ST. JOSEPH'S COLLEGE (AUTONOMOUS), DEVAGIRI, KOZHIKODE

(Affiliated to the University of Calicut)

CURRICULUM & SYLLABI

FOR

B.Sc. Applied Mathematics Honours

UNDER FOUR YEARS UNDER GRADUATE PROGRAMME (FYUGP) SYSTEM 2024

(EFFECTIVE FROM 2024 ADMISSION)

PROGRAMME OUTCOMES (PO):

At the end of the graduate programme, 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. Applied Mathematics Honours Programme, 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 FYUGP

Sl. No.	Academic Pathway	Major	Minor/ Other Disciplines	Foundation Courses AEC: 4 MDC: 3 SEC: 3 VAC: 3	Internship	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: Applied Mathematics + six courses in different disciplines in different combinations
2	Major (A) with Multiple Disciplin e s (B, C)	68 (17 courses)	12 + 12 (3 + 3 = 6 courses)	39 (13 courses)	2	133	Major: Applied Mathematics + Statistics and Computer Science
3	Major (A) with Minor (B)	68 (17 courses)	24 (6 courses)	39 (13 courses)	2	133	Major: Applied Mathematics Minor: Statistics

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	Applied Mathematics and
	(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)				Computer Science double major
Exit with UG Degree / Proceed to Fourth Year with 133 Credits							

SYLLABUS

(*w.e.f.* 2024 admission onwards)

(FYUGP Regulations 2024)

B.Sc. APPLIED MATHEMATICS HONOURS PROGRAMME

Course Structure for pathways 1-4

1. Single Major
2. Major with multiple minor
3. Major with minor

Semester	Course Code	Course Title	Total Hours	Hours/ Week	Credits	Marks		
						Internal	external	Total
1	AMA1CJ101	Major A-Course 1-Calculus I	45+30	3+2	4	30	70	100
	02	Minor B- Course	45+30	3+2	4	30	70	100
	03	Minor C- Course	45+30	3+2	4	30	70	100
	04	Ability Enhancement Course 1(P) (E)	30+30 (T+P)	2+2 (T+P)	2+1 (T+P)	30	70	100
	05	Ability Enhancement Course 2 (AL)	45	3	3	25	50	75
	06	Multi-Disciplinary Course 1 (Other Department)	45	3	3	25	50	75
		Total		**25**	**21**	25	50	75
2	AMA2CJ101	Major A- Course 2—Calculus II	45+30	3+2	4	30	70	100
	02	Minor B-Course 2	75	5	4	30	70	100
	03	Minor C- Course 2	75	5	4	30	70	100
	04	Ability Enhancement Course 3 (P)(E)	60	4	3	30	70	100
	05	Ability Enhancement Course 4(AL)	30+30	2+2	2+1	25	50	100
	06	Multi-Disciplinary Course 2(Other Department)	45	3	3	25	50	100
		Total		**25**	**21**	25	50	100
	AMA3CJ201	Major A- Course 3- Vector Calculus	45+30 (T+P)	3+2	3+1	30	70	100

3	AMA3CJ202	Major A- Course 4 – Linear Programming and Application	60	4	4	30	70	100
	03	Minor B-Course 3	45+30	3+2	4	30	70	100

	04	Minor C- Course 3	75	5	4	30	70	100
	05	Multi-Disciplinary Course 3 (KS) (E & AL)	45	3	3	25	50	75
	06	Value-Added Course 1(E)	45	3	3	25	50	75
		Total		**25**	**22**			
4	AMA4CJ203	Major A-Course 5-Linear Algebra	45+30	3+2	4	30	70	100
	AMA4CJ204	Major A-Course 6-Differential Equations	45+30	3+2	4	30	70	100
	AMA4CJ205	Major A- Course 7 Real Analysis	45+30	3+2	4	30	70	100
	04	Skill Enhancement Course 1 (P) (E)	30+30	2+2	3	25	50	75
	05	Value-Added Course 2(E)	45	3	3	25	50	75
	06	Value-Added Course 3 (AL)	60	3	3	25	50	75
		Total		**25**	**21**			
5	AMA5CJ301	Major A-Course 8- Abstract Algebra	45+30	3+2	4	30	70	100
	AMA5CJ302	Major A-Course 9- Object Oriented Programming using C++	45+30	3+2	4	30	70	100
	AMA5CJ303	Major A-Course 10- Number Theory	60	4	4	30	70	100
		A*-Elective 1	60	5	4	30	70	100
		A*- Elective 2	60	4	4	30	70	100
		Skill Enhancement Course 2	45	3	3	25	50	75
		Total		**25**	**23**			
	AMA6CJ304	Major A-Course 11- Numerical Computing Using Python	45+30	3+2	4	30	70	100

6	AMA6CJ305	Major A-Course 12- Complex Analysis	60	4	4	30	70	100
	AMA6CJ306	Major A-Course 13 Theory of Equations and Graph Theory	60	4	4	30	70	100
		A*-Elective3	60	5	4	30	70	100
		A*-Elective 4	60	4	4	30	70	100
	AMA6FS113	Data Science with Python (Skill Enhancement Course 3)	45	3	3	25	50	75
	AMA6CJ349	Internship in Major (Credit for internship to be awarded only at the end of Semester 6)	60		2	50	-	50
		Total		**25**	**25**			
Total Credits for Three Years					**133**			
7	AMA7CJ401	Major A-Course 14- Introduction to Topology	45+30	3+2	3+1	30	70	100
	AMA7CJ402	Major A- Course 15-Advanced Linear Algebra	45+30	3+2	3+1	30	70	100
	AMA7CJ403	Major A - Course 16 - Cryptography and Automata theory	45+30	3+2	3+1	30	70	100
	AMA7CJ404	Major A – Course 17- Partial differential Equations	45+30	3+2	3+1	30	70	100
	AMA7CJ405	Major A- Course 18 – Advanced Abstract Algebra	45+30	3+2	3+1	30	70	100
		Total		**25**	**20**			
8	AMA8CJ406	Major A- Course 19 -Introduction to Fractals	45+30	3+2	3+1	30	70	100
	AMA8CJ407	Major A- Course 20 - Fluid dynamics	60	4	4	30	70	100
	AMA8CJ408	Major A- Course 21- Stochastics Processes	60	4	4	30	70	100
	OR (instead of Courses 19 to 21 in Major)							
		Project (in Honours programme)	360*	13*	12	90	210	300
	OR (instead of Courses 19 to 21 in Major)							
		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)							
		Research Methodology in Applied Mathematics	60	4	4	30	70	100
		Total		25	24			
Total Credits for four years					**177**			

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Choose any four elective courses (two in fifth and two in sixth semester) from the basket of electives with specialization

ELECTIVE COURSES IN APPLIEDMATHEMATICS WITH SPECIALISATION

Groups	Sl. No.	Course Code	Title	Semester	Total Hrs	Hrs/ Week	credits	Marks		
								Internal	External	Total
1		**MATHEMATICAL COMPUTING**								
	1	AMA5EJ301 (1)	Mathematical Foundations of Computing	5	60	4	4	30	70	100
	2	AMA5EJ302 (1)	Data Structures	5	60	4	4	30	70	100
	3	AMA6EJ301 (1)	Numerical Analysis	6	60	4	4	30	70	100
	4	AMA6EJ302 (1)	Mathematics for Digital Images	6	60	4	4	30	70	100

2		**DATA SCIENCE***								
	1	AMA5EJ303 (2)	Convex Optimization	5	60	4	4	30	70	100
	2	AMA5EJ304 (2)	Applied Probability	5	60	4	4	30	70	100
	3	AMA6EJ303 (2)	Machine Learning I	6	60	4	4	30	70	100
	4	AMA6EJ304 (2)	Machine Learning II	6	60	4	4	30	70	100

3	**APPLIED ALGEBRA**									
	1	AMA5EJ305 (3)	Graph Theory and application	5	60	4	4	30	70	100
	2	AMA5EJ3026 (3)	Lattice Theory	5	60	4	4	30	70	100
	3	AMA6EJ305 (3)	Fuzzy Mathematics	6	60	4	4	30	70	100
	4	AMA6EJ306 (3)	Coding Theory	6	60	4	4	30	70	100
	OPTIMIZATION									
	1	AMA5EJ307 (4)	Financial Mathematics	5	60	4	4	30	70	100

4	2	AMA5EJ308 (4)	Mathematical Modeling	5	60	4	4	30	70	100
	3	AMA6EJ307 (4)	Mathematical Economics	6	60	4	4	30	70	100
	4	AMA6EJ308 (4)	Operation Research	6	60	4	4	30	70	100
	ACTUARIAL SCIENCES									
5	1	AMA5EJ309 (5)	Introduction to Actuarial Science	5	60	4	4	30	70	100
	2	AMA5EJ310 (5)	Mathematics of Finance I	5	60	4	4	30	70	100
	3	AMA6EJ309 (5)	Principles of Insurance	6	60	4	4	30	70	100
	4	AMA6EJ310 (5)	Mathematics of Finance II	6	60	4	4	30	70	100

Elective course for VIII semester

SI. No.	Course code	Title	Total Hrs.	Hrs./ Week	Credits	Marks		
						Internal	Externa l	Total
1	AMA8EJ401	Analytical Number Theory	60	4	4	30	70	100
2	AMA8EJ402	Numerical Methods for Partial Differential Equations	60	4	4	30	70	100
3	AMA8EJ403	Differential Equations and Dynamical System	60	4	4	30	70	100
4	AMA8EJ404	Relativity and Cosmology	60	4	4	30	70	100
5	AMA8EJ405	Elasticity	60	4	4	30	70	100
6	AMA8EJ406	Discrete Time Control System	60	4	4	30	70	100
7	AMA8EJ407	Differential Geometry	60	4	4	30	70	100
8	AMA8EJ408	Rings & Modules	60	4	4	30	70	100
9	AMA8EJ409	Mathematics of Wavelets	60	4	4	30	70	100
10	AMA8EJ410	Functional analysis	60	4	4	30	70	100

GROUPING OF MINORS FOR APPLIED MATHEMATICS

1		Minor Group I- Discrete Mathematics								
	1	AMA1MN104	Mathematical Logic, Set Theory and Combinatorics	1	60	4	4	30	70	100
	2	AMA2MN104	Graph theory and Automata	2	60	4	4	30	70	100
	3	AMA3MN204	Boolean Algebra and System of Equations	3	60	4	4	30	70	100
2		Minor Group II – Corporate Mathematics								
	1	AMA1MN101	COMMERCIAL ARITHMETIC	1	60	4	4	30	70	100
	2	AMA2MN102	BUSINESS MATHEMATICS	2	60	4	4	30	70	100
	3	AMA3MN201	MANAGEMENT SCIENCE	3	60	4	4	30	70	100

DISTRIBUTION OF GENERAL FOUNDATION COURSES IN APPLIED MATHEMATICS

Semester	Course code	Course title	Total Hrs	Hrs/week	Credits	Marks		
						Internal	External	Total
1	AMA1FM105(1)	Multi-Disciplinary Course 1 - Matrices and Basics of Probability theory	45	3	3	25	50	75
1	AMA1FM105(2)	Multi-Disciplinary Course 2 Mathematics for Competitive Exams - Part I	45	3	3	25	50	75
2	AMA2FM106(2)	Multi-Disciplinary Course 4 – Mathematics for Competitive Exams - Part II	45	3	3	25	50	75
1	AMA5FS112	Skill Enhancement Course 2 - Mathematical Type Setting System - LaTeX	45	3	3	25	50	75
2	AMA6FS113	Skill Enhancement Course 3 - Data Science with Python	45	3	3	25	50	75

Credit Distribution For Different Pathways

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
Total for Four Years	**88 + 12 = 100**	**36**	**39**	**2**	**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 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/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 Applied 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	Openended Module	4 Theory Modules	Practical/ Pra cticum
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

1.1.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 incharge 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/ Pra cticum	Weig htage
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-incharge and additional examiner	3	15%
	Total Marks	20	

1.2.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 University 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, firm, industry or 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 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. Applied 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. 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

- 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 of University of Calicut or any other university/ HEI can offer the Honours with Research programme. The departments in the affiliated colleges under University of Calicut, 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 members with Ph.D., and they should also have the necessary infrastructure to offer Honours with Research programme.

- A faculty member of the University/ 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 Applied 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 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 University.
- 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 university	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 Applied Mathematics are with only theory component.

4.1. INTERNAL EVALUATION

Sl. No.	Components of Internal Evaluation of a General Foundation Course in Applied Mathematics	ternal Marks of a General Foundation Course of 3-credits in Applied 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 University 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 10point 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	ange 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 CUFYUGP shall be calculated by the following formula.

CGPA for the four-year programme in CUFYUGP 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 University shall issue the transcript for each semester and a consolidated transcript indicating the performance in all semesters.

MAJOR COURSES

Programme	B.Sc. Applied Mathematics Honours			
Course Code	AMA1CJ101			
Course Title	**Calculus I**			
Type of Course	**Major**			
Semester	1			
Academic Level	100-199			
Course Details	Credit	Lecture/Tutorial per week	Practical/Practicum per week	Total Hours
	4	3	2	5
Pre-requisites	Basic knowledge of Sets, Relations and Functions, School Level Algebra and Real Numbers (0-99 level).			
Course Summary	This course covers key concepts such as extrema of functions, including absolute and relative extrema, and the application of Fermat's Theorem and the Mean Value Theorem. It explores techniques for analyzing the behavior of functions through derivatives, concavity, and optimization, along with methods for evaluating limits, asymptotes, and curve sketching. Students will also learn integration techniques, including indefinite and definite integrals, and apply the Fundamental Theorem of Calculus to solve problems. The course further delves into applications like finding areas between curves, volumes of solids of revolution, and arc length and surface area of revolution.			

COURSE OUTCOME

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used
CO1	Students will be able to understand how to identify and analyze increasing and decreasing functions, absolute and relative extrema of functions	**An**	**P**	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO2	Students will be able to Conceptually understand and calculate the area between curves, volume of solids of revolution, arc length, and surface areas of revolution.	**U**	**C**	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO3	Students will be able to analyze the concavity and points of inflection, understand and identify limits involving infinity and asymptotes, sketch the graph of a function including slant asymptotes, and solve optimization problems to find absolute extrema.	**An**	**P**	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam

CO4	Students will be able to understand and apply basic theorems on integral calculus, solve definite integrals	**Ap**	**P**	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
* - 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:

Text Book	**Calculus: Soo T Tan Brooks/Cole, Cengage Learning (2010).**			
Module	**Unit**	**Content**	**Hours**	**Marks**
				Ext:70
I	**1**	3.1: Extrema of Functions- Absolute Extrema of Functions, Relative Extrema of Functions, Fermat's Theorem**,** Finding the Extreme Values of a Continuous Function on a Closed Interval.	**8**	**Min. 10**
	2	3.2: The Mean Value Theorem- Rolle's Theorem, The Mean Value Theorem.		
	3	3.3: Increasing and Decreasing Functions- definition, inferring the behavior of function from sign of derivative.		
	4	3.3 Finding the Relative Extrema of a Function, first derivative test.		
II	**5**	3.4: Concavity and Inflection points- Concavity, Inflection Points, The Second Derivative Test.	**16**	**Min. 15**
	6	3.5: Limits involving Infinity; Asymptotes- Infinite Limits, Vertical Asymptotes, Limits at Infinity, Horizontal Asymptotes, Infinite Limits at Infinity.		
	7	3.6: Curve Sketching- The Graph of a Function, Guide to Curve Sketching, Slant Asymptotes.		
	8	3.7: Optimization Problems- guidelines for finding absolute extrema.		
III	**9**	4.1: Indefinite integrals- Basic Rules of Integration, a few basic integration formulas and rules of integration.	**17**	**Min. 15**
	10	4.1 Differential Equations, Initial Value Problems.		
	11	4.4: The Definite Integral- Definition of the Definite Integral, Properties of the Definite Integral, More General Definition of the Definite Integral.		
	12	4.5: The Fundamental Theorem of Calculus- The Mean Value Theorem for Definite Integrals.		

