical Computing with R, second edition. Boca Raton, FL: Chapman & Hall/CRC Press

References

2. McLachlan, G.J. and Krishnan, T. (1997): The EM Algorithms and Extensions, Wiley.
3. Robert, C.P. & Casella, G. (2004) Monte Carlo Statistical Methods, 2ndEdn., Springer.
4. Ross, S. M. (2022). Simulation. Academic Press.
5. Rubinstein, R.Y. (2017). Simulation and the Monte Carlo Methods, Wiley.
6. Shao, J., & Tu, D. (2012). The jackknife and bootstrap. Springer Science & Business Media.

Programme	B. Sc. Statistics				
Course Code	STA6EJ302				
Course Title	Reliability Theory				
Type of Course	**Major Elective**				
Semester	VI				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites					
Course Summary Objective	Determine the reliability of systems based on defined/determined reliability of the system elements and defined block diagram for the reliability of the observed system.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Describe the structural properties of coherent systems.	U	C	Instructor-created exams / Quiz
CO2	Determine the reliability of a system.	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Discuss the different parametric distributions in reliability	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Discuss the lifetime of a system based on ageing properties	U	C	Instructor-created exams / Home Assignments
CO5	Discuss different censoring schemes.	Ap	P	One Minute Reflection Writing assignments
CO6		Ap	P	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive				

Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I			**10**	**15**
	1	System of components		
	2	series and parallel structure with examples		
	3	dual structure function		
	4	coherent structure		
	5	preservation of coherent system in terms of paths and cuts		
	6	representation of bridge structure		
	7	relative importance of components		
	8	modules of coherent systems		
	Sections from References:			
II			**10**	**15**
	9	Reliability of a system of independent components		
	10	Some basic properties of system reliability		
	11	Computing exact system reliability		
	12	Inclusion exclusion method		
	13	Reliability importance of components		
	Sections from References:			
III			**16**	**20**
	14	Reliability function, hazard function,		
	15	Residual life time, mean residual life function, one-one correspondence of these functions.		
	16	Common life distributions, exponential, weibull, gamma, pareto, lognormal and their characteristics.		
	17	Type –I, Type-II and random censoring schemes.		

	18	Likelihood functions based on these sampling schemes.		
	Sections from References:			
IV			**12**	**20**
	19	IFR, IFRA, DMRL, NBU, NBUE classes and their duals.		
	20	Exponential distribution and its aging property		
	21	Aging properties of common life distributions		
	22	Classes under formation of coherent structures.		
	Sections from References:			
V		**Open Ended Module:**	**12**	
	1	Estimation and testing based on these schemes for various parametric models.		
	Sections from References:			

Books and References:

Text Books

1. **Barlow R.E. and Proschan F.(1985).** Statistical Theory of Reliability and Life Testing; Ho Rinehart and Winston.
2. **Lawless, J.F. (2003).** Statistical Models and Methods for Lifetime (Second Edition), John Wiley Sons Inc., New Jersey.

References

3. **Bain L.J. and Engelhardt (1991).** Statistical Analysis of Reliability and Life Testing Mode Marcel Dekker.
4. **Aven, T. and Jensen,U. (1999).** Stochastic Models in Reliability, Springer-Verlag, New York, Inc.
5. **Nelson, W (1982).** Applied Life Data analysis; John Wiley.
6. **Zacks, S. (1992).** Introduction to Reliability Analysis: Probability Models and Statistics Method New York: Springer-Verlag.

Programme	B. Sc. Statistics				
Course Code	STA6EJ303				
Course Title	Life Time Data Analysis				
Type of Course	**Major Elective**				
Semester	VI				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites					
Course Summary Objective	The student has a thorough knowledge of the basic theory of stochastic modelling and statistical analysis of survival data, including graphical techniques. This includes both parametric and non-parametric analysis of censored survival data and data for recurrent events, as well as related regression models				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the basic concepts and ideas of survival analysis.	U	C	Instructor-created exams / Quiz
CO2	Examine the properties and methods for standard survival time distributions	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Estimate survival functions using parametric and non-parametric methods.	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Apply and interpret semi-parametric and parametric regression models for survival data.	U	C	Instructor-created exams / Home Assignments
CO5	To apply the concepts learned in the previous modules to a real-life data set.	Ap	P	One Minute Reflection Writing assignments

CO6		Ap	P	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I			**10**	**15**
	1	Basic Quantities and Models- Survival Function, Hazard function, Mean residual life function		
	2	Common Parametric models for survival data.		
	3	Log location scale models,		
	4	Mixture models.		
	Sections from References:			
II			**10**	**15**
	5	Right censoring		
	6	Left censoring		
	7	Interval censoring		
	8	Truncation		
	9	Likelihood construction for censored and truncated data.		
	Sections from References:			
III			**18**	**20**
	10	Nonparametric Estimation of Basic Quantities		
	11	Estimators of the Survival Functions for Right-Censored Data		
	12	Estimators of Cumulative Hazard Functions for Right-Censored Data		
	13	Point-wise Confidence Intervals for the Survival Function		
	14	Life Table		
	15	Estimation of Survival in the Cohort Life Table.		
	16	Hypothesis testing- One sample tests		

	17	Tests for two or more samples.		
	Sections from References:			
IV			**10**	**20**
	18	Semiparametric Proportional Hazards Regression with Fixed Covariates		
	19	Model Building Using the Proportional Hazards Model		
	20	Graphical Checks of the Proportional Hazards Assumption,		
	21	Additive hazards regression models.		
	22	Regression Diagnostics		
	Sections from References:			
V		**Open Ended Module:**	**12**	
	1	**Practical exercises on lifetime data using the statistical software R: Fitting the Parametric models for survival data.**		
	Sections from References:			

Books and References:

1. Klein J.P. and Moeschberger M.L. (2003) Survival Analysis - Techniques for censored and truncated data, Second Edition, Springer-Verlag , New York.
2. Lawless J.F (2003) Statistical Models and Methods for Lifetime Data, Second Editon, John Wiley & Sons, Relevant Sections of the Chapters 9.
3. Kalbfleisch J.D and Prentice, R.L. (2002) The Statistical Analysis of Failure Time Data, Second Edition, John Wiley & Sons Inc.
4. Deshpande, J .V. and Purohit, S. G. (2006). Lifetime Data: Statistical Models and Methods. World Scientific.

Programme	B. Sc. Statistics				
Course Code	STA6EJ304				
Course Title	Demography				
Type of Course	**Major Elective**				
Semester	VI				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites					
Course Summary Objective	On completion of the course, the students shall be able to Understand basics of Statistical Techniques used in population data analysis.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand various sources of demographic data	U	C	Instructor-created exams / Quiz
CO2	Understand life tables and their main features	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Calculate and interpret mortality and fertility measures	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Analyze internal migration and its measurement, exploring migration models	U	C	Instructor-created exams / Home Assignments
CO5	Apply demographic concepts and measures practically using data analysis tools like R or Excel.	Ap	P	One Minute Reflection Writing assignments
CO6		Ap	P	Viva Voce

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I			**10**	**15**
	1	Sources of demographic data		
	2	Census and Registration		
	3	Ad-hoc surveys, Hospital records		
	4	Demographic profiles of the Indian Census.		
	Sections from References:			
II			**10**	**15**
	5	Complete life table and its main features		
	6	Uses of life table. Makehams and Gompertz curves.		
	7	National life tables. UN model life tables.		
	8	Abridged life tables. Stable and stationary populations.		
	Sections from References:			
III			**16**	**20**
	9	Measurement of Mortality: Crude death rate		
	10	Standardized death rates		
	11	Age-specific death rates		
	12	Infant Mortality rate		
	13	Death rate by cause		
	14	Measurement of Fertility: Crude birth rate		
	15	General fertility rate		
	16	Age specific birth rate		
	17	Total fertility rate		
	Sections from References:			
IV			**12**	**20**

	18	Gross reproduction rate, Net reproduction rate		
	19	Internal migration and its measurement, migration models		
	20	Concept of international migration		
	21	Net migration. International and postcensal estimates		
	22	Decennial population census in India		
	Sections from References:			
V	**Open Ended Module:**		**12**	
	1	**Hands-on in R or Excel: Mortality and fertility measures.**		
	Sections from References:			

Books and References:

1. S. C. Gupta and V. K. Kapoor. Fundamentals of Applied Statistics. Sultan Chand and Sons.
2. Benjamin B, Health and Vital Statistics, Allen and Unwin

Programme	B. Sc. Statistics				
Course Code	STA6EJ305				
Course Title	Actuarial Statistics				
Type of Course	**Major Elective**				
Semester	VI				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites					
Course Summary Objective	To learn the life tables used in insurance products. To learn the concept of interest, different life insurance products, life annuities, net premiums. To motivate students to prepare for exams required for employment in the actuarial science profession.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Discuss future life time distributions and their probabilities.	U	C	Instructor-created exams / Quiz
CO2	Know the concept of life table.	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Apply different kinds of interest rates expressed in different time periods.	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Understand the basics life assurance and life annuity contracts.	U	C	Instructor-created exams / Home Assignments
CO5	Understand the utility theory, insurance products and life tables.	Ap	P	One Minute Reflection

	Understand the concept of interest.			Writing assignments
CO6	: Understand the concept of life insurance and the existing insurance products of different insurance company. Know life annuities, net premium and net premium reserves	Ap	P	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I		**Future life time distribution**	10	15
	1	Future life time random variables,		
	2	Force of mortality, Laws of mortality		
	3	De Moivre's law, Gompertz's Law (Definition only)		
	4	Makeham's Law, Weibull's Law (Definition only)		
	5	Probabilities of survival and death, Curtate Future life time		
	Sections from References:			
II		**Life Tables**	12	20
	6	Construction of a life table		
	7	Assumptions for fractional ages		
	8	Uniform distribution of deaths		
	9	Balducci assumption,		
	10	Constant force of mortality assumption		
	11	Select and ultimate life tables		
	Sections from References:			
III		**Rates of interests and Annuities**	16	20

	12	Compound interest and discount factor		
	13	Nominal rate of interest		
	14	Force of interest		
	15	Accumulated value		
	16	Annuities		
	17	Annuities certain- Immediate and due		
	18	monthly annuity certain		
	19	Continuous annuity certain		
	20	Deferred annuity		
	Sections from References:			
IV	**Life insurance and annuity contracts**		**10**	**15**
	21	Continuous Life insurance contracts		
	22	Term life assurance, Endowment		
	23	Whole life, Continuous Life annuities- whole lie annuity		
	24	n-year temporary life annuity,		
	25	n- year certain and life annuity		
	Sections from References:			
V	**Open Ended Module:**		**12**	
	1			
	Sections from References:			

Books and References:

Textbook:

1. Shailaja R. Deshmukh- Actuarial Statistics-an introduction using R, Universities Press.

Reference:

1. Rotar, V.I. (2015). Actuarial Models – The mathematics of Insurance – Second Edition. CRC Press, New York.

2. Promislow, S.D. (2015). Fundamentals of Actuarial Mathematics- Third Edition. John Wiley & Sons, New York.

3. Bowers, N.L., Gerber, H.U., Hickman, J.C., Jones, D.A.& Nesbitt, C.J. (1997). Actuarial Mathematics, Society of Actuaries.

SEMESTER VIII

Programme	B. Sc. STATISTICS				
Course Code	STA8 EJ 411				
Course Title	STATISTICAL METHODS FOR MACHINE LEARNING				
Type of Course	**Major Elective**				
Semester	VIII				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Basic knowledge in Statistics and programming skills in Python				
Course Summary	Understanding Machine learning using Statistics				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
1.	Describe the application of statistical concepts and methods in machine Learning	U	F	Seminar Presentation /
2.	Apply various popular machine learning methods to practical situations	Ap	C	Instructor-created exams
3.	Apply the model assessment methods in machine learning techniques	Ap	P	Group Tutorial Work
4.	Connect computing software into machine learning problems	An	P	Home Assignments
5.	Explain basic concepts of Neural Networks in machine learning	U	F	Practical Skill
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (60)	Marks (70)
I	**Statistical Learning**		**10**	
	1	Variable types; Predictors, Features, Responses, Quantitative variables, Categorical variables, Ordered categorical variables		
	2	Approaches to prediction; Least squares and nearest neighbors		
	3	Supervised and Unsupervised learning		
	4	Regression and classification problems		
	5	Assessing model accuracy, Mean square error, The bias-variance trade off		
	6	Comparison of linear regression with K-Nearest Neighbors(KNN) regression		
II	**Classifications**		**14**	
	7	Classification; concepts and its appropriateness in the case of qualitative responses		
	8	Th logistic model		
	9	Linear Discriminant Analysis (LDA) with only one predictor		
	10	Confusion matrix		
	11	Comparison of logistic regression and LDA methods		
	12	Cross validation; Leave-one-out cross validation, K-Fold cross validation		
	13	Decision trees, Regression trees, Classification trees		
	14	Bagging, Random Forests, Boosting.		
III	**Support Vector Machines and Clustering**		**10**	
	15	Maximal margin classifier		
	16	Support vector classifier		
	17	Support vector machines		
	18	K-means clustering		
	19	Hierarchical clustering		
IV	**Neural Networks**		**14**	
	20	Neural Networks; The Basic Architecture of Neural networks		
	21	The perceptron, Activation and Loss functions		
	22	Multi-Layer Neural Networks		
V	**Open –Ended**		**12**	
	Apply machine learning to real-life projects using software packages in R or Python. (Based on reference books)			

Text Book

1. **Hastie, T., Tibshirani, R. and Friedman, J. (2017)**. The Elements of Statistical Learning: Data Mining, Inference and Prediction, 2nd edition. Springer, New York
2. **James, G., Witten, D., Hastie, T. and Tibshirani, R. (2013)**. An Introduction to Statistical Learning with Applications in R. Springer, New York

3. **Charu C. Aggarwal (2018).** Neural Networks and Deep Learning: A Textbook, Springer

Reference

1. **Burger, S. V. (2018).** Introduction to Machine Learning with R, O'Reilly Media, Inc.
2. **Avila. J, Hauck. T. (2017**). Scikit-learn Cookbook: Over 80 Recipes for Machine Learning in Python. Packt Publishing, UK

Programme	B. Sc. STATISTICS				
Course Code	STA8 EJ 412				
Course Title	OPERATIONS RESEARCH				
Type of Course	**Major Elective**				
Semester	VIII				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Good idea about Linear Programming Problems				
Course Summary	Understand advanced models of Linear Programming Problems and Non-Linear Programming Problems.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
1.	Express theoretical knowledge of Simplex method for solving Linear Programming Problems and Expertise with Revised Simplex method and Dual Simplex method.	U	F	Seminar Presentation /
2.	Develop and solve Integer Programming Models.	Ap	C	Instructor-created exams
3.	Identify Classical Optimization techniques and Non- linear Programming techniques.	U	F	Group Tutorial Work
4.	Formulate Network models like PERT and CPM to improve decision making and develop critical thinking objective analysis of decision making.	Ap	C	Home Assignments
5.	Develop and solve Inventory Models and acquire skills in analyzing Queuing Models.	Ap	C	Practical Skill
6.	Estimate the allocation of resources to demand points in the best possible way using various techniques and minimize the cost or time of completion of jobs.	An	P	Observation of Practical Skills

* - Remember (R), Understand (U), Apply (Ap), Analyze (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (60)	Marks (70)
I	**Theory of Simplex Method & Revised Simplex Method**		**12**	**20**
	1	Canonical and Standard form of LP problem		
	2	Canonical and Standard form of LP problem- Reduction of Feasible solution to Basic Feasible solution		
	3	Improving a Basic Feasible Solution-Alternative optimal solutions		
	4	Unbounded Solutions-Unrestricted variables–degeneracy and its Resolution		
	5	Standard forms for Revised Simplex Method- Computational Procedure		
	6	Comparison of Simplex method and Revised Simplex method		
	7	Dual Simplex Method		
II	**Integer Linear Programming & Classical Optimization Methods**		**12**	**20**
	8	Types of Integer Programming Problems-Gomory's all Cutting Plane Method		
	9	Gomory's Mixed Integer Cutting Plane Method		
	10	Branch and Bound Method		
	11	Applications of Zero-One Integer Programming		
	12	Unconstrained Optimization- Optimizing single variable and Multivariable functions		
	13	Constrained Multi Variable Optimization with equality and Inequality constraints		
	14	Lagrange Multipliers Methods		
	15	Kuhn-Tucker Necessary and Sufficient Conditions.		
III	**Non-Linear Programming Methods, Quadratic Programming & Dynamic Programming**		**12**	**15**
	16	The General Non-Linear Programming Problem- Graphical Solution Method		
	17	Quadratic Programming -Kuhn-Tucker Conditions- Wolfe's Modified Simplex Method		
	18	Dynamic Programming -Terminology -Optimal Decision Policy-General Algorithm-		
	19	Dynamic Programming Approach for solving LPP		
IV	**Project Management PERT and CPM, Inventory Control Models**		**12**	**15**
	20	Basic difference between PERT and CPM-Critical Path Analysis		
	21	Estimation of Project completion time- Project Time cost Trade off -Project Crashing -Resource allocation		
	22	Deterministic Inventory Models- EOQ Inventory Models without shortages and with Shortages-		

	23	Probabilistic Models-Newspaper Boy Problem.		
V	**Open –Ended**		**12**	
	Sequencing Problem, Replacement and Maintenance Models Simulation Techniques			

Reference

1. **Mital. K. V. and Mohan. C. (1996).** Optimization Methods in OperationsResearch and Systems Analysis Third Edition, New Age International (Pvt) Ltd., New Delhi.

2. **Taha. H.A. (2007).** Operations Research – An Introduction-Eighth Edn. Pearson Printice Hall, new Jersey.

3. **Sharma J.K. (2003).** Operations Research-Theory and Applications, Macmillan Indian Ltd., New Delhi

4. **Man Mohan, Kanti Swarup and Gupta (1999).** Operations Research, Sulthan Chand & Sons, New Delhi.

Programme	B. Sc. STATISTICS				
Course Code	STA 8 EJ 413				
Course Title	QUEUEING MODELS				
Type of Course	**Major Elective**				
Semester	VIII				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Basic knowledge of Markov Chain & Stochastic process				
Course Summary	Detail analysis of Queueing Models				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
1.	Identify basic concepts of queueing theory	U	F	Seminar Presentation
2.	Analyze behaviors of queueing models	An	P	Instructor-created exams
3.	Explain on queueing Networks	Ap	F	Group Tutorial Work
4.	Apply queueing models	Ap	F	Home Assignments
5.	Evaluate performance measures	An	P	Practical Skill
6.	Create significance and applications of queueing theory	C	M	Group Tutorial Work
* - Remember (R), Understand (U), Apply (Ap), Analyze (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (60)	Marks (70)
I	**Queueing Theory**		12	20
	1	Introduction to queueing theory, Cost Equations, Steady-State Probabilities		
	2	Characteristics of queueing processes, Measures of effectiveness		
	3	Markovian queueing models		
	4	steady state solutions of the M/M/I model, waiting time distributions		
	5	Little’s formula, queues with unlimited service, finite source queues		
II	**Transient Behavior**		12	15

	6	Transient behavior of M/M/1 queues		
	7	Transient behavior of M/M/∞		
	8	Busy period analysis for M/M/1 and M/M/c models		
	9	Advanced Markovian models		
	10	Bulk input $M^{[X]}$ /M/1 model, Bulk service $M/M^{[Y]}$ /1 model		
	11	Erlangian models, M/Ek/1 and Ek/M/1		
	12	A brief discussion of priority queues		
III	**Queueing Networks**		**12**	**20**
	13	Queueing networks-series queues		
	14	Open Jackson networks		
	15	Closed Jackson network		
	16	Cyclic queues		
	17	Extension of Jackson networks		
	18	Non Jackson networks		
IV	**General Queueing Models**		**12**	**15**
	19	Models with general arrival pattern, The M/G/1 queueing model		
	20	The Pollaczek-khintchine formula, Departure point steady state systems size probabilities, ergodic theory		
	21	Special cases M/Ek/1 and M/D/1, waiting times, busy period analysis, general input and exponential service models,		
	22	Arrival point steady state system size probabilities		
V	**Open –Ended**		**12**	
	Problems regarding Module I to Module IV			

Reference

1. **Gross, D. and Harris, C.M.(1985).** Fundamentals of Queuing Theory, 2nd Edition, John Wiley and Sons, new York.

2. **Kleinrock L (1975).** Queuing Systems, Vol. I &Vol 2, John Wiley and Sons, New York.

3. **Ross, S.M. (2007).** Introduction to Probability Models. 9th Edition, Academic Press, New York.

4. **Bose, S.K. (2002).** An Introduction to Queuing Systems, Kluwer Academic/Plenum Publishers, New York.

Programme	B. Sc. STATISTICS
Course Code	STA 8 EJ 414
Course Title	STATISTICAL DECISION THEORY
Type of Course	**Major Elective**
Semester	VIII
Academic Level	400-499

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60

Pre-requisites	Statistical testing hypothesis, Priori & Posterior probability
Course Summary	To understand different decision rule using statistics and Bayesian analysis .

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
1.	Explain different loss functions and decision Principle	Ap	C	Seminar Presentation /
2.	Describe the use of prior information in decision making.	R	F	Instructor-created exams
3.	Calculate Posterior distribution and check the admissibility of Bayes rules	Ap	C	Group Tutorial Work
4.	Develop general techniques for solving games	Ap	C	Home Assignments

* - Remember (R), Understand (U), Apply (Ap), Analyze (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (60)	Marks (70)
I	**Statistical decision Problem**		**12**	**15**
	1	Decision rule		
	2	Loss-randomized decision rule		
	3	Decision Principle - sufficient statistic and convexity		
	4	Utility and		
	5	Loss-loss functions		
	6	Standard loss functions vector valued loss functions		

II	**Prior information**		**12**	**20**
	7	subjective determination of prior density		
	8	Non-informative priors		
	9	Maximum entropy priors he marginal distribution to determine the prior		
	10	the ML-II approach to prior selection		
	11	Conjugate priors		
III	**The posterior distribution**		**12**	**20**
	12	Bayesian inference		
	13	Bayesian decision theory		
	14	Empirical Bayes analysis		
	15	Hierarchical Bayes analysis		
	16	Bayesian robustness Admissibility of Bayes rules		
IV	**Game theory**		**12**	**15**
	17	Basic concepts		
	18	General techniques for solving games		
	19	Games with finite state of nature		
	20	the supporting and separating hyper plane theorems		
	21	The minimax theorem		
	22	Statistical games		
V	**Open –Ended**		**12**	
	Problems regarding Module I to Module IV			

Text Book

Berger, O.J. (1985). Statistical Decision Theory and Bayesian Analysis – Second Edition. Springer, New York.

Reference

1. **Ferguson, T.S. (1967)**. Mathematical Statistics-A Decision Theoretic Approach. Academic Press, New York.
2. **Lehman, E.L. (1998)**. Theory of Point Estimation-Second Edition. John Wiley, New York.

Programme	B. Sc. STATISTICS				
Course Code	STA 8 EJ 415				
Course Title	ANALYSIS OF CLINICAL TRIALS				
Type of Course	**Major Elective**				
Semester	VIII				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Different sampling techniques and design of experiments				
Course Summary	To understand different methods to analyze medical data				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
1.	Appraise the basic concepts of clinical trials	E	P	Seminar Presentation /
2.	Plan and develop the design of clinical trials	An	C	Instructor-created exams
3.	Determine the sample size in clinical trials	Ap	C	Group Tutorial Work
4.	Conduct bioassays and assimilate the concepts of meta-analysis in clinical Trials	Ap	C	Home Assignments
* - Remember (R), Understand (U), Apply (Ap), Analyze (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (60)	Marks (70)
I	**Basics of Clinical Trials**		**12**	**20**
	1	Introduction to clinical trials		
	2	The need and ethics of clinical trials, bias and random error in clinical studies		
	3	Protocols, conduct of clinical trials, over view of Phase I-IV trials		
	4	Data management-data definitions, standard operating Procedure		
	5	Informed consent form, case report forms, database design		
	6	Data collection systems for good clinical practice		
II	**Design of Clinical Trials**		**12**	**15**

	7	Design of clinical trials		
	8	Different phases, Comparative and controlled trials, Random allocation, Randomization, response adaptive methods and restricted randomization		
	9	Methods of Blinding, Parallel group designs, Crossover designs, Symmetric designs, Adaptive designs, Group sequential designs		
	10	Zelen's designs, design of bioequivalence trials		
	11	Outcome measures		
III	**Sample Size Determination and Testing**		**12**	**20**
	12	Sample size determination in one and two sample cases		
	13	Comparative trials, activity studies, testing and other purposes		
	14	Unequal sample sizes and case of anova		
	15	Surrogate endpoints-selection and design of trials with surrogate endpoints		
	16	analysis of surrogate end point data		
	17	Reporting and Analysis		
	18	Interpretation of result, multi-center trials		
IV	**Meta-Analysis**		**12**	**15**
	19	Meta-analysis in clinical trials-concept and goals, fixed and random effect approaches		
	20	Bioassay: Direct and indirect assays		
	21	Quantal and quantitative assays		
	22	Parallel line and slope ratio assays, Design of bioassays		
V	**Open –Ended**		**12**	
	Problems regarding Module I to Module IV			

Text Book

1. **Friedman, L. M., Furburg, C. D. Demets, L. (1998).** Fundamentals of Clinical Trials, Springer Verlag.

2. **Jennison and Turnbull, B.W. (1999).** Group Sequential Methods with Applications to Clinical Trials, CRC Press.

3. **Kulinskaya, E, Morgeathaler, S and Staudte R G (2008).** Meta-analysis, Wiley**.**

Reference

1. **Fleiss, J. L. (1989).** The Design and Analysis of Clinical Experiments, Wiley.

2. **Marubeni, E. and M. G. Valsecchi (1994).** Analyzing Survival Data from Clinical Trials and Observational Studies, Wiley and Sons.

3. **Piantadosi S. (1997).** Clinical Trials: A Methodological Perspective. Wiley.

4. **W Rosenberger, J MLachin (2002).** Randomization in Clinical Trials Theory and Practice, Wiley

Programme	B. Sc. STATISTICS				
Course Code	STA 8 EJ 416				
Course Title	APPLIED ALGORITHMS AND BIG DATA TECHNIQUES				
Type of Course	**Major Elective**				
Semester	VIII				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Statistical Machine Learning				
Course Summary	To understand how handle big data using EM algorithm, supervisory and unsupervisory learning				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
1.	Explain the concept of EM clustering algorithms.	U	F	Seminar Presentation /
2.	Understand the classification techniques and the concept of support vector machines	U	F	Instructor-created exams
3.	Explain the basic concepts related to big data	Ap	C	Group Tutorial Work
4.	Illustrate the multidimensional scaling techniques in unsupervised learning	Ap	C	Home Assignments
* - Remember (R), Understand (U), Apply (Ap), Analyze (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (60)	Marks (70)
I	**EM Algorithm**		**12**	**20**
	1	Two-Component Mixture Model		
	2	Gaussian Models		
	3	The EM Algorithm in General		
	4	EM as a Maximization–Maximization Procedure		
II	Support Vector Machines		**10**	**15**
	5	Maximal Margin Classifier		
	6	Support Vector Classifiers		
	7	Support Vector Machines		

	8	SVMs with More than Two Class- One- Versus-One Classification and One-Versus-All Classification		
III	**Big Data**		**10**	**15**
	9	Definition, Characteristics		
	10	Data Analytics		
	11	General Categories of Data Analytics		
	12	Structured, Unstructured and Semi Structured Data		
	13	Met data		
	14	Big Data Analytics Life Cycle.		
IV	**Multi-Dimensional Scaling**		**16**	**20**
	15	Definition, Perceptual Map		
	16	Decision Frame- work for Perceptual Mapping,		
	17	Non-metric versus Metric methods		
	18	Similarities Data,		
	19	Preferences Data		
	20	Aggregate and Disaggregate Analysis		
	21	De-compositional and Compositional approaches		
	22	Interpreting the MDS results		
V	**Open –Ended**		**12**	
	Practical Problems from Module I to Module IV using software's			

Text Books/ References

1. **Hastie, T., Tibshirani, R. and Friedman, J. (2017)**.The Elements of Statistical Learning, Data Mining,Inference and Prediction, 2nd edition. Springer, New York.

2. **James, G., Witten, D., Hastie, T. and Tibshirani,R.(2013)**. An Introduction to Statistical Learning withApplications in R. Springer, New York.

3. **Erl, T. and Khattak, W. (2016)**. Big Data Fundamentals Concepts, Drivers & Techniques. Prentice Hall.

4. **Hair, J. F., Black, W. C., Babin, B. J. and Anderson, R. E.(2009)**. Multivariate Data Analysis, 7thedition. Prentice Hall, New York.

Programme	B. Sc. STATISTICS
Course Code	STA 8 EJ 417
Course Title	ADVANCED TRENDS IN STATISTICS
Type of Course	**Major Elective**
Semester	VIII
Academic Level	400-499

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60

Pre-requisites	Thorough knowledge of probability distributions
Course Summary	To understand Johnson's system of distributions, Burr family of distributions, Infinite divisibility, U-Statistics & Stochastic ordering.

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
1.	Discuss the Johnson's S_B system, Johnson's system S_u and Burr family of distributions.	U	F	Seminar Presentation
2.	Identify the general theory of infinite divisibility and its applications	U	F	Instructor-created exams
3.	Explain the concept and properties of U-statistics, and their role in non-parametric modelling	An	P	Group Tutorial Work
4.	Describe various types stochastic order relations between random variables in univariate setup.	U	C	Home Assignments
* - Remember (R), Understand (U), Apply (Ap), Analyze (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (60)	Marks (70)
I	**Distribution Theory**		**12**	**15**
	1	Systems of distributions		
	2	Johnson's S_B system		
	3	Johnson's S_u system		

	4	Burr distributions		
	5	Infinite divisibility of probability distributions- (i) the non-negative integers		
	6	Infinitely divisible distribution on (ii) the non-negative real's		
II	**U-Statistics**		**12**	**20**
	7	Basic description of U-statistics		
	8	Variance and other moments of a U- statistic		
	9	Projection of a U-statistic on the basic observations		
	10	Almost sure behavior of U-statistics		
	11	Asymptotic distribution theory of U-statistics		
	12	Non-parametric density estimation		
III	**Univariate stochastic orders**		**12**	**20**
	13	Usual stochastic order		
	14	Hazard rate order		
	15	Likelihood ratio order		
	16	Convolution order		
	17	Mean residual life orders		
IV	U**nivariate variability orders**		**12**	**15**
	18	Convex order, dispersive order,		
	19	Excess wealth order & peakedness order		
	20	Monotone convex and monotone concave orders		
	21	Transform orders: convex, star orders		
	22	Super additive orders		
V	**Open –Ended**		**12**	
	Practical applications of the concepts discussed in Module I to Module IV			

References

1. **Laha, R.G. and Rotatgi, V.K. (1979)**. Probability Theory. Wiley, New York.

2. **Serfling, R.J.(1980)**. Approximation Theorems of Mathematical Statistics (Chapter-5). John Wiley and Sons, Canada.

3. **Steutel, F.W. and van Harn, K. (2004)**. Infinite Divisibility of Probability Distributions on the Real Line. Marcel Dekker Inc., New York.

4. **Shaked, M. and Shanthikumar, J. G. (Eds.). (2007)**. Stochastic Orders. Springer, New York.

MINOR COURSES IN STATISICS

SYLLABUS

PROVIDENCE WOMEN'S COLLEGE
Four Year UG Program Syllabus - Minor

Programme	BSc Statistics				
Course Code	STA1MN101 (P)				
Course Title	Descriptive Statistics for Data Science				
Type of Course	Minor				
Semester	I				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic knowledge of data, variables, charts and graphs, Basic computer skills				
Course Summary	This course aims to equip students with a holistic understanding of different data types and probability, enabling them to make informed decisions and draw meaningful conclusions from data.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Describe different types of data	U	F	Instructor-created exams / Quiz
CO2	Compare and differentiate various types of data	U	C	Instructor-created exams / Home Assignments
CO3	Visualize different types of data and analyze data to help entrepreneurial decisions using critical thinking skills.	R	P	Seminar Presentation / Group Tutorial Work
CO4	Summarize various descriptive measures of data and critically evaluate ethical implications of statistical methods aligning with human values.	U	C	Instructor-created exams / Home Assignments
CO5	Define basic terms in probability	R	F	One Minute

				Reflection Writing assignments
CO6	Solving uncertainty with sample data with spread sheet	Ap	P	Viva-Voce/Practical Assignment/Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hours (45 +30)	Marks (70)
I		**Introduction to Statistics**	**8**	**10**
	1	Basic terms and types of Variables	2	
	2	Collection of data- Primary and secondary data,	2	
	3	Methods of collecting primary data	2	
	4	Sources of Secondary data	2	
	Sections from References: Unit 1: 1.2&1.3 [Ref 3] Unit 2: 2.2 [Ref 2] Unit 3: 2.3 [Ref 2] Unit 4: 2.5 [Ref 2]			
II		**ORGANIZING AND GRAPHING DATA**	9	**15**
	5	Frequency Distribution	2	
	6	Cumulative Frequency distribution	2	
	7	Diagrammatic Representations	3	
	8	Graphical Representation of data	2	
	Sections from References: Unit 5: 3.3 [Ref 2] Unit 6: 3.5 [Ref 2] Unit 7: 4.3(4.3.2 to 4.3.7) - [Ref 2] Unit 8: 4.4(4.4.3 to 4.4.5)- [Ref 2]			
III		**NUMERICAL DESCRIPTIVE MEASURES**	**12**	**25**
	9	Measures of central tendency	1	
	10	Arithmetic Mean	2	
	11	Median and Mode	2	
	12	Geometric mean and Harmonic Mean	2	
	13	Partition values	1	

	14	Measures of dispersion	3	
	15	Skewness and Kurtosis (Concept only)	1	
	Sections from References: Unit 9: 2.4 [Ref 1] Unit 10: 2.5 [Ref 1] Unit 11: 2.6, 2.7 [Ref 1] Unit 12: 2.8, 2.9 [Ref 1] Unit 13: 2.11 [Ref 1] Unit 14: 2.13 [Ref 1] Unit 15: 2.16, 2.17 [Ref 1]			
IV	**PROBABILITY**		**16**	**20**
	16	Random Experiment, Sample Space, Events (Basic terminology), Three Conceptual Approaches to Probability	2	
	17	Addition theorem (for two and three events) and simple problems	2	
	18	Conditional probability	3	
	19	Multiplication theorem of probability	2	
	20	Independent events and its Multiplication Theorem	2	
	21	Pairwise and mutual independence (Concept and Problems)	2	
	22	Baye's theorem	3	
	Sections from References: Unit 16: 3.3, 3.4, 3.5, 3.6 & 3.8 [Ref 1] Unit 17: 3.9 [Ref 1] Unit 18: 3.10[Ref 1] Unit 19: 3.11 [Ref 1] Unit 20: 3.12, 3.13& 3.14 [Ref 1] Unit 21: 3.15[Ref 1] Unit 22: 4.2 [Ref 1]			
V	**PRACTICUM**		**30**	
	Do practice problems in spreadsheet from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course.			
	1	Types of data		
	2	Introduction to spreadsheet		
	3	Frequency distributions for organizing and summarizing data		
	4	Histograms		
	5	Graphs that enlighten and graphs that deceive		

	6	Measures of central tendency		
	7	Measures of dispersion		
	8	Measures of Relative Standing and Boxplots		
	Sections from References: Unit 1: 1.2 Ref [5] Unit 2: 1.4 Ref [5] Unit 3: 2.1 Ref [5] Unit 4: 2.2 Ref [5] Unit 5: 2.3 Ref [5] Unit 6: 3.1 Ref [5] Unit 7: 3.2 Ref [5] Unit 8: 3.3 Ref [5]			

Books and References:

1. Gupta, S. C. and Kapoor, V. K. (2020). Fundamentals of Mathematical Statistics, 12th edition, Sulthan Chand, New Delhi
2. Gupta, S. C. (2015). Fundamentals of Statistics, Himalaya Publishing House.
3. Prem S. Mann (2016), Introductory Statistics 9 th Edition, Wiley
4. Neil A. Weiss, Introductory Statistics, 9th Edition, Addison Wesley Pearson Learning (2011)
5. Mario F Triola, Elementary Statistics using Excel, (2018), 6th edition.

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	3	1	2	-	-	2	-	2	-	-	-
CO 2	3	3	-	2	1	-	3	1	2	3	-	-
CO 3	1	2	-	2	-	-	2	-	2	-	-	-
CO 4	3	2	-	1	-	-	3	-	2	2	-	-
CO 5	3	2	-	-	-	-	3	-	2	-	-	-
CO 6	1	1	2	-	3	3	2	2	1	-	3	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	BSc Statistics				
Course Code	STA2MN101 (P)				
Course Title	Probability theory I				
Type of Course	Minor				
Semester	II				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Students should have a strong foundation in algebra and calculus, including functions, differentiation, and integration. Basic knowledge about descriptive Statistics				
Course Summary	Students will acquire a comprehensive understanding of key statistical concepts; random variable, standard theoretical distributions and sampling distributions.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Define random variables and distinguish different types of random variables	R	C	Instructor-created exams / Quiz
CO2	Identify discrete and continuous probability function and analyze data to help entrepreneurial decisions using critical thinking skills.	R	C	Practical Assignment / Instructor-created exams
CO3	Describe standard theoretical distributions	R	F	Seminar Presentation / Group Tutorial Work/Instructor-created exams
CO4	Discuss various tools for association between the bivariate variables.	U	C	Instructor-created exams / Home Assignments
CO5	Distinguish between a population distribution and a sampling distribution and critically evaluate ethical implications of statistical methods aligning with human values.	U	F	One Minute Reflection Writing assignments, Instructor-created exams
CO6	Explain the calculation of correlation	U	P	Viva

	coefficent using spread sheet.			Voce/Instructor -created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Units	Content	Hrs (45 +30)	Marks (70)
I	**DISCRETE RANDOM VARIABLES AND THEIR PROBABILITY DISTRIBUTIONS**		12	15
	1	Random Variables- Discrete	1	
	2	Probability mass function, properties and problems	1	
	3	Cumulative distribution function and its properties	1	
	4	Mathematical expectation of a random variable, function of a random variable and properties of expectation	1	
	5	Properties of variance	1	
	6	Covariance	2	
	7	Moments (definition only), Moment Generating Function (Definition, Simple problems and Properties (without proof))	1	
	8	Binomial Distribution (Mean, variance, m.g.f.,Simple Problems)	2	
	9	Poisson Distribution (Mean, variance, m.g.f.,Simple Problems)	2	
	Sections from References: Unit 1: 5.1 & 5.3 [Ref 1] Unit 2: 5.3.1 [Ref 1] Unit 3: 5.2, 5.2.1,5.3.2[Ref 1] Unit 4: 6.1,6.2,6.3,6.4 [Ref 1] Unit 5: 6.3 [Ref 1] Unit 6: 6.6 [Ref 1] Unit 7: 7.1,7.1.2 [Ref 1] Unit 8: 8.4, 8.4.1 [Ref 1] Unit 9: 8.5, 8.5.2 [Ref 1]			
II	**CONTINUOUS RANDOM VARIABLES AND THEIR PROBABILITY DISTRIBUTIONS**		12	20
	10	Probability density function, properties and problems	2	

	11	Rectangular distribution (Mean and Variance)	2	
	12	Exponential distribution (Mean and Variance)	2	
	13	Normal Distribution (Moments, Moment Generating Function, Additive Property ,Area property and their problems)	6	
	Sections from References: Unit 10: 5.4, 5.4.1, 5.4.2 [Ref 1] Unit 11: 9.3.1 [Ref 1] Unit 12: 9.8, 9.8.1[Ref 1] Unit 13: 9.2, 9.2.5, 9.2.7, 9.2.8, 9.2.11[Ref 1]			
III	**DESCRIPTIVE METHODS IN CORRELATION AND REGRESSION**		10	20
	14	Simple correlation	3	
	15	Simple regression	3	
	16	Coefficient of determination	2	
	17	Curve linear regression	2	
	Sections from References: Unit 14: 10.1, 10.2, 10.3, 10.4, 10.4.1, 10.4.2 [Ref 1] Unit 15: 11.1, 11.2, 11.2.1, 11.2.2 [Ref 1] Unit 16: 11.2.6 [Ref 1] Unit 17: 11.3 [Ref 1]			
IV	**SAMPLING DISTRIBUTIONS**		11	15
	18	Parameter and Statistic, sampling distribution, standard error.	2	
	19	Distribution of sample mean	2	
	20	Chi- square distribution (definition, mean, variance, m.g.f, additive property)	4	
	21	F distribution (definition only)	1	
	22	t distribution	2	
	Sections from References: Unit 18: 14.3, 14.3.1, 14.3.2 [Ref 1] Unit 19: 4.2 [Ref 3] Unit 20: 4.3 [Ref 3] Unit 21: 4.4 [Ref 3] Unit 22: 4.5 [Ref 3]			
V	**PRACTICUM**		30	
	Do practice problems in spreadsheet from any 5 units of the given list and one additional problem decided by the teacher- in-charge, related to the content of the course. Other units listedhere may be used as demonstrations of the concepts			

	taught in the course.			
	1	Scatterplot and correlation		
	2	Linear correlation coefficient r		
	3	Regression		
	4	Calculate factorials, permutations and combinations		
	5	Concept of simulation		
	6	Finding mean and variance of a probability distribution		
	7	Methods for finding binomial probabilities		
	8	Methods for finding Poisson probabilities		
	Sections from References: Unit 1: 2.4 [Ref 5] Unit 2: 2.4 [Ref 5] Unit 3: 2.4 [Ref 5] Unit 4: 4.4 [Ref 5] Unit 5: 4.5 [Ref 5] Unit 6: 5.1 [Ref 5] Unit 7: 5.2 [Ref 5] Unit 8: 5.3 [Ref 5]			

Books and References:

1. Gupta, S. C. and Kapoor, V. K. (2002). Fundamentals of Mathematical Statistics, 11th edition, Sulthan Chand, New Delhi
2. Prem S. Mann (2016), Introductory Statistics 9 th Edition, Wiley
3. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn., (Reprint), Tata McGraw-Hill Pub. Co. Ltd.
4. Neil A. Weiss, Introductory Statistics, 9th Edition ,Addison Wesley Pearson Learning (2011)
5. Mario F Triola, Elementary Statistics using Excel, (2018), 6th edition.

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	3	-	-	-	2	3	2	-	-	-	-
CO 2	-	-	-	-	-	3	3	2	-	-	-	-
CO 3	-	-	-	-	-	2	2	3	-	-	-	-
CO 4	-	-	-	-	-	-	3	3	-	-	1	1

CO 5	-	2	-	3	2	-	2	-	1	-	2	-
CO 6	2	-	2	-	-	3	2	3	-	3	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6	✓			✓

Programme	BSc Statistics
Course Code	STA3MN201 (P)

Course Title	Statistical inference using R				
Type of Course	Minor				
Semester	III				
Academic Level	200 – 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Students should be comfortable with concepts such as probability distributions, random variables, and conditional probability.				
Course Summary	Upon completion of this course, students will be proficient in understanding and applying the concept of estimation and testing of hypothesis in statistics, allowing them to make informed decisions and draw reliable conclusions from sample data.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Articulate the purpose of estimation in making inferences about population parameters based on sample data and analyze data to help entrepreneurial decisions using critical thinking skills.	Ap	C	Instructor-created exams / Quiz
CO2	Explain the difference between point estimation and interval estimation	U	C	Practical Assignment / Observation of Practical Skills
CO3	Calculate and interpret confidence intervals for both population mean and proportion and critically evaluate ethical implications of statistical methods aligning with human values	Ap	F	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Explain how to formulate null and alternative hypotheses for different types of research questions	U	C	Instructor-created exams / Home Assignments
CO5	Introduce R software and discuss R code for various graphical representations of data.	U	F	One Minute Reflection Writing assignments/ Instructor-creat

				ed exams
CO6	Apply estimation and hypothesis testing methods to real-world data sets.	Ap	P	Viva Voce/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Units	Content	Hrs (45 +30)	Marks (70)
I		**THEORY OF ESTIMATION**	14	25
	1	Point estimation	1	
	2	Unbiasedness	2	
	3	Consistency	2	
	4	Efficiency	2	
	5	Sufficiency	2	
	6	Methods of estimation	2	
	7	Interval estimation	1	
	8	Confidence limits for mean	1	
	9	Confidence limits for proportion	1	
	Sections from References: Unit 1: 16.1, 16.2, 16.2.1 [Ref 1] Unit 2: 16.2.2 [Ref 1] Unit 3: 16.2.3 [Ref 1] Unit 4: 16.2.4 [Ref 1] Unit 5: 16.6.5 [Ref 1] Unit 6: 16.2.6 [Ref 1] Unit 7: 16.4 [Ref 1] Unit 8: 16.4.2 [Ref 1] Unit 9: 16.4.3 [Ref 1]			
II		**TESTING OF HYPOTHESIS**	10	20
	10	Statistical hypothesis, Simple and composite hypothesis	2	
	11	Null and alternate hypothesis, Two types of errors, Level of significance, Critical region, one tatiled and two tailed	2	

		Tests		
	12	Large sample tests: Test for single proportion	3	
	13	Test of significance for a single mean	3	
	Sections from References: Unit 10: 16.6.1 [Ref 1] Unit 11: 16.6.3, 16.6.4, 16.6.5, 16.6.6, 16.6.7, 16.6.8 [Ref 1] Unit 12: 17, 17.2.1 [Ref 1] Unit 13: 17.3.2 [Ref 1]			
III	**CHI SQUARE TEST**		9	15
	14	Applications of Chi square distribution	2	
	15	Chi square test of goodness of fit	3	
	16	Chi square test for independence of attributes	4	
	Sections from References: Unit 14: 18.3 [Ref 1] Unit 15: 18.4 [Ref 1] Unit 16: 18.6 [Ref 1]			
IV	**INTRODUCTION TO R**		12	10
	17	Installation & Basic Mathematical Operations	2	
	18	R Preliminaries	1	
	19	Methods of Data Input	1	
	20	Graphical Representations (R Code)	2	
	21	Diagrammatic Representations (R Code)	3	
	22	Descriptive Measures (Mean, Median, Mode, Range, Standard deviation, variance)	3	
	Sections from References: Unit 19: 1.2&1.3 [Ref 5] Unit 20: 1.4 [Ref 5] Unit 21: 1.5&1.6 [Ref 5] Unit 22: 1.8,2.3 [Ref 5] Unit 23:2.2 [Ref 5] Unit 24: 2.4,2.5 [Ref 5]			
V	**PRACTICUM**		30	
	Do practice problems in R software from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as			

	demonstrations of the concepts taught in the course.			
	1	Basic mathematical operations and R preliminaries		
	2	Methods of data input		
	3	Data accessing or indexing		
	4	Built in functions in R		
	5	Graphical representations (R Code)		
	6	Diagrammatic representations (R Code)		
	7	Mean, Median, Mode		
	8	Range, Standard deviation, variance		
	Sections from References: Unit 1: 1.3&1.4 [Ref 5] Unit 2: 1.5 [Ref 5] Unit 3: 1.6 [Ref 5] Unit 4: 1.7 [Ref 5] Unit 5: 1.8 [Ref 5] Unit 6: 2.2 [Ref 5] Unit 7: 2.4 [Ref 5] Unit 8: 2.5 [Ref 5]			

Books and References:

1. Gupta, S. C.. (2015). Fundamentals of Statistics, Himalaya Publishing House.
2. Gupta, S. C. and Kapoor, V. K. (2002). Fundamentals of Mathematical Statistics, 11th edition, Sulthan Chand, New Delhi
3. Prem S. Mann (2016), Introductory Statistics 9 th Edition, Wiley
4. The R book (2007) , Michael J. Crawley John Wiley Series
5. Sudha G Purohith, Sharad D Core, Shailaja R Deshmukh (2015), Statistics Using R

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	3	1	-	-	2	2	3	-	-	3	-
CO 2	-	2	-	3	2	3	3	3	1	-	-	-
CO 3	2	-	2	-	-	-	2	2	-	3	-	3

CO 4	-	-	3	-	-	-	1	3	-	3	-	-
CO 5	-	-	2	-	-	-	1	3	-	3	-	-
CO 6	2	-	2	-	-	-	1	2	-	2	-	2

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	BSc Statistics

Course Code	STA1MN102 (P)				
Course Title	Applied statistics using R				
Type of Course	Minor				
Semester	I				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic Knowledge in the Descriptive Measures				
Course Summary	Upon successful completion of this course, students will possess a solid understanding of fundamentals of sampling concepts, index numbers, vital statistics and R software.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Explain the importance of sampling as a method for gathering data and making inferences about populations	U	C	Instructor-created exams / Quiz
CO2	Describe the ability to implement simple random sampling techniques and understand their advantages and limitations.	U	F	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO3	Develop skills in interpreting index numbers and analyze data to help entrepreneurial decisions using critical thinking skills.	Ap	C	Seminar Presentation / Group Tutorial Work
CO4	Explain the significance of vital statistics in capturing essential demographic information and critically evaluate ethical implications of statistical methods aligning with human values.	U	C	Instructor-created exams / Home Assignments
CO5	Understand various methods of collecting vital statistics.	R	F	One Minute Reflection Writing assignments/ Instructor-create

				d exams
CO6	Demonstrate the ability to write and execute simple R scripts.	Ap	P	Viva Voce/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	**Units**	**Content**	**Hrs (45 +30)**	**Marks (70)**
I		**SAMPLING METHODS**	10	15
	1	Population and Sample, Census and Sampling Method	1	
	2	Advantages and Limitations of Sampling	1	
	3	Principal steps in a sample survey	1	
	4	Sampling and Non-Sampling Errors	1	
	5	Types of sampling (Purposive, Probability, Mixed)	1	
	6	Simple Random Sampling (Concept and Method of Selection)	2	
	7	Stratified Random Sampling	2	
	8	Systematic Random Sampling	1	
	Sections from References: Unit 1: 15.2,15.3,15.6 [Ref 1] Unit 2: 15.6,15.7[Ref 1] Unit 3: 15.8 [Ref 1] Unit 4: 15.9.1[Ref 1] Unit 5:15.10[Ref 1] Unit 6:15.11,15.11.1 [Ref 1] Unit 7: 15.12,15.12.1 [Ref 1] Unit 8: 15.13 [Ref 1]			
II		**INDEX NUMBERS**	10	25
	9	Introduction and Uses of Index Numbers	1	
	10	Types of Index Numbers	1	
	11	Problems in the construction of Index Number	1	

	12	Methods of Construction of Index Numbers- Simple and Weighted Index Number	5	
	13	Tests for an Ideal Index Number- Time Reversal Test and Factor Reversal Test	2	
	Sections from References: Unit 9: 10.1&10.2[Ref 1] Unit 10: 10.3 [Ref 1] Unit 11: 10.4[Ref 1] Unit 12: 10.5 [Ref 1] Unit 13:10.6.2&10.6.3 [Ref 1]			
III	**VITAL STATISTICS**		11	20
	14	Introduction to Vital Statistics	1	
	15	Uses of Vital Statistics	2	
	16	Collection of Vital Statistics-Registration Method, Census Enumeration Method, Survey Method, Analytical Method	2	
	17	Measures of Fertility –Crude Birth Rate (CBR), General Fertility Rate (GFR), Specific Fertility Rate (ASFR). Total Fertility Rate (TFR) (Concept and Problems)	3	
	18	Measurement of Mortality- Crude Death Rate (CDR), Specific Death Rate (ASDR), Standardized Death Rate (SDR), Infant Mortality Rate, Maternal Mortality Rate(Concept and Problems)	3	
	Sections from References: Unit 14: 16.2 [Ref 2] Unit15: 16.2&16.3 [Ref 2] Unit 16: 16.3&16.4[Ref 2] Unit 17: 16.5&16.6 [Ref 2] Unit 18:16.14,16.15,16.16,16.18 [Ref 2]			
IV	**INTRODUCTION TO R**		14	10
	19	Installation & Basic Mathematical Operations	1	
	20	R Preliminaries	1	
	21	Methods of Data Input	1	
	22	Graphical Representations (R Code)	4	
	23	Diagrammatic Representations (R Code)	3	
	24	Descriptive Measures (Mean, Median, Mode, Range,	4	

		Standard deviation, variance)		
	Sections from References: Unit 19: 1.2&1.3 [Ref 5] Unit 20: 1.4 [Ref 5] Unit 21: 1.5&1.6 [Ref 5] Unit 22: 1.8,2.3 [Ref 5] Unit 23:2.2 [Ref 5] Unit 24: 2.4,2.5 [Ref 5]			
	PRACTICUM			
V	Do practice problems in R software from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course.		30	
	1	Basic mathematical operations and R preliminaries		
	2	Methods of data input		
	3	Data accessing or indexing		
	4	Built in functions in R		
	5	Graphical representations (R Code)		
	6	Diagrammatic representations (R Code)		
	7	Mean, Median, Mode		
	8	Range, Standard deviation, variance		
	Sections from References: Unit 1: 1.3&1.4 [Ref 5] Unit 2: 1.5 [Ref 5] Unit 3: 1.6 [Ref 5] Unit 4: 1.7 [Ref 5] Unit 5: 1.8 [Ref 5] Unit 6: 2.2 [Ref 5] Unit 7: 2.4 [Ref 5] Unit 8: 2.5 [Ref 5]			

Books and References:

1. Gupta, S. C.. (2015). Fundamentals of Statistics, Himalaya Publishing House
2. Gupta S.P (2021), Statistical Methods, 46 th edition, Sultan Chand and Sons.
3. Gupta, S. C. and Kapoor, V. K. (2014). Fundamentals of applied Statistics, Sultan Chand and Sons.
4. The R book(2007) , Michael J. Crawley John Wiley Series
5. Sudha G Purohith, Sharad D Core, Shailaja R Deshmukh (2015), Statistics Using R

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	2	-	-	-	2	2	2	-	-	-	-
CO 2	-	-	-	-	-	2	1	2	-	-	-	-
CO 3	-	-	3	-	-	3	3	2	-	2	3	-
CO 4	2	2	-	3	2	-	2	2	2	-	-	3
CO 5	2	2	-	-	-	-	1	1	-	-	-	-
CO 6	-	2	-	-	-	3	2	1	-	-	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignm ent	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	BSc Statistics
Course Code	STA2MN102 (P)
Course Title	Probability theory II
Type of Course	Minor

Semester	II				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic Knowledge in the concept of Probability and Random Variables				
Course Summary	Students will possess a comprehensive understanding of bivariate random variables, enabling them to analyze and interpret the joint behavior of two random variables.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Define and explain the concept of bivariate random variables.	U	C	Instructor-created exams / Quiz
CO2	Explore the concept of joint and marginal probability density functions	U	C	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO3	Calculate bivariate expectations for various functions of two random variables	Ap	F	Seminar Presentation / Group Tutorial Work/Instructor-created exams
CO4	Identify and describe common standard distributions like rectangular, beta, gamma and analyze data to help entrepreneurial decisions using critical thinking skills.	U	C	Instructor-created exams / Home Assignments
CO5	Identify the importance of time series analysis and explain various components of time series and critically evaluate ethical implications of statistical methods aligning with human values.	U	F	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Locate probability curves for different distributions using R	Ap	P	Viva Voce/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

COURSE CONTENT

Module	Units	Content	Hrs (45 +30)	Marks (70)
I		**TWO DIMENSIONAL RANDOM VARIABLES**	11	20
	1	Introduction to two dimensional random variables	1	
	2	Joint PMF and Joint pdf (Concept and Problems)	2	
	3	Joint DF(Concept and Problems)	2	
	4	Marginal Distributions(Concept and Problems)	2	
	5	Conditional Distributions(Concept and Problems)	3	
	6	Independence of Random Variables(Concept and Problems)	1	
		Sections from References: Unit 1: 5.5 [Ref 1] Unit 2: 5.5.1 & 5.5.4 [Ref 1] Unit 3: 5.5.2 [Ref 1] Unit 4: 5.5.1 & 5.5.4[Ref 1] Unit 5:5.5.1 & 5.5.5 [Ref 1] Unit 6:.5.5.6 [Ref 1]		
II		**BIVARIATE EXPECTATION**	12	15
	7	Expectation of two random variables (Concept and Problems),Addition Theorem (Statement Only), Multiplication Theorem (Statement Only)	3	
	8	Properties of Variance	1	
	9	Covariance & Correlation Coefficient	3	
	10	Conditional Expectation and Conditional Variance (Concept and Problems)	5	
		Sections from References: Unit 7: 6.4 [Ref 1] Unit 8: 6.5 [Ref 1] Unit 9: 6.6&10.4 [Ref 1] Unit 10: 6.9[Ref 1]		
III		**STANDARD DISTRIBUTIONS**	12	15
	11	Discrete Uniform Distribution (Mean, variance, mgf,	1	

		Problems)		
	12	Geometric Distribution (Mean, variance, mgf, Problems)	1	
	13	Hypergeometric Distribution (Mean, variance, mgf, Problems)	1	
	14	Negative Binomial Distribution (Mean, variance, mgf, Problems)	1	
	15	Rectangular Distribution(Mean, variance, mgf, Problems)	2	
	16	Gamma Distribution(Mean, variance, mgf, Problems)	2	
	17	Beta Distribution(Mean, variance, mgf, Problems)	2	
	18	Order Statistics[Distribution function of single order statistic ,Examples]	2	
	Sections from References: Unit 11: 8.2 [Ref 1] Unit 12: 8.7 [Ref 1] Unit 13: 8.8 [Ref 1] Unit 14: 8.6[Ref 1] Unit 15: 9.3[Ref 1] Unit 16:.9.5 [Ref 1] Unit 17:.9.6,9.7 [Ref 1] Unit 18:.9.18 [Ref 1]			
IV		**TIME SERIES ANALYSIS**	10	20
	19	Introduction to Time Series & Utility of Time Series	1	
	20	Components of Time Series	1	
	21	Measurment of Trend- Graphic Method,Semi Average Method, Method of Moving Average, Method of Least squares (Linear Trend) (Concept and Problems)	4	
	22	Measurement of Seasonal Variations-Method of Simple Averages ,Ratio to Trend Method	4	
	Sections from References: Unit 19: 11.1& 11.3[Ref 2] Unit 20:11.2[Ref 2] Unit 21:.11.5[Ref 2] Unit 22:.11.6 [Ref 2]			
V	**PRACTICUM**		30	
	Do practice problems in R software from any 5 units of the given list			

	and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course.			
	1	Measures of skewness		
	2	Measures of kurtosis		
	3	Obtain the probability distribution		
	4	Plot the probability distribution		
	5	Obtain the cumulative distribution function		
	6	Plot the cumulative distribution function		
	7	Obatain any one discrete probability		
	8	Obatain any one continuous probability		
	Sections from References: Unit 1: 2.6 [Ref 5] Unit 2: 2.6 [Ref 5] Unit 3: 3.2, 3.3 [Ref 5] Unit 4:3.2, 3.3 [Ref 5] Unit 5: 3.2, 3.3 [Ref 5] Unit 6: 3.2, 3.3 [Ref 5] Unit 7: 3.4 [Ref 5] Unit 8: 3.6 [Ref 5]			

Books and References:

1. Gupta, S. C. and Kapoor, V. K. (2020). Fundamentals of Mathematical Statistics, 12th edition, Sulthan Chand, New Delhi
2. Gupta, S. C.. (2015). Fundamentals of Statistics. **,** & 7th edition, Himalaya Publishing House
3. Gupta S.C (2021), Statistical Methods, 46 th edition, Sultan Chand and Sons.
4. The R book(2007) , Michael J. Crawley John Wiley Series
5 Sudha G Purohith, Sharad D Core, Shailaja R Deshmukh ,Statistics Using R(2015)

Mapping of COs with PSOs and POs :

	PSO	PSO	PSO	PSO4	PSO	PSO6	PO	PO2	PO3	PO4	PO5	PO6

	1	2	3		5		1					
CO 1	2	3	-	-	-	3	1	2	2	-	-	-
CO 2	-	2	-	-	-	-	2	-	-	-	-	-
CO 3	-	3	-	2	2	2	1	2	-	-	-	-
CO 4	-	-	3	-	-	3	3	-	1	3	3	-
CO 5	3	-	-	-	-	2	3	1	-	-	-	3
CO 6	-	-	-	-	-	2	2	3	-	-	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	BSc Statistics
Course Code	STA3MN202 (P)
Course Title	Statistical inference for data science
Type of Course	Minor
Semester	III
Academic Level	200 – 299

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75

Pre-requisites	Thorough knowledge in probability concept and Random variables.
Course Summary	Students will possess a wide understanding of Law of Large Numbers, ANOVA, and non-parametric tests and they will be equipped to apply these statistical techniques to various scenarios, making informed decisions and drawing meaningful conclusions from data.

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Introduce and explore different law of large numbers	U	C	Instructor-created exams / Quiz
CO2	Define and understand the rationale for testing differences between two populations	R	C	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO3	Formulate null and alternate hypothesis for a real life two population problem and analyze data to help entrepreneurial decisions using critical thinking skills.	U	C	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Differentiate between one-way and two-way ANOVA and critically evaluate ethical implications of statistical methods aligning with human values.	U	C	Instructor-created exams / Home Assignments
CO5	Define and understand the principles of non parametric statistics	U	F	One Minute Reflection Writing assignments/

				Instructor-created exams
CO6	Describe analysis of variance and hypothesis testing using R software.	Ap	P	Viva Voce/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Units	Content	Hrs (45 +30)	Marks (70)
I		**LAW OF LARGE NUMBERS**	10	15
	1	Chebychev's inequality (Definition and Problems)	2	
	2	Modes of Convergence of a Sequence of Random Variables	1	
	3	Weak Law of Large Numbers (Statement and Problems)	2	
	4	Bernoulli's Law of Large Numbers		
	5	Strong Law of Large Numbers	2	
	6	CLT (Lindeberg- Levy)	3	
	Sections from References: Unit 1: 7.5 [Ref 1] Unit 2: 7.6 [Ref 1] Unit 3: 7.7 [Ref 1] Unit 4:7.7 [Ref 1] Unit 5: 7.8[Ref 1] Unit 6: 9.16[Ref 1]			
II		**HYPOTHESIS TESTING: TWO POPULATIONS**	12	20
	6	Test of Significance for difference of two population proportions (Concept and Problems)	2	
	7	Test of Significance for difference of two population means (Large Sample-Concept and Problems)	2	
	8	Test of Significance for difference of two population means (Small Sample-Concept and Problems)	3	

	9	Paired t test(Concept and Problems)	3	
	10	F test for equality of proportions	2	
	Sections from References: Unit 6: 14.7.2 [Ref 1] Unit 7: 14.8.4 [Ref 1] Unit 8: 16.3.2 [Ref 1] Unit 9: 16.3.3[Ref 1] Unit 10: 16.7[Ref 1]			
III	**ANALYSIS OF VARIANCE**		8	15
	11	ANOVA	1	
	12	One-Way Analysis of Variance	3	
	13	Two -Way Analysis of Variance	4	
	Sections from References: Unit 11: 23.1,23.2 [Ref 2] Unit 12: 23.3[Ref 2] Unit 13: 23.4[Ref 2]			
IV	**NON PARAMETRIC TEST**		15	20
	14	Introduction to Non Parametric Methods	1	
	15	Advantages and Limitations	1	
	16	Sign Test- one sample	3	
	17	Wilcoxon Signed Rank Test	2	
	18	Mann- Whitney Test	2	
	19	Kruskal- Wallis Test	2	
	20	Single Sample Run Test	2	
	21	Median Test	2	
	Sections from References: Unit 14: 26.2[Ref 2] Unit 15:26.2.1 [Ref 2] Unit 16: 26.3[Ref 2] Unit 17: 26.4 [Ref 2] Unit 18:26.5 [Ref 2] Unit 19:26.7[Ref 2] Unit 20: 26.8[Ref 2] Unit 21: 26.9[Ref 2]			

V	PRACTICUM		30	
	Do practice problems in R software from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course.			
	1	Plots to check normality		
	2	Hypothesis testing		
	3	Goodness of fit tests		
	4	Correlation		
	5	Inference procedures for correlation coefficient		
	6	Linear regression		
	7	Inference procedures for simple linear model		
	8	Polynomial regression models		
	Sections from References: Unit 1: 4.4 [Ref 5] Unit 2: 4.5 [Ref 5] Unit 3: 4.6 [Ref 5] Unit 4: 5.2 [Ref 5] Unit 5: 5.3 [Ref 5] Unit 6: 5.4 [Ref 5] Unit 7: 5.5 [Ref 5] Unit 8: 5.8 [Ref 5]			

Books and References:

1. Gupta, S. C. and Kapoor, V. K. (2002). Fundamentals of Mathematical Statistics. , 11th edition, Sulthan Chand, New Delhi.
2. Gupta, S. C. (2015). Fundamentals of Statistics,7 th Edition ,Himalaya Publishing House.
3. Gupta S.C (2021), Statistical Methods, 46 th edition, Sultan Chand and Sons.
4. Prem S. Mann (2016), Introductory Statistics 9 th Edition ,Wiley
5. W. N. Venables, D. M. Smith and the R Core Team, An Introduction to R (2023)
6. Sudha G Purohith, Sharad D Core, Shailaja R Deshmukh (2015), Statistics Using R

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	2	-	-	-	3	1	2	-	-	-	-
CO 2	2	-	-	-	-	2	2	1	-	-	-	-
CO 3	-	-	2	-	-	2	2	-	-	1	3	-
CO 4	2	-	-	-	-	-	2	1	-	-	-	3
CO 5	-	3	-	2	3	3	-	2	1	-	-	-
CO 6	-	-	-	-	-	2	3	1	-	-	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5	✓	✓		✓
CO 6	✓			

Programme	BSc Statistics				
Course Code	STA1MN103 (P)				
Course Title	Introductory statistics with R				
Type of Course	Minor				
Semester	I				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic knowledge about data, basic mathematical knowledge				
Course Summary	This course covers data types, distributions, graphs, and statistical measures using R programming. Students learn to analyze data effectively for informed decision-making across diverse domains.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Identify data types and construct frequency distributions.	U	C	Instructor-created exams / Quiz
CO2	Create diverse graphical representations effectively and critically evaluate ethical implications of statistical methods aligning with human values.	Ap	F	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO3	Calculate and apply central tendency measures practically and analyze data to help entrepreneurial decisions using critical thinking skills..	Ap	C	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Use measures of central tendency to summarize and describe data, demonstrating the ability to communicate the findings in both written and graphical formats	U	C	Instructor-created exams / Home Assignments
CO5	Master R programming basics and descriptive statistics.	Ap	C	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Implement R for practical data analysis and graphical representation.	Ap	P	Viva Voce/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)				

- Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs (45 +30)**	**Marks (70)**
I		**Data**	**12**	**15**
	1	Types of data: Primary data, Secondary data, Quantitative data, Qualitative data, discrete data, continuous data	4	
	2	Frequency distribution: Ungrouped and grouped	4	
	3	Cumulative frequency distribution	4	
	Unit 1:2.2,11.1,2.1 Ref[1] Unit 2: 2.2 Ref[1] Unit 3: 3.5 Ref[3]			
II		**Graphical representation of data**	**9**	**15**
	4	Line diagram, Bar diagram	3	
	5	Pictogram, Pie diagram, Histogram	3	
	6	Frequency Polygon, Frequency curve, Ogives.	3	
	Unit 4: 4.3.3 Ref[3] Unit 5:4.3.4, 4.3.6 Ref[3] Unit 6: 4.4.3 Ref[3]			
III		**Measures of central tendency**	**10**	**25**
	7	Arithmetic Mean	2	
	8	Median	2	
	9	Mode	2	
	10	Geometric mean	2	
	11	Harmonic mean	2	
	Unit 7: 5.4 Ref[3] Unit 8: 5.6.1 Ref[3] Unit 9: 5.7.1 Ref[3] Unit 10: 5.9 Ref[3] Unit 11: 5.10 Ref[3]			
IV		**Introduction to R programming**	**14**	**15**
	12	Installing R	1	
	13	Objects in R	1	
	14	Using functions in R	1	
	15	Importing data	1	
	16	Exporting data	1	
	17	Simple base R plots	2	
	18	Multiple graphs	2	

	19	R packages	1	
	20	Exporting plots	2	
	21	Getting help	1	
	22	Saving stuff in R	1	
	Unit 12: 1.1 Ref[2] Unit 13: 2.2 Ref[2] Unit 14: 2.3 Ref[2] Unit 15: 3.3 Ref[2] Unit 16: 3.6 Ref[2] Unit 17: 4.2 Ref[2] Unit 18: 4.4 Ref[2] Unit 19: 1.5 Ref[2] Unit 20: 4.5 Ref [2] Unit 21: 2.5 Ref[2] Unit 22: 2.6 Ref[2]			
V	**PRACTICUM**		**30**	
	Do practice problems in R software from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course.			
	1	Functions in R— data.frame		
	2	multiply_columns()		
	3	return()		
	4	identical()		
	5	Conditional statements-if and else		
	6	Combining logical operators		
	7	For loop		
	8	While loop		
	Sections from References: Unit 1: 7.2 Ref[2] Unit 2: 7.2Ref[2] Unit 3: 7.2Ref[2] Unit 4: 7.2Ref[2] Unit 5: 7.3Ref[2] Unit 6: 7.4 Ref[2] Unit 7: 7.5.1 Ref[2] Unit 8: 7.5.2 Ref[2]			

Books and References:

1. Gupta, S.C. and Kapoor, V.K. (1997) Fundamentals of Mathematical Statistics. Sultan Chand and Sons, New Delhi
2. Douglas, Alex, Deon Roos, Francesca Mancini, Ana Couto, and David Lusseau. (2020), *An Introduction to R*. https://intro2r.com/index.html.