		4.5The Fundamental Theorem of Calculus: Part I, inverse relationship between differentiation and integration,		
	13	4.5Fundamental Theorem of Calculus: Part 2, Evaluating Definite Integrals Using Substitution, Definite Integrals of Odd and Even Functions.		
	14	Definite Integrals of Odd and Even Functions		
IV	**15**	5.1: Areas between Curves- The Area Between Two Curves	**12**	**Min. 15**
	16	5.2: Volume- Solids of revolution, Volume by Disk Method, Region revolved about the x-axis, Region revolved about the y-axis.		
	17	Volume by the Method of Cross Sections [‘Washer Method’ omitted]		
	18	5.4: Arc Length and Areas of surfaces of revolution- Definition of Arc Length, Length of a Smooth Curve, arc length formula.		
	19	5.4Surfaces of Revolution, surface area as surface of revolution		
	20	5.4 surface area as surface of revolution		
V-Open Ended **Practical**		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 running group discussions, supervising class seminars and referring library books for self-study and note preparation. Overview of limits and continuity of functions (Chapter 1) 3.1: An Optimization Problem. 3.2: Some Consequences of the Mean Value Theorem, Determining the Number of Zeros of a Function. 3.4: The roles of ‘and f’ in determining the Shape of a Graph. 3.5: Precise Definitions 3.6: Finding Relative Extrema Using a Graphing Utility. 3.7: Formulating Optimization Problems- application involving several real-life problems. 4.4: Geometric Interpretation of the Definite Integral, The Definite Integral and Displacement. 4.5: How Are Differentiation and Integration Related? The Definite Integral as a Measure of Net Change. 5.1: A Real-Life Interpretation, Integrating with Respect to -adapting to the shape of the region, What Happens When the Curves Intertwine? 5.4: Arc length function, arc length differentials	**12**	

	Graphing of the following functions using any software (any 5). $f(x) = 2x + 3$ on $[-1, \infty)$ $f(t) = 4t^{1/3} + 3t^{4/3}$ on $\mathbb{R}$ $g(t) = 2t^3 + 3t^2 - 12t + 4$ $f(x) = x^3$ $f(x) = \frac{1}{x}$ $f(x) = (x-1)^{1/3}$ $f(x) = \cos(\sin x)$ on $(-2, 2)$ $f(x) = \frac{1}{1-\cos x}$ on $(0, 2\pi)$ $f(x) = 2\sin x + \sin 2x$ on $(0, \pi)$ $f(x) = \frac{x}{(x+1)(x-2)}$		

References:
Joel Hass, Christopher Heil & Maurice D. Weir: Thomas' Calculus (14/e) Pearson (2018). Robert A Adams & Christopher Essex: Calculus Single Variable (8/e) Pearson Education Canada (2013).
Jon Rogawski & Colin Adams: Calculus Early Transcendentals (3/e) W. H. Freeman and Company (2015).
Anton, Bivens & Davis: Calculus Early Transcendentals (11/e) John Wiley & Sons, Inc. (2016).
James Stewart: Calculus (8/e) Brooks/Cole Cengage Learning(2016)
Jerrold Marsden & Alan Weinstein: Calculus I and II (2/e) Springer Verlag NY (1985).

***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	-	2	1	3	-	1
CO 2	2	3	2	1	3	-	2	1	3	-	1
CO 3	2	3	2	1	3	-	2	2	3	-	1
CO4	2	3	2	1	3		1	1	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	✓	✓	✓	✓	✓
CO4	✓	✓			✓

<table>
<tr><td>Programme</td><td colspan="4">B.Sc. Applied Mathematics Honours</td></tr>
<tr><td>Course Code</td><td colspan="4">AMA2CJ101</td></tr>
<tr><td>Course Title</td><td colspan="4">Calculus II</td></tr>
<tr><td>Type of Course</td><td colspan="4">Major</td></tr>
<tr><td>Semester</td><td colspan="4">2</td></tr>
<tr><td>Academic Level</td><td colspan="4">100-199</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture/Tutorial per week</td><td>Practical/Practicum per week</td><td>Total Hours</td></tr>
<tr><td>4</td><td>3</td><td>2</td><td>5</td></tr>
<tr><td>Pre-requisites</td><td colspan="4">Basic knowledge of Functions, Limits, Continuity and Differentiation (Calculus I)</td></tr>
<tr><td>Course Summary</td><td colspan="4">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.</td></tr>
</table>

Course outcome

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluatio n Tools used
CO1	Students will understand the properties and derivatives of natural logarithmic and exponential functions, hyperbolic functions, apply logarithmic and exponential differentiation and integration techniques, and use L'Hôpital's Rule to resolve indeterminate forms.	**U**	**C**	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO2	To practically apply several different tests for sequences and series such as integral test, comparison test and so on. As a special case, a study on power series- their region of convergence, differentiation, and integration etc., is also done.	**Ap**	**F**	Internal Exam/ Assignment/S eminar/ Viva/Report/ End Sem Exam

CO 4	To recognize and evaluate the area of surface of revolution of a parametrized plane curve.	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)				

Text Book	**Calculus: Soo T Tan Brooks/Cole, Cengage Learning (2010).**			
Module	**Unit**	**Content**	**Hours (45+30)**	**Marks** **Ext:70**
I	**1**	6.1: The Natural logarithmic functionDefinition, The Derivative of $ln\ x$, Laws of Logarithms, The Graph of the Natural Logarithmic Function, The Derivatives of Logarithmic Functions, Logarithmic Differentiation, Integration Involving Logarithmic Functions	**10**	
	2	6.3: Exponential Functions - The number e, Defining the Natural Exponential Function, properties, The Laws of Exponents, The Derivatives of Exponential Functions, Integration of the Natural Exponential Function.		
	3	6.4: General Exponential and Logarithmic Functions - Exponential Functions with Base a, laws of exponents, The Derivatives of a^x and a^u, Graphs of $y = ax$, integrating a^x, Logarithmic Functions with Base a, change of base formula, The Power Rule (General Form), The Derivatives of Logarithmic Functions with base a, The Definition of the Number e as a Limit [‘Compound Interest’ omitted]		
	4	6.6: Hyperbolic functions - The Graphs of the Hyperbolic Functions, Hyperbolic Identities, Derivatives and Integrals of Hyperbolic Functions, Inverse Hyperbolic Functions, representation in terms of logarithmic function, Derivatives of Inverse Hyperbolic Functions, An Application		

	5	6.7: Indeterminate forms and L' H$\hat{o}$pital rule- motivation, The Indeterminate forms $\frac{0}{0}$ and $\frac{\infty}{\infty}$, The indeterminate forms $\infty - \infty$ and 0, Indeterminate forms 0^0, ∞^0 and 1^∞.		
II	**6**	7.6: Improper integrals- definition, Infinite Intervals of Integration, Improper Integrals with Infinite Discontinuities, A Comparison Test for Improper Integrals. (Only statements are needed; proofs are omitted).	**10**	
	7	9.1: Sequences- definition, recursive definition, Limit of a Sequence, limit laws, squeeze theorem, Bounded Monotonic Sequences, definition, monotone convergence theorem. (Only statements are needed; proofs are omitted).		
	8	9.2: Series- defining the sum, convergence and divergence, Geometric Series, The Harmonic Series.		
	9	The Divergence Test, Properties of Convergent Series. (Only statements are needed; proofs are omitted).		
	10	9.3: The Integral Test- investigation of convergence, integral test, The p Series, its convergence and divergence. (Only statements are needed; proofs are omitted).		
	11	9.4: The Comparison Test- test series, The Comparison Test, The Limit Comparison Test. (Only statements are needed; proofs are omitted).		
III	**12**	9.5: Alternating Series- definition, the alternating series test, its proof, examples, Approximating the Sum of an Alternating Series by Sn. (Only statements are needed; proofs are omitted).	**12**	
	13	9.6: Absolute Convergence- definition, conditionally convergent, The Ratio Test, The Root Test, Summary of Tests for Convergence and Divergence of Series, Rearrangement of Series. (Only statements are needed; proofs are omitted).		
	14	9.7: Power Series- definition, Interval of Convergence, radius of convergence, Differentiation and Integration of Power Series. (Only statements are needed; proofs are omitted).		

	15	9.8: Taylor and Maclaurin Series- definition, Taylor and Maclaurin series of functions, Techniques for Finding Taylor Series. (Only statements are needed; proofs are omitted).		
IV	**16**	10.2: Plane Curves and Parametric Equations- Why We Use Parametric Equations, Sketching Curves Defined by Parametric Equations.	**13**	
	17	10.3: The Calculus of parametric equations- Tangent Lines to Curves Defined by Parametric Equations, Horizontal and Vertical Tangents, Finding $\frac{d^2y}{dx^2}$ from Parametric Equations, The Length of a Smooth Curve, The Area of a Surface of Revolution.		
	18	10.4: Polar coordinates- The Polar Coordinate System, Relationship between Polar and Rectangular Coordinates.		
	19	10.5: Areas and Arc Lengths in polar coordinates- Areas in Polar Coordinates, area bounded by polar curves, Area Bounded by Two Graphs, Arc Length in Polar Coordinates, Area of a Surface of Revolution, Points of Intersection of Graphs in Polar Coordinates.		
	20	Area of a Surface of Revolution, Points of Intersection of Graphs in Polar Coordinates.		
V		Practicum/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 running group discussions, supervising class seminars and referring library books for self-study and note preparation. 6.4: Compound Interest 10.4 , Graphs of Polar Equations, Symmetry, Tangent Lines to Graphs of Polar Equations.	**30**	

	List of Practical (using any software): Plotting of graphs of function: e^{ax+b}, $log(ax+b)$, $\frac{1}{ax+b}$, $sin(ax+b)$, $cos(ax+b)$, $\|ax+b\|$ and be able to find the effect of a and b on the graph. Sketching parametric curves: • $x=\sqrt{t}, y=t$ • $x=t, y=t^2$ • $x=\sin t, y=\sin 2t, 0\le t\le 2\pi$ • $x=\theta-\sin\theta, y=1-\cos\theta, -\infty<\theta<\infty$ Polar curves: • $r=2$ • $r=1+\cos\theta$ • $r=2\cos 2\theta$ • $r=2\sqrt{\cos 2\theta}$ • $r=1-2\cos\theta$ • $r^2=4\sin 2\theta$ • $r=\sin 3\theta$ • $r=4\sin 4\theta$ • $r=e^{\theta}$ • $r=\frac{1}{\theta}$ • $r=\theta$		

References:

Joel Hass, Christopher Heil & Maurice D. Weir: Thomas' Calculus (14/e) Pearson (2018).
Robert A Adams & Christopher Essex: Calculus Single Variable (8/e) Pearson Education Canada (2013).
Jon Rogawski & Colin Adams: Calculus Early Transcendentals (3/e) W. H. Freeman and Company (2015).
Anton, Bivens & Davis: Calculus Early Transcendentals (11/e) John Wiley & Sons, Inc. (2016).
James Stewart: Calculus (8/e) Brooks/Cole Cengage Learning (2016).
Jerrold Marsden & Alan Weinstein: Calculus I and II (2/e) Springer Verlag NY (1985).

***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	-	3	1	3	-	1
CO 2	2	3	2	1	3	-	3	1	3	-	1
CO 3	2	3	2	1	3	-	3	2	3	-	2
CO4	2	3	2	1	3	-	3	2	3	-	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	✓	✓	✓	✓	✓
CO4	✓	✓	✓		✓

Programme	B.Sc. Applied Mathematics Honours			
Course Code	**AMA3CJ201**			
Course Title	**Vector Calculus**			
Type of Course	**Major**			
Semester	**III**			
Academic Level	200-299			
Course Details	Credit	Lectureper week/ Tutorialper week	Practical/ Practicum per week	Total Hours
	4	3	2	75
Pre-requisites	Derivatives and antiderivatives			
Course Summary	To understand the extension of the studies of single variable differential and integral calculus to functions of two or more independent variables. Also, the emphasis will be on the use of Computer Algebra Systems by which these concepts may be analyzed and visualized to have a better understanding. This course will facilitate to become aware of applications of multivariable calculus tools in physics, economics, optimization, and understanding the architecture of curves and surfaces in plane and space etc.			

CO	CO Statement	Cognitiv eLevel*	Knowledg e Category#	Evaluation Tools used
CO1	Students will be able to analyze and graph functions of two or more variables, including understanding level curves and surfaces. They will gain proficiency in analyzing the behavior of these functions, determining limits, and assessing the continuity of functions in multiple dimensions.	Ap	P	Assignment/ Quiz/ Discussion / Seminars/ Internal Exam/Viva
CO2	Students will be able to compute partial derivatives of functions of two and three variables, interpret these derivatives geometrically, and use them to solve problems involving rates of change, slopes, and higher-order derivatives.	Ap	P	Assignment/ Quiz/ Discussion / Seminars/ Internal Exam/Viva
CO3	Students will be able to identify and classify the relative and absolute extrema of functions of two or more variables using the second partial test and apply Lagrange multipliers to solve constrained optimization problems.	Ap	P	Assignment/ Quiz/ Discussion / Seminars/ Internal Exam/Viva
CO4	Students will be able to compute and interpret line integrals, surface integrals, and flux integrals, applying fundamental theorems	Ap	P	Assignment/ Quiz/ Discussion / Seminars/ Internal Exam/Viva

	such as Green's Theorem, Stokes' Theorem, and the Divergence Theorem.			
CO5	Students will understand the concept of the gradient of a function and compute directional derivatives in multiple directions. They will learn how to interpret the gradient in terms of maximal increase, normal properties, and tangent planes,	U	F	Assignment/ Quiz/ Discussion / Seminars/ Internal Exam/Viva
* - 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 OUTCOME

Detailed Syllabus:

Text Book	**Strauss, Monty J., Bradley, Gerald L., & Smith, Karl J. (2007). Calculus (3rd ed.). Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). Delhi. Indian Reprint 2011.**			
Module		Functionsof several variables	**Hrs (45+30)**	**External Marks (70)**
I	1	11.1 Basic concepts, level curves and surfaces, graphs of functions of two variables.	12	Min15
	2	11.2 Limits and continuity – Open and Closed sets in $\mathbb{R}^2$ and $\mathbb{R}^3$, limit of a function of two variables, limit of functions of three variables.		
	3	11.3 Partial Derivatives- Partial derivatives of a function of two variables, Partial derivative as a slope, Partial Derivatives as a rate, Higher order partial derivatives, Equality of mixed partials.		
	4	11.4 Tangent planes, incremental approximations, the total differential, differentiability.		
	5	11.5 Chain Rules – Chain rule for one parameter, extensions of the chain rule.		
	6	11.6Directional Derivatives and the Gradient- the directional derivative, the gradient, maximal property of the gradient, functions of three variables, normal property of the gradient, tangent planes and normal lines.		
II	7	11.7 Extrema of Functions of Two Variables- relative extrema, second partial test, absolute extrema of continuous function, least squares approximation of data	10	Min15
	8	11.8Lagrange Multipliers- Method of Lagrange multipliers, constrained optimization problems, Lagrange multipliers with two parameters, a geometric interpretation of Lagrange’s theorem.		
	9	13.1 Definition of a vector field, divergence, curl		
	10	12.1Double integration over Rectangular Regions- Definition of the double integral, properties of double integral.	12	Min15
	11	12.1 Volume interpretation, iterated integration, an informal		

III		argument for Fubini's Theorem		
	12	12.2 Double integration over Nonrectangular Regions- Double integration over type I and Type II regions.		
	13	12.2 More on area and volume, choosing the order of integration in a double integral		
	14	12.3 Double Integrals in Polar Coordinates- change of variables to polar form, area and volume in polar form.		
	15	12.5 Triple integrals- definition of the triple integral, iterated integration, volume by triple integrals		
IV	16	13.2 Line integrals: Definition of a line integrals with respect to x, y and z; line integrals of vector fields; application of line integrals; mass work	11	Min 15
	17	13.3 Fundamental theorem of path independence		
	18	13.4 Green's theorem		
	19	13.5 Surface integrals- surface integration, flux integrals, integrals over parametrically defined surfaces		
	20	13.6 Stoke's theorem- Stoke's theorem, theoretical application of Stokes's theorem, physical interpretation of Stoke's theorem		
V	**Practicum:** **The goal is for the students to learn the following topics in practicum sessions 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**	
	12.4 Surface area: definition of surface area projections, area of a surface defined parametrically. 12.6 Mass, Moment and probability Density functions 12.7 cylindrical and Spherical coordinates- cylindrical coordinates, integration with cylindrical coordinates, spherical coordinates, integration with spherical coordinates. 12.8 Jacobian: change of variables 13.7 Divergence theorem- the divergence theorem, application of the divergence theorem, physical interpretation of divergence. **Practicals using any software:** Sketch the solid bounded by the graphs of the equations, i. $3x+2y+z=6\ x=0, y=0, z=0$ ii. $y=2z, y=x^2, y=4, z=0$ iii. $x=4-y^2, x+z=4, x=0, z=0$ iv. $z=1-x^2, y=x, y=2-x, z=0$ v. $z=x^2+y^2, z=8-x^2-y^2$ vi. $x^2+z^2=4, y^2+z^2=4$ Sketch the solid under the surface i. z=xy and above the triangular region in the xy plane bounded by the lines y=2x, y=-x+6 and y=0 ii. the paraboloid $z=x^2+y^2$ and above the region in the xy plane bounded by the line y==x and the parabola y=x^2. Sketch the region of integration for the integrated integral i. $\int_0^1 \int_0^{1-x} f(x,y)dy\,dx$			

	ii. $\int_0^1 \int_{y^2}^{\sqrt[3]{x}} f(x, y)dxdy$		

References:

Joel Hass, Christopher Heil & Maurice D. Weir: Thomas' Calculus (14/e) Pearson (2018).
Robert A. Adams & Christopher Essex: Calculus Single Variable (8/e) Pearson Education Canada (2013).
Jon Rogawski & Colin Adams: Calculus Early Transcendentals (3/e) W. H. Freeman and Company (2015).
Anton, Bivens & Davis: Calculus Early Transcendentals (11/e) John Wiley & Sons, Inc. (2016)
James Stewart: Calculus (8/e) Brooks/Cole Cengage Learning (2016).
Jerrold Marsden & Alan Weinstein: Calculus I and II (2/e) Springer Verlag NY (1985).

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	1	3	-	1
CO 2	2	3	2	1	3	-	3	1	3	-	1
CO 3	2	3	2	1	3	-	3	2	3	-	2
-O4	2	3	2	2	3	-	2	1	2	-	1
-CO5	2	3	2	2	3	-	2	1	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	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

Programme	B.Sc. Applied Mathematics Honours			
Course Code	AMA3CJ202			
Course Title	**Linear Programming and Applications**			
Type of Course	**Major**			
Semester	3			
Academic Level	200-299			
Course Details	Credit	Lecture/Tutorial per week	Practical/Practicum per week	Total Hours
	4	4	-	4
Pre-requisites	Basic knowledge of Linear Programming Problems, solution using(0-99 level).			
Course Summary	The course covers basic definitions of Linear Programming Problems, Solution using graphical method, Solution using Simplex method, Duality Theorem, Transportation and Assignment problems.			

COURSE OUTCOME(CO)

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used
CO1	Develop mathematical formulations for real-world problems involving profit maximization and cost minimization, using appropriate objective functions and constraint sets.	**E**	**P**	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO2	Students will be able to apply the simplex algorithm to solve both maximization and minimization linear programming problems, with a strong understanding of the underlying mechanics, including pivot transformations, and the use of Tucker Tableaus techniques to a wide range of practical optimization problems in various fields, including economics, operations research, and business planning.	**AP**	**P**	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam

CO3	Apply graphical methods to solve two-variable linear programming problems, finding feasible and optimal solutions.	**Ap**	**P**	Internal Exam/ Assignment/Seminar/ Viva/Report/
				End Sem Exam
CO4	Students will be able to solve complex transportation and assignment problems using a variety of methods. They will be able to apply the **Vogel's Approximation Method (VAM)**, **Hungarian Algorithm**, and other related techniques, understanding when to use each method and how to achieve the most efficient solution. These skills will be applicable in fields such as logistics, supply chain management, operations research, and project management.	**An**	**C**	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
* - 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

Text Book	Linear Programming and Its Applications: James K. Strayer Under- Graduate Texts in Mathematics Springer (1989) ISBN: 978-1-4612-6982-3			
Module	**Unit**	**Content**	**Hours**	**Marks**
				Ext:70
I	**1**	**Chapter 1: Geometric Linear Programming**: Profit Maximization and Cost Minimization, typical motivating examples.	**8**	**Min. 10**
	2	mathematical formulation, Canonical Forms for Linear Programming Problems, objective functions, constraint set, feasible solution, optimal solution.		
	3	Polyhedral Convex Sets, convex set, extreme point, theorems asserting existence of optimal solutions		
	4	The Two Examples Revisited, graphical solutions to the problems, A Geometric Method for Linear Programming, the difficulty in the method, Concluding Remarks.		
II	**5**	**Chapter 2: The Simplex Algorithm**: Canonical Slack Forms for Linear Programming Problems; Tucker Tableaus, slack variables, Tucker tableaus, independent variables or non-basic variables, dependent variables or basic variables.	**16**	**Min. 15**

	6	An Example: Profit Maximization, method of solving a typical canonical maximization problem, The Pivot Transformation, The Pivot Transformation for Maximum and Minimum Tableaus, An Example: Cost Minimization, method of solving a typical canonical minimization problem		
	7	The Simplex Algorithm for Maximum Basic Feasible Tableaus		
	8	The Simplex Algorithm for Maximum Tableaus		
	9	Negative Transposition;		
	10	The Simplex Algorithm for Minimum Tableaus, Cycling, Simplex Algorithm Anti cycling Rules, Concluding Remarks.		
III	**11**	**Chapter 4: Duality Theory**: Duality in Canonical Tableaus.	**10**	**Min. 15**
	12	The Dual Simplex Algorithm, The Dual Simplex Algorithm for Maximum Tableaus.		
	13	Matrix Formulation of Canonical Tableaus,		
	14	The Duality Equation, The Duality theorem, Concluding Remarks.		
IV	**15**	**Chapter 6: Transportation and Assignment Problems**: The Balanced Transportation Problem The Vogel Advanced-Start Method (VAM)	**12**	**Min. 15**
	16	The Transportation Algorithm, Another Example		
	17	Unbalanced Transportation Problems		
	18	The Minimum-Entry Method		
	19	The Northwest-Corner Method		
	20	The Assignment Problem: The Hungarian Algorithm, Concluding Remarks.		
V-Open Ended		**Chapter 3:** Non-cannonical Linear Programming Problems: Introduction, Unconstrained variables Equations of constraints. **Chapter 5: Matrix Games** An example: Two- Person Zero-Sum Marix Games.	**12**	

References:

1. Robert J. Vanderbei: Linear Programming: Foundations and Extensions (2/e) Springer Science + Business Media LLC (2001) ISBN: 978-1-4757-5664-7
2. Frederick S Hiller, Gerald J Lieberman: Introduction to Operation Research (10/e) McGrawHill Education, 2 Penn Plaza, New York (2015) ISBN: 978-0-07-352345-3
3. Paul R. Thie, G. E. Keough: An Introduction to Linear Programming and Game Theory (3/e) John Wiley and Sons, Ins. (2008) ISBN: 978-0-470-23286-6
4. Louis Brickman: Mathematical Introduction to Linear Programming and Game Theory UTM, Springer Verlag, NY (1989) ISBN: 0-387-96931-4
5. Jiri Matoušek, Bernd Gartner: Understanding and Using Linear Programming Universitext, Springer-Verlag Berlin Heidelberg (2007) ISBN: 978-3-540-30697-9

***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	2	3	2	1	1	1	1	3
CO 2	2	2	2	2	3	2	1	1	2	1	1
CO 3	3	2	1	1	3	2	1	1	1	1	2
CO4	3	2	2	1	3	2	1	1	1	1	2

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	B.Sc. Applied Mathematics Honours			
Course Code	AMA4CJ203			
Course Title	**LINEAR ALGEBRA**			
Type of Course	**Major**			
Semester	**IV**			
Academic Level	200-299			
Course Details	Credit	Lecture/ Tutorial per week	Practical/ Practicum per week	Total Hours
	4	3	2	75
Pre-requisites	1. Familiarity with system of equations and their solutions. 2. Knowledge about matrices and matrix operations.			
Course Summary	This course should enable the student to study the linear systems of equations, vector spaces, and linear transformations. A number of methods for solving a system of linear equations are discussed. The introduction of central topic of linear algebra namely the concept of a vector space. The idea of a subspace, spanning vectors, basis and dimension are discussed and fundamental results in these areas are explored. This enables the student to understand the relationship among the solutions of a given system of linear equations and some important subspaces associated with the coefficient matrix of the system.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used
CO1	Develop a comprehensive understanding of systems of linear equations, Gaussian elimination, and the use of matrices in representing and solving such systems. Apply matrix operations and properties to manipulate and simplify linear equations and systems effectively.	U	P	Internal Exam/ Assignment/ Seminar/Viva/ End Sem Exam
CO2	Gain proficiency in identifying and working with special types of matrices, such as diagonal, triangular, symmetric, and elementary matrices. Use these properties to find inverses, understand invertibility, and perform matrix transformations to solve complex systems and model real-world scenarios.	U	C	Internal Exam/ Assignment/ Seminar/Viva/ End Sem Exam

CO3	Learn to compute determinants using cofactor expansion, minors, and row reduction techniques. Understand the properties of determinants and apply Cramer's Rule to solve linear systems. Explore the role of determinants in defining properties of linear transformations and vector spaces.	Ap	P	Internal Exam/ Assignment/ Seminar/Viva/ End Sem Exam
CO4	Synthesize knowledge from matrices, determinants, and vector spaces to analyze and solve real- world problems. Demonstrate the ability to apply algebraic structures and methods of linear algebra to model, interpret, and resolve practical and theoretical challenges in various disciplines.	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	**Elementary Linear Algebra: Application Version(11/e): Howard Anton & Chris Rorres, Wiley (2014) ISBN 9781118434413**			
Module	**Unit**	**Content**	**Hours**	**Marks** **Ext:70**
I	**1**	**1.1: Introduction to Systems of Linear Equations** Linear equation in n variables, linear system of equations in n variables, solution, Linear Systems in Two and Three Unknowns, solution by geometric analysis	**12**	**Min. 15**
	2	consistent and inconsistent systems, linear system with no, one, and infinite number of solutions, augmented matrix and elementary row operations.		
	3	**1.2: Gaussian elimination** Considerations in Solving Linear Systems, Echelon Forms, reduced row echelon form		
	4	Elimination Methods, Gauss–Jordan elimination, Gaussian elimination		
	5	Homogeneous Linear Systems, Free Variables, Free Variable Theorem for Homogeneous Systems, Gaussian Elimination and Back Substitution, Some Facts about Echelon Forms.		

	6	**1.3 : Matrices and Matrix operations** Matrix Form of a Linear System (All other topics are omitted). **1.4 : Inverses and algebraic properties of matrices** Inverse of a Matrix, Properties of Inverses, Solution of a Linear System by Matrix Inversion. (All other topics are omitted).		
II	**7**	**1.5: Elementary matrices and a method for finding A^{-1}** Equivalence, elementary matrix, Row Operations by Matrix Multiplication, invertibility of elementary matrices, invertibility and equivalent statements. A method for inverting matrices, Inversion algorithm and illustrations.	**13**	**Min. 15**
	8	**1.6: More on linear systems and invertible matrices** Number of Solutions of a Linear System, Solving Linear Systems by Matrix Inversion, Linear Systems with a Common Coefficient Matrix, Properties of Invertible Matrices, equivalent statements for unique solution of $Ax = b$, determining consistency.		
	9	**1.7 : Diagonal, Triangular and symmetric matrices** Diagonal Matrices, Inverses and Powers of Diagonal Matrices, Triangular Matrices. Properties of Triangular Matrices		
	10	, Symmetric Matrices, Algebraic Properties of Symmetric Matrices, Invertibility of Symmetric Matrices.		
	11	**1.8 : Matrix transformations** Definition, Properties of Matrix Transformations, standard matrix, A Procedure for Finding Standard Matrices.		
III	**12**	**2.1** : **Determinants by cofactor expansion Minors** Cofactors, cofactor expansion, Definition of a General Determinant, A Useful Technique for Evaluating 2 × 2 and 3×3 Determinants (Only Problems)	**10**	**Min. 15**

	13	**2.2** : **Evaluating determinants by row reduction** Examples and problems to find determinant by row reduction (Theory omitted)		
	14	**2.3** : **Properties of Determinants; Cramer's Rule** Cramer's Rule (Only problems), Inverse of matrices using adjoint formula (Only problems).		
	15	**4.1 : Real vector space** Vector Space Axioms, examples, Some Properties of Vectors. (Example 8 omitted) **4.2 : Subspaces** Definition, criteria for a subset to be a subspace, examples, Building Subspaces, linear combination, spanning,		
	16	Solution Spaces of Homogeneous Systems as subspace, The Linear Transformation Viewpoint, kernel, different set of vectors spanning the subspace. (Example 8 omitted)		
IV	17	**4.3: Linear Independence** Linear Independence and Dependence, illustrations, A Geometric Interpretation of Linear Independence. (All other topics are omitted)	10	**Min. 15**
	18	**4.4: Coordinates and basis** Coordinate Systems in Linear Algebra, Basis for a Vector Space		
	19	Finite and infinite dimensional vector spaces, illustrations, Coordinates Relative to a Basis, Uniqueness of Basis Representation		
	20	**4.5: Dimension** Number of Vectors in a Basis, dimension, Some Fundamental Theorems, dimension of subspaces		
V-Open Ended		**Practicum:** The goal is for the students to learn the following topics in practicum sessions 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**	
		• **Omitted topics of 1.4** • **4.6: Change of Basis** Coordinate Maps, Change of Basis, Transition Matrices, Invertibility of Transition Matrices, An Efficient Method for		

		Computing Transition Matrices for $\mathbb{R}^n$, Transition to the Standard Basis for $\mathbb{R}^n$.		

References:

1. Linear Algebra Done Right: Sheldon Axler, Second Edition, Springer (2015) ISBN 978- 3-319-11079-0.
2. Jim DeFranza, Daniel Gagliardi: Introduction to Linear Algebra with Applications Waveland Press, Inc. (2015) ISBN: 1478627778.
3. Otto Bretscher: Linear Algebra with Applications (5/e) Pearson Education, Inc. (2013) ISBN: 0321796977.
4. Ron Larson, Edwards, David C Falvo: Elementary Linear Algebra (6/e) Houghton Mifflin Harcourt Publishing Company (2009) ISBN: 0618783768.
5. David C. Lay, Steven R. Lay, Judi J. McDonald: Linear Algebra and its Application (5/e) Pearson Education, Inc. (2016) ISBN: 032198238X.
6. Martin Anthony, Michele Harvey: Linear Algebra: Concepts and Methods Cambridge University Press (2012) ISBN: 9780521279482.