3.	S.C. Gupta, Fundamentals of Statistics, Himalaya Publishing house,

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	3	-	-	-	2	2	2	-	-	-	-
CO 2	-	2	-	3	2	3	-	3	1	-	3	-
CO 3	-	2	-	2	-	2	1	2	2	-	-	3
CO 4	-	-	-	-	-	1	3	1	-	-	-	-
CO 5	-	-	3	-	-	-	2	-	2	3	-	-
CO 6	2	-	-	-	-	2	1	-	1	3	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4		✓		✓
CO 5	✓	✓		✓
CO 6	✓			

Programme	BSc Statistics				
Course Code	STA2MN103 (P)				
Course Title	Regression and probability theory				
Type of Course	Minor				
Semester	II				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic knowledge about set theory, fundamental concepts of data				
Course Summary	This course covers dispersion, correlation, regression, and probability theory with practical applications using R programming, enhancing students' statistical skills for diverse scenarios.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Utilize dispersion measures effectively in practical scenarios and critically evaluate ethical implications of statistical methods aligning with human values.	U	C	Instructor-created exams / Quiz
CO2	Demonstrate mastery in correlation, regression, and their applications and analyze data to help entrepreneurial decisions using critical thinking skills.	U	F	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO3	Comprehend and employ basic probability concepts and theorems.	U	F	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Explain fundamental concepts of probability theory including events, saple space, outcomes.	U	C	Instructor-created exams / Home Assignments
CO5	Understand and employ conditional probability and Bayes' theorem	U	C	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Implement R for creating scatter plots and performing statistical calculations.	Ap	P	Viva Voce/ Instructor-creat

				ed exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**Measures of dispersion**	**10**	**10**
	1	Range	1	
	2	Quartile deviation	3	
	3	Standard deviation	3	
	4	Coefficient of variation	3	
	Unit 1: 2.1.3 Ref[1] Unit 2: 2.1.3 Ref[1] Unit 3: 2.1.3 Ref[1] Unit 4: 2.1.3 Ref[1]			
II		**Correlation and regression**	**13**	**20**
	5	Bivariate distribution, correlation	1	
	6	Scatter diagram	2	
	7	Karl Pearson coefficient of correlation	2	
	8	Limits of Correlation coefficient	2	
	9	Regression	2	
	10	Lines of regression	3	
	11	Regression coefficients	2	
	Unit 5: 10.1 Ref[2] Unit 6: 10.1Ref[2] Unit 7: 10.3 Ref[2] Unit 8:10.3.1 Ref[2] Unit 9: 10.7 Ref[2] Unit 10: 10.7.1 Ref[2] Unit 11:10.7.3 Ref[2]			
III		**Probability theory**	**10**	**25**
	12	Random experiment	1	
	13	Samplespace	1	
	14	Event	1	
	15	Classical Probability-definition	2	
	16	Statistical probability-definition	2	
	17	Axiomatic approach to Probability	2	
	18	Addition theorem (Statement only)	1	
	Unit 12:4.5.1 Ref[2] Unit 13: 4.5.1 Ref[2] Unit 14: 4.5.2 Ref[2] Unit 15: 4.3.1 Ref[2] Unit 16: 4.3.2 Ref[2]			

	Unit 17: 4.5 Ref[2] Unit 18: 4.6.2 Ref[2]			
IV	**Conditional Probability**		**12**	**15**
	18	Conditional Probability of two events	3	
	19	Multiplication theorem (Statement only)	2	
	20	Independence of events	2	
	21	Conditions of mutual independence of three events	2	
	22	Bayes theorem and its applications (Statement only)	3	
	Unit 18: 4.7 Ref[2] Unit 19: 4.7 Ref[2] Unit 20: 4.7.3 Ref[2] Unit 21: 4.7.5 Ref[2] Unit 22: 4.8 Ref[2]			
V	**PRACTICUM**		**30**	
	Do practice problems in R software from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course.			
	1	cor() function		
	2	Use of cor() function with missing values in data		
	3	Ggplot		
	4	Diagrammatic representation of data		
	5	Graphical representation of data		
	6	Measures of central tendency (Any two)		
	7	Measures of dispersion (Any two)		
	8	Any two exercises of above		
	Sections from References: Unit 1: 6.2 Ref[3] Unit 2: 6.2 Ref[3] Unit 3: 6.3 Ref[3] Unit 4: 2.2 Ref[4] Unit 5: 2.3 Ref[4] Unit 6: 2.4 Ref[4] Unit 7: 2.5 Ref[4] Unit 8: 2.8 Ref[4]			

Books and References:

1. S.P Gupta (2021),Statistical Methods 46 th Edition
2. Gupta, S.C. and Kapoor, V.K. (1997) Fundamentals of Mathematical Statistics. Sultan Chand and Sons, New Delhi
3. Douglas, Alex, Deon Roos, Francesca Mancini, Ana Couto, and David Lusseau. (2020), *An Introduction to R*. **https://intro2r.com/index.html.**
4. Sudha G. Purohit (2008), Statistics using R, Alpha Science International

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	2	-	-	-	3	2	2	2	-	-	3
CO 2	2	-	1	-	-	2	2	2	3	-	3	-
CO 3	-	1	-	2	2	-	3	1	1	-	-	-
CO 4	3	-	-	-	-	-	1	2	2	-	-	-
CO 5	2	-	-	-	-	3	2	3	3	-	-	-
CO 6	-	-	2	-	-	2	2	2	2	3	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignm ent	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4		✓		✓
CO 5	✓	✓		✓
CO 6	✓			

Programme	BSc Statistics
Course Code	STA3MN203 (P)
Course Title	Random variables and CART

Type of Course	Minor				
Semester	III				
Academic Level	200 – 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic knowledge of set theory and probability theory				
Course Summary	This course offers a comprehensive understanding of random variables, distributions, and statistical learning methods like classification and regression trees, bagging, random forest, with hands-on experience in R				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Grasp random variables, distributions.	U	C	Instructor-created exams / Quiz
CO2	Summarize discrete, continuous distributions and analyze data to help entrepreneurial decisions using critical thinking skills.	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Calculate probabilities and statistical parameters for various standard distributions.	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Introduce to statistical learning, variables, models and critically evaluate ethical implications of statistical methods aligning with human values.	U	C	Instructor-created exams / Home Assignments
CO5	Understand bagging, random forest.	Ap	P	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Implement classification, regression trees in R.	Ap	P	Viva Voce/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45+ 30)	Marks (70)
I	**Random variables**		**14**	**20**
	1	Random variable	2	
	2	Distribution function	2	
	3	Discrete random variable	2	
	4	Probability mass function	2	
	5	Discrete distribution function	2	
	6	Continuous random variable	2	
	7	Probability density function	2	
	Unit 1: 5.1 Ref[2] Unit 2: 5.2 Ref[2] Unit 3: 5.3 Ref[2] Unit 4: 5.3.1 Ref[2] Unit 5: 5.3.2 Ref[2] Unit 6: 5.4 Ref[2] Unit 7: 5.4.1 Ref[2]			
II	**Standard distributions**		**15**	**20**
	8	Bernoulli distribution	2	
	9	Binomial distribution	4	
	10	Poisson distribution	4	
	11	Normal distribution	4	
	12	Importance of Normal distribution	1	
	Unit 8: 7.1 Ref[2] Unit 9: 7.2 Ref[2] Unit 10: 7.3 Ref[2] Unit 11: 8.2 Ref[2] Unit 12: 8.2.13 Ref[2]			
III	**Statistical learning**		**10**	**20**
	13	An introduction to Statistical learning	1	
	14	Input and output variables	1	
	15	Response and predictor variables	1	
	16	Supervised and unsupervised learning	1	
	17	Classification verses regression	1	
	18	Classification and regression trees (CART)	2	
	19	Trees versus linear models	2	
	20	Advantages and disadvantages of trees	1	
	Unit 13: 2.1 Ref[1] Unit 14: 2.1 Ref[1] Unit 15: 2.1 Ref[1] Unit 16: 2.1.4 Ref[1] Unit 17:2.1.5 Ref[1] Unit 18: 8.1.1,8.1.2 Ref[1] Unit 19: 8.1.3 Ref[1] Unit 20: 8.1.4 Ref[1]			
IV	**Bagging**		**6**	**10**
	21	An introduction to Bagging	3	

	22	Random forest	3	
	Unit 21: 8.2.1 Ref[1] Unit 22: 8.2.2 Ref[1]			
V	**PRACTICUM**		**30**	
	Do practice problems in R software from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course.			
	1	Fitting classification trees		
	2	Pruning trees		
	3	Use the function–lm.fit		
	4	Use the function–names()		
	5	Use the function–predict()		
	6	Plotting of least square regression line-abline()		
	7	Plotting of least square regression line- plot()		
	8	residuals() function		
	Sections from References: Unit 1: 8.3.1 Ref[1] Unit 2: 8.3.1 Ref[1] Unit 3: 3.6.2 Ref[1] Unit 4: 3.6.2 Ref[1] Unit 5: 3.6.2 Ref[1] Unit 6: 3.6.2 Ref[1] Unit 7: 3.6.2 Ref[1] Unit 8: 3.6.2 Ref[1]			

Books and References:

1. G. James, D. Witten, T. Hastie, and R. Tibshirani. (2013), An Introduction to Statistical Learning: with Applications in R, Springer.

2. Gupta, S.C. and Kapoor, V.K. (1997) Fundamentals of Mathematical Statistics. Sultan Chand and Sons, New Delhi

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	2	-	-	-	2	2	1	1	-	-	-
CO 2	2	2	-	3	2	2	2	1	2	-	3	-
CO 3	3	-	-	-	-	3	3	2	-	3	-	-
CO 4	2	-	-	-	-	2	2	3	1	-	-	3
CO 5	2	-	2	-	2	-	2	-	2	-	-	-
CO 6	-	-	-	2	-	2	1	2	-	3	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	BSc Statistics
Course Code	STA1MN104 (P)
Course Title	Applied statistics
Type of Course	Minor
Semester	I

Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic mathematical knowledge about calculus, introductory knowledge about data				
Course Summary	Gain a solid understanding of statistical concepts such as measurement scales, sampling methods, index numbers, and time series analysis, alongside practical applications, while acquiring hands-on data analysis skills using statistical software.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand grouped and ungrouped data, scales of measurement, and questionnaire design and critically evaluate ethical implications of statistical methods aligning with human values.	U	C	Instructor-created exams / Quiz
CO2	Comprehend statistical surveys, both census and sample, along with probability and nonprobability sampling methods.	U	C	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO3	Understand index numbers, emphasizing weighted aggregate index numbers and analyze data to help entrepreneurial decisions using critical thinking skills..	U	F	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Identify and describe key measures in vital statistics	U	C	Instructor-created exams / Home Assignments
CO5	Gain proficiency in time series analysis, including the measurement of secular trends and seasonal indices.	U	F	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Implement theoretical knowledge to practical scenarios through hands-on exercises using any software.	Ap	P	Viva Voce/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive				

Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (48+ 30)	Marks (70)
I		**Data and questionnaire**	**9**	**15**
	1	Statistical Survey—An Introduction	1	
	2	Planning the Survey	1	
	3	Specification of the Purpose	1	
	4	Scope of the Survey	1	
	5	Sources of Data	2	
	6	Methods of collecting primary data	2	
	7	Drafting the questionnaire	1	
	Unit 1: 2.2 Ref[1] Unit 2: 2.3 Ref[1] Unit 3: 2.3 Ref[1] Unit 4: 2.3 Ref[1] Unit 5: 2.5 Ref[1] Unit 6: 3.3 Ref[1] Unit 7: 3.8 Ref[1]			
II		**Sample Survey**	**10**	**15**
	4	Introduction	1	
	5	Types of sampling	2	
	6	Purposive sampling	2	
	7	Random sampling	1	
	8	Simple sampling	2	
	9	Stratified sampling	2	
	Unit 1: 12.1 Ref[2]			

	Unit 2:12.2 Ref[2] Unit 3: 1 2.2.1 Ref[2] Unit 4: 12.2.2 Ref[2] Unit 5: 12.2.3 Ref[2] Unit 6: 12.2.4 Ref [2]			
III	**Index numbers and Vital Statistics**		**16**	**20**
	7	Introduction and Uses of Index Numbers	1	
	8	Types of Index Numbers	1	
	9	Problems in the construction of Index Number	1	
	10	Methods of Construction of Index Numbers- Simple and Weighted Index Number	1	
	11	Tests for an Ideal Index Number- Time Reversal Test and Factor Reversal Test	2	
	12	Introduction to Vital Statistics	1	
	13	Uses of Vital Statistics	1	
	14	Collection of Vital Statistics-Registration Method, Census Enumeration Method, Survey Method, Analytical Method	2	
	15	Measures of Fertility –Crude Birth Rate (CBR), General Fertility Rate (GFR), Specific Fertility Rate (ASFR). Total Fertility Rate (TFR) (Concept and Problems)	3	
	16	Measurement of Mortality- Crude Death Rate (CDR), Specific Death Rate (ASDR), Standardized Death Rate (SDR), Infant Mortality Rate, Maternal Mortality Rate(Concept and Problems)	3	
	Unit 7: 10.1&10.2[Ref 3] Unit 8: 10.3 [Ref 3] Unit 9: 10.4[Ref 3] Unit 10: 10.5 [Ref 3] Unit 11:10.6.2&10.6.3 [Ref 3] Unit 12: 16.2 [Ref 1] Unit 13:16.2&16.3 [Ref 1] Unit 14: 16.3&16.4[Ref 1] Unit 15: 16.5&16.6 [Ref 1] Unit 16:16.14,16.15,16.16,16.18 [Ref 1]			
IV	**Time series**		**10**	**20**
	17	Introduction to Time Series & Utility of Time Series	1	
	18	Components of Time Series	1	

	19	Measurement of Trend- Graphic Method	2	
	20	Semi Average Method	2	
	21	Method of Moving Average(Concept and Problems)	2	
	22	Measurement of Seasonal Variations-Method of Simple Averages	2	
	Sections from References: Unit 17: 11.1& 11.3[Ref 3] Unit 18:11.2[Ref 3] Unit 19:.11.5[Ref 3] Unit 20: 11.5[Ref 3] .Unit 21: 11.5[Ref 3] Unit 22:11.6 [Ref 3]			
V	**PRACTICUM**		**30**	
	Do practice problems using any software from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations ofthe concepts taught in the course.			
	1	Problems on graphic method		
	2	Problems on Semi average method		
	3	Problems on Moving average		
	4	Problems on method of Simple averages		
	5	Determination of sample size in sampling		
	6	Sampling errors		
	7	Method of reducing sampling errors		
	8	Non sampling errors		
	Sections from References: Unit 1: 11.5 Ref[3] Unit 2: 11.5 Ref[3] Unit 3:11.6 Ref[3] Unit 4: 11.6 Ref[3] Unit 5: 4.16 Ref[1] Unit 6:4.19 Ref[1] Unit 7: 4.20 Ref[1] Unit 8: 4.21 Ref[1]			

Books and References:

1. S.P Gupta (2021),Statistical Methods 46 th Edition
2. Gupta, S.C. and Kapoor, V.K. (1997) Fundamentals of Mathematical Statistics. Sultan Chand and Sons, New Delhi
3. Gupta, S. C.. (2015). Fundamentals of Statistics, Himalaya Publishing House

Mapping of COs with PSOs and POs :

	PSO	PSO	PSO	PSO4	PSO	PSO6	PO1	PO2	PO3	PO4	PO5	PO6

	1	2	3		5							
CO 1	2	1	-	-	-	1	1	1	2	-	-	3
CO 2	-	2	-	1	2	-	2	-	1	3	-	-
CO 3	-	-	3	-		-	2	1	-	-	3	-
CO 4	-	-	-	-	-	2	3	2	-	-	-	-
CO 5	-	-	2	-	2	3	-	3	-	3	-	-
CO 6	2	-	-	-	-	2	2	-	-	-	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignm ent	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	BSc Statistics
Course Code	STA2MN104 (P)
Course Title	Regression using JASP software
Type of Course	Minor
Semester	II

Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic understanding of statistical concepts, familiarity with algebraic concepts				
Course Summary	Covering advanced statistical concepts like skewness, kurtosis, multiple regression, and JASP software utilization, alongside developing skills in descriptive statistics, data manipulation, result interpretation, and understanding sampling distributions and test statistics using JASP.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Grasp skewness and kurtosis measures, emphasizing Pearson's measure and percentile measure and critically evaluate ethical implications of statistical methods aligning with human values.	U	C	Instructor-created exams / Quiz
CO2	Understand multiple regression concepts and the selection process and analyze data to help entrepreneurial decisions using critical thinking skills..	U	F	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO3	Proficiently use JASP software for statistical analysis and result interpretation.	U	C	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Comprehend sampling distributions and test statistics for Chi-square, F, and t distributions.	U	C	Instructor-created exams / Home Assignments
CO5	Implement theoretical knowledge in practical scenarios through hands-on exercises using JASP	Ap	C	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Illustrate how to draw scatter plot for correlation between variables.	Ap	P	Viva Voce/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)				

- Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**Skewness and Kurtosis**	**8**	**10**
	1	Skewness	2	
	2	Kurtosis	2	
	3	Pearson's measure of skewness	2	
	4	Percentile measure of Kurtosis	2	
	Unit 1:3.13 Ref[2] Unit 2: 3.14 Ref[2] Unit 3: 3.13 Ref[2] Unit 4: 3.14 Ref[2]			
II		**Multiple regression**	**12**	**25**
	5	Multiple regression	1	
	6	Multiple Regression and Correlation Analysis	1	
	7	Assumptions of Linear Multiple Regression Analysis	1	
	8	Coefficient of Multiple Determination	1	
	9	Partial correlation	1	
	10	Partial correlation coefficient	2	
	11	The Significance of a Partial Correlation Coefficient	1	
	12	Multiple correlation	1	
	13	Coefficient of Multiple Correlation	1	
	14	Advantages of Multiple Correlation Analysis	1	

	15	Limitations of Multiple Correlation Analysis	1	
	Unit 5: 9.9 Ref[1] Unit 6: 9.9 Ref[1] Unit 7: 9.10 Ref[1] Unit 8: 9.7 Ref[1] Unit 9: 9.2 Ref[1] Unit 10: 9.2 Ref[1] Unit 11: 9.6 Ref[1] Unit 12: 9.7Ref[1] Unit 13: 9.7 Ref[1] Unit 14: 9.8 Ref[1] Unit 15: 9.9 Ref[1]			
III	**JASPstatistical software**		**13**	**20**
	16	Installing JASP	2	
	17	Loading data in JASP	2	
	18	Changing data from one measurement scale to another	3	
	19	Calculating Mean, Median and Mode in JASP	3	
	20	Calculating Range, standard deviation and variance using JASP	3	
	Unit 16: 3.1 Ref[3] Unit 17: 3.3 Ref[3] Unit 18: 3.5 Ref[3] Unit 19: 4.1 Ref[3] Unit 20: 4.2 Ref[3]			
IV	**Sampling distributions**		**12**	**15**
	21	Chi-square distribution	4	
	22	Student's t distribution	4	

	23	F distribution	4	
	Unit 21: 13.1 Ref[2] Unit 22: 14.2 Ref[2] Unit 23: 14.5 Ref[2]			
V	**PRACTICUM**		**30**	
	Do practice problems in JASP software from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations ofthe concepts taught in the course.			
	1	Problems on plotting scatter plots		
	2	Correlation calculation		
	3	Interpretation of correlation coefficient in JASP		
	4	Finding Rank correlation		
	5	Introduce correlation matrix in JASP		
	6	Linear regression model		
	7	Model checking		
	8	Model selection		
	Books and References: Unit 1: 11.1.1 Ref[3] Unit 2: 11.1.3 Ref[3] Unit 3:11.1.5 Ref[3] Unit 4: 11.1.6 Ref[3] Unit 5: 11.2 Ref[3] Unit 6: 11.3 Ref[3] Unit 7:11.10 Ref[3] Unit 8:11.11 Ref[3]			

Books and References:

1. S.P Gupta (2021), Statistical Methods 46 th Edition
2. Gupta, S.C. and Kapoor, V.K. (1997) Fundamentals of Mathematical Statistics. Sultan Chand and Sons, New Delhi
3. Navarro, D.J., Foxcroft, D.R., & Faulkenberry, T.J. (2019). Learning Statistics with JASP: A Tutorial for Psychology Students and Other Beginners. (Version 1/(√2)).

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	1	-	-	-	-	1	2	-	-	-	3
CO 2	-	-	2	-	-	2	2	2	-	-	3	-
CO 3	3	2	3	-	2	3	3	3	2	3	-	-
CO 4	3	3	-	-	-	3	3	2	1	-	-	-
CO 5	-	-	3	2	-	-	2	1	-	3	-	-
CO 6	2	1	-	-	-	2	2	2	-	-	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal	Assignm	Project	End Semester

	Exam	ent	Evaluation	Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	BSc Statistics
Course Code	STA3MN204 (P)
Course Title	Tests of hypothesis and SVM

Type of Course	Minor				
Semester	III				
Academic Level	200 – 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Familiarity with algebraic concepts, basic statistics and probability concepts. Understanding of data visualization methods.				
Course Summary	Explore hypothesis testing basics like null and alternative hypotheses, critical regions, significance levels, and one/two-tailed tests, alongside t-tests, chi-square tests, and support vector machines, emphasizing practical applications with R				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Grasp fundamentals of hypothesis testing, including null and alternative hypotheses, critical regions, and significance levels.	U	C	Instructor-created exams / Quiz
CO2	Understand small and large sample tests, focusing on tests for single mean and single proportion, t-tests, and chi-square tests.	U	C	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO3	Interpret results and understand the implications of large and small sample tests in real life situations and analyze data to help entrepreneurial decisions using critical thinking skills.	U	F	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Explain the fundamental purpose of one way ANOVA and its purpose in statistical analysis and critically evaluate ethical implications of statistical methods aligning with human values.	U	C	Instructor-created exams / Home Assignments
CO5	Gain an overview of support vector machines, hyperplanes, and classifiers.	U	C	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Implement theoretical knowledge to practical scenarios through hands-on	Ap	P	Viva Voce/ Instructor-creat

	exercises using R			ed exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**Testing of hypothesis**	**10**	**15**
	1	Tests of significance-Introduction	1	
	2	Null hypothesis	2	
	3	Alternative hypothesis	2	
	4	errors in hypothesis testing	2	
	5	Critical region and Level of Significance	2	
	6	One and two tailed tests	1	
	Unit 1: 12.4 Ref[2] Unit 2:12.5 Ref[2] Unit 3:12.5.1 Ref[2] Unit 4: 12.6 Ref[2] Unit 5:12.7 Ref[2] Unit 6: 12.7.1 Ref[2]			
II		**Small and Large sample tests**	**9**	**15**
	7	Steps for testing of hypothesis	1	
	8	t test for single mean	4	
	9	t test for difference of means	4	
	Unit 7:12.7.3 Ref[2] Unit 8: 14.2.9 Ref[2] Unit 9: 14.2.10 Ref[2]			

III		**Chi square tests and ANOVA**	**18**	**25**
	10	Chi square tests for Goodness of fit	3	
	11	Chi square test for independence of two attributes	3	
	12	Introduction to Analysis of variance	2	
	13	Assumptions	1	
	14	Techniques of ANOVA	4	
	15	One way ANOVA	5	
	Unit 10: 13.7.2 Ref[2] Unit 11: 13.7.3 Ref[2] Unit 12: 5.5 Ref[1] Unit 13:5.6 Ref[1] Unit 14: 5.7 Ref[1] Unit 15:5.7 Ref[1]			
IV		**Support vector machine**	**8**	**15**
	16	Definition of hyperplane	1	
	17	Classification using separating hyperplane	1	
	18	Maximal margin classifier	1	
	19	Construction of Maximal Margin Classifier	2	
	20	Non separable case	1	
	21	An overview on support vector classifier	1	
	22	A brief concept of Support vector machine	1	
	Unit 16: 9.1.1 Ref[3] Unit 17: 9.1.2 Ref[3] Unit 18: 9.1.3 Ref[3] Unit 19: 9.1.4 Ref[3] Unit 20: 9.1.5 Ref[3] Unit 21: 9.2.1 Ref[3] Unit 22: 9.3.2 Ref[3]			
V		**PRACTICUM**	**30**	
	Do practice problems in R and JASP software from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of			

	the concepts taught in the course.			
	1	Fitting of regression trees in R		
	2	Random forest in R		
	3	Chi-square goodness of fit test in JASP		
	4	Chi-square test for independence in JASP		
	5	One sample t test in JASP		
	6	How ANOVA works in JASP		
	7	Running ANOVA in JASP		
	8	An illustrative data set		
	Sections from References: Unit 1:8.3.2 Ref[3] Unit 2: 8.3.3 Ref[3] Unit 3:9.1Ref[4] Unit 4: 9.2 Ref[4] Unit 5: 10.2 Ref[4] Unit 6:12.2 Ref[4] Unit 7:12.3 Ref[4] Unit 8:12.1 Ref[4]			

Books and References:

1. S.P Gupta (2021), Statistical Methods 46 th Edition
2. Gupta, S.C. and Kapoor, V.K. (1997) Fundamentals of Mathematical Statistics. Sultan Chand and Sons, New Delhi
3. G. James, D. Witten, T. Hastie, and R. Tibshirani. (2013), An Introduction to Statistical Learning: with Applications in R, Springer.
4. Navarro, D.J., Foxcroft, D.R., & Faulkenberry, T.J. (2019). Learning Statistics with JASP: A Tutorial for Psychology Students and Other Beginners. (Version).

Mapping of COs with PSOs and POs :

	PSO	PSO	PSO	PSO4	PSO	PSO6	PO1	PO2	PO3	PO4	PO5	PO6

	1	2	3		5							
CO 1	2	2	-	-	-	1	1	-	-	-	-	-
CO 2	-	2	-	2	-	3	-	-	2	-	-	-
CO 3	-	-	2	-	-	-	2	-	-	-	3	-
CO 4	2	-	-	-	-	2	-	2	-	-	-	2
CO 5	-	-	3	-	-	2	-	1	-	2	-	-
CO 6	-	-	2	-	-	3	-	-	-	2	3	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	BSc Statistics
Course Code	STA1MN105 (P)
Course Title	Descriptive statistics
Type of Course	Minor
Semester	I
Academic	100 – 199

Level					
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Familiarity with different types of data, understanding of common data visualization techniques, basic algebraic concepts.				
Course Summary	Build a foundation in data understanding, covering primary/secondary, quantitative/qualitative data, along with graphical representation like bar diagrams, central tendency, and dispersion measures, leading to practical survey and software applications.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand data types and sampling techniques and critically evaluate ethical implications of statistical methods aligning with human values.	U	C	Instructor-created exams / Quiz
CO2	Master diagrammatic representation and frequency distribution	U	F	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO3	Apply measures of central tendency with practical examples and analyze data to help entrepreneurial decisions using critical thinking skills.	Ap	C	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Grasp measures of dispersion and their applications	U	C	Instructor-created exams / Home Assignments
CO5	Conduct a survey and apply acquired skills using software	U	F	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Exlapin how to calculate measures of central tendency and dispersion using JASP software.	Ap	P	Viva Voce/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45+ 30)	Marks
I		**A basic idea about data**	**6**	**15**
	1	Primary and secondary data	3	
	2	Quantitative and qualitative data	1	
	3	Population and sample, Sampling and census	1	
	4	Discrete and continuous data	1	
	Sections from References: Unit 1: 2.2 [Ref 2] Unit 2: 11.1 [Ref 2] Unit 3: 12.1 [Ref 1] Unit 4: 2.1 [Ref 2]			
II		**Diagrammatic representation of data**	**15**	**15**
	5	Bar diagrams, pie diagram, Pictograms	5	
	6	Four types of classification	1	
	7	Frequency distribution, discrete and continuous frequency tables	6	
	8	Terms used in a frequency distribution, Cumulative frequency tables	3	
	Sections from References: Unit 5: 4.3(4.3.2 to 4.3.7) [Ref 2] Unit 6: 5.3 Ref[2] Unit 7: 3.3[Ref 2] Unit 8: 3.5 [Ref 2]			
III		**Measures of central tendency**	**14**	**20**

	9	Mean, Median, Mode	9	
	10	Geometric mean and Harmonic mean with simple applications	4	
	11	Empirical relation connecting mean, median and mode	1	
	Sections from References: Unit 9: 2.5,2.6,2.7 [Ref 1], Chapter 2 [Ref 3] Unit 10: 2.8,2.9 [Ref 1] Unit 11: 2.7 [Ref 1]			
IV	**Measures of dispersion**		**10**	**20**
	12	Range, Standard deviation,	4	
	13	Quartile deviation	4	
	14	Coefficient of variation	2	
	Sections from References: Unit 12: Section 1 and 4, Chapter 3 [Ref 3] Unit 13: Section 2, Chapter 3 [Ref 3] Unit 14: 3.8.1 [Ref 1]			
V	**PRACTICUM**		**30**	
	Do practice problems in JASP software from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course.			
	1	Installing JASP		
	2	Loading data in JASP		
	3	Quitting JASP		

	4	Calculating mean in JASP		
	5	Calculating Median in JASP		
	6	Calculating mode in JASP		
	7.	Calculating range in JASP		
	8	Calculating interquartile range in JASP		
	Sections from References: Unit 1: 3.1 Ref[4] Unit 2: 3.3 Ref[4] Unit 3: 3.6 Ref[4] Unit 4: 4.1.2 Ref[4] Unit 5: 4.1.3 Ref[4] Unit 6: 4.1.6 Ref[4] Unit 7: 4.2.1 Ref[4] Unit 8: 4.2.2 Ref[4]			

Books and References:

1. Gupta, S.C. and Kapoor, V.K. (1997) Fundamentals of Mathematical Statistics. Sultan Chand and Sons, New Delhi
2. S.P Gupta (2021),Statistical Methods 46 th Edition
3. Garrett, H.E. and Woodworth, R.S. (1973) Statistics in Psychology and education. Vakils, Feffer and Simons Private Ltd, Bombay.
4. Navarro, D.J., Foxcroft, D.R., & Faulkenberry, T.J. (2019). Learning Statistics with JASP: A Tutorial for Psychology Students and Other Beginners. (Version).

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	3	-	-	-	2	3	2	-	-	-	3
CO 2	-	2	3	-	-	2	2	2	-	-	3	-
CO 3	3	-	2	-	3	3	3	2	2	3	-	-
CO 4	-	-	-	-	-	3	2	3	-	-	-	-
CO 5	2	-	-	-	-	-	2	1	-	-	-	2
CO 6	-	3	-	-	-	2	1	2	-	-	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓

CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	BSc Statistics				
Course Code	STA2MN105 (P)				
Course Title	Introduction to Probability				
Type of Course	Minor				
Semester	II				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Understanding of fundamental probability concepts. Ability to manipulate and analysze basic data sets, perform simple calculations.				
Course Summary	Deepen statistical knowledge with correlation types, regression properties, and probability theory, including the relationship between correlation and regression coefficients, alongside introducing probability concepts, random variables, and distribution functions, applied through practical exercises.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Comprehend types of correlation and scatter diagrams and analyze data to help entrepreneurial decisions using critical thinking skills.	U	C	Instructor-created exams / Quiz/ Instructor-created exams
CO2	Understand properties of regression coefficients and critically evaluate ethical implications of statistical methods aligning with human values.	U	C	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO3	Introduce and apply probability theory concepts.	U	C	Seminar Presentation / Group Tutorial Work
CO4	Grasp the definition and types of	U	C	Instructor-crea

	random variables.			ted exams / Home Assignments
CO5	Develop critical thinking skills to interpret and communicate results of statistical analysis effectively.	U	F	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Describe how to draw scatter plot for correlation in JASP.	Ap	P	Viva Voce/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45+30)	Marks 70
I		**Correlation**	**12**	**15**
	1	Bivariate Distribution, Correlation	2	
	2	Scatter Diagram	1	
	3	Karl Pearson coefficient of correlation	2	
	4	Limits for Correlation Coefficient	2	
	5	Assumptions Underlying Karl Pearson's Correlation Coefficient	1	
	6	Rank Correlation	3	
		Sections from References: Unit 1: 10.1 Ref[2] Unit 2: 10.2 Ref[2] Unit 3: 10.3 Ref[2] Unit 4: 10.3.1 Ref[2] Unit 5: 10.3.2 Ref[2] Unit 6: 10.6 Ref[2]		

II		**Regression**	**14**	**20**
	7	Regression	2	
	8	The two regression lines	3	
	9	Regression coefficients	3	
	`10	Properties of regression coefficients	3	
	11	Relation between coefficient of correlation and regression coefficients	3	
	Sections from References: Unit 7: 10.7 Ref[2] Unit 8: 10.7.1 Ref[2] Unit 9: 10.7.3 Ref[2] Unit 10: 10.7.4 Ref[2] Unit 11: 10.7.4 Ref[2]			
III		**Introduction to Probability**	**10**	**15**
	12	Terms in Probability	3	
	13	Mathematical or Classical Probability	1	
	14	Statistical or Empirical Probability	1	
	15	Axiomatic approach to Probability	2	
	16	Addition theorem for two events (statement only)	1	
	17	Conditional Probability	2	
	18	Independence of events		

	Sections from References: Unit 12: 4.3 Ref[2] Unit 13: 4.3.1 Ref[2] Unit 14: 4.3.2 Ref[2] Unit 15: 4.5 Ref[2] Unit 16: 4.6.2 Ref[2] Unit 17: 4.7 Ref[2] Unit 18: 4.7.3 Ref[2]			
IV		**Random variables**	**9**	**20**
	19	Definition of random variable	2	
	20	Probability mass function	2	
	21	Probability density function	2	
	22	Distribution function	3	
	Sections from References: Unit 19: 5.1 Ref[2] Unit 20: 5.6 Ref[2] Unit 21: 5.4.1 Ref[2] Unit 22: 5.4 Ref[2]			
V		**PRACTICUM**	**30**	
	Do practice problems in JASP software from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course.			
	1	Problems on plotting scatter plots		
	2	Correlation calculation		
	3	Interpretation of correlation coefficient in JASP		

	4.	Finding Rank correlation		
	5	Introduce correlation matrix in JASP		
	6	Linear regression model		
	7	Model checking		
	8	Model selection		
	Sections from References: Unit 1: 11.1.1 Ref[4] Unit 2: 11.1.3 Ref[4] Unit 3:11.1.5 Ref[4] Unit 4: 11.1.6 Ref[4] Unit 5: 11.2 Ref[4] Unit 6: 11.3 Ref[4] Unit 7:11.10 Ref[4] Unit 8:11.11 Ref[4]			

Books and References:

1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I , 8th Edn. The World Press, Kolkata.
2. Gupta, S.C. and Kapoor, V.K. (1997) Fundamentals of Mathematical Statistics. Sultan Chand and Sons, New Delhi
3. Garrett, H.E. and Woodworth, R.S. (1973) Statistics in Psychology and education. Vakils, Feffer and Simons Private Ltd, Bombay.
4. Navarro, D.J., Foxcroft, D.R., & Faulkenberry, T.J. (2019). Learning Statistics with JASP: A Tutorial for Psychology Students and Other Beginners. (Version).

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	3	2	-	-	2	2	1	-	-	3	-

CO 2	2	-	-	-	-	-	1	2	-	-	-	3
CO 3	-	3	-	2	2	2	2	1	2	-	-	-
CO 4	3	2	-	-	-	3	3	2	-	-	-	-
CO 5	2	-	-	-	-	-	2	2	-	-	-	-
CO 6	2	2	3	-	-	3	3	2	-	3	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓

CO 2	✓	✓		✓
CO 3	✓			✓
CO 4		✓		✓
CO 5	✓	✓		✓
CO 6	✓			

Programme	BSc Statistics				
Course Code	STA3MN205 (P)				
Course Title	Inferential statistics				
Type of Course	Minor				
Semester	III				
Academic Level	200 – 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Awareness of different types of data sets, basic understanding of probability theory				
Course Summary	Discover statistical testing basics, including null and alternative hypotheses, critical regions, and test statistics like z, t, F, and Chi-square, with applications such as t-tests, ANOVA, and practical software exercises.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand testing fundamentals and hypotheses.	U	C	Instructor-created exams / Quiz
CO2	Grasp test statistics and critical values.	U	C	Practical

				Assignment / Observation of Practical Skills/ Instructor-created exams
CO3	Apply t-tests and chi-square tests and analyze data to help entrepreneurial decisions using critical thinking skills.	Ap	F	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Ability to calculate probabilities using normal distribution.	U	C	Instructor-created exams / Home Assignments
CO5	Comprehend Analysis of Variance and critically evaluate ethical implications of statistical methods aligning with human values.(ANOVA)	U	F	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Conduct one sample tests in JASP software.	Ap	P	Viva Voce/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48+30)	Marks 70
I		**Fundamentals of Testing**	**12**	**15**
	1	Tests of significance-Introduction	2	
	2	Null hypothesis	1	
	3	Alternative hypothesis	1	
	4	Errors in hypothesis testing	3	
	5	Critical region and Level of Significance	3	
	6	One and two tailed tests	2	

	Sections from References: Unit 1: 12.4 Unit 2:12.5 Unit 3:12.5.1 Unit 4: 12.6 Unit 5:12.7 Unit 6: 12.7.1			
II	**Distribution Theory**		**10**	**15**
	7	Normal distribution-Properties	2	
	8	Properties of Normal distribution	1	
	9	Standard normal distribution	1	
	10	Problems with table values	2	
	11	Statistic of Chi-square distribution	2	
	12	Statistic of Student's t distribution	1	
	13	Statistic of F distribution	1	
	Sections from References: Unit 7:8.2.2 Ref[2] Unit 8: 8.2.2 Ref[2] Unit 9: 8.2.14 Ref[2] Unit 10: 8.2.14 Ref[2] Unit 11: 13.1 Ref[2] Unit 12: 14.2 Ref[2] Unit 13: 14.5 Ref[2]			

III		**Tests of Hypothesis**	**14**	**20**
	14	Steps for testing of hypothesis	2	
	15	t test for single mean	3	
	16	t test for difference of means	3	
	17	Chi square tests for Goodness of fit	3	
	18	Chi square test for independence of two attributes	3	
	Sections from References: Unit 14:12.7.3 Ref[2] Unit 15: 14.2.9 Ref[2] Unit 16: 14.2.10 Ref[2] Unit 17: 13.7.2 Ref[2] Unit 18: 13.7.3 Ref[2]			
IV		**Analysis of variance**	**9**	**20**
	19	Introduction to Analysis of variance	1	
	20	Assumptions	2	
	21	Techniques of ANOVA	2	
	22	One way ANOVA	4	
	Sections from References: Unit 19: 5.5 Ref[1] Unit 20:5.6 Ref[1] Unit 21: 5.7 Ref[1] Unit 22:5.7 Ref[1]			

V	**PRACTICUM**		**30**	
	Do practice problems using JASP software from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course.			
	1	Chi-square goodness of fit test		
	2	Chi-square test for independence		
	3	One sample t test		
	4	How ANOVA works in JASP		
	5	Running ANOVA in JASP		
	6	An illustrative data set		
	7	Assumptions of one way ANOVA		
	8	Continuity correction		
	Unit 1:9.1Ref[3] Unit 2: 9.2 Ref[3] Unit 3: 10.2 Ref[3] Unit 4:12.2 Ref[3] Unit 5:12.3 Ref[3] Unit 6:12.1 Ref[3] Unit 7: 12.6 Ref[3]			

	Unit 8: 9.3 Ref[3]		

Books and References:

1. S.P Gupta (2021), Statistical Methods 46 th Edition Gupta, S.C. and Kapoor, V.K. (1997)

2. Fundamentals of Mathematical Statistics. Sultan Chand and Sons, New Delhi

3. Navarro, D.J., Foxcroft, D.R., & Faulkenberry, T.J. (2019). Learning Statistics with JASP: A Tutorial for Psychology Students and Other Beginners. (Version).

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	2	-	-	-	2	2	2	-	-	-	-
CO 2	3	3	-	-	-	3	3	1	-	-	-	-
CO 3	-	-	2	-	-	2	2	2	-	-	3	-
CO 4	2	3	2	-	-	3	3	2	-	3	-	-
CO 5	-	2	-	2	3	-	2	2	1	-	-	3
CO 6	3	-	3	-	-	-	2	1	-	3	-	-

Correlation Levels:

Level	**Correlation**

-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	BSc Statistics					
Course Code	STA1MN106 (P)					
Course Title	Introductory statistics with JASP					
Type of Course	Minor					
Semester	I					
Academic Level	100 – 199					
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours	
	4	3	-	2	75	
Pre-requisites	Basic mathematical and computer skills. Basic knowledge of probability theory.					
Course Summary	Introduce statistical concepts with JASP software, covering data collection, questionnaire types, measurement scales, and graphical representation, while familiarizing students with installation, file manipulation, and descriptive statistics application, preparing for practical analysis in Psychology.					

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand data collection methods and questionnaire types and critically evaluate ethical implications of statistical methods aligning with human	U	C	Instructor-created exams / Quiz

	values.			
CO2	Identify the differences between primary data and secondary data	U	C	Practical Assignment / Observation of Practical Skills
CO3	Assess scales of measurement, reliability, and validity and analyze data to help entrepreneurial decisions using critical thinking skills..	U	C	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Design survey questions that minimize bias and encourage accurate response.	U	C	Instructor-created exams / Home Assignments/ Instructor-created exams
CO5	Formulate and represent frequency distributions graphically.	U	F	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Master JASP software for descriptive statistics.	Ap	P	Viva Voce/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs (45+ 30)**	**Marks**
I		**Organizing a Statistical Survey**	**10**	**15**
	1	Statistical Survey—An Introduction	2	
	2	Planning the Survey	1	
	3	Specification of the Purpose	1	
	4	Scope of the Survey	1	
	5	Sources of Data	2	
	6	Methods of collecting primary data	2	

	7	Drafting the questionnaire	1	
	Unit 1: 2.2 Ref[1] Unit 2: 2.3 Ref[1] Unit 3: 2.3 Ref[1] Unit 4: 2.3 Ref[1] Unit 5: 2.5 Ref[1] Unit 6: 3.3 Ref[1] Unit 7: 3.8 Ref[1]			
II		**An introduction to Research Design**	**9**	**20**
	6	Introduction of Psychological measurement and variable	2	
	7	Scales of measurement	2	
	8	Accessing the reliability of measurement	3	
	9	Assessing validity of a study	2	
	Unit 6: 2.1 Ref[1] Unit 7: 2.2 Ref[1] Unit 8: 2.3 Ref[1] Unit 9:2.6 Ref[1]			
III		**Graphical Representation**	**15**	**20**
	9	Graphical representation of a Frequency Distribution	2	
	10	Histogram	1	
	11	Frequency Polygon	1	
	12	Ogives	3	
	13	Smoothed frequency curve	2	
	14	Technique of Constructing Graphs	2	
	15	Graphs of Time Series or Line Graphs	2	

	16	Range Chart	1	
	17	Band Graph	1	
	Unit 9: 2.2 Ref[2] Unit 10: 2.2.1 Ref[2] Unit 11: 2.2.2 Ref[2] Unit 12: 2.11.1 Ref[2] Unit 13: 6.40 Ref[1] Unit 14: 6.24 Ref[1] Unit 15: 6.24 Ref[1] Unit 16:: 6.29 Ref[1] Unit 17: 6.30 Ref[1]			
IV	**An Introduction to JASP**		**11**	**15**
	18	Installing JASP	1	
	19	Loading data in JASP	1	
	20	Changing data from one measurement scale to another	1	
	21	Calculating Mean, Median and Mode in JASP	4	
	22	Calculating Range, standard deviation and variance using JASP	4	
	Sections from References: Unit 18: 3.1 Ref[3] Unit 19: 3.3 Ref[3] Unit 20: 3.5 Ref[3] Unit 21: 4.1 Ref[3] Unit 22: 4.2 Ref[3]			
V	**PRACTICUM**		**30**	

	Do practice problems using JASP software from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course.			
	1	Standard scores in JASP		
	2	Saving image files		
	3	Histogram		
	4	Box plots		
	5	Drawing multiple box plots		
	6	Examples on Nominal scale		
	7	Examples on ordinal scale		
	8	Examples on Interval scale		
	9	Examples on Ratio scale		
	Sections from References: Unit 1: 4.5 Ref[3] Unit 2: 5.3 Ref[3] Unit 3: 5.1 Ref[3] Unit 4:5.2 Ref[3] Unit 5:5.2.2 Ref[3] Unit 6:2.2.1Ref[3] Unit7:2.2.2 Ref[3] Unit 8:2.2.3 Ref[3] Unit 9:2.2.4 Ref[3]			

Books and References:

1. S.P Gupta (2021),Statistical Methods 46 th Edition

2. Gupta, S.C. and Kapoor, V.K. (1997) Fundamentals of Mathematical Statistics. Sultan Chand and Sons, New Delhi

3. Navarro, D.J., Foxcroft, D.R., & Faulkenberry, T.J. (2019). Learning Statistics with JASP: A Tutorial for Psychology Students and Other Beginners. (Version).

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	3	-	-	-	2	1	2	-	-	-	3
CO 2	-	-	-	-	-	3	2	2	-	-	-	-
CO 3	-	2	-	3	2	-	2	2	2	-	3	-
CO 4	-	-	-	-	3	-	3	1	2	-	-	-
CO 5	3	-	-	-	-	-	2	2	-	-	-	-
CO 6	-	-	3	-	-	3	1	1	-	3	2	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	BSc Statistics				
Course Code	STA2MN106 (P)				
Course Title	Correlation and regression				
Type of Course	Minor				
Semester	II				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Understanding of fundamental statistical concepts, familiarity with common data formats and basic data processing.				
Course Summary	Delve into advanced statistical techniques like skewness, kurtosis, multiple correlation, multiple regression, and R programming, equipping students to apply statistical analysis practically in real-world scenarios.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Grasp skewness, kurtosis, and their measures.	U	C	Instructor-created exams / Quiz
CO2	Define correlation and distinguish between positive, negative and zero correlation and critically evaluateethical implications of statistical methods aligning with human values.	U	C	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO3	Understand partial and multiple correlation and analyze data to help entrepreneurial decisions using critical thinking skills.	U	F	Seminar Presentation / Group Tutorial/ Instructor-created exams Work
CO4	Describe and apply multiple linear regression to model relationship with more than one predictor variable.	U	C	Instructor-created exams / Home Assignments/ Instructor-created exams
CO5	Implement multiple regression techniques effectively.	U	C	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Introduce and apply R programming for	Ap	P	Viva Voce/

	statistical analysis.			Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hours (45 +30)	Marks 70
I	**Skewness and Kurtosis**		9	15
	1	Skewness	2	
	2	Kurtosis	2	
	3	Pearson’s measure of skewness	3	
	4	Percentile measure of Kurtosis	2	
	Unit 1:3.13 Ref[2] Unit 2: 3.14 Ref[2] Unit 3: 3.13 Ref[2] Unit 4: 3.14 Ref[2]			
II	**Partial and multiple correlation**		14	20
	5	Partial correlation	2	
	6	Partial correlation coefficient	2	
	7	The Significance of a Partial Correlation Coefficient	2	
	8	Multiple correlation	2	
	9	Coefficient of Multiple Correlation	2	
	10	Advantages of Multiple Correlation Analysis	2	
	11	Limitations of Multiple Correlation Analysis	2	

	Unit 5: 9.2 Ref[1] Unit 6: 9.2 Ref[1] Unit 7: 9.6 Ref[1] Unit 8: 9.7Ref[1] Unit 9: 9.7 Ref[1] Unit 10: 9.8 Ref[1] Unit 11: 9.9 Ref[1]			
III		**Multiple regression**	**12**	**20**
	12	Multiple regression	3	
	13	Multiple Regression and Correlation Analysis	3	
	14	Assumptions of Linear Multiple Regression Analysis	3	
	15	Coefficient of Multiple Determination	3	
	Unit 12: 9.9 Ref[1] Unit 13: 9.9 Ref[1] Unit 14: 9.10 Ref[1] Unit 15: 9.7 Ref[1]			
IV		**Introduction to R programming**	**10**	**15**
	16	Installing R	1	
	17	Objects in R	1	
	18	Using functions in R	1	
	19	Importing data	1	
	20	Exporting data	1	
	21	Simple base R plots	2	
	22	Multiple graphs	3	

	Unit 16: 1.1 Ref[3] Unit 17: 2.2 Ref[3] Unit 18:2.3 Ref[3] Unit 19: 3.3 Ref[3] Unit 20: 3.6 Ref[3] Unit 21: 4.2 Ref[3] Unit 22: 4.4 Ref[3]		
V	**PRACTIUM**	**30**	
	Do practice problems using R software from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course.		
	1 Correlation in R		
	2 Customising plots		
	3 Simple base r plots		
	4 R packages		
	5 Installing R studio		
	6 Projects in R studio		
	7 Backing up projects		
	8 File names		
	Sections from References: Unit 1: 6.2 Ref[3] Unit 2: 4.3 Ref[3] Unit 3: 4.2 Ref[3] Unit 4: 1.5Ref[3] Unit 5: 1.2 Ref[3]		

	Unit 6: 1.6 Ref[3] Unit 7: 1.12 Ref[3] Unit 8: 1.9 Ref[3]		

Books and References:

1. S.P Gupta (2021),Statistical Methods 46 th Edition

2. Gupta, S.C. and Kapoor, V.K. (1997) Fundamentals of Mathematical Statistics. Sultan Chand and Sons, New Delhi

3. Douglas, Alex, Deon Roos, Francesca Mancini, Ana Couto, and David Lusseau. (2020), *An Introduction to R*. https://intro2r.com/index.html.

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	3	-	-	-	3	1	2	-	2	2	-
CO 2	1	-	2	-	-	3	2	1	-	2	2	3
CO 3	-	-	2	-	-	2	2	2	-	1	3	-
CO 4	-	-	-	-	-	-	1	1	-	2	-	-
CO 5	-	3	-	2	2	-	3	2	2	2	-	-
CO 6	-	-	-	-	-	2	2	1	-	2	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial /

	High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	BSc Statistics
Course Code	STA3MN206 (P)

Course Title	Tests of hypothesis with JASP software				
Type of Course	Minor				
Semester	III				
Academic Level	200 – 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Familarity with common data formats, awareness of hypothesis testing concepts including null and alternate hypothesis, significance levels and p-values.				
Course Summary	Cover sampling, probability distributions, and mediation/moderation analysis, introducing JASP software for correlation, t-tests, and ANOVA. Equip students with skills for hypothesis testing, normal distribution properties, and psychological research analysis.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO 1	Explain why sampling is used in statistical analysis.	U	C	Instructor-created exams / Quiz
CO 2	Describe and explain various sampling techniques such as simple random sampling, stratified sampling.	U	F	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO 3	Introduce mediation and moderation analysis concepts .	U	C	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO 4	Define what non parametric tests are and explain how they differ from parametric tests and analyze data to help entrepreneurial decisions using critical thinking skills.	U	C	Instructor-created exams / Home Assignments
CO 5	Define correlation and explain its significance in statistical analysis and critically evaluate ethical implications of statistical methods aligning with human values.	R	F	One Minute Reflection Writing assignments/ Instructor-created exams
CO 6	Apply JASP software for hypothesis testing and analysis.	Ap	P	Viva Voce/ Instructor-created exams

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks 70
I		**Sampling methods**	**10**	**15**
	1	Introduction	1	
	2	Types of sampling	1	
	3	Purposive sampling	2	
	4	Random sampling	2	
	5	Simple sampling	2	
	6	Stratified sampling	2	
		Sections from References: Unit 1: 12.1 Ref[2] Unit 2:12.2 Ref[2] Unit 3: 1 2.2.1 Ref[2] Unit 4: 12.2.2 Ref[2] Unit 5: 12.2.3 Ref[2] Unit 6: 12.2.4 Ref[2]		
II		**An introduction to Mediation analysis**	**9**	**15**
	7	The Simple Mediation Model	2	
	8	Estimation of the Direct, Indirect, and Total Effects of X- Brief concept	2	

	9	Concept of confounding and causal order	2	
	10	Conditional and Unconditional Effects	3	
	Sections from References: Unit 7: 3.1 Ref[3] Unit 8: 3.2 Ref[3] Unit 9: 4.2 Ref[3] Unit 10: 7.1 Ref[3]			
III	**Introduction to Non parametric tests**		**14**	**20**
	11	Non-parametric Methods	2	
	12	Advantages and Disadvantages of Non parametric Methods over parametric methods	2	
	13	Sign test	3	
	14	Median test	2	
	15	Mann Whitney Wilcoxon U test	2	
	16	Wald-Wolfowitz Run Test	3	
	Sections from References: Unit 11: 16.8 Ref[2] Unit 12 16.8.1 Ref[2] Unit 13:16.8.3 Ref[2] Unit 14: 16.8.5 Ref[2] Unit 15:16.8.7 Ref[2] Unit 16: 16.8.3 Ref[2]			
IV	**Correlation and test in JASP software**		**12**	**20**
	17	The one-sample z-test .	2	
	18	The one-sample t-test .	2	
	19	The independent samples t-test	3	
	20	The paired-samples t-test	2	

	21	Correlations	2	
	22	Scatter plots	1	
	Sections from References: Unit 17: 10.1 Ref[4] Unit 18: 10.2 Ref[4] Unit 19: 10.3 Ref[4] Unit 20: 10.5 Ref[4] Unit 21:11.1 Ref[4] Unit 22: 11.2 Ref[4]			
V	**PRACTICUM**		**30**	
	Do practice problems using JASP software from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course.			
	1	Checking the normality of a sample		
	2	Testing non normal data with Wilcoxon tests		
	3	Reporting the results of a hypothesis test		
	4	Making decisions		
	5	p value of a test		
	6	Running hypothesis test in practice		
	7	Discussion on various examples of population		
	8	Discussion on simple random sampling		
	Sections from References: Unit 1: 10.8 Ref[4] Unit 2:10.9 Ref[4] Unit 3: 8.6 Ref[4]			

	Unit 4: 8.4 Ref[4] Unit 5: 8.5 Ref[4] Unit 6: 8.7 Ref[4] Unit 7: 7.1.1 Ref[4] Unit 8:7.1.2 Ref[4]		

Books and References:

1. S.P Gupta (2021),Statistical Methods 46 th Edition
2. Gupta, S.C. and Kapoor, V.K. (1997) Fundamentals of Mathematical Statistics. Sultan Chand and Sons, New Delhi
3. Hayes, A.F. (2017) Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach. Guilford Press, New York
4. Navarro, D.J., Foxcroft, D.R., & Faulkenberry, T.J. (2019). Learning Statistics with JASP: A Tutorial for Psychology Students and Other Beginners. (Version

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	2	-	-	-	-	1	1	-	-	-	-
CO 2	-	-	-	-	-	3	2	1	-	-	-	-
CO 3	-	2	-	3	2	-	2	2	2	-	-	-
CO 4	-	-	3	-	-	3	3	3	2	-	3	-
CO 5	3	-	-	-	-	2	1	2	-	-	-	3
CO 6	-	-	3	-	-	-	2	3	-	3	-	-

Correlation Levels:

Lev	**Correlation**

el	
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	BSc Statistics
Course Code	STA1MN107 (P)
Course Title	Basic statistics

Type of Course	Minor				
Semester	I				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic knowledge of data, variables, charts and graphs. Basic computer skills				
Course Summary	To provide students with a fundamental understanding of life science data and statistical methods for its analysis.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Demonstrate proficiency in collecting life science data and understanding the distinction between population and sample	U	C	Instructor-created exams / Quiz
CO2	Identify and analyze sampling and non-sampling errors, determine appropriate sample sizes, and recognize different variables and observational units within life science datasets.	U	C	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO3	Apply frequency distributions and plotting techniques to visualize life science data effectively and analyze data to help entrepreneurial decisions using critical thinking skills.	Ap	F	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Explore relationships between variables within life science datasets, employing statistical methods to quantify and analyze these relationships and critically evaluate ethical implications of statistical methods aligning with human values.	U	C	Instructor-created exams / Home Assignments/ Instructor-created exams
CO5	Define key terms in probability, including events, outcomes and sample spaces.	R	P	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Develop a basic understanding of how to do measures of central tendency and dispersion using spread sheet.	Ap	C	Viva Voce/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)				

- Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

COURSE CONTENT

Module	Unit	Content	Hrs (45 +30)	Marks (70)
1		**Collection of Data and Sampling**	**10**	20
	1	Examples of Life Science data	1	
	2	Collection of data- Primary and secondary data,	1	
	3	Population and Sample, Census and Sampling	1	
	4	Advantages and Limitations of Sampling	1	
	5	Simple Random Sampling (Concept and Method of Selection)	2	
	6	Stratified Random Sampling	2	
	7	Systematic Random Sampling	1	
	8	Sampling and Non Sampling Errors	1	
		Sections from References: Unit 1: 1.1[Ref 1] Unit 2:2.2 [Ref 2] Unit 3: 15.2,15.3,15.6 [Ref 2] Unit 4: 15.6,15.7[Ref 2] Unit 5:15.11,15.11.1 [Ref 2] Unit 6: 15.12,15.12.1 [Ref 2] Unit 7: 15.13 [Ref 2] Unit 8:15.9.1[Ref 2]		
2		**Frequency Distribution and Descriptive Statistics**	12	10
	9	Frequency Distribution	2	
	10	Cumulative Frequency distribution	2	
	11	Diagrammatic Representations	4	
	12	Graphical Representation of data	4	
		Sections from References: Unit 9: 3.3[Ref 2]		

	Unit 10: 3.5[Ref 2] Unit 11: 4.3[Ref 2] Unit 12: 4.4[Ref 2]			
3	**Measures of Central Tendency&Dispersion**		12	20
	13	Measures of Central Tendency	1	
	14	Arithmetic Mean	2	
	15	Median	2	
	16	Mode	2	
	17	Measures of Dispersion	1	
	18	Range,Quartile Deviation	2	
	19	Standard Deviation	2	
	Sections from References: Unit 13: 5.1&5.3[Ref 2] Unit 14: 5.4[Ref 2] Unit 15: 5.6[Ref 2] Unit 16: 5.7[Ref 2] Unit 17: 6.1,6.3&6.4[Ref 2] Unit 18: 6.5&6.6[Ref 2] Unit 19: 6.9[Ref 2]			
4	**Theory of Probability**		11	20
	20	Random Experiment, Sample Space, Events (Basic terminology), Three Conceptual Approaches to Probability, Calculation of Probabilities	4	
	21	Addition theorem (for two and three events) and simple problems (Statement Only)	3	
	22	Conditional Probability & Multiplication theorem of probability(Concept and Problems)	4	
	Sections from References: Unit 20: 12.3,12.5,12.6,12.7[Ref 2] Unit 21: 12.8[Ref 2] Unit 22: 12.9[Ref 2]			
5	**PRACTICUM**		**30**	
	Do practice problems in spreadsheet from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course.			