*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	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	1	1	-	-	-						
CO 2	2	1	2	3	-	-						
CO 3	2	1	2	3	-	-						
CO 4	1	1	2	3	1	-						

Correlation Levels:

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

Assessment Rubrics:

- Assignment/ Quiz/ Discussion / Seminar
- Internal Exam
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Interna Exam	Assignment	Practical Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4		✓		✓

Program	B.Sc. Applied Mathematics Honours			
Course Code	AMA4CJ204			
Course Title	**Differential Equations**			
Type of Course	**Major**			
Semester	4			
Academic Level	200-299			
Course Details	Credit	Lecture/Tutorial per week	Practical/Practicum per week	Total Hours
	4	3	2	5
Pre-requisites	Basic Knowledge of integration, differentiation, standard integrals and differentials			
Course Summary	To model the physical world around us. To introduce many of the laws or principles governing natural phenomenon are statements or relations involving the rate at which one quality changes with respect to another. To formulate relations (modelling) that often results in an equation involving derivative (differential equation). To intend to find out ways and means for solving differential equations and the topic has wide range applications in physics, chemistry, biology, medicine, economics and engineering.			

COURSE OUTCOME(CO)

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used
CO1	To analyze basic mathematical models and behavior of solutions to differential equations using direction fields and to classify, solve various types of differential equations, including linear equations with variable coefficients, separable equations, exact equations.	**U**	**F**	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO2	To solve linear homogeneous equations with constant coefficients and nonhomogeneous differential equations using undetermined coefficients, and variation of parameters and to explain fundamental solutions and linear independence.	**AP**	**C**	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam

CO4	To apply Fourier series and transforms to solve problems, utilize Fourier integral formulas and properties, compute Fourier transforms of generalized functions, and demonstrate proficiency in Fourier cosine and sine transforms.	**Ap**	**P**	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
* - 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

Text	1.W.E. Boyce & R.C. Diprima, Elementary Differential Equations and Boundary Value Problems. John Wiley & Sons, 7th Edition. 2. L. Debnath, Integral transforms and their Applications, CRC Press, New York-London- Tokyo, 1995.			
Module	**Unit**	**Content**	**Hours (45+30)**	**Marks**
I	1	Text 1: 1.1 Some Basic mathematical Models; Direction Fields 1.2 Solutions of Some Differential Equations	12	
	2	1.3 Classification of Differential Equations		
	3	2.1 Linear equations with variable coefficients 2.2 Separable Equations		
	4	2.4 Differences Between Linear and Nonlinear Equations		
	5	2.6 Exact equations and integrating factors.		
II	6	3.1 Homogeneous equation with constant coefficients	10	
	7	3.2 Fundamental solutions of Linear Homogeneous equations		
	8	3.3 Linear independence and Wronskian		
	9	3.4 Complex roots of characteristic equations, 3.5 Repeated roots; Reduction of order		
	10	3.6 Non homogeneous equations; Method of Undetermined coefficients, 3.7 Variation of parameters		
III	11	6.1 Definition of Laplace Transforms	10	
	12	6.2 Solution of Initial Value Problem		
	13	6.3 Step functions		
	14	6.5 Impulse functions		
	15	6.6 The Convolution Integral		
IV	16	Text 2: 1.1Brief Historical Introduction 1.2 Fourier Series and Fourier Transforms 1.4 Basic Concepts and Definitions	13	
	17	2.1 Introduction 2.2 The Fourier Integral Formulas 2.3 Definition of the Fourier Transform and Examples		
	18	2.4 Fourier Transforms of Generalized Functions		

<table>
<tr><td rowspan="3"></td><td></td><td>2.5 Basic Properties of Fourier Transforms</td><td rowspan="3"></td><td rowspan="3"></td></tr>
<tr><td>19</td><td>2.11 Solutions of Integral Equations</td></tr>
<tr><td>20</td><td>2.13 Fourier Cosine and Sine Transforms with Examples</td></tr>
<tr><td colspan="2">V</td><td>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.

Text 1-
Chapter 1
1.4: Historical Remarks
Chapter 2
2.3: Modeling with first order equations
2.8: The existence and uniqueness theorem (proof omitted)
Chapter 3
3.8: Mechanical and Electrical vibrations.
Chapter 7
Introduction, Basic theory of systems of first order Linear Equation
Text 2
2.14 Properties of Fourier Cosine and Sine Transforms
Applications of Fourier transforms to find the solution of ODE
Applications of Fourier transforms to find the solution of Boundary value problem
Application of Laplace transformation to find solution of Ordinary Differential Equations.
Application of Laplace transformation to find solution of Boundary Value.
Problems and solution of system of differential equations.

Numerical computation of following methods using Python;

Euler Method, Runge-Kutta Method, Picard’s Method.</td><td>30</td><td></td></tr>
<tr><td colspan="5">1. S.L. Ross: Differential Equations, 3rd edition, Wiley.
2. A.H. Siddiqi & P. Manchanda: A First Course in Differential Equation with Applications, Macmillan, 2006.
3. E.A. Coddington: An Introduction to Ordinary Differential Equation, PHI.
4. G.F. Simmons: Differential Equation with Application and Historical Notes, 2nd edition.
5. M. Braun: Differential Equations and their Applications, Springer.
6. S.S. Sastri: Introductory Methods of Numerical Analysis (5/e) PHI Learning Pvt. Ltd. (2012).</td></tr>
</table>

7. Ward Cheney, David Kincaid: Numerical Mathematics and Computing (6/e) Thomson Brooks/ Cole (2008).
8. Erwin Kreyszig, Advanced Engineering Mathematics (8th Edition), Willey Publication, 2010
9. H. K. Dass, Advanced Engineering Mathematics, S. Chand Publication.
10. Ravish R. Singh and Mukul Bhatt, Advanced Engineering Mathematics (4th Edition), McGraw Hill publication,2018

11.Wiley & Barrett: Advanced Engineering Mathematics, Mc Graw Hill publication,

***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
CO4	3	3	3	3	3	2	2	-	2	-	3
CO5	3	3	3	3	3	2	2	-	2	-	3

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	√		√	√	√
CO4	√				√
CO5	√				√

Programme	B. Sc. Applied Mathematics Honours				
Course Code	AMA4CJ205				
Course Title	**REAL ANALYSIS**				
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	Mathematical Logic and necessary exposure to set theory. Basic Calculus.				
Course Summary	After introducing the basic notions in set theory, the course develops into the construction of the Real number system. There after 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	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
CO4	To understand the concept of Mean value theorem and Riemann integral.	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) MetacognitiveKnowledge(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	**Module 1**		12	Min 15	10
	1	Section 3.1 – Sequences and their limits. (Proofs of the Theorems 3.1.5, 3.1.9 and 3.1.10 are omitted)			
	2	Section 3.1 – Problems to find limits of sequences			
	3	Section 3.2 – Limit theorems. (Proofs of the Theorems 3.2.3, 3.2.9, 3.2.10 and 3.2.11 are omitted)			
	4	Section 3.3 – Monotone sequences – (Proof of Theorem 3.3.2 is omitted) (The topics The Calculation of Square Roots and Euler's Number are omitted)			
	5	Section 3.4 – Subsequences and the Bolzano-Weierstrass Theorem – (Proofs of Theorems 3.4.4, 3.4.7, 3.4.8 and 3.4.11 are omitted)			
II	**Module II**		12	Min 15	
	6	Section 3.7 - Introduction to Infinite Series upto 3.7.5			
	7	Section 3.7 – from 3.7.6 (Proofs of the Theorems 3.7.7 and 3.7.8 are omitted)			
	8	Section 4.1- Limit of functions (Proofs of all Theorems are omitted)).			
	9	Section 5.1 – Continuous functions.			
	10	Section 5.3 – Continuous functions on Intervals - 5.3.1 to 5.3.6			
III	**Module III**		10	Min 15	
	11	Section 5.3 – from 5.3.7 to 5.3.10			
	12	Section 5.4 – Uniform Continuity - 5.4.1 to 5.4.6			
	13	Section 5.4 – Uniform continuity – 5.4.7 to 5.4.14			
	14	Section 6.1 – The Derivative – 6.1.1 to 6.1.4			
	15	Section 6.1 – from 6.1.5 to 6.1.7(Proofs of the Theorems 6.1.5 and 6.1.6 are omitted)			
IV	**Module IV**		11	Min 15	
	16	Section 6.2- The Mean Value Theorem - 6.2.1 to 6.2.8 (Proof of 6.2.8 is omitted)			
	17	Section 6.2- from 6.2.10 to 6.2.13 (Proof of Lemma 6.2.11 is omitted)			
	18	Section 7.1 Riemann Integral – upto 7.1.3 (Without proof))			
	19	Section 7.1 Riemann Integral – from 7.1.5 (Without proof))			
	20	Section 8.1 – Pointwise and Uniform Convergence–8.1.1 to 8.1.6			

V	**Practicum:** The goal is for the students to learn the following selected topics in 15 practicum sessions 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: Properly Divergent Sequences – Section 3.6			
	Session 10: Section 4.2 - Limit theorems			
	Session 11: Section 5.2 – Combinations of continuous functions			
	Session 12: L'Hospital's Rules - Section 6.3			
	Session 13: Taylor's Theorem - Section 6.4			
	Session 14: Section 8.1 – from 8.1.7 to 8.1.10			
	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: 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

Assessment Rubrics:

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

Correlation Levels:

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

Mapping of COs to Assessment Rubrics:

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

Programme	B. Sc. Applied Mathematics Honours			
Course Code	AMA5CJ301			
Course Title	**ABSTRACT ALGEBRA**			
Type of Course	**Major**			
Semester	**V**			
Academic Level	300-399			
Course Details	Credit	Lecture/Tutorial per week	Practical/ Practicum per week	Total Hours
	4	3	2	75
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 he Theory of Groups. Elementary properties, Subgroups, Finite Groups, Cyclic Groups, ŧ 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	Demonstrate a thorough understanding of binary operations, isomorphic binary structures, and the foundational concepts of group theory, including properties and examples of groups.	U	C	Internal Exam/ Assignment/Seminar/ Viva/ End Sem Exam
CO2	Identify and analyze subgroups, cyclic groups, and groups of permutations, with a focus on subgroup criteria, cyclic properties, and permutation functions.	An	P	Internal Exam/ Assignment/Seminar/ Viva/End Sem Exam
CO3	Investigate orbits, cycles, alternating groups, cosets, and apply Lagrange's theorem to understand the relationship between subgroups and group orders.	E	P	Internal Exam/ Assignment/Seminar/ Viva/ End Sem Exam
CO4	Develop an understanding of homomorphisms, as well as the structural properties and differences among rings, fields, and integral domains, applying these concepts to abstract algebraic structures.	Ap	C	Internal Exam/ Assignment/Seminar/ Viva/End Sem Exam
CO5	Synthesize knowledge from group theory, homomorphisms, and ring structures to solve theoretical and	U	C	Internal Exam/ Assignment/Seminar/ Viva/ End

	practical problems, demonstrating the interconnections within abstract algebra.			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)				

Text Book	**A first course in abstract algebra, Fraleigh, John B. Seventh Edition, Pearson Education India, 2003**			
Module	**Unit**	**Content**	**Hours (45+30)**	**External Marks:70**
I	1	Section 2- Binary Operations	**10**	**Min.17**
	2	Section 3- Isomorphic Binary Structures		
	3	Section 4- Groups		
	4	Section 5- Subgroups – Notation and Terminology, Subsets and Subgroups		
	5	Section 5- Subgroups – cyclic subgroups		
II	6	Section 6 -Cyclic Groups – Elementary Properties of Cyclic Groups	**12**	**Min.17**
	7	Section 6 -Cyclic Groups – The structure of Cyclic Groups, Subgroups of Finite Cyclic Groups		
	8	Section 8 – Groups of Permutations – Permutation Groups		
	9	Section 8 – Groups of Permutations – Two Important Examples		
	10	Section 8 – Groups of Permutations – Cayley's Theorem		
III	11	Section 9 **-** Orbits, Cycles, and the Alternating Groups – Orbits, Cycles	**11**	**Min.18**
	12	Section 9 **-** Orbits, Cycles, and the Alternating Groups – Even and odd Permutations, The Alternating Groups (Proof of theorem 9.15 is omitted)		
	13	Section 10- Cosets and the theorem of Lagrange – Cosets		
	14	Section 10- Cosets and the theorem of Lagrange – The Theorem of Lagrange		
	15	Section 11 – Direct Products and Finitely Generated Abelian Groups		
IV	16	Section 13- Homomorphisms – Structure Relating Maps	**12**	**Min.18**
	17	Section 13- Homomorphisms – Properties of Homomorphism		
	18	Section 18-Rings and Fields – Definitions and Basic Properties		
	19	Section 18-Rings and Fields – Homomorphisms and Isomorphisms, Multiplicative Questions: Fields		
	20	Section 19-Integral Domains		

V	**Practicum:** The goal is for the students to learn the following topics in practicum sessions 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. • Generating Sets in Groups • Factor Groups • The Field of Quotients of an Integral Domain • 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)). • List S3. Find a subgroup from this group. How many distinct subgroups can be found from this group? List all of them. • Form the Dihedral group D4, 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)). • Test the command is normal () on a few subgroups of S3. (Ref (1)). • Create cyclic groups. (Section 9.5, Ref (3)). • Form finitely generated abelian groups. (Section 9.6, Ref (3)). • Form a subgroup of a group (say, S3) (Section 9.8, Ref (3)).		

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
7. Robert A. Beezer; Group Theory and SAGE: A Primer, http://people.reed. edu/~davidp/332/sage-group-theory.pdf
8. Group Theory and Sage - SageMath tutorial https://doc.sagemath.org/html/ en/thematic_tutorials/group_theory.html
9. Ajit Kumar, Vikas Bist; Group Theory An Expedition with SageMath, Narosa Publishing House.
10. 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

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	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
CO 4													
CO 5													

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
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

Programme	B.Sc. Applied Mathematics Honours			
Course Code	**AMA5CJ302**			
Course Title	**OBLECT ORIENTED PROGRAMMING USING C++**			
Type of Course	**MAJOR**			
Semester	**V**			
Academic Level	300-399			
Course Details	Credit	Lectureper week/ Tutorialper week	Practical/ Practicum per week	Total Hours
	4	3	2	75
Pre-requisites				
Course Summary	Object-oriented programming (OOP) introduces the concept of objects and classes, enabling modular and reusable code. Key principles include encapsulation, hiding internal details of objects; inheritance, creating new classes based on existing ones; and polymorphism, allowing objects to take on multiple forms. Students will learn to design and implement object-oriented programs using these principles, focusing on concepts like classes, objects, inheritance, and polymorphism.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Able to develop programs with reusability, data abstraction and inheritance.	Ap	P	Assignment/ Quiz/ Discussion / Seminars/ Internal Exam/Viva
CO2	Apply the principles of virtual functions and polymorphism.	Ap	P	Assignment/ Quiz/ Discussion / Seminars/ Internal Exam/Viva
CO3	Handle exceptions in programming.	Ap	P	Assignment/ Quiz/ Discussion / Seminars/ Internal Exam/Viva
CO4	Design programs involving constructors, destructors	Ap	P	Assignment/ Quiz/ Discussion / Seminars/ Internal Exam/Viva
CO5		Ap	P	Assignment/ Quiz/ Discussion / Seminars/ Internal Exam/Viva

* - 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	Object Oriented Programming with C++ by E. Balagurusamy, McGraw-Hill Education (India).			
Module	UNIT		**Hrs (45+30)**	**External Marks (70)**
I	1	Introduction to object-oriented programming, Characteristics of OOPS, Object oriented languages, comparison between Procedural and object-oriented programming		
	2	Basic principles of Object Orientation-class, object, Abstraction, encapsulation, inheritance, polymorphism, modularity, and message passing.		
	3	C++ Language Components: Primitive Data Types, Comments, Keywords, literals, Operators, Loops, The break and continue statement		
II	4	Classes and Objects, Defining classes, Creating objects		
	5	Defining member function, Static class members, Friend functions		
	6	Passing and returning objects to and from functions		
	7	Constructors: Default constructors, Parameterized constructors		
	8	Constructor overloading, Constructors with default arguments, Copy constructors- Destructors.		
III	9	Dynamic memory management, new and delete operators		
	10	Pointers to objects, Pointers to object members		
	11	Accessing members, this pointer		
	12	Operator overloading: Overloading unary and binary operators		
	13	Type conversion: Between objects and basic types and between objects of different classes		
	14	Inheritance: Single Inheritance, Overriding base class members, Abstract classes, Constructors and destructors in derived classes		
	15	Multilevel inheritance, Multiple Inheritance, Hierarchical Inheritance, Hybrid Inheritance		
	16	Virtual functions, Virtual base		
IV	17	Polymorphism: Binding, Static binding, Dynamic binding		
	18	Static polymorphism: Function Overloading, Ambiguity in function overloading		
	19	Dynamic polymorphism: Base class pointer, object slicing, late binding, method overriding with virtual functions, pure virtual functions		
	20	Exception handling: Try, throw, and catch, exceptions and derived classes.		
	PRACTICUM/ PRACTICALS **The goal is for the students to learn the following topics in practicum sessions 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.**			

	1. Write a C++ Program to display Names, Roll No., and grades of 3 students who have appeared in the examination. Declare the class of name, Roll No. and grade. 2. Create an array of class objects. Read and display the contents of the array. 3. Write a C++ program to declare Struct. Initialize and display contents of member variables. 4. Write a C++ program to declare a class. Declare pointer to class. Initialize and display the contents of the class member. 5. Given that an EMPLOYEE class contains following members: data members: Employee number, Employee name, Basic, DA, IT, Net Salary and print data members. 6. Write a C++ program to read the data of N employee and compute Net salary of each employee (DA=52% of Basic and Income Tax (IT) =30% of the gross salary). 7. Write a C++ to illustrate the concepts of console I/O operations. 8. Write a C++ program to use scope resolution operator. Display the various values of the same variables declared at different scope levels. 9. Write a C++ program to allocate memory using new operator. 10. Write a C++ program to create multilevel inheritance. (Hint: Classes A1, A2, A3). 11. Write a program that demonstrates function overloading, operator overloading. 12. Write a C++ program to create an array of pointers. Invoke functions using array objects. 13. Write a program that demonstrates friend functions, inline functions. 14. Write a C++ program to use pointer for both base and derived classes and call the member function. Use Virtual keyword. 15. a) Write a program that handles Exceptions. Use a Try Block to Throw it and a Catch Block to Handle it Properly. b) Write a Program to demonstrates user defined exceptions.		