	1	Types of data		
	2	Introduction to spreadsheet		
	3	Frequency distributions for organizing and summarizing data		
	4	Histograms		
	5	Graphs that enlighten and graphs that deceive		
	6	Measures of central tendency		
	7	Measures of dispersion		
	8	Measures of Relative Standing and Boxplots		
	Sections from References: Unit 1: 1.2 Ref [5] Unit 2: 1.4 Ref [5] Unit 3: 2.1 Ref [5] Unit 4: 2.2 Ref [5] Unit 5: 2.3 Ref [5] Unit 6: 3.1 Ref [5] Unit 7: 3.2 Ref [5] Unit 8: 3.3 Ref [5]			

Books and References:

1. Myra L. Samuels, Jeffrey A. Witmer, Andrew A. Schaffner, Statistics for the Life Sciences, fifth edition (2016),Pearson Education

2. Gupta, S. C.. (2015). Fundamentals of Statistics, Himalaya Publishing House

3. Prem S. Mann (2016), Introductory Statistics 9 th Edition, Wiley

4. Gupta, S. C. and Kapoor, V. K. (2020). Fundamentals of Mathematical Statistics, 12th edition, Sulthan Chand, New Delhi

5. Mario F Triola, Elementary Statistics using Excel

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	3	-	-	-	2	1	2	-	-	-	-
CO 2	-	-	-	-	-	2	2	2	-	-	-	-
CO 3	-	2	-	-	2	3	2	2	-	3	3	-
CO 4	-	-	3	-	-	2	2	1	-	-	-	3
CO 5	-	-	-	3	-	-	1	2	2	-	-	-
CO 6	-	-	3	-	-	-	3	2	1	3	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	BSc Statistics
Course Code	STA2MN107 (P)
Course Title	Statistical Inference I
Type of Course	Minor

Semester	II				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Understanding of fundamental statistical concepts. Basic knowledge in probability theory and random Variables.				
Course Summary	To equip students with a comprehensive understanding of theoretical distributions, sampling distributions,, hypothesis testing, and comparisons between independent and paired samples.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Develop a basic understanding of Theoretical Distributions such as Binomial,Poisson and Normal distributions	U	C	Instructor-created exams / Quiz
CO2	Grasp the fundamental principles underlying sampling distributions.	R	C	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO3	Analyze and interpret data effectively by comparing two means, calculating confidence intervals for the difference of two population means and analyze data to help entrepreneurial decisions using critical thinking skills.	Ap	F	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Evaluate the significance of differences between paired observations.	U	C	Instructor-created exams / Home Assignments
CO5	Explain the principles of relationships between categorical variables, including independence and association and critically evaluate ethical implications of statistical methods aligning with human values.	U	C	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Demonstrate how to plot probability curves using any software.	Ap	P	Viva Voce/ Instructor-created exams

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

COURSE CONTENT

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**Theoretical Distributions**	**12**	**15**
	1	Binomial Distribution	3	
	2	Poisson Distribution	3	
	3	Normal Distribution	6	
	Sections from References: Unit 1:14.2 [Ref 1] Unit 2:14.3[Ref 1] Unit 3:14.4 [Ref 1]			
II		**Testing of Hypothesis**	**13**	**20**
	4	Statistical Hypothesis-Simple and Composite, Null and Alternative	1	
	5	Types of errors in testing ,Level of Significance, Critical Region	3	
	6	One tailed and two tailed, p- value	1	
	7	Procedure of testing of hypothesis	1	
	8	Test for Single Proportion-Large Sample	1	
	9	Test of Significance for Difference of Proportions-Large Sample	2	
	10	Test of Significance for a single mean	2	
	11	Test of Significance for difference of Means	2	
	Sections from References: Unit 4: 16.6,16.6.1,16.6.3,16.6.4[Ref 1] Unit 5: 16.6.5,16.6.6,16.6.7[Ref 1] Unit 6: 16.6.8,16.6.9[Ref 1] Unit 7: 16.7[Ref 1] Unit 8: 17.2.1[Ref 1] Unit 9: 17.2.2[Ref 1] Unit 10: 17.3.1[Ref 1] Unit 11: 17.3.2[Ref 1]			
III		**Chi- Square Test**	**11**	**20**

	12	Chi-square Distribution	2	
	13	Chi- Square Test of goodness of fit	2	
	14	Chi Square Test for Independence of Attributes	2	
	15	Degrees of Freedom	1	
	16	2×2 Contingency table	2	
	17	2×k Contingency table	2	
	Sections from References: Unit 12: 18.2[Ref 1] Unit 13: 18.4&18.5[Ref 1] Unit 14: 18.6[Ref 1] Unit 15: 18.7[Ref 1] Unit 16: 18.8[Ref 1] Unit 17: 18.9[Ref 1]			
IV		**Small sample Tests**	**9**	**15**
	18	Student's t distribution	2	
	19	Applications of t distribution	1	
	20	Test for single mean	2	
	21	t- Test for Difference of Means	2	
	22	Paired t- Test for difference of Means	2	
	Sections from References: Unit 18: 19.2[Ref 1] Unit 19: 19.4[Ref 1] Unit 20: 19.5[Ref 1] Unit 21: 19.6[Ref 1] Unit 22: 19.7[Ref 1]			
V	**PRACTICUM**		**30**	
	Do practice problems using spreadsheet from any 5 units of the given list and one additional problem decided by the teacher-in- charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught inthe course.			
	1	Draw probability histogram		
	2	Finding mean and variance of a probability distribution		
	3	Methods for finding Binomial probability		
	4	Methods for finding Poisson probability		

	5	Find normal distribution areas		
	6	Find z scores from known area of normal probability		
	7	Assessing normality		
	8	Normal quantile plots		
	Sections from References: Unit 1: 5.1 [Ref 5] Unit 2: 5.1 [Ref 5] Unit 3: 5.2 [Ref 5] Unit 4: 5.4 [Ref 5] Unit 5: 6.1 [Ref 5] Unit 6: 6.1[Ref 5] Unit 7: 6.5[Ref 5] Unit 8: 6.5 [Ref 5]			

Books and References:

1. Gupta, S. C.. (2015). Fundamentals of Statistics, Himalaya Publishing House
2. Myra L. Samuels, Jeffrey A. Witmer, Andrew A. Schaffner, Statistics for the Life Sciences ,fifth edition (2016),Pearson Education
3. Gupta, S. C. and Kapoor, V. K. (2020). Fundamentals of Mathematical Statistics, 12th edition, Sulthan Chand, New Delhi
4. Prem S. Mann (2016), Introductory Statistics 9 th Edition, Wiley
5. Mario F Triola, Elementary Statistics using Excel

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6

CO 1	3	2	-	-	-	2	1	1	-	-	-	-
CO 2	-	-	-	-	-	3	2	2	-	-	-	-
CO 3	-	-	3	-	-	2	2	2	-	-	3	-
CO 4	-	2	-	-	-	-	2	3	-	-	-	-
CO 5	-	-	-	-	-	2	3	1	-	-	-	3
CO 6	-	2	-	2	3	-	2	2	3	3	-	2

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal	Assignm	Project	End Semester

	Exam	ent	Evaluation	Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	BSc Statistics
Course Code	STA3MN207 (P)
Course Title	Statistical inference II
Type of Course	Minor
Semester	III

Academic Level	200 – 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Strong foundation in sampling distributions. Familiarity with simple hypothesis tests.				
Course Summary	This course covers inferential statistics, non-parametric tests, correlation analysis, and regression analysis. Students learn to analyze data using techniques such as ANOVA, Mann-Whitney Test, correlation coefficients, and regression models, enabling them to draw meaningful insights and make informed decisions from statistical data				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the fundamental concepts and applications of inferential statistics and critically evaluate ethical implications of statistical methods aligning with human values .	U	C	Instructor-created exams / Quiz
CO2	Evaluate differences in means among multiple independent samples using one-way analysis of variance	U	C	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO3	Define and understand the principles of non parametric statistics.	R	F	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Relate the fundamentals of linear regression and correlation and analyze data to help entrepreneurial decisions using critical thinking skills.	U	C	Instructor-created exams / Home Assignments
CO5	Explain what regression analysis is and how it differs from correlation analysis.	U	F	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Apply statistical techniques in software to analyze categorical data effectively	Ap	P	Viva Voce/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)				

- Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

COURSE CONTENT

Module		**Content**	**Hrs (45 +30)**	**Marks (70)**
1		**ANOVA**	**10**	**20**
	1	F Statistic	2	
	2	F Test for Equality of Population Variance	2	
	3	ANOVA	2	
	4	One-Way Analysis of Variance	2	
	5	Two -Way Analysis of Variance	2	
		Sections from References: Unit 1: 19.10,19.10.1,19.10.2[Ref 1] Unit 2:19.10.4[Ref 1] Unit 3: 23.1,23.2 [Ref 1] Unit 4: 23.3[Ref 1] Unit 5: 23.4[Ref 1]		
2		**Non Parametric Test**	**15**	**15**
	5	Introduction to Non Parametric Methods	1	
	6	Advantages and Limitations	1	
	7	Sign Test- one sample	3	
	8	Wilcoxon Signed Rank Test	2	
	9	Mann- Whitney Test	2	
	10	Kruskal- Wallis Test	2	
	11	Single Sample Run Test	2	
	12	Median Test	2	
		Sections from References: Unit 5: 26.2[Ref 2] Unit 6: 26.2.1[Ref 2] Unit 7:26.3 [Ref 2] Unit 8: 26.4[Ref 2] Unit 9: 26.5 [Ref 2] Unit 10: 26.7[Ref 2]		

	Unit 11: 26.8[Ref 2] Unit 12: 26.9[Ref 2]			
3	**Correlation Analysis**		**9**	**15**
	13	Correlation	1	
	14	Types of Correlation	1	
	15	Methods of Studying Correlation	1	
	16	Scatter Diagram Method	2	
	17	Karl Pearson's coefficient of correlation (Concept and Problems)	4	
	Sections from References: Unit 13: 8.1 [Ref 1] Unit 14: 8.1.1[Ref 1] Unit 15: 8.2[Ref 1] Unit 16: 8.3[Ref 1] Unit 17: 8.4[Ref 1]			
4	**Regression Analysis**		**11**	**20**
	18	Introduction to Regression	1	
	19	Linear and Non Linear Regression	1	
	20	Lines of Regression	3	
	21	Coefficients of Regression	3	
	22	Properties of Regression Coefficients	3	
	Sections from References: Unit 18: 9.1 [Ref 1] Unit 19: 9.2[Ref 1] Unit 20: 9.3(9.3.1&9.3.2)[Ref 1] Unit 21: 9.4[Ref 1] Unit 22: 9.4.1,9.5,9.6[Ref 1]			
5	**PRACTICUM**		**30**	
	Do practice problems in spreadsheet from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course.			
	1	Scatterplot		
	2	Correlation		
	3	Regression		

	4	Linear correlation coefficient r		
	5	Graphing regression line		
	6	Outliers		
	7	Influential points		
	8	Residual plot		
	Sections from References: Unit 1: 2.4 [Ref 5] Unit 2: 2.4 [Ref 5] Unit 3: 2.4 [Ref 5] Unit 4: 10.1 [Ref 5] Unit 5: 10.2 [Ref 5] Unit 6: 10.2 [Ref 5] Unit 7: 10.2 [Ref 5] Unit 8: 10.2 [Ref 5]			

Books and References:

1. Gupta, S. C.. (2015). Fundamentals of Statistics, Himalaya Publishing House
2. Myra L. Samuels, Jeffrey A. Witmer, Andrew A. Schaffner, Statistics for the Life Sciences ,fifth edition (2016),Pearson Education
3. Prem S. Mann (2016), Introductory Statistics 9 th Edition, Wiley
4. Gupta, S. C. and Kapoor, V. K. (2002). Fundamentals of Mathematical Statistics, 11th edition, Sulthan Chand, New Delhi
5. Mario F Triola, Elementary Statistics using Excel

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6

CO 1	3	2	-	-	-	2	1	2	-	-	-	3
CO 2	-	-	-	-	-	2	2	2	-	-	-	-
CO 3	-	-	-	-	3	-	2	1	-	-	-	-
CO 4	-	3	-	2	2	1	3	3	2	-	3	-
CO 5	-	-	-	-	-	2	2	2	-	-	-	-
CO 6	-	-	3	-	-	-	1	1	-	3	-	2

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal	Assignm	Project	End Semester

	Exam	ent	Evaluation	Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	BSc Statistics
Course Code	STA1MN108 (P)
Course Title	Statistics for critical thinking I
Type of Course	Minor

Semester	I				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic mathematical knowledge				
Course Summary	This course aims to illustrate the relevance of statistics in social studies by delving into the concept of data, its various forms, generation methods, diverse techniques for summarization and visualization, ultimately fostering a comprehensive understanding.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Identify different types of variables, including categorical, ordinal, interval, and ratio variables, and analyze their characteristics.	U	C	Instructor-created exams / Quiz
CO2	Analyze relationships between variables, including correlations, associations, and causality and analyze data to help entrepreneurial decisions using critical thinking skills..	U	F	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO3	Diffrentiate between qualitative and quantitative data	U	C	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Evaluate the advantages and disadvantages of four sampling methods: simple, stratified, cluster, and multistage sampling and critically evaluate ethical implications of statistical methods aligning with human values.	U	C	Instructor-created exams / Home Assignments
CO5	Calculate and interpret measures of dispersion, including range, variance, standard deviation, and coefficient of	U	C	One Minute Reflection Writing assignments/

	variation, to assess the spread or variability within a data set.			Instructor-created exams
CO6	Apply various methods for summarizing data, including numerical techniques such as scatter plots, dot plots, histograms, and box plots, and interpret their characteristics such as shape, symmetry, and outliers using R software.	Ap	P	Viva Voce/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

COURSE CONTENT

Module	**Unit**	**Content**	**Hrs (45 +30)**	**Marks (70)**
1		**Data basics**	**10**	**15**
	1	Qualitative and Quantitative data, variables, and data matrices.	2	
	2	Types of variables, Relationships between variables.	2	
	3	Explanatory and response variables.	2	
	4	Introducing observational studies and experiments.	4	
		Sections from References: Unit 1-4: 1.2 [Ref 2]		
		Sampling principles and strategies	**11**	**15**
2	**5**	Populations and samples, anecdotal evidence.	2	
	6	Sampling from a population, Observational studies. confounding variable, Retrospective studies.	2	
	7	Four sampling methods: simple, stratified, cluster, and multistage sampling.	2	

	8	Experiments: randomized experiment, Principles of experimental design.	3	
	9	Reducing bias in human experiments, treatment group, control group.	2	
		Sections from References: Unit 5-7: 1.3 [Ref 2] Unit 8-9: 1.4 [Ref 2]		
		Summarizing data	**15**	**25**
3	**10**	Examining numerical data, Scatterplots for paired data.	1	
	11	Dot plots, the mean and the weighted mean.	2	
	12	Histograms, shape, symmetry, and mode of a data set.	2	
	13	Dispersion: Range, Variance, standard deviation, and coefficient of variation.	2	
	14	Box plots, quartiles, and the median.	2	
	15	Outliers, Inter quantile rage, Quantile deviation.	2	
	16	Robust statistics .	1	
	17	Transforming data.	1	
	18	Mapping data.	2	
		Sections from References: Unit 10-18: 2.1 [Ref 2]		
		Categorical data	**9**	**15**
4	**19**	Contingency tables and bar plots.	2	
	20	Row and column proportions, pie chart.	2	
	21	Using a bar plot with two variables, stacked bar plot, side-by-side bar plot, Mosaic plots.	3	
	22	Comparing numerical data across groups: side-by-side box plots and hollow histograms.	2	
		Sections from References: Unit 19-22: 2.2 [Ref 2]		
5	**PRACTICUM**		30	
	Do practice problems in R software from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course.			
	1	Basic Mathematical Operations and R		

		Preliminaries		
	2	Methods of Data Input		
	3	Graphical Representations (R Code)		
	4	Diagrammatic Representations (R Code)		
	5	Descriptive Measures -Mean		
	6	Median and Mode		
	7	Range		
	8	Standard deviation, variance		
	Sections from References: Unit 1: 1.3&1.4 [Ref 5] Unit 2: 1.5&1.6 [Ref 5] Unit 3: 1.8,2.3 [Ref 5] Unit 4: 2.2 [Ref 5] Unit 5: 2.4 [Ref 5] Unit 6: 2.4 [Ref 5] Unit 7: 2.5[Ref 5] Unit 8: 2.5[Ref 5]			
	Books and references: 1. Moore, D. S. (2009). *Introduction to the Practice of Statistics*. WH Freeman and company. 2. Diez, D. M., Barr, C. D., & Cetinkaya-Rundel, M. (2019). *OpenIntro statistics*. Boston, MA, USA:: OpenIntro. (Available Online) 3. Asthana, H. S., & Bhushan, B. (2016). *Statistics for social sciences (with SPSS applications)*. PHI Learning Pvt. Ltd.. 4. Aron, A., Coups, E. J., & Aron, E. N. (2013). *Statistics for the behavioral and social sciences: A brief course: Pearson new international edition*. Pearson Higher Ed. 5. Sudha G Purohith, Sharad D Core, Shailaja R Deshmukh ,Statistics Using R(2015) 6. Sirkin, R. M. (2006). *Statistics for the social sciences*. Sage. 7. Mukherjee, S. P., Sinha, B. K., & Chattopadhyay, A. K. (2018). *Statistical methods in social scienceresearch* (pp. 29-37). Springer Singapore. 8. Gupta, S. C. and Kapoor, V. K. (2002). Fundamentals of Mathematical Statistics. **,** 11th edition, Sulthan Chand, New Delhi.			

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	2	-	-	-	-	2	2	-	-	-	-
CO 2	-	-	3	-	-	2	3	3	-	-	3	-
CO 3	-	2	-	3	1	-	2	2	2	-	-	-
CO 4	3	-	-	-	-	1	1	2	-	-	-	3
CO 5	-	-	3	-	-	2	3	2	2	3	-	-
CO 6	-	-	-	-	-	2	2	3	-	3	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓

CO 2	✓	✓		✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	BSc Statistics				
Course Code	STA2MN108 (P)				
Course Title	Statistics for critical thinking II				
Type of Course	Minor				
Semester	II				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours

	4	3	-	2	75
Pre-requisites	Basic mathematical knowledge, familiarity with functions, graphs and basic equations.				
Course Summary	This course explores different ways to collect data, builds a foundation on probability, describes how to model a random experiment effectively using random variable and discusses some special distributions.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Design and develop questionnaires and schedules, ensuring reliability and validity through appropriate measures and techniques and critically evaluate ethical implications of statistical methods aligning with human values.	U	C	Instructor-created exams / Quiz
CO2	Evaluate the reliability of data through various techniques and analyze data to help entrepreneurial decisions using critical thinking skills..	U	F	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO3	Utilize random variables to model outcomes of random experiment.	U	C	Seminar Presentation / Group Tutorial Work
CO4	Define probability and analyze scenarios involving disjoint or mutually exclusive outcomes using probability concepts and tools.	U	C	Instructor-created exams / Home Assignments/ Instructor-created exams
CO5	Identify and describe key properties of common statistical distributions.	Ap	P	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Explore various probability distributions such as Bernoulli, binomial, Poisson, geometric, and negative binomial distributions, including understanding their	Ap	P	Viva Voce/ Instructor-created exams

	characteristics and differences using R software.			
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

COURSE CONTENT

Module		Content	Hours (45 +30)	Marks (70)
		Methods of Data Collection	**9**	**10**
1	**1**	Case study, Observation, Interview, Survey, Use of Secondary Data	3	
	2	Questionnaires and Schedules : Reliability and Validity of Questionnaire	3	
	3	Cleaning Data, Methods to Check reliability of Data.	3	
		Sections from References: Unit 1-3:		
		Probability	**11**	**20**
2	**4**	Defining probability, Disjoint or mutually exclusive outcomes, Probabilities when events are not disjoint, Venn-diagrams.	2	
	5	Probability distributions, Complement of an event, Independence.	2	
	6	Exploring probabilities with a contingency table, Marginal and joint probabilities.	1	
	7	Defining conditional probability, General multiplication rule.	2	
	8	Sum of conditional Probabilities, Independence considerations in conditional probability, Tree diagrams.	2	
	9	Bayes’ Theorem and its applications.	2	
		Sections from References: Unit 4-9: 3.1,3.2 [Ref 2]		
		Continuous distributions	**14**	**20**
3	**10**	Sampling from a small population, without replacement, with replacement.	1	
	11	Random variable and its Expectation.	2	

	12	Variability in random variables.	2	
	13	Linear combinations of random variables, its Expectation and Variability in linear combinations of random variables.	2	
	14	Continuous distributions, From histograms to continuous distributions.	1	
	15	Probabilities from continuous distributions.	2	
	16	Normal distribution, standard normal distribution.	2	
	17	Standardizing with Z-scores, Finding tail areas, examples.	2	
		Sections from References: Unit 10-15: 3.3,3.4,3.5 [Ref 2] Unit 16-17: 4.1 [Ref 2]		
		Discrete distributions	**11**	**20**
4	**18**	Bernoulli distribution, binomial distribution,	2	
	19	Normal approximation to the binomial distribution,	1	
	20	Poisson distribution.	3	
	21	Geometric distribution.	2	
	22	Negative binomial distribution, Binomial vs Negative binomial distribution.	3	
		Sections from References: Unit 18-22: 4.2,4.3,4.4,4.5 [Ref 2]		
5	**PRACTICUM**		**30**	
	Do practice problems in R software from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course.			
	1	Obtain the probability distribution		
	2	Plot the probability distribution		
	3	Obtain the cumulative distribution function		
	4	Plot the cumulative distribution function		
	5	Calculation of Probabilities from binomial distribution		
	6	Calculation of Probabilities from binomial distribution		
	7	Calculation of Probabilities from binomial distribution		

	8	Fitting of Binomial distribution		
	Sections from References: Unit 1: 3.3 [Ref 5] Unit 2: 3.3 [Ref 5] Unit 3: 3.3 [Ref 5] Unit 4:3.4&3.5 [Ref 5] Unit 5: 3.4 &3.5 [Ref 5] Unit 6: 3.4 &3.5 [Ref 5] Unit 7: 3.4 &3.5 [Ref 5] Unit 8: 3.4 &3.5 [Ref 5]			
	Books and References: 1. Asthana, H. S., & Bhushan, B. (2016). *Statistics for social sciences (with SPSS applications)*. PHI Learning Pvt. Ltd.. 2. Diez, D. M., Barr, C. D., & Cetinkaya-Rundel, M. (2019). *OpenIntro statistics*. Boston, MA, USA:: OpenIntro. 3. Aron, A., Coups, E. J., & Aron, E. N. (2013). *Statistics for the behavioral and social sciences: A brief course: Pearson new international edition*. Pearson Higher Ed. 4. Sirkin, R. M. (2006). *Statistics for the social sciences*. Sage. 5. Sudha G Purohith, Sharad D Core, Shailaja R Deshmukh ,Statistics Using R(2015) 6. Mukherjee, S. P., Sinha, B. K., & Chattopadhyay, A. K. (2018). *Statistical methods in social science research* (pp. 29-37). Springer Singapore. 7. Gupta, S. C. and Kapoor, V. K. (2002). Fundamentals of Mathematical Statistics. , 11th edition, Sulthan Chand, New Delhi. 8. Gupta, S. C. and Kapoor, V. K. (2007). Fundamentals of applied Statistics, Sultan Chand and Sons.			

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO	2	2	-	-	-	3	1	2	-	-	-	3

1												
CO 2	-	-	3	-	-	2	2	1	-	-	3	-
CO 3	-	-	-	-	-	-	3	2	-	-	-	-
CO 4	-	3	-	3	2	-	2	2	3	-	-	-
CO 5	-	-	-	-	-	-	2	1	-	-	-	-
CO 6	-	-	3	-	-	2	1	2	-	3	-	2

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓			✓
CO 3	✓	✓		✓

CO 4		✓		✓
CO 5	✓	✓		✓
CO 6	✓			

Programme	BSc Statistics					
Course Code	STA3MN208 (P)					
Course Title	Statistics for critical thinking III					
Type of Course	Minor					
Semester	III					
Academic Level	200 – 299					
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours	
	4	3	-	2	75	
Pre-requisites	Basic understanding of introductory statistical concepts. Familiarity					

	with the fundamentals of probability.
Course Summary	This course examines different ways to analyse data to make meaningful conclusions about the larger population from it is drawn. Course also explores ways to describe relationships between different variables in a data matrix.

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Explain the concept of a sampling distribution and calculate standard error for different statistics.	U	C	Instructor-created exams / Quiz
CO2	Explain central limit theorem and its importance in statistics.	U	C	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO3	Construct and interpret confidence intervals for proportions, including understanding the margin of error and changing the confidence level and analyze data to help entrepreneurial decisions using critical thinking skills.	U	C	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Analyze the difference of two proportions using hypothesis tests and confidence intervals.	U	C	Instructor-created exams / Home Assignments
CO5	Perform paired data analysis using paired t-tests and interpret the results and critically evaluate ethical implications of statistical methods aligning with human values.	U	f	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Conduct ANOVA tests to compare means across multiple groups and interpret ANOVA tables using R software.	Ap	P	Viva Voce/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)				

- Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

COURSE CONTENT

Module		Content	Hours (45+ 30)	Marks (70)
		Statistical Inference	**12**	**17**
1	**1**	Point estimates and sampling variability, Sampling error, Bias.	1	
	2	Sampling distribution, standard error, Central Limit Theorem.	1	
	3	Applying the Central Limit Theorem to a real-world setting, More details regarding the Central Limit Theorem.	2	
	4	Confidence intervals for a proportion, Capturing the population parameter.	2	
	5	Constructing a 95% confidence interval	1	
	6	Changing the confidence level, margin of error, case studies, Interpreting confidence intervals.	1	
	7	Hypothesis testing for a proportion, null hypothesis and alternative hypothesis, Type I and Type II errors, Formal testing using p-values.	4	
		Sections from References: Unit 1-7: 5.1,5.2,5.3 [Ref 2]		
		Hypothesis testing	**12**	**17**
2	**8**	Inference for categorical data, Inference for a single proportion, Confidence intervals for a proportion.	2	
	9	Hypothesis testing for a proportion, Choosing a sample size when estimating a proportion.	1	
	10	Difference of two proportions, Sampling distribution of the difference of two proportions.	2	
	11	Hypothesis tests for the difference of two proportions.	1	
	12	Testing for goodness of fit using chi-square: Creating a test statistic for one-way tables, The chi-square test statistic.	2	
	13	The chi-square distribution and finding areas,	2	

		Finding a p-value for a chi-square distribution, Evaluating goodness of fit for a distribution.		
	14	Testing for independence in two-way tables, The chi-square test for two-way tables.	2	
		Sections from References: Unit 8-14: 6.1-6.4 [Ref 2]		
		Small sample tests	**14**	**19**
3	**15**	Inference for numerical data: One-sample means with the t-distribution, The sampling distribution of smaple mean, Introducing the t-distribution, One sample t-tests.	3	
	16	Paired data, paired t-test. Difference of two means,	2	
	17	Hypothesis tests for the difference of two means, Confidence interval for a difference of means	4	
	18	Comparing many means with ANOVA: Core ideas of ANOVA, Analysis of variance (ANOVA) and the F -test.	3	
	19	Reading an ANOVA table from software, Multiple comparisons and controlling Type 1 Error rate.	2	
		Sections from References: Unit 15-19: 7.1-7.5 [Ref 2]		
		Regression	**7**	**17**
4	**20**	Introduction to linear regression: Fitting a line, residuals, and correlation, Describing linear relationships with correlation.	3	
	21	Least squares regression, Conditions for the least squares line, Finding the least squares line.	2	
	22	Interpreting regression model parameter estimates, Using R2 to describe the strength of a fit, Categorical predictors with two levels.	2	
		Sections from References: Unit 20-24:8.1-8.4 [Ref 2]		
5	**PRACTICUM**		**30**	
	Do practice problems in R software from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course.			
	1	Test Concerning Means-One sample		
	2	Analytical Methods of checking assumption of normality of parent population		

	3	Test of Significance for difference of two population means		
	4	Test of Significance for difference of two population proportions		
	5	ANOVA		
	6	Correlation		
	7	Inference procedures for correlation coefficient		
	8	Linear regression		
	Sections from References: Unit 1: 4.5[Ref 5] Unit 2:4.5[Ref 5] Unit 3: 4.5[Ref 5] Unit 4: 4.5[Ref 5] Unit 5: 4.5[Ref 5] Unit 6: 5.2[Ref 5] Unit 7: 5.3[Ref 5] Unit 8: 5.4[Ref 5]			
	Books and References: 1. Asthana, H. S., & Bhushan, B. (2016). *Statistics for social sciences (with SPSS applications)*. PHI Learning Pvt. Ltd.. 2. Diez, D. M., Barr, C. D., & Cetinkaya-Rundel, M. (2019). *OpenIntro statistics*. Boston, MA, USA:: OpenIntro. 3. Aron, A., Coups, E. J., & Aron, E. N. (2013). *Statistics for the behavioral and social sciences: A brief course: Pearson new international edition*. Pearson Higher Ed. 4. Sirkin, R. M. (2006). *Statistics for the social sciences*. Sage. 5. Sudha G Purohith, Sharad D Core, Shailaja R Deshmukh ,Statistics Using R(2015). 6. Mukherjee, S. P., Sinha, B. K., & Chattopadhyay, A. K. (2018). *Statistical methods in social science research* (pp. 29-37). Springer Singapore. 7. Gupta, S. C. and Kapoor, V. K. (2002). Fundamentals of Mathematical Statistics. , 11th edition, Sulthan Chand, New Delhi. 8. Gupta, S. C. and Kapoor, V. K. (2007). Fundamentals of applied Statistics, Sultan Chand and Sons.			

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	-	-	-	2	-	-	-	3	-	-	-
CO 2	-	-	-	-	-	-	3	-	-	-	-	-
CO 3	2	2	-	-	-	-	1	-	-	-	3	-
CO 4	-	-	2	3	1	3	-	3	2	-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	3
CO 6	-	-	3	-	-	2	-	-	-	3	3	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4		✓		✓
CO 5	✓	✓		✓
CO 6	✓			

Programme	BSc Statistics				
Course Code	STA1MN109 (P)				
Course Title	Elementary statistics				
Type of Course	Minor				
Semester	I				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic knowledge of mathematics, including algebra and calculus. Familiarity with geographical concepts and spatial data.				

Course Summary	To equip students with the fundamental principles of statistical analysis and their application in geographical contexts, enabling them to effectively analyze, interpret, and communicate spatial data.

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Recognize the importance of statistical methods in geographical research and analysis.	U	C	Instructor-created exams / Quiz
CO2	Evaluate different types of data used in geography, including qualitative and quantitative variables, and analyze data to help entrepreneurial decisions using critical thinkingskills.	Ap	F	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO3	Calculate and interpret measures of central tendency, such as mean, median, and mode, and measures of dispersion, including range, variance, and standard deviation, in the context of geographical data analysis.	Ap	F	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Analyze higher-order moments or other numerical measures of the characteristics of distributions, such as skewness and kurtosis, and interpret their implications for spatial patterns and trends and critically evaluate ethical implications of statistical methods aligning with human values.	U	C	Instructor-created exams / Home Assignments
CO5	Introduce the concepts of correlation and regression analysis and their applications in geography, including assessing the strength and direction of relationships between variables and making predictions based on statistical models.	U	C	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Demonstrate measures of central	Ap	P	Viva Voce/ Instructor-creat

	tendency using spreadsheet.			ed exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

COURSE CONTENT

Module	Unit	Content	Hours (45 +30)	Marks (70)
1		**STATISTICS AND GEOGRAPHY**	**10**	**15**
	1	Statistical Analysis and Geography	1	
	2	Data, sources of data, internal data, external data, primary and secondary data, meta data	2	
	3	Data collection, characteristics of data sets	2	
	4	Quantitative and qualitative data sets	1	
	5	Measurement Evaluation: Validity, accuracy, precision	2	
	6	Data and Information	1	
	Sections from References: Unit 1: 1, 1.1 [Ref 1] Unit 2: 1.2 [Ref 1] Unit 3: 1.2 [Ref 1] Unit 4: 1.2 [Ref 1] Unit 5: 1.3 [Ref 1] Unit 6: 1.4 [Ref 1]			
2		**DISPLAYING AND INTERPRETING DATA**	**12**	**15**
	7	Organization of data	2	
	8	Classification	2	
	9	Frequency distribution	2	

	10	Basic principles for forming a groupes frequency distribution	2	
	11	Cumulative and bivariate frequency distribution	2	
	12	Tabulation, requisites of a good table	2	
	Sections from References: Unit 7: 3.1 [Ref 2] Unit 8: 3.2 [Ref 2] Unit 9: 3.3, 3.3.1, 3.3.2, 3.3.3, 3.3.4 [Ref 2] Unit 10: 3.4, 3.4.1, 3.4.2, 3.4.3, 3.4.4 [Ref 2] Unit 11: 3.5, 3.5.1, 3.5.2, 3.6 [Ref 2] Unit 12: 3.7, 3.7.2 [Ref 2]			
3	**REPRESENTATIONS OF DATA**		**14**	**25**
	13	Types of diagrams	1	
	14	Graphical representation of data	3	
	15	Limitations of diagrams and graphs	1	
	16	Measures of Central Tendency:	4	
	17	Selection and limitations of an average	2	
	18	Measures of Dispersion	3	
	Sections from References: Unit 13: 4.3.2, 4.3.3, 4.3.44.3.6, 4.3.7 [Ref 2] Unit 14: 4.4.2, 4.4.3, 4.4.4 [Ref 2] Unit 15: 4.5 [Ref 2] Unit 16: 5.4,5.6, 5.7, 5.8, 5.9, 5.10 [Ref 2] Unit 17: 5.12, 5.13 [Ref 2] Unit 18: 6.5, 6.6, 6.9 [Ref 2]			
4	**CORRELATION AND REGRESSION**		**10**	**15**
	19	Correlation	2	
	20	Correlation coefficient	2	

	21	Regression	3	
	22	Lines of regression	3	
	Sections from References: Unit 19: 8.1, 8.1.1, 8.1.2, 8.3 [Ref 2] Unit 20: 8.4 [Ref 2] Unit 21: 9.2 [Ref 2] Unit 22: 9.3, 9.3.1, 9.3.2, 9.3.4 [Ref 2]			
5	**PRACTICUM**		**30**	
	Do practice problems in spreadsheet from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course.			
	1	Types of data		
	2	Introduction to spreadsheet		
	3	Frequency distributions for organizing and summarizing data		
	4	Histograms		
	5	Graphs that enlighten and graphs that deceive		
	6	Measures of central tendency		
	7	Measures of dispersion		
	8	Measures of Relative Standing and Boxplots		
	Sections from References: Unit 1: 1.2 Ref [5] Unit 2: 1.4 Ref [5] Unit 3: 2.1 Ref [5] Unit 4: 2.2 Ref [5] Unit 5: 2.3 Ref [5] Unit 6: 3.1 Ref [5] Unit 7: 3.2 Ref [5] Unit 8: 3.3 Ref [5]			
	Books and References: 1. James E. Burt_ Gerald M. Barber_ David L. Rigby - Elementary Statistics for Geographers-The Guilford Press (2009) 2. Gupta, S. C.. (2015). Fundamentals of Statistics,			

	Himalaya Publishing House. 3. J. Chapman McGrew Jr., Arthur J. Lembo Jr., Charles B. Monroe - An Introduction to Statistical Problem Solving in Geography, Third Edition-Waveland Press, Inc. (2014) 4. Mario F Triola, Elementary Statistics using Excel.		