References

1. ANSI and Turbo C++ by Ashoke N. Kamthane, Pearson Education.

2. C++: The Complete Reference- Schildt, McGraw-Hill Education (India).

3. Bjarne Stroustrup, "The C++ Programming Language", Pearson Education, 2004.

Mapping of COs with PSOs and POs:

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

CO 3	2	1	2	3	-	-						
CO 4	2	-	2	3	-	-						
CO 5	1	1	2	3	1	-						

Correlation Levels:

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

Assessment Rubrics:

- Assignment/ Quiz/ Discussion / Seminar
- Internal Exam
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Interna Exam	Assignment	Practical Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5		✓		✓

Programme	B.Sc. Applied Mathematics Honours			
Course Code	AMA5CJ303			
Course Title	**NUMBER THEORY**			
Type of Course	**Major**			
Semester	**V**			
Academic Level	300-399			
Course Details	Credit	Lecture/ Tutorial Per week	Practical/ Practicum per week	Total Hours
	4	3	2	75
Prerequisites	1. A solid understanding of algebraic concepts, including equations, inequalities, and functions. 2. Knowledge of topics like modular arithmetic, combinatorics, and mathematical reasoning.			
Course Summary	This course explores fundamental concepts in number theory and cryptography. Topics include divisibility, modular arithmetic, prime numbers, and key theorems like Fermat's Little Theorem and the Chinese Remainder Theorem. Building on these foundations, students learn classical and modern cryptographic techniques, including symmetric and public-key cryptography, hash functions, and digital signatures.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Students will understand and apply fundamental concepts of number theory, to solve problems related to integers and linear Diophantine equations.	Ap	P	Internal Examination/ Assignment/ End Sem Examination
CO2	Students will use the Fundamental Theorem of Arithmetic, the Sieve of Eratosthenes, and basic properties of congruence to decompose numbers into prime factors, explore integer representations, and solve congruences and other modular arithmetic problems.	U	C	Internal Examination/ Seminar/ Assignment/ Report/ End Sem examination

CO3	Students will apply Fermat's Little Theorem, Wilson's Theorem, and Mobius Inversion Formula to understand divisors, prime recognition, and pseudoprime numbers, and use these results to explore divisors properties and related functions.	Ap	P	Internal Examination/ Seminar/ Assignment/ Report/ End Sem examination
CO4	Students will gain foundational knowledge of sum and number of divisors, mobius inversion formula and greatest integer function.	U	C	Internal Examination/ 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	**Text : Elementary Number Theory (7th Edition), David M. Burton, McGraw-Hill.**			
Module	**Unit**	**Content**	**Hours (45+30)**	**External Marks:70**
I	1	**2.2:** The Division Algorithm		
	2	**2.3:** The Greatest Common Divisor(Definition 2.1 up to and including of corollary to theorem 2.3)		
	3	**2.3:** The Greatest Common Divisor(Definition 2.3 – Theorem 2.6)		
	4	**2.4:** The Euclidean Algorithm(up to and including corollary of Theorem 2.7)		
	5	**2.4:** The Euclidean Algorithm(Definition 2.4 , Theorem 2.8, corollary		
II	6	**2.5:** The Diophantine Equation $ax + by = c$		
	7	**3.1:** The Fundamental Theorem of Arithmetic(up to and including corollary 2 of Theorem 3.1)	**10**	**Min. 15**
	8	**3.1:** The Fundamental Theorem of Arithmetic (Theorem 3.2 to up to and including Theorem 3.3)		
	9	**3.2:** The Sieve of Eratosthenes		
III	10	**4.2:** Basic Properties of Congruence (up to and including theorem 4.3)		
	11	**4.2:** Basic Properties of Congruence (Theorem 4.3 onwards)		
	12	**4.4** Linear congruences		
	13	**5.3:** Fermat's Little Theorem and Pseudoprimes	**20**	**Min. 15**
	14	**5.4:** Wilson's Theorem		

IV	15	**6.1** The Sum and Number of Divisors (up to and including theorem 6.2)	10	Min. 15
	16	**6.1** The Sum and Number of Divisors (Definition 6.2 onwards)		
	17	**6.2** The Mobius Inversion Formula (up to and including Theorem 6.5)		
	18	**6.2** The Mobius Inversion Formula (Theorem 6.6 onwards)		
	19	**6.3** The greatest integer function (up to and including Example 6.2)		
	20	**6.3** The greatest integer function (Theorem 6.10 onwards)		
V		**Practicum/ Practicals:** The goal is for the students to learn the following topics in practicum sessions 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**	
		3.3 The Goldbach Conjecture **4.1** Carl Friedrich Gauss **4.3** Binary and Decimal Representations of Integers 7.2 Euler phi function 7.4 Some properties of Euler phi- function		

References:

1. A Classical Introduction to Modern Number Theory, Kenneth Ireland and Michael Rosen, Springer Science + Business Media, LLC.
2. An Introduction to the Theory of Numbers (4th Edition), G. H. Hardy and E. M. Wright, Oxford at the Clarendon Press.
3. An Introduction to the Theory of Numbers, Ivan Niven, Herbert S. Zuckerman and Hugh L. Montgomery, Wiley (1991), ISBN 9780471625469 (ISBN10: 0471625469).
4. Jeffrey Hoffstein: Jill Pipher, Joseph H. Silverman, An Introduction to Mathematical Cryptography, Springer International Edition.
5. H. Deff's & H. Knebl: Introduction to Cryptography, Springer Verlag,2002.

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

CO 3	2	2	1	1			2	3	2	2	3	2	3
CO 4	2	2	2	2			2	3	2	2	2	3	2

Assessment Rubrics:

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

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Report	End Semester Examinations
CO1	√	√			√
CO2	√		√	√	√
CO3	√		√	√	√
CO4	√		√	√	√
CO5	√		√	√	√

Correlation Levels:

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

Programme	B. Sc. Applied Mathematics Honours				
Course Code	AMA6CJ304				
Course Title	**NUMERICAL COMPUTING USING PYTHON**				
Type of Course	Major				
Semester	VI				
Academic Level	300- 399				
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours	
	4	3	2	75	
Pre-requisites	1. Real analysis 2. Linear algebra 3. Basics of Python Programming				
Course Summary	This course familiarizes 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		[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**	Total Hrs
I		**Numerical Solutions of Algebraic and Transcendelntal 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	Numerial 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. Hidebrand : 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 978-3030-50355-0. 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.

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

Mapping of COs to Assessment Rubrics:

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

Program	B.Sc. Applied Mathematics Honours			
Course Code	AMA6CJ305			
Course Title	Complex Analysis			
Type of Course	**Major**			
Semester	6			
Academic Level	300-399			
Course Details	Credit	Lecture/Tutorial per week	Practical/Practicum per week	Total Hours
	4	4		4
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 Outcome (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluatio n Tools used
CO1	Visualize and Interpret Complex Numbers in the Complex Plane	**An**	**F**	Intenal Exam/Viva/ Assignment/Seminar /End Sem Exam
CO2	To understand the difference between differentiability and analyticity of a complex function and construct examples.	**C**	**F**	Intenal Exam/Viva/ Assignment/Seminar /End Sem Exam
CO3	To understand definition of complex integral, its properties and evaluation and To know a few fundamental results on contour integration theory such as Cauchy's theorem, Cauchy-Goursat theorem and their applications.	**E**	**P**	Intenal Exam/Viva/ Assignment/Seminar /End Sem Exam

CO4	To see another application of residue theory in locating the region of zeros of an analytic function.	**Ap**	**P**	Internal Exam/Viva/ Assignment/Seminar /End Sem Exam
* - 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:

Textbook	A First Course in Complex Analysis with Application 2nd Edition; dennis G. Zill, Patrick D. Shanahan			
Module	**Unit**	**Content**	**Hrs (75)**	**Marks**
				Ext : 80
I	**Module I**		12	
	1	1.1Complex Numbers and Their Properties		
	2	1.2Complex Plane		
	3	1.3Polar Form of Complex Numbers		
	4	1.4 Powers and Roots		
	5	1.5 Sets of Points in the Complex Plane		
II	**Module II**		12	
	6	2.1Complex Functions		
	7	2.2Complex functions As Mappings		
	8	2.6 Limits and continuity(Branches, Branch cut points omitted)		
	9	3.1Differentiability and Analyticity		
	10	3.2Cauchy- Riemann Equations		
	11	3.3Harmonic Functions		
III	**Module III**		12	
	12	5.2complex Integrals		
	13	5.3Cauchy -Goursat Theorem(Proof of Cauchy' theorem omitted)		
	14	5.4Independence of Path		
	15	5.5Cauchy's Integral Formula and Their Consequences		
IV	**Module IV**		12	
	16	6.2taylor Series		
	17	6.3Laurent Series		
	18	6.4Zeros and Poles		
	19	6.5Residues and Residue Theorem		
V	**Module V (Open Ended)**		12	

	2.3 Linear Mapping 2.4 Special Power Functions 2.5Reciprocal Functions 2.6 Branches, Branch cut points. 2.7Applications 3.4 Applications. 5.3Proof of Cauchy's Theorem 5.6Applications 6.6 Some consequences of the Residue Theorem 7.1Conformal Mapping 7.2Linear Fractional Transformation Lab work to be performed 1. Declaring a complex number and graphical representation. E.g. Z1=3+4i, Z2=4-7i 2.Program to discuss the algebra of complex numbers Z1=3+4i, Z2=4-7i, then find Z1+Z2,Z1-Z2, Z1*Z2 and Z1/Z2 3.To find the modulus ,conjugate,phase angle of an array of complex numbers e.g. Z=[2+3i,4-2i,6+11i,2-5i] 4. To plot the complex functions and analyze the graph. E.g. f(z)+z,iz,z ^{2}, e^zetc		

References

1. James Ward Brown, Ruel Vance Churchill: Complex variables and applications(8/e)
McGraw-Hill Higher Education, (2009)
2. John B. Conway, Functions of one complex variable (2ndedn.), Springer international student edition, 1973
3. Alan Jeffrey: Complex Analysis and Applications(2/e) Chapman and Hall/CRC Taylor Francis Group (2006)
4. Swaminathan Ponnusamy, Herb Silverman: Complex Variables with Applications Burkhouse Boston (2006)
5. John H. Mathews & Russell W. Howell: Complex Analysis for Mathematics and Engineering (6 /e)
6. H A Priestly: Introduction to Complex Analysis(2/e) Oxford University Press (2003)
7. Jerrold E Marsden, Michael J Hoffman: Basic Complex Analysis(3/e) W.H Freeman, N.Y.(1999)

*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	3	-	1	2	-	1	-	1	-	1
CO 2	3	3	3	-	3	-	1	-	1	-	1
CO 3	3	2	2	1	3	-	1	-	2	-	2
CO 4	3	2	2	1	3	-	1	-	1	-	2

Correlation Levels:

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

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Report	End Semester Examinations
CO 1	√	√		√	√
CO 2	√	√	√		√
CO3	√	√			√
CO4	√	√			√

Program	B.Sc. Applied Mathematics Honours			
Course Code	AMA6CJ306			
Course Title	Theory of Equations and Graph Theory			
Type of Course	**Major**			
Semester	6			
Academic Level	300-399			
Course Details	Credit	Lecture/Tutorial per week	Practical/Practicum per week	Total Hours
	4	3	2	5
Pre-requisites	Sets, matrices, integration, differentiation			
Course Summary	This course gives the knowledge of basic concepts graph theory and integral equations, solution of Fredholm and Volterra integral equations.			

COURSE OUTCOME(CO)

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used
CO 1	Students will be able to perform and apply key polynomial operations, including multiplication, division and evaluation through Horner's process	**Ap**	**P**	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO 2	Students will understand and utilize the Remainder Theorem, apply the Taylor formula to expand polynomials and compute the highest common divisor of two polynomials to simplify and solve algebraic expressions efficiently.	**AP**	**p**	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO 3	Students will be able to understand the concepts of algebraic equations and their roots, apply the Fundamental Theorem of Algebra, factor polynomials into linear factors, and determine the multiplicity of roots.	**U**	**F**	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO 4	Students will be able define and recognize the key concepts of graph.	**U**	**C**	Internal Exam/ Assignment/Seminar/ Viva/Report/

				End Sem Exam
CO 5	Students will be able to analyze Euler tours and distinguish between plane and planar graphs	**An**	**P**	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO 6	Students will be able to apply basic concepts of graph theory to solve graph-related real life problems and understand the structural properties of various types of graphs.	**Ap**	**P**	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyze (An), Evaluate (E), Create (C) # - Factual Knowledge (F), Conceptual Knowledge (C), Procedural Knowledge (P), Metacognitive Knowledge (M)				

Text Book	1. Theory of Equations: J V Uspensky McGraw Hill Book Company, Inc. ISBN: 07- 066735-7.(2004), 2.A First Look at Graph Theory: John Clark & Derek Allan Holton, Allied Publishers, First Indian Reprint 1995			
Module	**unit**	**Content**	**Hours**	**Marks**
I	**1**	Chapter II (Text 1) II.1 Integral rational functions or polynomials. II.2 Multiplication of polynomials.	**15**	**Min 15**
	2	II.3 Division of polynomials, quotient and remainder, method of detached coefficients II.4 The remainder theorem		
	3	II.5 Synthetic Division II.6 Horner's process		
	4	II.7 Taylor formula, expansion of a polynomial in powers of $x - c$		
	5	II.8 Highest common divisor of two polynomials		
II	**6**	Chapter III (Text 1) III.1 Algebraic equations, roots, maximum number of roots	**15**	**Min 15**
	7	III.2 Identity theorem III.3 The Fundamental theorem of Algebra (statement only), factorisation to linear factors, multiplicity of roots		
	8	III.4 Imaginary roots of equations with real coefficients		

	9	III.5 Relations between roots and coefficients		
	10	III.6 Discovery of multiple roots		
III	**11**	Text 2: Graph Theory 1.1 Definition of a graph 1.2 Graphs as models	**10**	**Min 15**
	12	1.3 More definitions 1.4 Vertex degrees		
	13	1.5 Sub graphs		
	14	1.6 Paths and Cycles		
	15	1.7 Matrix representation of a graph [up to Theorem 1.6; proof of Theorem 1.5 is omitted]		
IV	**16**	2.1 Definitions and Simple Properties	**10**	**Min 15**
	17	2.2 Bridges [Proof of Theorem 2.6 and Theorem 2.9 are omitted]		
	18	2.3 Spanning Trees		
	19	2.6 Cut Vertices and Connectivity [Proof of Theorem 2.21 omitted]		
	20	3.1 Euler Tour [up to Theorem 3.2, proof of Theorem 3.2 omitted]		
	21	5.1 Plane and Planar graphs [Proof of Theorem 5.1 omitted]		
V		OPEN END The binary number system, logic circuit elements, addition of binary numbers, subtraction of binary numbers, accumulation, binary multiplication 3.3 Hamiltonian Graphs [Proof of Theorem 3.6 omitted] 5.2 The Euler's formula	**10**	

References
1. Susanna S. Epp: Discrete Mathematics with Applications (4/e), Brooks/ Cole Cengage Learning (2011), ISBN: 978-0-495-39132-6.
2. Kenneth H. Rosen: Discrete Mathematics and Its Applications (7/e), McGraw-Hill, NY (2007), ISBN: 978-0-07-338309-5.

***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	3	2	2	3	2	1	-	3	-	1
CO 3	2	2	2	3	3	2	1	1	1	-	1

CO 4	2	1	2	3	3	1	2	1	3	-	3

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	√		√	√	√
CO4	√	√			√

Programme	B. Sc. Applied Mathematics Honours			
Course Code	AMA7CJ401			
Course Title	**INTRODUCTION TO 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.			
Course Summary	The subject of general topology is introduced with motivations from the theory of real functions. Basic concepts like open and closed sets, interiors, closures, boundaries, neighborhoods, bases and sub-bases are introduced. After a discussion of continuity and related topics, the compactness, connectedness, and various countability axioms are discussed in some detail. The course concludes with separation axioms.			

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 analyze 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	James R. Munkres- Topology A First Course, 2nd edition- Prentice Hall of India.			
Module	**Unit**	**Content**	**Hrs (45+30)**	**External Marks (70)**
I	**Module I**			
	1	Topological spaces		
	2	Basis for a Topology		
	3	The Order Topology	**11**	**Min.15**
II	**Module II**			
	4	The Product Topology on X × Y		
	5	The Subspace Topology		
	6	Closed Sets and Limit Points	**12**	**Min.15**
III	**Module III**			
	7	Continuous Functions (Constructing Continuous Functions is omitted)		
	8	The Metric Topology (Proofs of theorems 20.4 and 20.5 are omitted)		
	9	Connected Spaces	**12**	**Min.15**
IV	**Module IV**			
	10	Compact Spaces		
	11	The Countability Axioms (Proofs of theorems are omitted)		
	12	The Separation Axioms (Example 3 is omitted)	**10**	**Min.15**
V	**PRACTICUM/PRACTICALS**			
	The goal is for the students to learn the following selected topics in 9 practicum sessions 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.			
	1	Constructing Continuous Functions, Theorem 18.2, Theorem 18.3, Theorem 18.4	**30**	
	2	The product topology, box topology, Comparison of the box and product topologies, Theorems on product topology.		
	3	The Metric Topology (continued)		
	4	The Quotient Topology; important definitions and examples (proofs of theorems are omitted).		

	5	Connected Subspaces of the Real Line		
	6	Components and Local Connectedness.		
	7	Compact Subspaces of the Real Line		
	8	Local Compactness (Definitions, examples and statements of proofs only)		
	9	Normal Spaces (Definitions, examples and statements of important theorems only)		

References:

1. C. Wayne Patty, Foundations of Topology, Second Edition- Jones & Bartlett India Pvt.Ltd., New Delhi, 2012.
2. K. D. Joshi, Introduction to General Topology, New Age International (P) Ltd. Publishers.
3. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill.
4. S. Willard, General Topology, Addison Wesley Publishing Company.

**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. Applied Mathematics Honours			
Course Code	AMA7CJ402			
Course Title	**ADVANCED 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, 2^{nd} 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	**30**	
	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		

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_ebook_English_Version_All

	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

***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 :

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. Applied Mathematics Honours		
Course Code		AMA7CJ403		
Course Title		Cryptography and Automata Theory		
Type of Course		Major		
Semester		VII		
Academic Level		400-499		
Course Details	Credits	Lecture/Tutorial per week	Practical/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/Assignm ent/ Seminar/ Viva / End Sem Exam
CO4	Gain the Knowledge of	U	F	Internal Exam/Assignm ent/ Seminar/ Viva /
	basic kinds of finite automata and their capabilities			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)				

Text Book	1.Cryptography Theory and Practice 3rd Edition, Douglas R. Stinson, , Chapman & Hall, 2.Theory Computer Science (Automata, Languages and Computation) by K.L.P. Mishra and N. Chandrasekhar, PHI			
Module	Unit	Content	Hrs/ week	External Marks
I	1	Chapter 1: Section 1.1-1.1.1: Some Simple Cryptosystems, Shift Cipher	12	MIN 15
	2	Chapter 1: Sections 1.1.2 & 1.1.3: The Substitution Cipher, Affine Cipher		
	3	Chapter 1: Sections 1.1.4 & 1.1.5: The Vigenere Cipher, The Hill Cipher		
	4	Chapter 1: Sections 1.1.6 : The Permutation Cipher		
	5	Chapter 1: Sections 1.1.7 : Stream Ciphers		
II	6	Chapter 1: Section 1.2 & 1.2.1 : Cryptanalysis: Cryptanalysis of the Affine Cipher	12	MIN 15
	7	Chapter 1: Section 1.2.2 : Cryptanalysis of the Substitution Cipher		

	8	Chapter 1: Section 1.2.3 : Cryptanalysis of the Vigenere Cipher		
	9	Chapter 1: Section 1.2.4 : A known plain text attack on the Hill Cipher		
	10	Chapter 1: Section 1.2.5 : Cryptanalysis of the LFSR-based Stream Cipher.		
III	11	Chapter 2 : Sections 2.1, 2.2 : Introduction, Elementary Probability Theory	10	MIN 15
	12	Chapter 2 : Sections 2.3: Perfect Secrecy		
	13	Chapter 2 : Sections 2.4: Entropy, Huffman Encodings		
	14	Chapter 2 : Sections 2.5: Properties of Entropy		
	15	Chapter 2 : Sections 2.6: Spurious Keys and Unicity Distance		

	16	Chapter 2 : Sections 2.7: Product Cryptosystems		
IV	17	**TEXT 2** 2.3 strings and their properties 2.3.1 Operations on strings 2.3.2 Terminal and Nonterminal symbols	14	
	18	3.1Definition of an Automation		
	19	3.2 Description of a finite Automation		
		3.3Transition system 3.4 Properties of transition functions		
	20	3.5Acceptability of a string by a finite automation 3.6Nondeterministic finite state machines		
	21	3.7deterministic finite state machines		
	22	3.9Minimization of finite Automata		

	23	4 Formal Languages 4.1 Basic Definitions and Examples 4.1.1 Definition of a Grammar		
	24	4.1.2 derivations and Language Generated by a Grammar		
V		**Text 1:Block Ciphers** Cryptographic Hash Functions Text 2: 3.8Mealy and Moore Models 3.8.1 Finite Automata with Outputs 3.8.2Procedure for transforming a Mealy Machine into a Moore Machine. 3.8.32Procedure for transforming a Moore Machine into a Mealy Machine Formal Languages Regular Grammars	12	

1. John E. Hopcroft, Rajeev Motwani, Jeffrey D. Ullman (2007), Introduction to Automata Theory Languages and Computation, 3rd edition, Pearson Education, India.

2.Introductory theory of computer science by E.V. Krishna Murthy, East-West Press.

3. Theory of Finite Automates with an introduction to formal languages by Carrel J and Lang D, PHI

4. Linz P, An Introduction to Formal Languages and Automata, Narosa Publishing House Pvt. Ltd., New Delhi, ISBN: 9788173197819.

5. Michael Sipser, Introduction to Theory of Computation, Cengage Learning India Private Limited, Indian Edition, ISBN: 8131505138.

6. H.R. Lewis and C.H. Papadimitriou, Elements of Theory of Computation, 2nd Edition, Prentice Hall, ISBN: 0132624788.

7. J. E. Savage, Models of Computation, Exploring the Power of Computing, Addison Wesley, 1998, Available at http://cs.brown.edu/~jes/book/.

8. MartinJ.C, Introduction to Languages and Theory of Computation, Tata McGraw Hill, 3rd Edition, ISBN: 9780070

****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	1	1	1	3	3	3	3	0	0	3
CO 3	3	2	1	1	3	3	3	3	0	0	3
CO4	3	2	1	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/ Report
- Seminar
- Internal Exam
- Viva
- Final Exam (70%)

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓
CO4	✓				✓

Programme	B. Sc. Applied Mathematics Honours				
Course Code	AMA7CJ404				
Course Title	**PARTIAL DIFFERENTIAL EQUATIONS**				
Type of Course	**Major**				
Semester	**VII**				
AcademicLevel	400-499				
Course Details	Credit	Lecture/Tutorial per week	Practical/ Practicum per week	Total Hours	
	4	3	2	75	
Pre-requisites	1. Real Analysis 2. Basic Concepts of Vector functions 3. 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 and different type of first order partial differential equations.	U	C	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO2	Understanding of basic concepts, definitions, and mathematical problems related to first-order quasilinear equations.	An	E	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO3	Analyse and evaluate the classification of second-order linear equations, including the Cauchy problem and wave equations.	E	P	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO4	Evaluate solutions for boundary value problems and apply them in solving PDEs.	Ap	E	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO5	To solve Vibrating string problems and Heat conduction problems	Ap	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	**Text: Amaranath – An elementary course in partial differential equations (2nd edition) – Narosa Publishing House, 2003**			
MODULE	**UNIT**	**CONTENT**	**Hrs (45+30)**	**MARKS Ext: 70**
I	MODULE I		10	**Min.15**
	1.1	Curves and Surfaces		
	1.2	Genesis of First Order P.D.E.		
	1.3	Classification of Integrals		
	1.4	Linear Equations of the First Order		
	1.5	Pfaffian Differential Equations		
	1.6	Compatible Systems of first order PDE.		
II	MODULE II		10	**Min.10**
	1.7	Charpit's Method		
	1.8	Jacobi's Method		
	1.9	Integral Surfaces Through a Given Curve		
	1.10	Quasi-Linear Equations		
	1.11	Non-linear First Order P.D.E.		
III	MODULE III		13	**Min.15**
	2.1	Genesis of Second Order PDE		
	2.2	Classification of Second Order PDE		
	2.3.1	Vibrations of an Infinite String		
	2.3.2	Vibrations of a Semi - Infinite String		
	2.3.3	Vibrations of a String of Finite Length		
	2.3.5	Vibrations of a String of Finite Length (Method of Separation of Variables)		
IV	MODULE IV		12	**Min.15**
	2.4.1	Boundary Value Problems		
	2.4.2	Maximum and Minimum Principles		
	2.4.3	The Cauchy Problem		

	2.5.1	Heat Conduction - Infinite Rod Case		
	2.5.2	Heat Conduction - Finite Rod Case		

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	
	2.6: Duhamel's principle 2.8: families of equipotential surfaces 2.9: Kelvin's inversion theorem		

References:

1. Ian Sneddon, Elements of Partial Differential Equations, Mc Graw- Hill, 2013.
2. Phoolan Prasad, Renuka Raveendran: Partial Differential Equations, Wiley Eastern, 1985.
3. M. D. Raisinghaniya, Ordinary and Partial Differential Equations, S Chand 18th Edition, 2008.

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	1	3	2			3	0	3	0	3	0	0
CO2	1	3	2	2			3	0	3	0	3	0	0
CO3	3	2	3	3			3	0	3	0	3	0	0
CO4													
CO5													

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	Seminar	Viva	End Semester Examinations
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

Programme	B.Sc. Applied Mathematics Honours			
Course Code	AMA7CJ405			
Course Title	**ADVANCED ABSTRACT ALGEBRA**			
Type of Course	**Major**			
Semester	**VII**			
Academic Level	400-499			
Course Details	Credit	Lecture/Tutorial per week	Practical/ Practicum per week	Total Hours
	4	3	2	75
Pre-requisites	Basic knowledge of binary operations, groups, subgroups, abelian groups			
Course Summary	This course gives the idea about group homomorphism, isomorphism, factor groups, Sylow theorems, Rings, Rings of polynomial, fields,field extensions e.t.c.			

Course Outcome (CO):

CO	CO Statement	Cognitive level*	Knowledge category#	Evaluation Tools used
CO1	Analyze and apply key concepts in group theory, including homomorphisms, factor groups, and isomorphism theorems, as well as Sylow theorems, to understand group structures and their classification.	An	C	Internal Exam/Viva/ Assignment/Seminar /End Sem Exam
CO2	Develop a foundational understanding of rings, fields, and integral domains, with an emphasis on Fermat's and Euler's theorems, and apply this knowledge to the field of quotients of an integral domain, fostering problemsolving in abstract algebra.	U	C	Internal Exam/Viva/ Assignment/Seminar /End Sem Exam
CO3	Investigate the structure of polynomial rings, understand their factorization over fields, and explore the concepts of homomorphisms and factor rings, along with the properties of prime and maximal ideals in ring theory.	An	P	Internal Exam/Viva/ Assignment/Seminar /End Sem Exam
CO4	Gain an understanding of extension fields and algebraic extensions, identifying their significance in abstract algebra and applications, including finite fields and the relationships among different types of field extensions.	U	P	Internal Exam/Viva/ Assignment/Seminar /End Sem Exam
CO5	Integrate knowledge of homomorphisms, ideals, factor rings, and extensions to solve complex	Ap	C	Internal Exam/Viva/ Assignment/Seminar /End Sem Exam

	problems in algebra, demonstrating an ability to reason abstractly and make connections between algebraic structures.			
* - 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	**John B Fraleigh: A First Course in Abstract Algebra, 7th Edition**			
MODULE	**UNIT**	**CONTENT**	**Hours (45+30)**	**External Marks:70**
I	1	14 - Factor Groups	**10**	**Min 15**
	2	15 – Factor Group Computations and Simple Groups		
	3	22 - Rings of Polynomials		
II	4	23 - Factorization of Polynomials over a field	**12**	**Min 15**
	5	26 - Homomorphisms and Factor Rings		
	6	27 - Prime and Maximal ideals		
III	7	29 - Introduction to Extension Fields	**13**	**Min 15**
	8	31 - Algebraic Extensions		
	9	33 - Finite Fields		
IV	10	34 - Isomorphism Theorems	**10**	**Min 15**
	11	36 - Sylow Theorems		
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**	
	16 - Group Action on a Set 21 - The Field of Quotients of an Integral Domain 35 - Series of Groups			

References:

1. I.N. Herstein: Topics in Algebra Wiley Eastern (Reprint)
2. N.H. Mc Coy and R.Thomas: Algebra. Allyn & Bacon Inc. (1977).
3. J. Rotman: The Theory of Groups Allyn & Bacon Inc. (1973)
4. Hall,Marshall: The Theory of Groups. Chelsea Pub. Co. NY. (1976)
5. Clark, Allan: Elements of Abstract Algebra Dover Publications (1984)
6. L.W. Shapiro: Introduction to Abstract Algebra McGraw Hill Book Co. NY (1975)

*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
CO1	3	1	2	2			3	1	-		3	1	2
CO2	3	1	2	2			3	1	-		3	1	2
CO3	3	1	2	2			3	1	1		3	1	2
CO4	3	1	2	2			3	1	1		3	1	2
CO5													

Correlation Levels:

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

Assessment Rubrics:

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

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

Programme	B Sc Applied Mathematics Honours			
Course Code	AMA8CJ406			
Course Title	**Introduction to Fractals**			
Type of Course	**Major**			
Semester	**VIII**			
Academic Level	400-499			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	5	..	75
Pre-requisites	Theory of functions of real and continous variables, differential and integral calculus, geometry, topology			
Course Summary	This course is an introduction to fractal geometry, a visually motivated mathematical technique for studying roughness.			