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	3	-	-	-	-	3	-	-	-	-	-
CO 2	-	2	-	-	-	-	-	-	-	-	2	-
CO 3	-	-	-	-	-	3	-	3	-	-	-	-
CO 4	1	-	-	-	2	-	-	-	-	-	-	3
CO 5	-	2	3	1	-	-	-	-	2	1	-	-
CO 6	-	-	3	-	-	2	-	-	-	2	3	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial /

	High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	BSc Statistics				
Course Code	STA2MN109 (P)				
Course Title	Theory of probability				
Type of Course	Minor				
Semester	II				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Knowledge of introductory statistics would be beneficial for students				

	to grasp the content covered in the course effectively.
Course Summary	Provide students with a foundational understanding of probability theory and its applications in statistical experiments, random variables, probability distributions, and sampling techniques.

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Define statistical experiments, sample spaces, and events, and recognize their significance in modeling uncertain outcomes.	U	C	Instructor-created exams / Quiz
CO2	Utilize conditional probability and understand the concept of statistical independence to analyze probabilistic relationships between events.	U	F	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO3	Define random variables and probability distributions, and analyze the distribution of discrete and continuous random variables, including calculating expectations and variances.	R	C	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Identify sampling biases and evaluate different types of non-probability sampling techniques, such as judgmental, convenience, quota, and volunteer sampling and analyze datato help entrepreneurial decisions using critical thinking skills.	U	C	Instructor-created exams / Home Assignments
CO5	Acquire a comprehensive knowledge of probability theory and its diverse applications in statistical experiments, random variables and critically evaluate ethical implications of statistical methods aligning with human values.	U	C	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Solve practical problems involving probability distributions using	Ap	P	Viva Voce/ Instructor-created exams

	spreadsheet.			
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

COURSE CONTENT

Module	**Units**	**Content**	**Hrs (45 +30)**	**Marks (70)**
1		**PROBABILITY**	**12**	**20**
	1	Mathematical Preliminaries	1	
	2	Set theory	2	
	3	Permutation and combination	1	
	4	Definitions of probability	1	
	5	Addition theorem of probability	2	
	6	Multiplication theorem of probability	2	
	7	Independent events, multiplication theorem for independent events	2	
	8	Pairwise and mutual independence	1	
		Sections from References: Unit 1: 12.4 [Ref 1] Unit 2: 12.4.1 [Ref 1] Unit 3: 12.4.2 [Ref 1] Unit 4: 12.5, 12.6, 12.7 [Ref 1] Unit 5: 12.8 [Ref 1] Unit 6: 12.9 [Ref 1] Unit 7: 12.9.1, 12.9.2 [Ref 1] Unit 8: 12.10 [Ref 1]		
II		**RANDOM VARIABLES**	**10**	**15**
	9	Random variable, probability distribution of discrete and continuous random variable	2	

	10	Distribution function	2	
	11	Moments (definition only)	2	
	12	Mathematical Expectation	2	
	13	Variance and covariance	2	
	Sections from References: Unit 9: 13.1, 13.2, 13.3 [Ref 1] Unit 10: 13.4 [Ref 1] Unit 11: 13.5 [Ref 1] Unit 12: 13.6 [Ref 1] Unit 13: 13.8, 13.9 [Ref 1]			
III	**STANDARD DISTRIBUTIONS**		**12**	**20**
	14	Binomial distribution	2	
	15	Poisson distribution	2	
	16	Normal distribution	4	
	17	Areas under standard normal probability curve, Importance of normal distribution	4	
	Sections from References: Unit 14: 14.2, 14.2.1, 1.2.2, 1.2.3 [Ref 1] Unit 15: 14.3, 14.3.1, 14.3.2, 14.3.3 [Ref 1] Unit 16: 14.4, 14.4.1, 14.4.2 [Ref 1] Unit 17: 14.4.6, 14.4.7 [Ref 1]			
	SAMPLING		**11**	**15**
IV	**18**	Census, sample, principal steps in sample survey	2	
	19	Purposive Sampling	2	
	20	Simple random Sampling	3	
	21	Stratified random sampling	2	
	22	Systematic Sampling	2	
	Sections from References: Unit 18: 15.6, 15.8[Ref 1] Unit 19: 15.10.1 [Ref 1] Unit 20: 15.11 [Ref 1]			

	Unit 21: 15.12 [Ref 1] Unit 22: 15.13 [Ref 1]		
5	**PRACTICUM**	**30**	
	Do practice problems in spreadsheet from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course.		
	1 Probability distribution		
	2 Probability histogram		
	3 Mean and variance of probability distribution		
	4 Finding binomial probabilities		
	5 Finding Poisson probabilities		
	6 Finding normal probabilities		
	7 Finding z scores from known areas		
	8 Find critical values		
	Sections from References: Unit 1: 5.1 [Ref 4] Unit 2: 5.1 [Ref 4] Unit 3: 5.1 [Ref 4] Unit 4: 5.2 [Ref 4] Unit 5: 5.3 [Ref 4] Unit 6: 6.1 [Ref 4] Unit 7: 6.1 [Ref 4] Unit 8: 6.1 [Ref 4]		
	Books and References: 1. Gupta, S. C.. (2015). Fundamentals of Statistics, Himalaya Publishing House. 2. James E. Burt_ Gerald M. Barber_ David L. Rigby - Elementary Statistics for Geographers-The Guilford Press (2009) 3. J. Chapman McGrew Jr., Arthur J. Lembo Jr., Charles B. Monroe - An Introduction to Statistical Problem Solving in Geography, Third Edition-Waveland Press, Inc. (2014) 4. Mario F Triola, Elementary Statistics using Excel.		

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	3	-	-	-	-	2	-	-	-	-	-
CO 2	-	-	-	-	2	-	-	-	3	-	-	-
CO 3	-	3	1	2	-	-	1	-	2	-	-	-
CO 4	-	-	2	-	-	2	-	-	-	-	3	-
CO 5	1	-	-	-	-	3	-	3	-	-	-	3
CO 6	-	-	3	-	-	-	-	-	-	2	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5	✓	✓		✓
CO 6	✓			

Programme	BSc Statistics				
Course Code	STA3MN209 (P)				
Course Title	Statistical inference				
Type of Course	Minor				
Semester	III				
Academic Level	200 – 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic knowledge of random variable, probability, standard distributions				

Course Summary	Equip students with a comprehensive understanding of sampling theory and its applications in statistical inference.

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Define parameters and statistics, and differentiate between them using examples to illustrate their roles in statistical inference.	U	C	Instructor-created exams / Quiz
CO2	Explain what a sampling distribution is and differentiate it from a population distribution.	U	F	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO3	Describe the procedures for statistical estimation, including point estimation and interval estimation, and analyze data to help entrepreneurial decisions using critical thinking skills.	U	C	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Identify unbiased and efficient estimators and apply them to estimate population parameters such as the mean, proportion, and variance.	U	C	Instructor-created exams / Home Assignments
CO5	Interpret interval estimators for population mean and population proportion and critically evaluate ethical implications of statistical methods aligning with human values.	Ap	P	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Perform testing of hypothesis using any software.	Ap	P	Viva Voce/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

COURSE CONTENT

Mo	Units	Content	Hrs	Marks

dul e			(45 +30)	(70)
	SAMPLING THEORY		**10**	**10**
1	**1**	Parameter and statistic	2	
	2	Sampling Distribution	2	
	3	Principles of sampling	2	
	4	Sampling distribution of a statistic	2	
	5	Central limit theorem	2	
	Sections from References: Unit 1: 15.4 [Ref 1] Unit 2: 15.4.1, 15.4.2 [Ref 1] Unit 3: 15.5 [Ref 1] Unit 4: 16.3 [Ref 1] Unit 5: 16.3.2 [Ref 1]			
	THEORY OF ESTIMATION		**11**	**25**
2	**6**	Statistical Estimation Procedures-Point Estimation and Interval estimation	2	
	7	Point estimation- Estimator and Estimate (Definition, Concept), Unbiases Estimator and Efficient Estimator, Point Estimators of Population Mean, Population Proportion, Population Variance	3	
	8	Interval estimation-Definition	3	
	9	Size of the random sample for specified precision	3	
	Sections from References: Unit 6: 16.2 [Ref 1] Unit 7: 16.2.1, 16.2.2, 1.62.3, 16.2.4, 16.2.5 [Ref 1] Unit 8: 16.4, 16.4.1, 16.4.2, 16.4.3 [Ref 1] Unit 9: 16.5 [Ref 1]			
3	**HYPOTHESIS TESTING**		**12**	**20**
	10	Testing of hypothesis, simple and composite hypothesis, null and alternate hypothesis	2	

	11	Types of errors, Size and power of tests, critical region	2	
	12	One tailed and two tailed tests	1	
	13	P- value or probability value of test statistic	1	
	14	Large sample tests	2	
	15	Test for single proportion	2	
	16	Test for single mean	2	
	Sections from References: Unit 10: 16.6, 16.6.1, 16.6.3, 16.6.4 [Ref 1] Unit 11: 16.6.5, 16.6.6, 16.6.7 [Ref 1] Unit 12: 16.6.8 [Ref 1] Unit 13: 16.6.10 [Ref 1] Unit 14: 17 [Ref 1] Unit 15: 17.2.1 [Ref 1] Unit 16: 17.3.1 [Ref 1]			
4	**CHI SQUARE TEST**		**12**	**15**
	17	Probability density function of Chi- square distribution	1	
	18	Applications of Chi square distribution	2	
	19	Chi square test of goodness of fit	3	
	20	Conditions for the validity for Chi square test	2	
	21	Chi square test for independence of attributes	3	
	22	Degrees of freedom	1	
	Sections from References: Unit 17: 18.2.1 [Ref 1] Unit 18: 18.3 [Ref 1] Unit 19: 18.4 [Ref 1] Unit 20: 18.5 [Ref 1] Unit 21: 18.6 [Ref 1]			

	Unit 22: 18.7 [Ref 1]			
5	**PRACTICUM**		**30**	
	Do practice problems in spreadsheet from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course.			
	1	Confidence interval for mean of single population		
	2	Confidence interval for difference of mean of double population		
	3	Confidence interval for proportion of single population		
	4	Confidence interval for difference of proportion of double population		
	5	Testing of hypothesis for mean of large population		
	6	Testing of hypothesis for mean of small population		
	7	Chi square test of goodness of fit		
	8	Chi square test for independence of attributes		

Books and References:

1. Gupta, S. C.. (2015). Fundamentals of Statistics, Himalaya Publishing House.
2. James E. Burt_ Gerald M. Barber_ David L. Rigby - Elementary Statistics for Geographers-The Guilford Press (2009)
3. J. Chapman McGrew Jr., Arthur J. Lembo Jr., Charles B. Monroe - An Introduction to Statistical Problem Solving in Geography, Third Edition-Waveland Press, Inc. (2014)
4. Mario F Triola, Elementary Statistics using Excel.

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	2	-	-	-	-	1	-	-	-	-	-
CO 2	-	-	-	-	1	3	-	1	-	-	-	-
CO	-	-	-	-	-	-	-	-	-	-	2	-

3												
CO 4	1	-	–	-	-	3	-	-	-	-	-	3
CO 5	-	3	2	2	-	-	-	-	2	-	-	-
CO 6	-	-	3	-	-	3	-	-	-	2	3	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓			✓

CO 4		✓		✓
CO 5	✓	✓		✓
CO 6	✓			

Programme	BSc Statistics				
Course Code	STA1MN110 (P)				
Course Title	Basic statistics and data visualization				
Type of Course	Minor				
Semester	I				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic mathematical knowledge, skills in logical thinking and problem solving				

Course Summary	Through theoretical concepts and practical applications, students will develop the skills necessary to classify data, organize frequency distributions, and calculate and interpret measures of central tendency and dispersion.

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Define and differentiate between primary data and secondary data, and understand the advantages and disadvantages of each type in research and analysis.	U	C	Instructor-created exams / Quiz
CO2	Classify data into quantitative and qualitative categories and recognize their characteristics and appropriate analysis techniques and analyze data to help entrepreneurial decisions using critical thinking skills.	U	F	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO3	Construct frequency distributions for discrete and continuous variables, including cumulative frequency distributions, to summarize and organize data effectively and critically evaluate ethical implications of statistical methods aligning with human values.	U	F	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Calculate positional values such as quartiles, deciles, and percentiles, and interpret their significance in understanding the distribution of data.	Ap	C	Instructor-created exams / Home Assignments
CO5	Apply measures of dispersion to assess the consistency or variability of data points within a data set and make comparisons between different data sets.	Ap	C	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Apply spreadsheet functions to calculate measures of central tendency and dispersion.	Ap	P	Viva Voce/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**Introduction of data**	**9**	**15**
	1	Types of data- Primary data, Secondary data, Quantitative data, Qualitative data, Discrete data, Continuous data	2	
	2	Frequency distributions for discrete and continuous variables- Cumulative frequency distribution	2	
	3	Histogram, Frequency Polygon	3	
	4	Frequency Curve, Ogives	2	
	Sections from References: Unit 1: 2.2-2.5 [Ref 3] Unit 2: 3.3 [Ref 3] Unit 3&4: 4.3-4.4 [Ref 3]			
II		**Measures of central tendency**	**9**	**15**
	5	Mean	2	
	6	Median, Mode	3	
	7	GM	2	
	8	HM	2	
	Sections from References: Unit 5: 2.5 [Ref 1] Unit 6: 2.6&2.7 [Ref 1] Unit 7: 2.8[Ref 1] Unit 8: 2.9[Ref 1]			
III		**Measures of dispersion**	**19**	**25**
	9	Positional values – Quartiles	2	
	10	Deciles	2	
	11	Percentiles	1	
	12	Range	1	
	13	Quartile deviation	3	
	14	Mean deviation	3	
	15	Standard deviation	3	
	16	Coefficient of variation	1	
	17	Coefficient of dispersion	3	
	Sections from References: Unit 9,10&11: 2.10,2.11[Ref 1] Unit 12,13,14&15: 2.12,2.13[Ref 1] Unit 16&17: 2.14[Ref 1]			
IV		**Statistical Quality Control**	**8**	**15**

	18	Concept of statistical quality control, assignable causes and chance causes, process control.	2	
	19	Construction of control charts, 3sigma limits	2	
	20	Control chart for variables: Mean chart and Range chart	2	
	21	Control chart for attributes: c chart	1	
	22	np chart	1	
	Sections from References: Unit 18: 25-1.1,1.2,2 [Ref 2] Unit 19: 25-3.1,3.2,3.3[Ref 2] Unit 20: 25:4.1,4.3[Ref 2] Unit 21: 25:5.4[Ref 2] Unit 22: 25:5.1[Ref 2]			
V	**PRACTICUM**		**30**	
	1	Do practice problems in spreadsheet from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course. 1. Types of data 2. Frequency distributions for organizing and summarizing data 3. Graphs of frequency distribution 4. Arithmetic mean 5. Median and Mode 6. Partition of values 7. Measure of dispersion 8. Different charts in quality control		
	Sections from References Unit 1: 1.2 Ref [4] Unit 2: 2.1 Ref [4] Unit 3: 2.2 Ref [4] Unit 4: 3.1 Ref [4] Unit 5: 3.2 Ref [4] Unit 6: 3.3 Ref [4] Unit 7: 3.4 Ref [4] Unit 8:2.2 Ref[4]			
Books and References:				

1. Gupta,S.C. and Kapoor,V.K.(2002).Fundamentals of Mathematical Statistics. , 11th edition, Sulthan Chand, New Delhi.
2. Gupta, P.K. and Man Mohan. (1987). Operations Research and Statistical Analysis, Third edition, Sultan Chand, New Delhi.
3. Gupta, S. C.(2015). Fundamentals of Statistics, Himalaya Publishing House.
4. Mario F Triola, Elementary Statistics using Excel, (2018), 6th edition.

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	2	-	-	-	-	1	-	-	-	-	-
CO 2	-	-	3	-	2	2	-	-	-	2	3	-
CO 3	-	-	-	-	-	-	2	-	-	-	-	3
CO 4	1	-	-	-	-	3	-	3	-	-	-	-
CO 5	-	3	2	2	-	-	-	-	3	-	-	-
CO 6							-	-	-	3	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4		✓		✓
CO 5	✓	✓		✓
CO 6	✓			

Programme	BSc Statistics				
Course Code	STA2MN110 (P)				
Course Title	Data analysis foundations in statistics				
Type of Course	Minor				
Semester	II				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic mathematical skills				
Course Summary	Equip students with the theoretical foundation and practical skills				

	necessary to analyze and interpret time-series data.

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Define the components of a time series and distinguish betweenadditive and multiplicative models, understanding their applications in time series analysis.	U	C	Instructor-created exams / Quiz
CO2	Explain the concept and significance of index numbers, and apply different types of simple and weighted index numbers to analyze changes in economic variables over time and analyze data to help entrepreneurial decisions using critical thinking skills.	U	C	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO3	Construct scatter diagrams and analyze the strength and direction of relationships between variables using correlation analysis and critically evaluate ethical implications of statistical methods aligning with human values.	U	F	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Apply arithmetic and geometric sequences and series to analyze financial data, including calculations related to simple interest, compound interest, and annual percentage rates.	Ap	C	Instructor-created exams / Home Assignments
CO5	Calculate annuities and analyze debt repayment schedules, sinking funds, and other financial instruments.	Ap	F	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Explain the concept of correlation and use R to calculate correlation coefficients.	Ap	P	Viva Voce/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**Time series analysis**	**9**	**15**
	1	Time series analysis : Components of time series, additive and multiplicative models	1	
	2	measurement of trend- Graphic method, Semi average method	3	
	3	Method of moving averages	3	
	4	Method of least squares- Straight line trend	2	
	Sections from References: Unit 19: 11.1&11.3 [Ref 1] Unit 20:11.2 [Ref 1] Unit 21&22:11.5 [Ref 1]			
II		**Index numbers**	**10**	**15**
	5	meaning and definition ,uses and types, problems in the construction of index numbers	3	
	6	different types of simple index numbers	3	
	7	different types of weighted index numbers	2	
	8	Test for an ideal index number, time and factor reversal test	2	
	Sections from References: Unit 5: 10.1,10.2,10.4[Ref 1] Unit 6: 10.3 [Ref 1] Unit 7&8: 10.5[Ref 1] Unit 8: 10.6.2,10.6.3 [Ref 1]			
III		**Correlation and Regression**	**18**	**25**
	9	Scatter diagram	2	
	10	Correlation	2	
	11	Types of correlation	1	
	12	Pearson’s coefficient of correlation	3	
	13	Spearman’s rank correlation	3	
	14	Spearman’s rank correlation with repeated ranks	3	
	15	Regression	1	
	16	Linear regression	1	
	17	Properties of regression lines	2	
	Sections from References: Unit 9: 10.3 [Ref 2] Unit 10&11: 10.2 [Ref 2] Unit 12: 10.4 [Ref 2] Unit 13&14: 10.7[Ref 2] Unit 15: 11.1[Ref 2]			

	Unit 16&17: 11.2[Ref 2]			
IV	**Introduction to R programming**		**8**	**15**
	18	Installation & Basic Mathematical Operations	2	
	19	R Preliminaries, Methods of Data Input	2	
	20	Graphical Representations (R Code)	2	
	21	Diagrammatic Representations (R Code)	1	
	22	Descriptive Measures (Mean, Median, Mode)	1	
	Sections from References: Unit 19: 1.2&1.3 [Ref 3] Unit 20: 1.4 [Ref 3] Unit 21: 1.5&1.6 [Ref 3] Unit 22: 1.8,2.3 [Ref 3]			
V	**PRATICUM**		**30**	
	1	Do practice problems in R Software from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course. 1. Basic mathematical operations 2. Frequency distributions for organizing and summarizing data 3. Histogram 4. Frequency curve 5. Pie diagram 6. Arithmetic mean 7. Median 8. Mode		
	Sections from References: Unit 1: 1.8 Ref[3] Unit 2: 1.9 Ref[3] Unit 3: 2.1 Ref[3] Unit 4: 2.2 Ref[3] Unit 5:2.2 Ref[3] Unit 6: 2.3 Ref[3] Unit 7: 2.3 Ref[3] Unit 8: 2.3 Ref[3]			

Books and References:

1. Gupta, S. C. (2015). Fundamentals of Statistics, Himalaya Publishing House
2. Gupta, S.C. and Kapoor,V.K. (2002). Fundamentals of Mathematical Statistics. **,** 11th edition, Sulthan Chand, New Delhi.
3. Sudha G Purohith, Sharad D Core, Shailaja R Deshmukh (2015), Statistics Using R.

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	2	-	-	-	-	3	-	-	-	-	-
CO 2	-	-	-	-	-	2	-	-	1	-	2	-
CO 3	-	-	2	-	-	-	-	-	-	-	-	3
CO 4	-	-	-	-	-	2	-	1	-	-	-	-
CO 5	-	2	-	1	3	-	-	-	1	-	-	-
CO 6	-	-	2	-	-	2	-	-	-	3	2	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam

- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4		✓		✓
CO 5	✓	✓		✓
CO 6	✓			

Programme	BSc Statistics				
Course Code	STA3MN210 (P)				
Course Title	Probability theory and sampling techniques				
Type of Course	Minor				
Semester	III				
Academic Level	200 – 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Understanding of basic algebraic operations and set theory. Familiarity with functions, graphs and their properties.				
Course Summary	Through theoretical concepts and practical applications, students will develop the skills necessary to analyze uncertainty, conduct sample surveys, and implement statistical quality control methods.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Define and apply basic concepts of probability, including classical probability and the axiomatic approach, to analyze uncertain events and outcomes.	U	C	Instructor-created exams / Quiz
CO2	Differentiate between census and sampling methods and recognize the advantages and limitations of each approach in data collection and critically evaluate ethical implications of statistical methods aligning with human values.	Ap	F	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO3	Describe the principal steps involved in sample surveys, including the organization and execution of large sample surveys.	U	C	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Define life tables and understand their construction, including calculating measures such as the force of mortality, and interpreting results in demographic analysis and analyze data to help entrepreneurial decisions using critical thinking skills.	U	C	Instructor-created exams / Home Assignments
CO5	Explain the concept of statistical quality control and differentiate between assignable causes and chance causes of variation in processes.	Ap	C	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Create basic plots in R to visualize range, variance and correlation between variables.	Ap	P	Viva Voce/ Instructor-created exams

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**Probability**	**10**	**15**
	1	Basic concepts of Probability ,Classical definition of Probability ,Axiomatic approach to Probability	2	
	2	Addition Theorem, Multiplication Theorem	3	
	3	Conditional Probability	3	
	4	Independence of events	2	
	Sections from References: Unit 1: 3.3-3.8 [Ref 1] Unit 2: 3.9,3.11 [Ref 1] Unit 3: 3.10[Ref 1] Unit 4: 3.11-3.15 [Ref 1]			
II		**Random Variables**	**8**	**15**
	5	Random Variables, Discrete and continuous random variables	2	
	6	Probability distribution , Distribution function (Applications in discrete case)	2	
	7	Mathematical expectation (Applications in discrete case)	2	
	8	Variance (Applications in discrete case)	2	
	Sections from References: Unit 5&6: 5.1-5.4.2 [Ref 1] Unit 7: 6.1-6.4 [Ref 1] Unit 8: 6.6 [Ref 1]			
III		**Sampling theory**	**19**	**25**
	9	Population and Sample	2	
	10	Census and Sampling Method	3	
	11	Advantages and Limitations of Sampling	1	
	12	principal steps in sample survey	3	
	13	Sampling Errors	3	
	14	Non-Sampling Errors	3	
	15	Simple random sampling(Concept and Methods of selection)	1	
	16	Stratified random sampling	1	
	17	Systematic Sampling	2	
	Sections from References: Unit 9: 15.2,15.3,15.6 [Ref 1] Unit 10: 15.6,15.7[Ref 1] Unit 11: 15.8 [Ref 1] Unit 12: 15.9.1[Ref 1] Unit 13&14:15.10[Ref 1] Unit 15:15.11,15.11.1 [Ref 1] Unit 17: 15.12,15.12.1 [Ref 1] Unit 17: 15.13 [Ref 1]			

IV		**R programming**	**8**	**15**
	18	Range	2	
	19	Variance	2	
	20	Loops- Brief explanation	2	
	21	Pearson’s correlation	1	
	22	Conditional statements(Brief)	1	
	Sections from References: Unit 18&19: 2.1-2.3[Ref 3] Unit 20: 7.5 [Ref 2] Unit 21: 6.2 [Ref 2] Unit 22: 7.3 [Ref 2]			
V		**PRACTICUM**	**30**	
		Do practice problems in R software from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course. 1. Range 2. Mean Deviation 3. Quartile Deviation 4. Standard Deviation 5. Variance 6. Covariance 7. Correlation 8. Rank correlation		
	Sections from References: Unit 1,2: 2.1 [Ref 3] Unit 3: 2.2 [Ref 3] Unit 4,5: 2.3 [Ref 3] Unit 6,7,8: 6.2-7.5 [Ref 2]			

Books and References:

1. Gupta, S. C. and Kapoor, V. K. (2020). Fundamentals of Mathematical Statistics, 12th edition, Sulthan Chand, New Delhi
2. Douglas, Alex, Deon Roos, Francesca Mancini, Ana Couto, and David Lusseau. (2020), *An Introduction to R*. https://intro2r.com/index.html.
3. Sudha G Purohith, Sharad D Core, Shailaja R Deshmukh (2015), Statistics Using R.

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6

CO 1	2	1	-	-	-	-	3	-	-	-	-	-
CO 2	-	-	1	-	-	2	-	-	-	-	-	3
CO 3	-	-	-	1	2	-	-	-	3	-	2	-
CO 4	-	-	-	-	-	2	-	1	2	-	-	-
CO 5	-	-	2	-	-	-	1	-	-	-	-	-
CO 6	-	-	3	-	-	2	-	-	-	2	1	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓

CO 3	✓			✓
CO 4		✓		✓
CO 5	✓	✓		✓
CO 6	✓			

Programme	BSc Statistics				
Course Code	STA1MN111				
Course Title	Fundamentals of data analysis				
Type of Course	Minor				
Semester	I				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Competence in basic algebraic concepts, knowledge of basic data visualization techniques.				
Course Summary	Provide students with a comprehensive understanding of different types of data, methods of data collection, frequency distributions, graphical representation techniques, measures of central tendency and dispersion, positional values, and utilization of statistical tools like R for data analysis.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Differentiate between quantitative and qualitative data and identify suitable methods for their collection and critically evaluate ethical implications of statistical methods aligning with human values.	U	C	Instructor-created exams / Quiz
CO2	Construct frequency distributions for both discrete and continuous variables.	U	c	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO3	Calculate measures of central tendency including mean, median, mode, geometric mean, and harmonic mean and analyze data to help entrepreneurial decisions using critical thinking skills.	U	F	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Understand what dispersion means in the context of statistics and why it matters.	U	C	Instructor-created exams / Home Assignments
CO5	Apply positional values such as quartiles, deciles, and percentiles to analyze data distribution.	Ap	F	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Utilize R as a calculator, statistical software, and programming language for data analysis.	Ap	P	Viva Voce/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I	**Introduction of data**		**9**	**15**
	1	Types of data- Primary data, Secondary data, Quantitative data, Qualitative data, Discrete data, Continuous data	2	
	2	Frequency distributions for discrete and continuous variables- Cumulative frequency distribution	2	
	3	Histogram, Frequency Polygon	3	
	4	Frequency Curve, Ogives	2	
	Sections from References: Unit 1: 2.2-2.5 [Ref 3] Unit 2: 3.3 [Ref 3] Unit 3&4: 4.3-4.4 [Ref 3]			
II	**Measures of central tendency**		**9**	**15**
	5	Mean	2	
	6	Median, Mode	3	
	7	GM	2	
	8	HM	2	
	Sections from References: Unit 5: 2.5 [Ref 1] Unit 6: 2.6&2.7 [Ref 1] Unit 7: 2.8[Ref 1] Unit 8: 2.9[Ref 1]			
III	**Measures of dispersion**		**19**	**25**
	9	Positional values – Quartiles	2	
	10	Deciles	3	
	11	Percentiles	1	

	12	Range	1	
	13	Quartile deviation	2	
	14	Mean deviation	3	
	15	Standard deviation	3	
	16	Coefficient of variation	1	
	17	Coefficient of dispersion	3	
	Sections from References: Unit 9,10&11: 2.10,2.11[Ref 1] Unit 12,13,14&15: 2.12,2.13[Ref 1] Unit 16&17: 2.14[Ref 1]			
IV	**Introduction to R programming**		**8**	**15**
	18	Installation & Basic Mathematical Operations	2	
	19	R Preliminaries, Methods of Data Input	2	
	20	Graphical Representations (R Code)	2	
	21	Diagrammatic Representations (R Code)	1	
	22	Descriptive Measures (Mean, Median, Mode)	1	
	Sections from References: Unit 18&19: 1.2&1.3 [Ref 2] Unit 20: 1.4 [Ref 2] Unit 21: 1.5&1.6 [Ref 2] Unit 22: 1.8,2.3 [Ref 2]			
V	**PRACTICUM**		**30**	
		Do practice problems in R Software from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course. 1. Basic mathematical operations 2. Frequency distributions for organizing and summarizing data 3. Histogram 4. Frequency curve		

		5. Pie diagram 6. Arithmetic mean 7. Median 8. Mode		
	Sections from References: Unit 1: 1.8 Ref[2] Unit 2: 1.9 Ref[2] Unit 3: 2.1 Ref[2] Unit 4: 2.2 Ref[2] Unit 5:2.2 Ref[2] Unit 6: 2.3 Ref[2] Unit 7: 2.3 Ref[2] Unit 8: 2.3 Ref[2]			

Books and References:

1. Gupta, S. C. and Kapoor, V. K. (2020). Fundamentals of Mathematical Statistics, 12th edition, Sulthan Chand, New Delhi.

2. Sudha G Purohith, Sharad D Core, Shailaja R Deshmukh (2015), Statistics Using R.

3. Gupta, S. C.(2015). Fundamentals of Statistics, Himalaya Publishing House.

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	-	-	-	-	2	-	-	-	-	-	2
CO 2	-	2	-	3	1	-	-	-	1	-	-	-
CO 3	-	-	2	-	-	1	-	-	2	-	3	-
CO 4	1	2	-	-	-	-	2	-	-	-	-	-

CO 5	-	-	-	-	-	2	-	3	-	-	-	-
CO 6	-	1	-	-	-	3	-	-	-	2	-	3

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	BSc Statistics				
Course Code	STA2MN111 (P)				
Course Title	Statistical modeling and sampling techniques				
Type of Course	Minor				
Semester	II				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Knowledge of fundamental statistics including measures of central tendency and dispersion. Basic knowledge of computer.				
Course Summary	Equip students with the theoretical foundation and practical skills necessary for understanding and applying statistical methods related to moments, measures of skewness and kurtosis, fitting different types of curves, analyzing relationships between variables through correlation and regression, understanding sampling techniques, and utilizing R programming for data computation and visualization.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Define and calculate moments of a distribution and understand their significance in describing the shape and characteristics of data.	U	C	Instructor-created exams / Quiz
CO2	Fit various types of curves including straight lines, parabolas, and exponentials to data sets for modeling and prediction purposes and analyze data to help entrepreneurial decisions using critical thinking skills.	U	F	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO3	Construct scatter diagrams and assess the strength and direction of relationships between variables using correlation and critically evaluate ethical implications of statistical methods aligning with human values.	U	C	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Determine sample size requirements and assess sampling errors in the context of survey design and analysis.	U	C	Instructor-created exams / Home Assignments
CO5	Calculate correlation coefficient using R software and interpret their strength and direction.	Ap	P	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Implement R programming for computing and visualizing univariate and bivariate data using box plots, bar plots, pie diagrams, and scatter plots.	Ap	P	Viva Voce/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**Skewness and Kurtosis**	**9**	**15**

	1	Skewness, Kurtosis definitions and different types	2	
	2	Pearson's coefficient of skewness	2	
	3	Bowley's coefficient of skewness	2	
	4	Percentile coefficient of kurtosis	3	
	Sections from References: Unit 1:3.13 Ref[2] Unit 2: 3.14 Ref[2] Unit 3: 3.13 Ref[2] Unit 4: 3.14 Ref[2]			
II	**Sampling Theory**		**9**	**15**
	5	Sample size, sampling errors, methods of sampling. Census and Sampling, principal steps in sample survey	2	
	6	organization and execution of large sample surveys, sampling and non-sampling errors	3	
	7	preparation of questionnaire	2	
	8	Simple random sampling, Stratified random sampling, Systematic Sampling	2	
	Sections from References: Unit 5: 15.2-15.8 [Ref 2] Unit 6&7: 15.9-15.10[Ref 2] Unit 8: 15.11-15.13 [Ref 2]			
III	**Correlation and Regression**		**19**	**25**
	9	Fitting a straight line	2	
	10	Fitting a Parabola	2	
	11	Scatter diagram	1	
	12	Correlation, Types of correlation	3	
	13	Pearson's coefficient of correlation	3	
	14	Spearman's rank correlation	3	
	15	Regression	1	
	16	Linear regression	1	
	17	Properties of regression lines	3	
	Sections from References: Unit 9: 10.3 [Ref 2] Unit 10&11: 10.2 [Ref 2] Unit 12: 10.4 [Ref 2] Unit 13&14: 10.7[Ref 2] Unit 15: 11.1[Ref 2] Unit 16&17: 11.2[Ref 2]			
IV	**R programming**		**8**	**15**
	18	Range	2	
	19	Inter Quartile Range	2	
	20	Standard Deviation	2	
	21	Pearson's correlation	1	
	22	Loops- Brief explanation	1	

<table>
<tr><td></td><td colspan="2">Sections from References:
Unit 18&19: 2.1-2.3[Ref 3]
Unit 20: 7.5 [Ref 1]
Unit 21: 6.2 [Ref 1]
Unit 22: 7.3 [Ref 1]</td><td></td><td></td></tr>
<tr><td rowspan="2">V</td><td colspan="2">PRACTICUM</td><td>30</td><td></td></tr>
<tr><td></td><td>Do practice problems in R software from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course.

1. Range
2. Mean Deviation
3. Quartile Deviation
4. Standard Deviation
5. Variance
6. Covariance
7. Correlation
8. Rank correlation</td><td></td><td></td></tr>
<tr><td></td><td colspan="2">Sections from References:
Unit 1,2: 2.1 [Ref 3]
Unit 3: 2.2 [Ref 3]
Unit 4,5: 2.3 [Ref 3]
Unit 6,7,8: 6.2-7.5 [Ref 2]</td><td></td><td></td></tr>
<tr><td colspan="5">Books and References:
1. Douglas, Alex, Deon Roos, Francesca Mancini, Ana Couto, and David Lusseau. (2020), An Introduction to R. https://intro2r.com/index.html.
2. Gupta, S.C. and Kapoor, V.K. (1997) Fundamentals of Mathematical Statistics. Sultan Chand and Sons, New Delhi
3. Sudha G Purohith, Sharad D Core, Shailaja R Deshmukh (2015), Statistics Using R.</td></tr>
</table>

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	1	-	-	-	-	3	-	-	-	-	-

CO 2	2	-	-	-	-	-	-	-	-	2	2	-
CO 3	-	-	-	2	-	-	-	-	-	-	-	3
CO 4	-	-	-	-	-	3	-	2	-	-	-	-
CO 5	-	2	-	1	3	-	-	2	3	-	-	-
CO 6	-	-	2	-	-	2	-	-	-	3	2	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4		✓		✓

CO 5	✓	✓		✓
CO 6	✓			

Programme	BSc Statistics				
Course Code	STA3MN211 (P)				
Course Title	Probability theory and statistical distributions				
Type of Course	Minor				
Semester	III				
Academic Level	200 – 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Familiarity with basic calculus such as differentiation and integration, basic knowledge of set theory. Experience with basic data visualization techniques.				
Course Summary	Provide students with a solid foundation in probability theory, including classical and axiomatic approaches, conditional probability, random variables, probability distributions and their applications.				

Course Outcomes (CO):

CO	CO Statement	Cognitive	Knowledge	Evaluation

		Level*	Category#	Tools used
CO1	Calculate probabilities of events using classical probability rules and understand their limitations.	U	C	Instructor-created exams / Quiz
CO2	Determine marginal probabilities and identify their role in joint probability distributions.	R	C	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO3	Define random variables and distinguish between discrete and continuous random variables and analyze data to help entrepreneurial decisions using critical thinking skills.	R	F	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Understand the significance of probability distributions in statistical analysis and critically evaluate ethical implications of statistical methods aligning with human values.	U	C	Instructor-created exams / Home Assignments
CO5	Apply discrete and continuous probability distributions and understand their properties and applications.	Ap	F	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Perform computations involving probabilities and using Rprogramming language.	Ap	P	Viva Voce/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Module	**Unit**	**Content**	**Hrs (45 +30)**	**Marks (70)**
I		**Probability**	**9**	**15**
	1	Basic concepts of Probability ,Classical definition of Probability ,Axiomatic approach to Probability	2	
	2	Addition Theorem, Multiplication Theorem	3	

	3	Conditional Probability	2	
	4	Independence of events	2	
	Sections from References: Unit 1: 3.3-3.8 [Ref 1] Unit 2: 3.9,3.11 [Ref 1] Unit 3: 3.10[Ref 1] Unit 4: 3.11-3.15 [Ref 1]			
II	**Random Variables**		**9**	**15**
	5	Random Variables, Discrete and continuous random variables	2	
	6	Probability distribution , Distribution function (Applications in discrete case)	3	
	7	Mathematical expectation (Applications in discrete case)	2	
	8	Variance (Applications in discrete case)	2	
	Sections from References: 4. Unit 5&6: 5.1-5.4.2 [Ref 1] 5. Unit 7: 6.1-6.4 [Ref 1] 6. Unit 8: 6.6 [Ref 1]			
III	**Discrete and Continuous distributions**		**19**	**25**
	9	Binomial distribution (Definition and problems)	2	
	10	Poisson distribution (Definition and problems)	2	
	11	Normal distribution (Definition and problems)	1	
	12	Properties of Normal distribution	3	
	13	Uniform distribution (Definition and properties)	3	
	14	Exponential distribution (Definition and properties)	3	
	15	Gamma distribution (Definition and properties)	1	
	16	Beta distribution (Definition and properties)	1	
	17	Cauchy, Pareto distribution (Definition only)	3	
	Sections from References: Unit 9:14.2 [Ref 2] Unit 10:14.3[Ref 2] Unit 11:14.4 [Ref 2] Unit 12:14.5 [Ref 2] Unit 13:14.6[Ref 2] Unit 14:14.7 [Ref 2] Unit 15:14.8 [Ref 2] Unit 16&17:14.9[Ref 2]			
IV	**R programming**		**8**	**15**
	18	R as a set of statistical tables	2	
	19	cumulative distribution	2	
	20	probability density function	2	
	21	plotting probability curves for standard discrete distributions.	1	
	22	plotting probability curves for standard continuous distributions	1	
	Sections from References:			

	Unit 18: 3.3 [Ref 3] Unit 19: 3.3 [Ref 3] Unit 20: 3.3 [Ref 3] Unit 21:3.4&3.5 [Ref 3] Unit 22: 3.4 [Ref 3]		
V	**PRACTICUM**	**30**	
	Do practice problems in R software from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Otherunits listed here may be used as demonstrations of the concepts taught in the course. 1. Graph of Binomial distribution 2. Graph of Poisson distribution 3. Graph of Normal distribution 4. Graph of Uniform distribution 5. Graph of Exponential distribution 6. Graph of Gamma distribution 7. Graph of Beta distribution 8. Graph of Cauchy distribution		
	Sections from References: Unit 1,2: 3.3 [Ref 3] Unit 3,4,5: 3.4 [Ref 3] Unit 6,7,8: 3.5 [Ref 3]		

Books and References:

1. Gupta, S. C. and Kapoor, V. K. (2020). Fundamentals of Mathematical Statistics, 12th edition, Sulthan Chand, New Delhi
2. Gupta, S. C.. (2015). Fundamentals of Statistics, Himalaya Publishing House
3. Sudha G Purohith, Sharad D Core, Shailaja R Deshmukh ,Statistics Using R(2015)

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	2	-	-	-	-	1	-	-	-	-	-
CO 2	-	-	-	-	1	-	-	1	-	1	-	-
CO 3	-	-	-	2	-	-	-	-	-	-	3	

CO 4	-	-	-	-	-	1	-	-	-	-	-	2
CO 5	-	3	-	1	-	-	-	-	2	-	-	-
CO 6	-	-	1	-	2	3	-	-	-	-	3	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4		✓		✓
CO 5	✓	✓		✓

CO 6	✓			

MINOR COURSES IN ACTUARIAL SCIENCE

SYLLABUS

Programme	BSc Statistics				
Course Code	ACT1MN101 (P)				
Course Title	Actuarial mathematics I				
Type of Course	Minor				
Semester	I				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic knowledge of rates of interest, arithmetic skills, Basic computer skills				
Course Summary	The aim of this course is to provide a grounding in the principles of modelling as applied to actuarial work				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Describe how to use a generalized cash flow model in financial transaction.	U	F	Instructor-created exams / Quiz
CO2	Apply different kinds of interest rates	Ap	P	Instructor-creat

	expressed in different time periods			ed exams / Home Assignments
CO3	Recall and use the more important compound interest functions including annuities certain.	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Describe how a loan may be repaid by regular instalments of interest and capital.	U	C	Instructor-created exams / Home Assignments
CO5	Recall how to take into account time value of money using the concepts of compound interest and discounting.	R	P	One Minute Reflection Writing assignments
CO6	Solving cash flow models with sample data with spread sheet	Ap	P	Viva-Voce/Practical Assignment
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hours (45 +30)	Marks (70)
I		**Cash flow models**	**8**	**10**
	1	Cash flow process, Examples of cash flow scenarios	2	
	2	A zero-coupon bond, A fixed interest security	2	
	3	An index-linked security, Cash on deposit	2	
	4	An equity, An “interest-only” loan, A repayment loan (or mortgage)	2	
	Sections from References: Unit 1: 3.1,3.2 [Ref 1] Unit 2: 3.2.1,3.2.2 [Ref 1] Unit 3: 3.2.3,3.2.4 [Ref 1] Unit 4: 3.2.5,3.2.7,3.2.8 [Ref 1]			
II		**The time value of money**	9	**15**
	5	Interest, Simple interest, Compound (effective) interest	2	
	6	Accumulation factors, The principle of	2	

		consistency, Present values		
	7	Discount rates, Simple discount, Compound (effective) discount, Discount factors, Effective rates of interest and discount	3	
	8	Equivalent rates	2	
	Sections from References: Unit 5: 4.1,4.1.1,4.1.2, [Ref 1] Unit 6: 4.1.3,4.1.4,4.2 [Ref 1] Unit 7: 4.3(4.3.1 to 4.3.3),4.4 - [Ref 1] Unit 8: 4.5- [Ref 1]			
III		**Interest Rates**	**12**	**25**
	9	Nominal rates of interest	2	
	10	Accumulating and discounting using nominal interest rates	2	
	11	Nominal rate of discount	2	
	12	Accumulating and discounting using nominal discount rates	2	
	13	The force of interest(Concept only)	1	
	14	Accumulating and discounting using the force of interest	2	
	15	Relationship between force of interest, effective rate of interest, effective rate of discount, and present value function, v.	1	
	Sections from References: Unit 9: 5.1,5.1.1([Ref 1] Unit 10: 5.1.2 [Ref 1] Unit 11: 5.1.3 [Ref 1] Unit 12: 5.1.4 [Ref 1] Unit 13: 5.2 [Ref 1] Unit 14: 5.2.2 [Ref 1] Unit 15: 5.2.2 [Ref 1]			
IV		**Level annuities and Equations of values**	16	**20**
	16	Present values, Payments made in arrear, Payments made in advance	2	
	17	Accumulations of annuities	2	
	18	Continuously payable annuities	3	
	19	Annuities payable pthly- Accumulations	2	
	20	Perpetuities, Perpetuities payable pthly, Deferred annuities	2	
	21	Equations of value, Solving for an unknown quantity	2	
	22	Solving for the timing of a payment (n), Solving	3	

		for the interest rate (i)		
	Sections from References: Unit 16: 8.1(8.1.1 to8.1.2) [Ref 1] Unit 17: 8.2 [Ref 1] Unit 18: 8.3[Ref 1] Unit 19: 8.4 (8.4.1 to 8.4.2) [Ref 1] Unit 20: 8.6,8.7,8.7.1[Ref 1] Unit 21: 10.1&10.1.2[Ref 1] Unit 22: 10.1.2 [Ref 1]			
V	**PRACTICUM**		**30**	
	Do practice problems in spreadsheet from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course.			
	1	Simple interest and compound interest		
	2	Present value		
	3	Accumulated value		
	4	Force of interest		
	5	Annuities		
	6	Relationship between various interest rates		
	7	Perpetuity		
	8	Equations of values		

Books and References:

6. Institute of Actuaries Act Ed. Study materials CM1
7. McCutcheon, J.J., Scott William (1986): An introduction to Mathematics of Finance
8. Butcher,M.V., Nesbit, Cecil. (1971)Mathematics of compound interest, Ulrich's Books
9. David Promislow, S. (2014), Fundamentals of Actuarial Mathematics, John wiley& sons.
10. Newton LBowers, et al (1997):Actuarial Mathematics, The Societies of Actuaries, 2nd Ed
11. Shailaja R. Deshmukh- Actuarial Statistics-an introduction using R, 3rd Ed.

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	1	3	1	1	-	2	-	3	-	-	-
CO 2	3	3	1	2	1	-	3	1	2	1	-	-
CO 3	1	2	-	2	-	-	2	-	2	-	-	-
CO 4	3	2	-	1	-	-	3	-	2	2	-	-

CO 5	3	2	-	-	-	-	3	-	2	-	-	-
CO 6	1	1	2	-	3	3	2	2	1	-	2	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	✓

Programme	BSc Statistics				
Course Code	ACT2MN101 (P)				
Course Title	Actuarial mathematics II				
Type of Course	Minor				
Semester	II				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic knowledge of present value, probability, mean and variance, Basic computer skills				
Course Summary	The aim of this course is to expose the students about Life and Health Contingencies.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	To demonstrate the life table functions and select mortality.	An	C	Instructor-created exams / Quiz
CO2	To explain the life assurance contract and benefits.	U	C	Instructor-created exams / Home Assignments
CO3	Develop formulae for the means and	Ap	P	Seminar

	variances of the payments under various assurance and annuity contracts			Presentation / Group Tutorial Work
CO4	Define various annuity contracts.	U	C	Instructor-created exams / Home Assignments
CO5	Summarize various Joint life and last survivor functions	R	F	One Minute Reflection Writing assignments
CO6	Solving life and health contingencies with sample data with spread sheet	Ap	P	Viva-Voce/Practical Assignment
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hours (45 +30)	Marks (70)
I		**The life table**	**12**	**20**
	1	Life table, Constructing a life table	3	
	2	The force of mortality, Lifetime random variables, The pattern of human mortality	2	
	3	Life table functions at non-integer ages, uniform distribution of deaths (UDD), constant force of mortality (CFM)	4	
	4	Evaluating probabilities without use of the life table	1	
	5	Select mortality, Mortality rates that depend on both age and duration	2	
	Sections from References: Unit 1: 15.0&15.2 (15.2.1 to 15.2.2) [Ref 1] Unit 2: 15.2.3,15.2.6,15.2.7 [Ref 1] Unit 3: 15.3 (15.3.1 to 15.3.3) [Ref 1] Unit 4: 15.4 [Ref 1] Unit 5: 15.5,15.5.1, 15.5.2 [Ref 1]			
II		**Life assurance contracts**	**13**	**20**
	6	Whole life assurance contracts, Term assurance contracts	4	

	7	Pure endowment contracts, Endowment assurance contracts, Deferred assurance benefits	4	
	8	Benefits payable immediately on death (Whole life assurance, Term assurance, Endowment assurance)	3	
	9	Evaluating means and variances using select mortality.	2	
	Sections from References: Unit 6: 16.1 (16.1.1 to 16.1.3), 16.2 (16.2.1 to 16.2.3) [Ref 1] Unit 7: 16.3(16.3.1 to 16.3.3), 16.4 (16.4.1 to 16.4.3), 16.5(16.5.1, 16.5.2) [Ref 1] Unit 8: 16.6(16.6.1 to 16.6.4) - [Ref 1] Unit 9: 16.7- [Ref 1]			
III	**Life annuity contracts**		**11**	**15**
	10	Life annuity contracts, Whole life annuities payable annually in arrears	2	
	11	Whole life annuities payable annually in advance	1	
	12	Temporary annuities payable annually in arrears	1	
	13	Temporary annuities payable annually in advance	2	
	14	Deferred annuities, Deferred annuities-due	3	
	15	Continuous annuities , Other annuities	2	
	Sections from References: Unit 10: 17.1,17.2(17.2.1 to 17.2.3) [Ref 1] Unit 11: 17.3 (17.3.1 to 17.3.2) [Ref 1] Unit 12: 17.4 (17.4.1 to 17.4.2) [Ref 1] Unit 13: 17.5(17.5.1 to 17.5.2) [Ref 1] Unit 14: 17.6(17.6.1 to 17.6.2), 17.7 [Ref 1] Unit 15: 17.10,17.10.1, 17.10.2 [Ref 1]			
IV	**Joint life and last survivor functions**		9	**15**
	16	Random variables to describe joint life functions	1	
	17	Joint lifetime random variables and joint life table functions	2	
	18	Last survivor lifetime random variables	1	
	19	Simple probabilities involving two lives	1	
	20	Evaluating last survivor functions	1	
	21	Present values involving two lives	2	
	22	Present values of joint life and last survivor annuities	1	
	Sections from References: Unit 16: 22.1(22.1.1 to 22.1.2) [Ref 1] Unit 17: 22.1.3 [Ref 1]			

	Unit 18: 22.1.4[Ref 1] Unit 19: 22.2,22.2.1 [Ref 1] Unit 20: 22.2.2 [Ref 1] Unit 21: 22.3 & 22.3.1[Ref 1] Unit 22: 22.3.2 [Ref 1]		
V	**PRACTICUM**	**30**	
	Do practice problems in spreadsheet from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course.		
	1 Life table using ultimate mortality		
	2 Select mortality		
	3 UDD and CFM assumption		
	4 Mean and variance of whole life assurance		
	5 Term assurance and endowment assurance		
	6 Life annuity contracts		
	7 Joint life functions		
	8 Last survivor functions		

Books and References:

1. Institute of Actuaries Act Ed. Study materials CM1
2. Dickson, Mary R. Hardy and Howard R.Waters (2019), Actuarial Mathematics for Life Contingent Risks , Cambridge University Press, India
3. McCutcheon, J.J., Scott William (1986): An introduction to Mathematics of Finance
4. Butcher,M.V., Nesbit, Cecil. (1971)Mathematics of compound interest, Ulrich's Books
5. David Promislow, S. (2014), Fundamentals of Actuarial Mathematics, John wiley& sons.
6. Newton LBowers, et al (1997):Actuarial Mathematics, The Societies of Actuaries, 2nd Ed
7. Shailaja R. Deshmukh- Actuarial Statistics-an introduction using R, 3rd Ed.

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	3	1	2	2	-	2	-	2	-	-	-
CO 2	3	3	1	2	1	-	3	1	2	3	-	-
CO 3	1	2	-	2	2	-	2	-	2	-	-	-
CO 4	3	2	1	1	-	-	3	-	2	2	-	-
CO	3	2	-	-	-	-	3	-	2	-	-	-

5												
CO 6	1	1	2	-	3	3	2	2	1	-	2	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	✓

Programme	BSc Statistics				
Course Code	ACT3MN201 (P)				
Course Title	Risk modeling and survival analysis				
Type of Course	Minor				
Semester	III				
Academic Level	200 – 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic knowledge of life table, probability, Basic computer skills				
Course Summary	The aim of this course is to provide a grounding in mathematical and statistical modelling techniques that are of particular relevance to actuarial work, including survival models and their application.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Describe and apply techniques of survival analysis	Ap	P	Instructor-created exams / Quiz
CO2	Describe Apply compound distributions in risk modelling.	Ap	P	Instructor-created exams / Home Assignments
CO3	Understand the concept of reinsurance	U	C	Seminar Presentation / Group Tutorial Work

CO4	Memorize the basic concepts of ruin theory.	R	C	Instructor-created exams / Home Assignments
CO5	Understand the basics of Machine Learning	U	F	One Minute Reflection Writing assignments
CO6	Solving survival models with sample data with spread sheet	Ap	P	Viva-Voce/Practical Assignment
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hours (45 +30)	Marks (70)
I		**Survival models-I**	**13**	**20**
	1	Survival models, Future lifetime, Probabilities of death and survival	3	
	2	The force of mortality, Survival probabilities	1	
	3	The probability density function of Tx, Life table functions, Initial and central rates of mortality	3	
	4	Expected future lifetime, Complete expectation of life, Curtate expectation of life, Some important formulae	3	
	5	Simple parametric survival models, The Gompertz and Makeham laws of mortality, Survival probabilities	3	
	Sections from References: Unit 1: 6.1 (6.1.1 to 6.1.2) [Ref 1] Unit 2: 6.1.3&6.1.4 [Ref 1] Unit 3: 6.1.5,6.1.6,6.1.7 [Ref 1] Unit 4: 6.2,6.2.1,6.2.2, 6.3 [Ref 1] Unit 5: 6.4, 6.5, 6.5.2 [Ref 1]			
II		**Risk Models- I**	**12**	**20**
	6	General features of a product, Models forshort-term insurance contracts	2	
	7	The collective risk model, The basic model, Notation and assumptions	1	
	8	Distribution functions and convolutions	2	

	9	Moments of compound distributions, The compound Poisson distribution,	3	
	10	The compound binomial distribution	2	
	11	The compound negative binomial distribution	2	
	Sections from References: Unit 6: 19.1(19.1.1 to 19.1.2), 19.2 [Ref 1] Unit 7: 19.3, 19.3.1 [Ref 1] Unit 8: 19.3.2 [Ref 1] Unit 9: 19.3.3,19.3.4 [Ref 1] Unit 10: 19.3.5 [Ref 1] Unit 11: 19.3.6 [Ref 1]			
III	**Reinsurance & Risk Models- II**		**11**	**18**
	12	Reinsurance and its types	1	
	13	Reinsurance arrangements, Excess of loss reinsurance(concept only), proportional reinsurance (concept only)	2	
	14	The individual risk model	2	
	15	Ruin theory, Basic concepts	2	
	16	The surplus process	2	
	17	The probability of ruin in continuous & discrete time	2	
	Sections from References: Unit 12: 18.0 [Ref 1] Unit 13: 18.1,18.1.1,18.1.3 [Ref 1] Unit 14: 20.2 [Ref 1] Unit 15: 8.1 [Ref 2] Unit 16: 8.1.2 [Ref 2] Unit 17: 8.1.3 & 8.1.4 [Ref 2]			
IV	**Machine learning**		**9**	**12**
	18	What is machine learning?	1	
	19	An overview of machine learning	2	
	20	Concepts in machine learning- The loss function, Model evaluation, Generalisation error and model validation, Train- validation- test	2	
	21	Branches of machine learning	2	
	22	Stages of Analysing Machine learning	2	
	Sections from References: Unit 18: 21.1 [Ref 1] Unit 19: 21.2 [Ref 1] Unit 20: 21.3(21.3.1 to 21.3.4)[Ref 1] Unit 21: 21.4 [Ref 1] Unit 22: 21.5 (21.5.1 to 21.5.9)[Ref 1]			

V	**PRACTICUM**	**30**	
	Do practice problems in spreadsheet from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course.		
	1 Survival probabilities		
	2 Expectation of life		
	3 Laws of mortality		
	4 Life table functions		
	5 Compound Poisson distribution		
	6 Compound binomial distribution		
	7 Distribution function		
	8 Surplus process		

Books and References:

1. Institute of Actuaries Act Ed. Study materials CS2.
2. Institute of Actuaries Act Ed. Study materials CT6.
3. Denuit,M., Marechal, X., Pitrebois, S., Walhin, J.F. (2007). Actuarial Modelling of claim counts: Risk classification, credibility and bonus-malus systems. John Wiley & Sons
4. Bowers, Newton Let al (1997): Actuarial mathematics, society of Actuaries, 2nd Ed
5. Benjamin,B; Pollard, J.H. (1993).The analysis of mortality and other actuarial Statistics: (3^{rd} Ed). Institute and faculty of Actuaries
6. Shailaja R. Deshmukh- Actuarial Statistics-an introduction using R, 3^{rd} Ed.
7. Daykin C.D, Pentikainen T. , Pesonen M.: Practical Risk theory for Actuaries (1194). Chapman& Hall.

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	3	1	2	1	-	2	-	2	-	-	-
CO 2	3	3	2	2	1	-	3	1	2	3	-	-
CO 3	1	2	-	3	-	-	2	-	2	-	-	-
CO 4	3	2	-	2	1	-	3	-	2	2	-	-
CO 5	3	2	-	-	-	-	3	-	2	-	-	-
CO	1	1	2	-	3	3	2	2	1	-	2	2

6												

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	✓

Programme	BSc Statistics				
Course Code	ACT1MN102 (P)				
Course Title	Financial Mathematics				
Type of Course	Minor				
Semester	I				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic knowledge of rates of interest, arithmetic skills, Basic computer skills				
Course Summary	The aim of this course is to provide a grounding in the principles of modelling as applied to actuarial work				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Describe the possible aims of data analysis	U	F	Instructor-created exams / Quiz
CO2	Explain the meaning and value of reproducible research and describe the elements required to ensure a data analysis is reproducible.	U	P	Instructor-created exams / Home Assignments
CO3	Describe why and how models are used including, in general terms, the use of models for pricing, reserving and capital modelling.	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Apply force of interest in various financial transaction.	An	C	Instructor-created exams / Home

				Assignments
CO5	Describe how a loan may be repaid by regular instalments of interest and capital.	Ap	P	One Minute Reflection Writing assignments
CO6	Solving cash flow models with sample data with spread sheet	Ap	P	Viva-Voce/Practical Assignment
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hours (45 +30)	Marks (70)
I		**Data Analysis**	**8**	**10**
	1	Aims of data analysis- Descriptive, inferential and predictive	2	
	2	The data analysis process	2	
	3	Data Sources, Big data	2	
	4	Data security privacy and regulation , Reproducible research	2	
	Sections from References: Unit 1: 1.1&1.1.1 to 1.1.3 [Ref 1] Unit 2: 1.2 [Ref 1] Unit 3: 1.3&1.3.1[Ref 1] Unit 4: 1.3.2&1.4 [Ref 1]			
II		**Principles of actuarial modelling**	**11**	**15**
	5	Model, How models are used, Modelling – the benefits and limitations	2	
	6	Stochastic and deterministic models, Discrete and continuous state spaces and time sets	2	
	7	Scenario-based and proxy models, Suitability of a model, Short-term and long-term properties of a model	3	
	8	Analysing the output of a model, Sensitivity testing, Communication of the results	2	
	9	Insurance contracts- Pure endowment, Endowment, term, contingent annuity, a car insurance policy, a health cash plan	2	

	Sections from References: Unit 5: 2.1,2.1.2 &2.2 [Ref 1] Unit 6: 2.3,2.4 [Ref 1] Unit 7: 2.5,2.6&2.7 [Ref 1] Unit 8: 2.8,2.9 & 2.10 [Ref 1] Unit 9: 3.1 (3.1.1 to 3.1.6) [Ref 1]			
III		**Real and Money interest rates**	**12**	**25**
	10	Real and Money interest rates	2	
	11	Deflationary conditions, Usefulness of real and money interest rates	2	
	12	Force of interest as a function of time	3	
	13	Relationship to constant force of interest, Applications of force of interest.	2	
	14	Present values of cash-flows	1	
	15	Payment streams, Sudden changes in interest rates	2	
	Sections from References: Unit 10: 6.1 ([Ref 1] Unit 11: 6.2 & 6.3[Ref 1] Unit 12: 5.4 [Ref 1] Unit 13: 5.4.2 [Ref 1] Unit 14: 7.1 [Ref 1] Unit 15: 7.2.2 & 7.2.3 [Ref 1]			
IV		**Loan Schedule & Varying annuities**	**14**	**20**
	16	Introduction, Calculating the capital outstanding	2	
	17	calculating the interest and capital elements	3	
	18	The loan schedule	1	
	19	Instalments payable more frequently than annually.	2	
	20	The consumer credit-APR	2	
	21	Varying annuities- Annual payments	3	
	22	Decreasing payments	1	
	Sections from References: Unit 16: 11.1&11.2 [Ref 1] Unit 17: 11.3 [Ref 1] Unit 18: 11.4[Ref 1] Unit 19: 11.5 [Ref 1] Unit 20: 11.6[Ref 1] Unit 21: 9.1.1[Ref 1] Unit 22: 9.1.3 [Ref 1]			
V		**PRACTICUM**	**30**	
	Do practice problems in spreadsheet from any 5 units of the given list and one additional problem decided by the			

	teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course.			
	1	Real and money interest rates		
	2	Present value of cash-flows		
	3	Payment streams		
	4	Relationship to constant force of interest		
	5	Loan schedule –preparation of loan amortization table		
	6	Loan schedule-Capital and interest calculations		
	7	APR		
	8	Flat rate of interest		

Books and References:

12. Institute of Actuaries Act Ed. *Study materials* CM1
13. McCutcheon, J.J., Scott William (1986): An introduction to Mathematics of Finance
14. Butcher,M.V., Nesbit, Cecil. (1971)Mathematics of compound interest, Ulrich's Books
15. David Promislow, S. (2014), Fundamentals of Actuarial Mathematics, John wiley& sons.
16. Newton LBowers, et al (1997):Actuarial Mathematics, The Societies of Actuaries, 2nd Ed
17. Shailaja R. Deshmukh- Actuarial Statistics-an introduction using R, 3rd Ed.