Course Outcome

CO	CO Statement	Cognitive level*	Knowledge category#	Evaluation Tools used
CO1	Understand the basic concepts to build fractals	U	F	Internal Exam/Viva/ Assignment/Seminar /End Sem Exam
CO2	Interpret the dimension of fractals	E	F	Internal Exam/Viva/ Assignment/Seminar /End Sem Exam
* - Remember (R , Understand (U), Apply (Ap), Analyse (An), valuate (E), Create (C # - Factual Knowledge (F), Conceptual Knowledge (C, Proceduaral Knowledge (P), Metacognitive Knowledge (M)				

Textbook	Kenneth Falconer, Fractal Geometry Mathematical Foundation and Application, Third edition, Wiley, 2014			
Module	**Unit**	**Content**	**Hrs (75)**	**Marks Ext : 70**
I		**Module I**	15	
	1	1.1 Basic set theory		
		1.2 Functions and limits		
		1.3 Measures and mass distributions		
		2.1 Box-counting dimensions		
II		**Module II**	15	
	2	2.2 Properties and problems of box-counting dimension		
		3.1 Hausdorff measure		

		3.2 Hausdorff dimension		
		3.3 Calculation of Hausdorff dimension – simple examples		
III	**Module III**		15	
	3	4.1 Basic methods		
		9.1 Iterated function systems		
		9.2 Dimensions of self-similar sets		
IV	**Module IV**		15	
	4	9.3 Some variations		
		10.2 Continued fractions		
		11.1 Dimensions of graphs		
V	**Module V (Open Ended)**		15	
	The Weierstrass function and self-affine graphs, Repeller's and iterated function system, The logistic map			

References

1. Falconer K.J, The Geometry of Fractal set, Cambridge University Press, Cambridge, 1986
2. Barnsley M F, (1988), Fractals Everywhere, Academic press
3. Pietgen, H.O., Jurgens, H. and Saupe, D., 2004, "Chaos and Fractals: New Frontiers of Science", 2nd Edition, Springer-Verlag, New York.
4. Barnsley, M, 2006, "Super Fractal", 2nd Edition, Cambridge University Press.

**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	2	2	2	1	1
CO 2	3	3	1	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/ Report
- 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	✓	✓	✓	✓	✓

Programme	B Sc Applied Mathematics Honours			
Course Code	AMA8CJ407			
Course Title	**Fluid Dynamics**			
Type of Course	**Major**			
Semester	**VIII**			
Academic Level	400-499			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	5	..	75
Pre-requisites	Basics of real number system and calculus			

COURSE OUTCOME(CO)

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used
CO 1	understand the concept of fluid and their classification, models and approaches to study the fluid flow.	**U**	**C**	Internal Exam/ Assignment/ Seminar/ Viva /Report/ End Sem Exam
CO 2	Formulate mass and momentum conservation principle and obtain solution for non- viscous flow.	**AP**	**P**	Internal Exam/ Assignment/ Seminar/ Viva /Report/ End Sem Exam
CO 3	Know potential theorems, minimum energy theorem and circulation theorem.	**An**	**C**	Internal Exam/ Assignment/ Seminar/ Viva /Report/ End Sem Exam
CO 4	Understand two-dimensional motion, circle theorem and Blasius theorem.	**U**	**C**	Internal Exam/ Assignment/ Seminar/ Viva /Report/ End Sem Exam

* - 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	Hours75	Marks
I	1	Types of fluids, Continuum hypothesis, Lagrangian and Eulerian method of describing fluid motion	10	
	2	Motion of Fluid element: Translation, Rotation and Deformation. Stream lines, Path lines and streak lines..		
	3	Material derivative. Acceleration of a fluid particle in Cartesian, Cylindrical Polar and Spherical Polar Coordinates		
	4	Vorticity Vector, Vortex Lines, Rotational and Irrotational motion of fluid, Rotational velocity, Velocity Potential, Boundary surface, Boundary condition.		
II	5	Reynold transport theorem. Principle of conservation of Mass-Equation of continuity (By Lagrangian and Eulerian method).	10	
	6	Equation of Continuity in different coordinate systems. Body force and Surface force.		
	7	Euler's equation of motion-conservation of momentum, Bernoulli's Equation, Energy Equation, Impulsive effects.		
III	8	Irrotational motion in two dimensions: Stream function, Physical significance of stream function, Sinks, Doublets and their images in two dimension,.	10	
	9	Complex Velocity Potential. Sources, Milne-Thompson circle theorem, Vortex, Vortex motion, Image of Vortex, Kelvin Circulation Theorem, Complex potential due to Vortex,		
IV	10	Irrotational motion produced by motion of circular cylinders in an infinite mass of liquid, Liquid Streaming past circular cylinder.	10	
	11	Kinetic energy of liquid, Motion of sphere through a liquid at rest at infinity.		
	12	Liquid streaming past a fixed sphere, Axis-Symmetric flow, Stoke's function.		
V		1. Kirchhoff vortex Theorem, Blasius Theorem and Kutta-Joukowski Theorem Frank Chorlton: Text Book of Fluid Dynamics, C.B.S. Publishers, Delhi.	35	

		2. Z.U.A. Warsi: Fluid Dynamics, Theoretical and Computational Approaches, C.R.C. Press 3. S.W. Yuan: Foundation of Fluid Mechanics, Prentice Hall of India Pvt. Ltd. New Delhi 4. N. Curle and H J Davies: Modern fluid dynamics 5. G. K. Bachelor: An Introduction to Fluid Dynamics. Cambridge University Press. London. 6. R.W. Fox, P.J. Pritchard and A.T. McDonald: Introduction to Fluid Mechanics, Seventh Edition, John Wiley & Sons, 2009. 7. Mechanics, Seventh Edition, John Wiley & Sons, 2009. Web References: Digital platforms web links: NPTEL/SWAYAM/ MOOCS/Openstax.org https://openlearninglibrary.mit/edu/courses http://heecontent.upsdc.gov.in/SearchContent.aspx https://www.lkouniv.ac.in/en/article/e-content-faculty-of-science		

**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	3	3	1	1	-	3	-	3
CO 2	3	3	2	3	3	1	1	-	3	-	3
CO 3	3	2	2	3	3	1	1	-	3	-	3
CO 4	3	2	2	3	3	1	1	-	3	1	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 Applied Mathematics Honours			
Course Code	AMA8CJ408			
Course Title	**Stochastics Process**			
Type of Course	**Major**			
Semester	**VIII**			
Academic Level	400-499			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	5	..	75
Pre-requisites	Basics of real number system and calculus			

COURSE OUTCOME(CO)

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used
CO 1	Carry out derivations involving conditional probability distributions and conditional expectations.	**Ap**	**P**	Internal Exam/Assignment/Seminar/ Viva/Report/ End Sem Exam
CO 2	Define basic concepts from the theory of Markov chains and present proofs for the most important theorems.	**An**	**C**	Internal Exam/Assignment/Seminar/ Viva/Report/ End Sem Exam
CO 3	Solve differential equations for distributions and expectations in time continuous processes and determine corresponding limit distributions.	**E**	**P**	Internal Exam/Assignment/Seminar/ Viva/Report/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyze (An), Evaluate (E), Create (C) # - Factual Knowledge (F), Conceptual Knowledge (C), Procedural Knowledge (P), Metacognitive Knowledge (M)				

Text	J. Medhi, "Stochastic Processes", New Age International (P) Ltd., New Delhi, 2nd Edition, 2001.			
Module	Unit	Content	Hours75	Marks
I	1	MARKOV AND STATIONARY PROCESSES 9 Specification of Stochastic Processes – Stationary Processes – Poisson Process – Generalizations – Birth and Death Processes – Markov Chain – Erlang Process	10	
II	5	RENEWAL PROCESSES 9 Renewal processes in discrete and continuous time – Renewal equation – Stopping time – Wald's equation – Renewal theorems – Delayed and Equilibrium renewal processes – Residual and excess life times – Renewal reward process – Alternating renewal process – Regenerative stochastic process	10	
III	8	MARKOV RENEWAL AND SEMI – MARKOV PROCESSES 8 Definition and preliminary results – Markov renewal equation – Limiting behaviour - First passage time.	10	
IV	10	BRANCHING PROCESSES 10 Generating functions of branching processes – Probability of extinction – Distribution of total number of progeny – Generalization of classical Galton – Watson process – Continuous time Markov branching process – Age dependent branching process – Bellman - Harris process	10	
	11	MARKOV PROCESSES WITH CONTINUOUS STATE SPACE 9 Brownian motion – Weiner process – Kolmogorov equations - First passage time distribution for Weiner process – Ornstein – Uhlenbeck process		
V		Applied problems of all modules		
REFERENCES: 1. U.N. Bhat, "Elements of Applied Stochastic Processes", John Wiley and Sons Limited, 2nd Edition, 1984. 2. D.R. Cox and H.D. Miller, "The theory of Stochastic Process", Methuen, London,1965. 3. S. M. Ross ,"Stochastic Processes", Wiley, New York, 2nd Edition,1996. 4. S. Karlin and H.M. Taylor, "A First Course in Stochastic Processes", 2nd Edition, Academic press, New York, 1975				

Mapping of COs with PSOs and POs :

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

ELECTIVE COURSES

Programme	B. Sc. Applied Mathematics Honours			
Course Code	AMA5EJ301(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		
	Probabilistic Method (Text 1)		**12**	
IV	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. Applied Mathematics Honours			
Course Code	AMA5EJ302(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.			

Course Outcome

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 Algorihtms		
	2	Effficiency 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.

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 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

Mapping of COs to Assessment Rubrics:

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

Programme	B. Sc. Applied Mathematics Honours			
Course Code	AMA6EJ301(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.			

Course Outcome

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand and apply the Bisection Method, Iteration Method, NewtonRaphson 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		[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**	Total Hrs
I		**Numerical Solutions of Algebraic and Transcendelntal 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	Numerial 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. Hidebrand : 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 9783030-50355-0. 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 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%)

Assessment Rubrics:

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

Programme	B. Sc. Applied Mathematics Honours			
Course Code	AMA6EJ302(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%)

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

Programme	B. Sc. Applied Mathematics Honours			
Course Code	MAT5EJ303 (2)			
Course Title	**CONVEX OPTIMIZATION**			
Type of Course	**Elective (Specialisation- Data Science)**			
Semester	V			
Academic Level	300 - 399			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites	Linear Algebra and Multi Variable Calculus			
Course Summary	The course covers the basic theory of convex sets and functions, optimization theory of convex functions and Lagrangian duality. The concepts explored in this course are important for data science, as they underpin many algorithms and methods in machine learning, optimization, and statistical analysis. For instance, understanding gradients and Hessians is essential for optimizing cost functions, while knowledge of convex optimization is vital for developing efficient algorithms. This mathematical foundation will enable data scientists to design, analyse, and implement sophisticated models and solutions.			

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Prove the basic properties of convex sets and functions.	Ap	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Model simple problems using convex optimization methods and solve them.	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Formulate the dual of a convex optimization problem and describe the properties.	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:

Text Book		**1. K. G. Binmore, Mathematical Analysis: A straightforward approach, 2nd edition, Cambridge University Press, 1982.** **2. Stephen Boyd, and Lieven Vandenberghe. Convex optimization. Cambridge university press, 2004.**		
Module	**Unit**	**Content**	**Hrs (48+12)**	**Ext. Marks (70)**
I		**Review of Multivariable Calculus**	**10**	
	1	Scalar and vector fields - Directional and Partial Derivatives		**Min 15**
	2	Differentiable functions and total Derivative - Matrix representation - Gradient and Jacobian		
	3	Chain rule for differentiation - matrix form		
	4	Stationary points - conditional for stationarity		
	5	Second derivatives and Hessian Matrix.		
	6	Mean value theorems, second order Taylor's theorem		
	7	Eigenvalues of Hessian		
	8	Classification of stationary points.		
	Chapter 19 of Text Book 1 - pages 190-231.			
II		**Convexity**	**14**	**Min 15**
	9	Affine and Convex Sets		
	10	Convexity preserving operations		
	11	Generalized inequalities		
	12	Supporting and separating hyperplanes		
	13	Dual cones and generalized inequality		
	14	Basic properties and examples of convex functions		
	15	Convexity preserving operations		

	16	Quasi convex, log convex functions		
	17	Convexity and generalized inequalities		
	Chapter 2 and 3 of Text Book 2.			
III	**Convex Optimization Problems**		**12**	
	18	Optimization problems and convex optimization	`	
	19	Linear optimization problems		**Min 15**
	20	Quadratic optimization problems		
	21	Geometric programming		
	22	Generalized inequality constraints		
	19	Vector optimization		
	Chapter 4 of Text Book 2			
IV	**Duality**		**12**	**Min 15**
	20	The Lagrange dual function		
	21	The Lagrangian dual and geometric interpretation		
	22	Saddle point interpretation		
	23	Optimality condition		
	24	Theorems of alternatives		
	25	Generalized inequalities		
	Chapter 5 of Text Book 2			
V (Open Ended)	**Open Ended**		**12**	
	27	Instances of practical problems that can be solved with convex optimization methods discussed in the course such as linear classifiers, support vector machines, linear and logistic regression.		

References:

1. David G. Luenberger and Yinyu Ye. Linear and nonlinear programming. 4th edition. Springer, 2015.
2. Niels Lauritzen, Undergraduate Convexity: From Fourier And Motzkin To Kuhn And Tucker, World Scientific, 2013.

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	0	2	3	2	3	2	3	1	2
CO 2	2	3	1	2	3	2	3	3	3	1	3
CO 3	2	2	0	3	3	2	3	2	3	1	2

Correlation Levels:

Level	Correlation
2-3	1N2il
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. Applied Mathematics Honours			
Course Code	MAT6EJ303 (2)			
Course Title	**MACHINE LEARNING - I**			
Type of Course	**Elective (Specialisation- Data Science)**			
Semester	V			
Academic Level	300 - 399			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites	Linear Algebra			
Course Summary	The course develops the basic theory of linear discriminative and generative learning models and techniques for linear regression and classification. Understanding both classical methods and modern neural network approaches will prepare students to tackle a wide range of data science challenges.			