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	3	1	3	-	-	1	-	2	2	-	-
CO 2	3	2	-	2	1	-	3	1	2	3	-	-
CO 3	1	2	-	2	-	-	2	-	2	-	-	-
CO 4	3	2	-	1	-	-	3	-	2	2	-	-
CO 5	3	2	-	-	-	-	3	-	2	-	-	-
CO 6	1	1	2	-	3	3	2	2	1	-	2	1

Correlation Levels:

Lev	**Correlation**

el	
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignm ent	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	✓

Programme	BSc Statistics				
Course Code	ACT2MN102 (P)				
Course Title	Actuarial Economics				
Type of Course	Minor				
Semester	II				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic knowledge of economic concepts				
Course Summary	The aim of this course is to provide the theoretical and practical understanding of the economic concepts and theories				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Assess the main strands of economic thinking.	An	P	Instructor-created exams / Quiz
CO2	Describe the factors that influence market demand and supply	U	F	Instructor-created exams / Home Assignments
CO3	Discuss how markets react to changes in demand and supply.	U	C	Seminar Presentation / Group Tutorial Work
CO4	Define and calculate price and income elasticities of demand and price elasticity of supply.	Ap	P	Instructor-created exams / Home Assignments
CO5	Remember the concept of marginal utility.	R	C	One Minute Reflection Writing assignments
CO6	Solving market economy with sample	Ap	P	Viva-Voce/Prac

	data with spread sheet			tical Assignment
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hours (45 +30)	Marks (70)
I		**Economic concepts and systems**	**10**	**15**
	1	What economists study, Problem of scarcity, Economic choices	2	
	2	Business economics, Introduction to microeconomics and Microeconomic, Production possibility curve	2	
	3	Main strands of economic thinking	2	
	4	The classical approach, Marxist socialism, Keynesian schools of thought: Neo-Keynesians, Post-Keynesians and New-Keynesians	2	
	5	The monetarist approach- The new classical approach, The Austrian School	2	
	Sections from References: Unit 1: 15.0&15.2 (15.2.1 to 15.2.2) [Ref 1] Unit 2: 15.2.3,15.2.6,15.2.7 [Ref 1] Unit 3: 15.3 (15.3.1 to 15.3.3) [Ref 1] Unit 4: 15.4 [Ref 1] Unit 5: 15.5,15.5.1, 15.5.2 [Ref 1]			
II		**Demand and Supply**	**13**	**20**
	6	Relationship between demand and price	4	
	7	The demand curve, Determinants of demand , Movements along and shifts in the demand curve	4	
	8	Supply: Supply and price, Supply curve , Determinants of supply, Movements along and shifts in the supply curve	3	
	9	Price and output determination: Equilibrium price and output, Movement to a new equilibrium, Incentives in markets	2	
	Sections from References: Unit 6: 16.1 (16.1.1 to 16.1.3), 16.2 (16.2.1 to 16.2.3) [Ref 1]			

	Unit 7: 16.3(16.3.1 to 16.3.3), 16.4 (16.4.1 to 16.4.3), 16.5(16.5.1, 16.5.2) [Ref 1] Unit 8: 16.6(16.6.1 to 16.6.4) - [Ref 1] Unit 9: 16.7- [Ref 1]			
III	**Elasticity and Uncertainty**		**11**	**20**
	10	Price elasticity of demand (PED)	2	
	11	measuring price elasticity of demand, Calculating PED using original and point method	1	
	12	Determinates of price elasticity of demand, Price elasticity of supply	1	
	13	Other elasticity: Income elasticity of demand, Cross-price elasticity of demand	2	
	14	The time dimension: Short- run and long-run adjustment, Price expectations and speculation, Dealing with uncertainty and risk, Control of prices	3	
	15	Indirect taxes and subsidies: Effect of imposing taxes, Effect of subsidizing goods	2	
	Sections from References: Unit 10: 17.1,17.2(17.2.1 to 17.2.3) [Ref 1] Unit 11: 17.3 (17.3.1 to 17.3.2) [Ref 1] Unit 12: 17.4 (17.4.1 to 17.4.2) [Ref 1] Unit 13: 17.5(17.5.1 to 17.5.2) [Ref 1] Unit 14: 17.6(17.6.1 to 17.6.2), 17.7 [Ref 1] Unit 15: 17.10,17.10.1, 17.10.2 [Ref 1]			
IV	**Consumer demand and uncertainty**		9	**15**
	16	Marginal utility theory	1	
	17	Timing of cost and benefits, indifference analysis	2	
	18	Demand under condition of risk and uncertainty	1	
	19	Utility and insurance	1	
	20	Behavioural economics	1	
	21	Prediction and cost, Meaning and types of costs	2	
	22	Production and cost in short run	1	
	Sections from References: Unit 16: 22.1(22.1.1 to 22.1.2) [Ref 1] Unit 17: 22.1.3 [Ref 1] Unit 18: 22.1.4[Ref 1] Unit 19: 22.2,22.2.1 [Ref 1] Unit 20: 22.2.2 [Ref 1] Unit 21: 22.3 & 22.3.1[Ref 1] Unit 22: 22.3.2 [Ref 1]			
V	**PRACTICUM**		**30**	

	Do practice problems in spreadsheet from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course.			
	1	Demand and price		
	2	Price elasticity of demand (PED)		
	3	Price elasticity of supply		
	4	Marginal utility		
	5	Income elasticity of demand		
	6	Cross-price elasticity of demand		
	7	Calculating PED using original and point method		
	8	Equilibrium price and output		
	Sections from References: Unit 1: 1.2 Ref [5] Unit 2: 2.1 Ref [5] Unit 3: 2.2 Ref [5] Unit 4: 3.1 Ref [5] Unit 5: 3.2 Ref [5] Unit 6: 3.3 Ref [5] Unit 7: 3.4 Ref [5] Unit 8: 3.5 Ref [5]			

Books and References:

8. Institute of Actuaries Act Ed. Study materials CB2
9. Slomon J, Wride A, Garratt D, 2018-Economics –10th edition, Pearson.
10. Sloman J, Garratt D, Guest J, Jones E, 2016- Economics for Business –7th edition, Pearson
11. Parkin, M., & Bade, R. (2007). Foundations of economics. Pearson Addison Wesley.
12. Perman, R. J., & Scouller, J. (2010). Economics of corporate and competitive strategy Oxford University Press Autralia and New Zealand.
13. Chrystal, K. A., & Lipsey, R. G. (1997). Economics for business and management. OUP Catalogue.

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	3	1	2	-	-	2	-	2	-	-	-
CO 2	3	3	-	2	1	-	3	1	2	3	-	-
CO 3	1	2	-	2	-	-	2	-	2	-	-	-
CO 4	3	2	-	1	-	-	3	-	2	2	-	-

CO 5	3	2	-	-	-	-	3	-	2	-	-	-
CO 6	1	1	2	-	3	3	2	2	1	-	3	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	✓

Programme	BSc Statistics				
Course Code	ACT3MN202 (P)				
Course Title	Life Contingencies				
Type of Course	Minor				
Semester	III				
Academic Level	200 – 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic knowledge of data, variables, charts and graphs, Basic computer skills				
Course Summary	The aim of this course is to provide a grounding in mathematical and statistical modelling techniques that are of particular relevance to actuarial work, including survival models and their application.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Calculate gross premium of assurance and annuity contracts using gross future loss random variable	Ap	P	Instructor-created exams / Quiz
CO2	Describe and calculate reserve under assurance and annuity contracts using prospective and retrospective method of valuation.	AP	P	Instructor-created exams / Home Assignments
CO3	Memorize the basic concepts of mortality profit.	R	C	Seminar Presentation / Group Tutorial Work
CO4	Define and calculate death strain at risk, expected death strain and actual death strain	An	P	Instructor-created exams / Home Assignments
CO5	Understand the basics of Multiple decrement model	U	F	One Minute Reflection Writing assignments

CO6	Analyse gross premium and reserve with sample data with spread sheet	Ap	P	Viva-Voce/Practical Assignment
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hours (45 +30)	Marks (70)
I		**Gross premiums**	11	20
	1	Gross premiums, Gross future loss random variable, Principle of equivalence	3	
	2	Determining gross premiums using the equivalence principle	2	
	3	Annual premium contracts	2	
	4	Premiums payable m times per year	2	
	5	Calculating gross premiums using simple criteria other than the equivalence principle	2	
	Sections from References: Unit 1: 20.1, 20.2 &20.3 [Ref 1] Unit 2: 20.3.2 [Ref 1] Unit 3: 20.3.5 [Ref 1] Unit 4: 20.3.7 [Ref 1] Unit 5: 20.4 [Ref 1]			
II		**Gross premium reserves**	13	20
	6	Gross premium reserves, Why hold reserves	2	
	7	Prospective reserves, Calculating gross premium prospective reserves,	3	
	8	Calculating prospective reserves that satisfy Probabilities	2	
	9	Retrospective reserves, Retrospective accumulations, Gross premium retrospective Reserve	2	
	10	Equality of prospective and retrospective reserves	2	
	11	Net premium reserves for conventional without profit contracts.	2	
	Sections from References: Unit 6: 21.0 &21.1 [Ref 1]			

	Unit 7: 21.2&21.2.1 [Ref 1] Unit 8: 21.2.2 [Ref 1] Unit 9: 21.3,21.3.1, 21.3.2 [Ref 1] Unit 10: 21.4 [Ref 1] Unit 11: 21.6 [Ref 1]			
III	**Mortality profit**		**12**	**15**
	12	Mortality profit on a single policy	2	
	13	Mortality profit on a portfolio of policies	2	
	14	Allowing for death benefits payable immediately	2	
	15	Allowing for survival benefits annuities	2	
	16	Allowing for different premium or annuity payment frequencies	1	
	17	Calculation of mortality profit for policies involving two lives.	3	
	Sections from References: Unit 12: 24.1(24.1.1 to 24.1.4) [Ref 1] Unit 13: 24.2 [Ref 1] Unit 14: 24.3 [Ref 1] Unit 15: 24.4 [Ref 1] Unit 16: 24.5 [Ref 1] Unit 17: 24.6 [Ref 1]			
IV	**Competing risks**		**9**	**15**
	18	Health insurance contracts	1	
	19	Multiple state models	2	
	20	Valuing continuous cash-flows using multiple state models	2	
	21	Designing the multiple state model	2	
	22	Multiple decrement models, Multiple decrement tables	2	
	Sections from References: Unit 18: 25.1 [Ref 1] Unit 19: 25.2 [Ref 1] Unit 20:25.2.2[Ref 1] Unit 21: 25.2.3 [Ref 1] Unit 22: 25.3&25.4[Ref 1]			
V	**PRACTICUM**		**30**	
	Do practice problems in spreadsheet from any 5 units of the given list and one additional problem decided by the teacher-in-charge, related to the content of the course. Other units listed here may be used as demonstrations of the concepts taught in the course.			
	1	Gross future loss random variable		

	2	Gross premium- Whole life		
	3	Gross premium- endowment		
	4	Annual premium contracts		
	5	Gross premium reserve		
	6	Prospective and retrospective reserve		
	7	Mortality profit		
	8	Multiple decrement tables		

Books and References:

8. Institute of Actuaries Act Ed. Study materials CM1.
9. Neill, Alistair, Heinemann, (1977): *Life contingencies.*
10. Bowers, Newton Let al (1997): Actuarial mathematics, society of Actuaries, 2nd Ed
11. Jones, H.E & Long, D.L (2005): Principles of Insurance: Life, Health and annuities. LOMA
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13. Neill, Alistair, Heinemann, (1977): *Life contingencies.*
14. Shailaja R. Deshmukh- Actuarial Statistics-an introduction using R, 3rd Ed.

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	2	2	2	-	-	2	1	2	-	-	-
CO 2	3	3	-	2	1	-	3	1	2	2	-	-
CO 3	1	2	-	2	-	-	2	-	2	-	-	-
CO 4	3	2	2	1	-	-	3	-	2	3	-	-
CO 5	3	2	-	-	-	-	3	-	2	-	-	-
CO 6	1	2	2	-	3	3	2	2	1	-	2	1

Correlation Levels:

Lev	**Correlation**

el	
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	✓

FOUNDATION COURSES IN STATISTICS

SYLLABUS

Programme	B. Sc. Statistics
Course Code	STA1FM101
Course Title	Quality Control
Type of Course	MDC
Semester	I
Academic Level	100-199

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-	-	45

Pre-requisites	HSE level Mathematics Course
Course Summary	To make students aware of Various Quality or standards in Industrial Production, Detecting, Controlling and Maintaining Quality and Total Quality Management

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Explain notion of Quality of products	U	C	Instructor-created exams / Quiz
CO2	Recall various meaning of Quality and critically evaluate ethical implications of statistical methods aligning with human values.	R	C	Quiz / Instructor-created exams
CO3	Explain causes of variation and Statistical Control and analyze data to help entrepreneurial decisions using critical thinking skills	U	F	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Construction of Control Charts and OC curves	Ap	C	Instructor-created exams / Home Assignments
CO5	Distinguish Process and Product Control	U	F	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Illustrate measures of central tendency using spread sheet.	Ap	P	Viva Voce/ Instructor-created exams

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Module	Unit	Content	Hrs (36+9)	Marks (50)
I	**Understanding Quality and Sources of Variation**		**9**	**15**
	1	Meaning of Quality. Various Aspects of Quality.		
	2	Causes of Variation, assessing within and between sample		
	3	variation using Statistical Measures		
	4	Concept of Statistical Quality Control, Process Control and Product Control		
	Sections from References:			
II	**Quantitative and Qualitative Variables**		**9**	**15**
	5	Variables and Attributes.		
	6	Concept of Control Charts for Process Control		
	7	Structure of a Control Chart		
	8	Assessment of Statistical control using control charts		
	Sections from References:			
III	**Construction of Charts**		**9**	**10**
	9	Construction of X (mean) chart		
	10	Construction of R (Range)chart		
	11	Construction of σ (Standard Deviation) chart		
	12	Construction of P (Proportion Defective) chart		
	13	Construction of np (Number of Defectives) chart		
	14	Construction of C (Number of Defects) chart.		
	Sections from References:			
IV	**Sampling Inspection Plan**		**9**	**10**
	15	Acceptance Sampling Plan		
	16	Incoming Quality and Outgoing Quality		
	17	Acceptable Quality Level, Rejectable Quality Level, LTPD		
	18	AOQ, AOQL		
	19	Errors in Sampling Inspection Plan Producers and Consumers Risk		
	Sections from References:			
V	**Open Ended Module: Spread sheet**		**9**	
	1	Exercises to compute Arithmetic Mean, Range, Standard Deviation for a set of data, Basic concepts of Probability		
	Sections from References:			
Books and References:				

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	2	-	-	-	2	2	1	-	-	-	-
CO 2	2	-	-	-	-	3	2	2	-	-	-	3
CO 3	-	-	3	-	-	2	1	-			3	
CO 4	-	-	2	2	-	-	2		2	3		
CO 5	-	-	2	2	2	-	2	3	2	-	-	-
CO 6	3	2	-	-	-	2	3	-	-	3	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

18. Quiz / Assignment/ Quiz/ Discussion / Seminar
19. Midterm Exam
20. Programming Assignments (20%)
21. Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	BSc Statistics				
Course Code	STA1FM102				
Course Title	Fundamentals of Statistics				
Type of Course	MDC				
Semester	I				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-	-	45
Pre-requisites	Basic mathematical knowledge				
Course Summary	Students will learn about different types of data, scales of measurement, and techniques for representing and summarizing data using measures of central tendency and dispersion, as well as exploring concepts of skewness and kurtosis.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Define statistics and its scope in various fields of study, including its role in decision-making.	U	C	Instructor-created exams / Quiz
CO2	Construct tables and diagrams to organize and summarize data efficiently for analysis and analyze data to help entrepreneurial decisions using critical thinking skills.	Ap	C	Instructor-created exams / Seminar Presentation
CO3	Create various types of diagrams such as bar graphs, pie charts, and histograms for visual representation of data and critically evaluate ethical implications of statistical methods aligning with human values.	Ap	F	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Compute measures of central tendency including mean, median, and mode to identify typical or central values within a data set.	Ap	C	Instructor-created exams / Home Assignments
CO5	Interpret partition values such as quartiles and percentiles to identify specific data points within a distribution.	U	F	One Minute Reflection Writing assignments/ Instructor-creat

				ed exams
CO6	Illustrate measures of central tendency and dispersion using spread sheet.	Ap	P	Viva Voce/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

COURSE CONTENT

Module		Content	Hours (36+9)	Marks (50)
1		**Introduction to Statistics**	**8**	**10**
	1	Definition of Statistics	1	
	2	Scope of Statistics	2	
	3	Concepts of statistical population and sample	2	
	4	Collection of data	3	
	Sections from References: Unit 1: 1.1&1.2 [Ref 1] Unit 2: 1.3 [Ref 1] Unit 3: 1.3 [Ref 2] Unit 4: 1.4 [Ref 2]			
2		**Organizing and Graphing Data**	**12**	**15**
	5	Types of data	3	
	6	Scale of measurements	2	
	7	Classification of data	2	
	8	Tabulation of data	2	
	9	Diagrammatic representation of data	3	
	Sections from References: Unit 5: 2.1 [Ref 2] Unit 6: 2.1 [Ref 1] Unit 7: 2.1[Ref 1] Unit 8: 2.3[Ref 2] Unit 9: 2.2 [Ref 1 and 2]			
3		**Measures of Central Tendency & Dispersion**	**11**	**15**
	10	Arithmetic Mean	2	
	11	Geometric Mean	1	
	12	Harmonic Mean	1	
	13	Median & Mode	2	

	14	Measures of Dispersion – Definition	1	
	15	Absolute Measures of Dispersion	4	
	Sections from References: Unit 10: 2.3, 2.4 & 2.5 [Ref 1] Unit 11: 2.8 [Ref 1] Unit 12: 2.9[Ref 1] Unit 13: 2.6 & 2.7[Ref 1] Unit 14: 3.1 [Ref 1] Unit 15: 3.4,3.5,3.6, & 3.7 [Ref 1]			
4	**Skewness & Kurtosis**		**5**	**10**
	16	Partition values	3	
	17	Skewness	1	
	18	Kurtosis	1	
	Sections from References: Unit 16: 2.11 [Ref 1] Unit 17: 3.13 [Ref 1] Unit 18: 3.14[Ref 1]			
5	**Open ended: practical problems Using Spreadsheet**		**9**	
	1	Frequency distributions for organizing and summarizing data	3	
	2	Measures of Central Tendency	3	
	3	Measures of Dispersion	3	
	Sections from References: Unit 1: 2.1Ref [3] Unit 2: 2.2 Ref [3] Unit 3: 3.2 Ref [3]			
	Books and References: ▪ Gupta, S. C. and Kapoor, V. K. (2002). Fundamentals of Mathematical Statistics. , 11^{th} edition, Sulthan Chand, New Delhi. ▪ Prem. S. Mann (2010). Introductory Statistics, 7th edition, Wiley ▪ Mario F Triola, Elementary Statistics using Excel, (2018), 6^{th} edition.			

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	-	1	-	2	-	2	1	-	-	-	-
CO 2	2	2	-	-	-	2	2	2	-	-	-	3
CO 3	-	-	3	-	-	-	1	-	-	-	3	-
CO 4	2	2	3	-	3	2	2	-	2	3	-	-
CO 5	-	2	-	2	2	3	2	3	2	-	-	-
CO 6	3	2	-	-	-	3	3	-	-	3	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

6. Quiz / Assignment/ Quiz/ Discussion / Seminar
7. Midterm Exam
8. Programming Assignments (20%)
9. Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	B. Sc. Statistics
Course Code	STA2FM103

Course Title	Managerial Decision Making				
Type of Course	MDC				
Semester	II				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-	-	45
Pre-requisites	HSE level Mathematics Course				
Course Summary	To make students aware of importance of managerial decisions and the use of Statistical theories in developing scientific decisions				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Explain various decision making environments in management	U	C	Instructor-created exams / Quiz/ Seminar presentation
CO2	Discuss the outcome of any payoff	R	F	Practical Assignment / Instructor-created exams
CO3	Assessing the purpose of Inventory for smooth Business operations and critically evaluate ethical implications of statistical methods aligning with human values.	U	C	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Explain the simulation of a real system	U	C	Instructor-created exams / Home Assignments
CO5	Describe the role of game theory in business and analyze data to help entrepreneurial decisions using critical thinking skills	U	F	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Define probability and discuss expected values.	R	F	Viva Voce/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Module	Unit	Content	Hrs (36+9)	Marks (50)

I		**Concepts of Decision Making**	**9**	
	1	Environment Uncertainty and Conflict		
	2	Decision Alternatives		
	3	States of Nature		
	4	Pay Off		
	5	Computation of Expected Monetary Value		
	Sections from References:			
II		**Inventory**	**9**	
	5	Inventory Management.		
	6	Need and necessity of Inventory		
	7	Parameters of Inventory management.		
	8	Economic Order Quantity with and without lead time		
	Sections from References:			
III		**Simulation of Inventory**	**9**	
	9	Simulation		
	10	Monte Carlo Method		
	11	Use of simulation in Inventory		
	12	Game theory		
	13	Strategy, Pay off, Pay off matrix,		
	14	Pure and Mixed strategies, Value of game		
	Sections from References:			
IV		**Solving games**	**9**	
	15	Minmax and Maxmin Criterions		
	16	Saddle Point and solution		
	17	Principle of Dominance		
	18	Solving 2x2 games		
	19	Graphical solution of 2xn and nx2 games		
	Sections from References:			
V		**Open Ended Module**	**9**	
	1	Basics of Matrices, Scalar and Vector multiplication, Concepts of Probability and Expected Value of Variables		
	Sections from References:			
Books and References:				

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	3	-	2	2	3	3	-	3	-	2	2
CO 2	3	-	-	-	-	-	2	-	-	-	-	2
CO 3	-	-	2	-	-	2	2	2	-	-	3	-
CO 4	-	-	3	-	-	2	2	2	-	-	3	3
CO 5	-	-	3	-	-	2	1	-	-	2	3	2
CO 6	3	2	-	-	-	3	3	3	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

6. Quiz / Assignment/ Quiz/ Discussion / Seminar
7. Midterm Exam
8. Programming Assignments (20%)
9. Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	BSc Statistics
Course Code	STA2FM104

Course Title	Statistical sampling and probability theory				
Type of Course	MDC				
Semester	II				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-	-	45
Pre-requisites					
Course Summary	Students will learn a comprehensive understanding of fundamental concepts in statistics, including data, variables, attributes, and methods of data collection and explore various types of sampling methods and understand the basics of probability theory.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Define and differentiate between data, variables, and attributes, and understand their role in statistical analysis.	U	C	Instructor-created exams / Quiz
CO2	Demonstrate proficiency in preparing questionnaires for data collection, considering factors such as clarity, relevance, and reliability and critically evaluate ethical implications of statistical methods aligning with human values..	U	F	Seminar Presentation / Instructor-created exams
CO3	Identify and describe different types of sampling methods, including simple random sampling, stratified random sampling, systematic sampling, and cluster sampling and analyze data to help entrepreneurial decisions using critical thinking skills.	R	C	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Define random experiment, sample space, and event, and understand their relevance in probability theory.	U	C	Instructor-created exams / Home Assignments
CO5	Define probability and understand its interpretation as a measure of uncertainty.	U	F	One Minute Reflection Writing assignments/ I

				nstructor-created exams
CO6	Represent how to list different types of data using any software	Ap	P	Viva Voce/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

COURSE CONTENT

Module		Content	Hours (36+9)	Marks (50)
	Basic Statistics		**10**	**10**
1	**1**	Data	2	
	2	Variables and Attributes	2	
	3	Definition of Population and Sample	3	
	4	Preparation of questionnaire for data collection	3	
	Sections from References: Unit 1: 2.1 [Ref 2] Unit 2: 1.5[Ref 2] Unit 3: 1.3 [Ref 2] Unit 4: 1 [Ref 2]			
	Census and Sampling		**6**	**10**
2	**5**	Census and Sampling	2	
	6	Principal steps in a sample survey	2	
	7	Types of sampling	1	
	8	Sampling methods	1	
	Sections from References: Unit 5: 15.2,15.3,15.6 [Ref 3] Unit 6: 15.8 [Ref 3] Unit 7:15.10[Ref 3] Unit 8:15.10[Ref 3]			
	Random Sampling Methods		**9**	**15**
3	**9**	simple random sampling with and without replacement	5	

	10	Stratified random sampling (concept only)	2	
	11	Systematic Sampling (concept only)	1	
	12	Cluster sampling (concept only)	1	
	Sections from References: Unit 9:15.11,15.11.1 [Ref 3] Unit 10: 15.12,15.12.1 [Ref 3] Unit 11: 15.13 [Ref 3] Unit 12:A2 [Ref 2]			
	Introduction to Probability		**11**	**15**
4	**13**	Random experiment	1	
	14	Sample space	1	
	15	Event	2	
	16	Statistical regularity	3	
	17	Definition of Probability	2	
	18	Concept of conditional probability of two events	2	
	Sections from References: Unit 13: 4.5.1 Ref [1] Unit 14: 4.5.1 Ref [1] Unit 15: 4.5.2 Ref [1] Unit 16: 4.5 Ref [1] Unit 17: 4.6 Ref [1] Unit 18: 4.6 Ref [1]			
5	**Open ended - Practical problems using softwares**		**9**	
	1	Data collection	**3**	
	2	Sample selection	**3**	
	3	Probability	**3**	
	Books and References: 6. Gupta, S. C. and Kapoor, V. K. (2002). Fundamentals of Mathematical Statistics. , 11^{th} edition, Sulthan Chand, New Delhi. 7. Prem. S. Mann (2010). Introductory Statistics, 7th edition, Wiley 8. Gupta, S. C. (2015). Fundamentals of Statistics, Himalaya Publishing House			

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	3	-	-	-	3	3	3	-	-	-	-
CO 2	2	2	-	-	-	2	2	2	-	-	-	3
CO 3	-	2	3	2	2	3	1	3	2	3	3	-
CO 4	3	2	-	-	-	3	3	3	-	-	-	-
CO 5	-	-	-	-	-	3	2	3	-	-	-	-
CO 6	-	-	3	-	-	-	2	2	-	3	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

10. Quiz / Assignment/ Quiz/ Discussion / Seminar
11. Midterm Exam
12. Programming Assignments (20%)
13. Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	B. Sc. Statistics
Course Code	STA5FS101
Course Title	Statistical analysis using Python
Type of Course	SEC

Semester	V				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-	-	45
Pre-requisites	HSE level Mathematics Course				
Course Summary	To make students aware of Various Quality or standards in Industrial Production, Detecting, Controlling and Maintaining Quality and Total Quality Management				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Explain the basics of Python programming language and its syntax.	U	F	Instructor-created exams / Quiz
CO2	Identify common types of errors and their underlying causes such as incorrect syntax, invalid variable assignments, and type mismatches.	R	C	Instructor-created exams / Home Assignments/ Seminar Presentation
CO3	Describe the funda mental data structures in Pandas and their rol e in data manipulation and analyzedata to help entrepreneurial decisions using critical thinking skills.	U	F	Instructor-created exams / Home Assignments/ Seminar Presentation
CO4	Familiarize themselves with popular data visualization libraries in Python and critically evaluate ethical implications of statistical methods aligning with human values.	R	C	Instructor-created exams / Quiz
CO5	Discuss the importance of random number generation in computational simulations	U	F	Instructor-created exams / Quiz/

	and statistical analysis.			Viva-Voce
CO6	Apply the basic concepts and principles of machine learning.	Ap	P	Instructor-created exams / Home Assignments/ Seminar Presentation
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I	**Introduction to Python Programming**		**12**	
	1	Interactive Python Environment: Jupyter notebooks, basic syntax, interactive shell	2	
	2	Data Fundamentals: Variables, assignments, arithmetic operators, expressions	3	
	3	Program Readability: Comments in code, interpreting error messages	3	
	4	Modular Programming: Importing modules, control flow statements	2	
	5	Function Fundamentals: Built-in and user-defined functions, arguments, return values, formal vs. actual parameters, named arguments	2	
	Sections from References: 2, 3, 5, 6			
II	**Data Manipulation with Pandas**		**10**	
	5	Pandas Introduction: Data Series, DataFrames	4	
	6	Data Operations: Importing, manipulating, merging, analyzing, and exporting DataFrames	4	
	7	Descriptive Statistics: Exploratory data analysis techniques	2	
	Sections from References: 1, 3, 7, 11			
III	**Data Visualization**		**8**	
	9	Data Visualization Libraries: Matplotlib, Seaborn, Plotly, ggplot, Geoplotlib, Pandas (and potentially others)	2	
	10	Plot-I : Line plot, bar plot, pie chart, box plot, histogram, strip plot, swarm plot,	3	
	11	Plot-II: Scatter plot, heatmap, density plot, cumulative frequencies, error Bars	3	
	Sections from References: 1, 4, 9, 10			
IV	**Statistical Data Analysis Using statsmodels**		**18**	
	18	Random Number Generation	3	

	19	Correlation	2	
	20	Hypothesis Testing -I: One sample, two sample and paired t test	2	
	21	Hypothesis Testing -II: One way and Two way ANOVA	3	
	22	Hypothesis Testing -III: Non Parametric Tests	3	
		Linear Regression Modeling: Simple and multiple linear regression	3	
		Logistic Regression Models	2	
	Sections from References: 4, 9,10,11			
V	**Open Ended Module:**		**12**	
	1	Numerical Methods with NumPy: Efficient arrays and linear algebra operations	4	
	2	Machine Learning Introduction: Fundamentals of machine learning with scikit-learn	4	
	3	Web Data Scraping: Scraping web data using requests and BeautifulSoup	4	
	Sections from References: 7, 9, 11			

Books and References:

1. Embarak, D. O., Embarak, & Karkal. (2018). *Data analysis and visualization using python*. Berkeley, CA, USA: Apress.
2. Gowrishankar, S., & Veena, A. (2018). *Introduction to Python programming*. Chapman and Hall/CRC.
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4. Haslwanter, T. (2016). *An introduction to statistics with python. With Applications in the Life Sciences;* Springer International Publishing: Cham, Switzerland.
5. Lambert, K. A., & Osborne, M. (2015). *Fundamentals of PYTHON*. Cengage Learning, IE.
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10. Unpingco, J. (2016). *Python for probability, statistics, and machine learning*. Cham, Switzerland: Springer International Publishing.
11. VanderPlas, J. (2016). *Python data science handbook: Essential tools for working with data*. " O'Reilly Media, Inc."

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	3	-	-	-	3	3	-	-	-	-	-
CO 2	3	2	-	-	-	3	3	-	-	-	-	-
CO 3	-	-	2	-	-	2	1	-	-	3	3	-
CO 4	2	-	2	-	-	-	2	-	-	3	-	2
CO 5	-	-	2	1	2	-	2	-	1	3	-	-
CO 6	2	2	-	-	-	2	3	-	-	3	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

5. Quiz / Assignment/ Quiz/ Discussion / Seminar
6. Midterm Exam
7. Programming Assignments (20%)
8. Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	B. Sc. Statistics				
Course Code	STA6FS102				
Course Title	Basic research methodology				
Type of Course	SEC				
Semester	VI				
Academic Level	**1**00-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-	-	45
Pre-requisites	HSE level Mathematics Course				
Course Summary	To make students aware of research methodology.				

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Identify gaps, contradictions and areas for further exploration within theexisting body of literature.	R	F	Instructor-created exams / Quiz
CO2	Ethically and accurately cite article references in accordance with academic integrity standards.	U	C	Instructor-created exams / Home Assignments
CO3	Develop a coherent and logically structured thesis report that adheres to academic conventions and standards.	R	P	Seminar Presentation / Group Tutorial Work
CO4	Construct text, equations, figures, tables and references in accordance with academic standards and publication guidelines and analyze data to help entrepreneurial decisions using critical thinking skills.	U	C	Instructor-created exams / Home Assignments /Seminar Presentation
CO5	Ethically and responsibly apply numerical methods in research, aknowledging	Ap	F	Seminar Presentation /Quiz

	limitations and uncertainties.			
CO6	Identify appropriate case study designs and data collection methods for specific research questions and contexts.	R	P	Seminar Presentation/ Group Tutorial Work
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Course Outcomes (CO):

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs (48 +12)**	**Marks (70)**
I		**Research in Statistics**	**12**	**15**
	1	Concept of Research in Statistics-Importance and Need for Research Ethics	2	
	2	Selection of Topic for Research-Research schedules	3	
	3	Review of Literature and its Use in Designing a Research Work-	3	
	4	Mode of Literature Survey	2	
	5	Thesis Writing – Computer Application in Scientific Research	2	
	Sections from References:			
II			**12**	**15**
	6	Scientific Word Processing with LaTeX	2	

	7	Article, References	2	
	8	Thesis Report and Slide Preparation	2	
	9	Statistical Programming with R: Arrays and Matrices-Lists	2	
	10	Data Frames-Grouping, Loops and Conditions	2	
	11	Probability Distributions and Statistical Models in R.	2	
	Sections from References:			
III			**15**	**25**
	112	Simulation: Concepts and Advantages of Simulation-	2	
	13	Event Type Simulation- Random Variable Generation-U(0,1)	2	
	14	Exponential, Gamma and Normal Random Variables – Monte Carlo Integration.	3	
	15	The MCMC Principle,	3	
	16	Algorithms and its Variants	2	
	17	Bootstrap Methods.	3	
	Sections from References:			
IV			**9**	**15**
	18	Computer Oriented Numerical Methods	2	
	19	Algorithms for Solving Algebraic Equations	2	
	20	Algorithms for Solving Transcendental Equations	1	
	21	Numerical Integration	2	
	22	Matrix operations.	2	

	Sections from References:			
V	**Open Ended Module:**		**12**	
	1	Analysis of a case study	12	
	Sections from References:			

Books and References:

7. Anderson, J., Durston, B.H., Pooole, M. (1970) Thesis and Assignment Writing. Wiley Eastern. Ltd., New Delhi.

8. Beveridege, B. (1979) The Art of Scientific Investigation. W.E. Norton & Co., New York. Braun, J., Duncan, W. and Murdock, J. (2008) A First Course in Statistical Programming with R. Cambridge University Press, London.

9. Chambers, J. (2008) Software for Data Analysis: Programming with R. Springer, New York.

10. Crewley, M.J. (2007) The R-.Book. John Wiley, New York.

11. Dalgaard, P.(2008) Introductory Statistics with R. Springer Science, New York.

12. Ghosh, J.K., Mitra, S.K. and Parthasarathy, K. R.(1992) Glilmpses of India's Statistical Heritage. Wiley Eastern Limited, New Delhi.

13. Hald, A.(1998) A History of Mathematical Statistics from 1750 to 1930. John Wiley & Sons, New York.

14. Kantiswarup, S., Gupta P.K. and Man Mohan (2008) Operations Research. Sultan Chand & Sons, New Delhi.

15. Kothari, C. (2005) Research Methodology. New Age International. Publishers, New York.

16. Lamport, L. (1999) LATEX: A Document Preparation System. Addison, nd Wesley, 2

17. Pannerselvan,R. (2006) Research Methodology. Prentice-Hall of India. Pvt., NewDelhi.

18. Robert, C.P. and Casella, G. (2004) Monte Carlo Statistical Methods. Springer Science, New York.

19. Venkataraman, M.K. (1998) Numerical Methods in Science and Engineering. The National Publishing Company, Chennai.

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	3	-	-	-	2	2	3	-	-	-	-
CO 2	-	-	2	-	-	-	-	-	-	3	-	2
CO 3	-	2	-	3	2	3	1	2	3	-	-	-
CO 4	3	2	2	-	-	3	3	1	-	3	3	-
CO 5	2	-	2	-	-	-	1	-	-	3	-	3
CO 6	-	-	3	-	-	2	1	2	-	3	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
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Mapping of COs to Assessment Rubrics :

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CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	