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Describe various regression and classification methods and apply them for simple problems.	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Apply methods of Bayesian inference to learning problems and analyse the solutions	An	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Describe the functioning of feedforward neural network models of learning.	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 (48+12)	Ext. Marks (70)
Text Book		**Pattern Recognition and Machine Learning - Christopher M. Bishop - Springer -2006**		
Module	**Unit**	**Content**	**Hrs (48+12)**	**Ext. Marks (70)**
I		**Introduction to Statistical Learning**	**12**	
	1	Review of probability theory, density and distribution functions		**Min 15**
	2	expectation and covariance, Bayesian probabilities.		
	3	Gaussian distribution: conditional and marginal distributions		
	4	Maximum Likelihood and Bayesian inference for Gaussian		
	5	Decision Theory - inference and decision, loss functions		
	6	Entropy, relative entropy and mutual information		
	Chapter 1 and Section 3 of Chapter 2 from text book.			
II		**Linear Regression**	**12**	
	7	Maximum likelihood and least squares		**Min 15**
	8	Regularized least squares		
	9	Bias-Variance Decomposition		
	10	Bayesian Linear Regression		
	11	Parameter and Predictive Distributions		
	12	Bayesian model comparison		
	Chapter 3 of text book			
III		**Linear Classification**	**12**	
	13	Discriminant functions		

	14	Least squares, Fischer discriminant and the relation between them.		Min 15
	15	The perceptron algorithm		
	16	Maximum likelihood classifier		
	17	Probabilistic generative models and Logistic Regression		
	18	Bayesian logistic regression		
	Chapter 4 of text book			
IV	**Neural Networks**		**12**	Min 15
	19	Feed forward neural networks		
	20	Network training and gradient descent optimization		
	21	Analysis of error backpropagation		
	22	Hessian matrix and diagonal approximation		
	23	Regularization in neural networks.		
	Chapter 5 of text book			
V	**Open Ended**		**12**	
		Model Selection and Validation Non-Uniform Learnability The Run Time of Learning		

References:
1)Understanding Machine Learning From Theory to Algorithms - Shai Shalev Shwartz, Shai Ben David
- Cambridge University Press - ISBN 978-1-107-05713-5 - 2014
2) Foundations of Machine Learning - Mehryar Mohri, Afshin Rostamizadeh, and Ameet Talwalkar - The MIT Press - 2012

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	2	3	2	3	3	3	1	3
CO 2	3	3	2	2	3	2	3	3	3	1	3
CO 3	3	2	2	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	B. Sc. Applied Mathematics Honours				
Course Code	MAT6EJ303 (2)				
Course Title	**APPLIED PROBABILITY**				
Type of Course	**Elective (Specialisation- Data Science)**				
Semester	VI				
Academic Level	300 - 399				
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours	
	4	4	-	60	
Pre-requisites	Basic Algebra and Calculus				
Course Summary	This course serves as an introduction to the fundamental principles and concepts of probability theory. Understanding probability distributions, expectations, and Markov chains is essential for modelling data, making predictions, and analysing complex systems in data science applications.				

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand basic concepts in probability theory, including discrete and continuous probability distributions, joint distributions for multiple random variables, and Markov chains.	U	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Apply probability distributions to practical scenarios and compute key measures such as expected value and variance, with an emphasis on their significance in decision-making and risk assessment.	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Explore and understand fundamental limit theorems, such as the law of large numbers and the central limit theorem, and their implications for probability theory and statistical inference.	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:

Text Book		**Introduction to Probability Models - Sheldon M Ross -10th (e)- Academic Press**		
Module	**Unit**	**Content**	**Hrs (48+12)**	**Ext. Marks (70)**
I			**12**	
	1	Sample space and events.		**Min 15**
	2	Probabilities defined on events.		
	3	Conditional Probabilities		
	4	Independent Events.		
	5	Bayes 'Formula.		
	6	Random Variables.		
	7	Discrete Random Variables.		
	8	Continuous Random Variables		
	Chapter 1: Sections 1.2, 1.3, 1.4, 1.5, 1.6 Chapter 2: Sections 2.1, 2.2, 2.3			
II			**12**	**Min 15**
	9	Expectation of a Random Variable Discrete Case and Continuous Case		
	10	Jointly distributed Random Variables.		
	11	Moment generating functions.		
	12	Limit Theorems		
	Chapter 2: sections 2.4, 2.5, 2.6, 2.8			
III			**12**	

	13	Conditional probability and conditional expectation- The discrete case.		**Min 15**
	14	Conditional probability and conditional expectation- The continuous case.		
	15	Computing expectations by conditioning.		
	16	Computing Probabilities by conditioning.		
	Chapter3: Sections 3.1, 3.2, 3.3, 3.4, 3.5			
IV			**12**	
	19	Markov chain definition and examples.		

	20	Chapman-Kolmogrov equations.		
	21	Classification of states of a Markov Chain.		
	22	Limiting Probabilities		**Min 15**
	Chapter4: Sections 4.1, 4.2, 4.3, 4.4			
V	**Open Ended**		**12**	
	23	Properties of exponential distribution, Counting processes, Poisson process, properties of Poisson process		

References:

ohn Wiley.

1. S. Ross, “A First Course in Probability,” Eighth Edition, Prentice Hall.
2. W. Feller, “An Introduction to Probability Theory and its Applications,” Vol.I, J
3. B.V. Gnedenko, “Theory of Probability,” Chelsea, New York n, Academi
4. S.M. Ross, “Stochastic Processes,” second edition, John Wiley
5. S. Karlyn and H. Taylor, “A First course in Stochastic Processes”, second editio c Press

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	2	3	2	3	2	3	1	2
CO 2	2	3	2	2	3	2	3	3	3	1	3
CO 3	3	2	1	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. Applied Mathematics Honours				
Course Code	MAT6EJ304 (2)				
Course Title	**MACHINE LEARNING - II**				
Type of Course	**Elective (Specialisation- Data Science)**				
Semester	VI				
Academic Level	300 - 399				
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours	
	4	4	-	60	
Pre-requisites	Machine Learning - I				
Course Summary	This course studies advanced models of machine learning. Mastery of techniques like regression, classification, and dimensionality reduction will enable students to handle complex data sets, perform advanced analytics, and develop robust predictive models. Understanding kernel methods, SVMs, graphical models, and PCA will provide the necessary tools for tackling a wide range of data-driven challenges in real-world applications.				

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	To analyse and design support vector machines and kernel methods for learning problem.	An	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	To analyse graphical models for learning and explore belief propagation in graph models.	An	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	To analyse and apply PCA and dimensionality reduction techniques	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	**Pattern Recognition and Machine Learning - Christopher M. Bishop - Springer - 2006**			
Module	**Unit**	**Content**	**Hrs (48+12)**	**Ext. Marks (70)**
I		**Kernel Methods**	**12**	
	1	Review of linear regression and classification		
	2	Dual representations and construction of kernels		
	3	Radial basis function networks - Nadaraya-Watson model		
	4	Gaussian processes for regression and classification		
	5	Laplace approximation		
	6	Connection to neural networks		
	Chapter 6 of text book			
II		**Support Vector Machines**	**12**	
	7	Maximum Margin Classifiers		
	8	Relation to logistic regression		
	9	Regression using SVM.		
	10	Relevance Vector Machines		
	11	Regression and classification using RVM		
	Chapter 7 of text book			
III		**Graphical Models**	**12**	
	12	Bayesian Networks		
	13	Markov Random Fields		
	14	Factorization properties		
	15	Inference in Graphical Models		

	16	Factor graphs and sum-products algorithm		
	17	Belief propagation		
	Chapter 8 of text book			
IV	**Principal Component Analysis**		**12**	
	18	Maximum variance and minimum error PCA		
	19	Dimensionality reduction		
	20	Maximum likelihood PCA and EM algorithm		
	21	Bayesian PCA and factor analysis		
	22	Kernel PCA		
	Chapter 12 of text book			
V	**Open Ended**		**12**	
		1. Boosting 2. Convex learning problems 3. Regularization in convex learning 4. Learning of convex Lipschitz and smooth bounded functions 5. Stochastic gradient descent		
References: 1)Understanding Machine Learning from Theory to Algorithms - Shai Shalev Shwartz, Shai Ben David - Cambridge University Press - ISBN 978-1-107-05713-5 - 2014 2) Foundations of Machine Learning - Mehryar Mohri, Afshin Rostamizadeh, and Ameet Talwalkar - The MIT Press - 2012				

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	3	3	2	2	3	2	3	2	3	3	3	1	3
CO 2	3	3	2	2	3	2	3	2	3	3	3	1	3
CO 3	3	3	2	2	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	B. Sc. Applied Mathematics Honours			
Course Code	AMA5EJ305(3)			
Course Title	**Graph theory and Application**			
Type of Course	**Elective (Specialization- Applied Algebra)**			
Semester	V			
Academic Level	300 - 399			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites	Definition of graph, trees , spanning trees etc			
Course Summary	In this we will overview various problems on graphs. While there will be a heavy focus on structure, efficient algorithms will also be integral to the course. Many problems can be modelled with graphs			

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Graph theory focuses on problem solving using the most important notions of graph theory with in dept study of concepts on the applications in the field of computer Science	Ap	P	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam
CO2	Provides an in-depth understanding of graphs and fundamental principles and models underlying the theory, algorithms and proof techniques in the field of graph theory.	An	C	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam
CO3	Student will have intimate knowledge about how the graph theory paly an important role to solve the technology driven researchoriented problems	E	P	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam

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

Text Book	John Clark Derek Allen Holton - A first look at graph theory, Allied Publishers			
Module	**Unit**	**Content**	**Hours**	**Marks**
				Ext:70
I	1	4.1 - Matching and Augmenting paths 4.2 – The Marriage Problem 4.3 - The personnel Assignment problem 4.4 - The optimal Assignment problem 4.5 – A Chinese Postman Problem Postscript		
II	2	6.1 – Vertex Colouring 6.2 – Vertex Colouring Algorithms 6.3 – Critical Graphs 6.4 – Cliques 6.5 – Edge Colouring 6.6 – Map Colouring		
III	3	7.1 – Definitions 7.2 – Indegree and Outdegree 7.3 – Tournaments 7.4 – Traffic Flow		
IV	4	8.1 – Flows and Cuts 8.2 - The Ford and Fulkerson Algorithm 8.3 - Separating Sets		
V-Open Ended		5.3 – The Platonic Bodies 5.4 – Kuratowski's Theorem 5.5 – Non – Hamiltonian Plane Graphs 5.6 – The Dual of A Plane Graph		

Reference:

1. Douglas B West Peter Grossman - Introduction to Graph Theory
2. W.D.Wallis - A Biginner's Guide to Discrete Mathematics, Springer
3. . R. Balakrishnan, K. Ranganathan - A textbook of Graph Theory, Springer International Edition
4. S.Arumugham, S. Ramachandran - Invitation to Graph Theory, Scitech. Peter Grossman,
5. J.K Sharma - : Discrete Mathematics(2nd edition), (Macmillion)
6. S. A. Choudam –A First Course in Graph Theory (Macmillian)

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	3	3	2	2	2	3	0	2
CO 2	2	3	2	2	2	1	2	2	2	0	2
CO 3	3	3	2	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/Semi nar
- 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 Applied Mathematics Honours			
Course Code	AMA5EJ306(3)			
Course Title	Lattice Theory			
Type of Course	**Elective (Specialization - Applied Algebra)**			
Semester	V			
Academic Level	300 - 399			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	4	-	60
Pre-requisites	Knowledge of numbers and sets.			
Course Summary	This course covers the knowledge of counting principles which is essential for study and apply it in real world and also the knowledge of Lattices and its applications.			

COURSE OUTCOME(CO)

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used
CO1	Knowledge about the relations and axioms related to natural numbers.	**U**	**C**	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO2	Understand the concepts of Lattices	**U**	**F**	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO3	Classify the various types of functions and make them to use in practical applications related to computer science	**An**	**P**	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO4	Gain Knowledge about the algebraic system	**An**	**P**	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyze (An), Evaluate (E), Create (C) # - Factual Knowledge (F), Conceptual Knowledge (C), Procedural Knowledge (P), Metacognitive Knowledge (M)				

Text Book	**J.P. Tremblay, R. Manohar, Discrete Mathematical structure with Applications to computer science, Tata Mc Graw hill, 2001.**

Module	Unit	Content	60 Hours	Marks
I	1	2.3: Relations and Ordering 2.3.1: Relations	10	
	2	2.3.2: Properties of Binary relations in a set		
	3	2.3.3: Relation Matrix and Graph of a Relation.		
	4	2.3.8: Partial Ordering		
	5	2.3.9: Partially ordered set: Representation and Associated terminology		
II	6	2.4: Functions 2.4.1: Definition and Introduction	10	
	7	2.4.2: Composition of functions		
	8	2.4.3: Inverse functions		
	9	2.4.5: Characteristic Function of a Set		
	10	2.5: Natural Numbers 2.5.1: Peano axioms and Mathematical induction		
III	11	Algebraic Systems: Examples and General Properties 3.1.1 Definition and examples		
	12	3.2Semigroups and Monoids 3.2.1 Definition and Examples		
	13	3.2.3 Subsemigroups and Submonoids		
IV	14	4.1 Lattices as Partially Ordered Sets 4.1.1 Definition and examples		
	15	4.1.2 Some properties of Lattices		
	16	4.1.4 Sub lattices		
	17	4.2 Boolean algebra 4.2.1 Definition and examples		
	18	4.2.2 Sub Algebra, Direct product and Homomorphism.		
V		2.3.4: Partition and Covering of a set. 2.3.5: Equivalence Relations 2.3.6: Compatibility Relations		

		2.3.7: Composition of Binary Relation 3.2.2 Homomorphism of Semigroups and Monoids 3.7 Group Codes		

REFERENCE BOOKS:

1. Dr.M.K. Sen and Dr. B.C. Charraborthy, Introduction to Discrete Mathematics, Arunabha Sen Books & allied Pvt.Ltd, 8/1, Chintamoni Das Lane, Kolkatta – 700 009.
2. Lattice theory by Garrett Birkhoff
3. Discrete Mathematics- M.K. Venkataraman, National Publishing Co, Chennai

***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	3	2	1	3	1	2	-	2	-	1
CO 4	3	3	2	1	3	1	2	-	2	-	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	✓				✓
CO 4	✓				✓

Programme	B. Sc. Applied Mathematics Honours				
Course Code	AMA5EJ305(3)				
Course Title	**Fuzzy Sets**				
Type of Course	**Elective (Specialization- Applied Algebra)**				
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				
Course Summary	This course explains the fundamental concepts of Fuzzy Mathematics the representations of Fuzzy Sets and the types of Operations				

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	To understand the basics of fuzzy mathematics	U	F	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam
CO2	To apply fuzzy set theory in modelling and analysing uncertainty in decision problem.	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)

Text Book	GEORGE J. KLIR AND BO YUAN, FUZZY SETS AND FUZZY LOGIC: THEORY AND APPLICATIONS, Prentice Hall, 1995.			
Module	**Unit**	**Content**	**Hours**	**Marks** **Ext:70**
I	**1**	1.3 Fuzzy Sets: Basic Types 2.1 Additional Properties of alpha-Cuts	**12**	
	2	1.4 Fuzzy Sets: Basic Concepts		
	3	1.5 Characteristics and Significance of the Paradigm Shift		
	4	2.1 Additional Properties of alpha-Cuts		
II	**5**	2.2. Representations of Fuzzy Sets	**14**	
	6	2.3 Extension Principle for Fuzzy Sets		
	7	3.1 Types of Operations		
	8	3.2 Fuzzy Complements		
	9	3.3 Fuzzy Intersections: t-Norms		
III	**10**	3.4 Fuzzy Unions: t-Conorms		
	11	3.5 Combinations of Operations		
	12	3.6 Aggregation Operations		
	13	4.1 Fuzzy Numbers	**10**	
IV	**14**	4.2 Linguistic Variables	**12**	
		4.3 Arithmetic Operations on Intervals		
		4.4 Arithmetic Operations on Fuzzy Numbers		
V-Open Ended		Problems of all the four modules using any of the software	**12**	

	Reference Books: 1. George J Klir and Tina A Folger, Fuzzy sets, Uncertainty and Information, Prentice Hall of India, 1988. 2. H. J. Zimmerman, Fuzzy Set theory and its applications, 4th Edition, Kluwer Academic Publishers, 2001. 3. Timothy J Ross, Fuzzy Logic with Engineering Applications, McGraw Hill International Editions, 1997		

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	2	3	1	2	1	3	0	2
CO 2	2	3	2	2	3	1	2	2	2	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	✓	✓	✓	✓	✓

Program	B. Sc. Applied Mathematics Honours			
Course Code	AMA6EJ306(3)			
Course Title	**CODING THEORY**			
Type of Course	Elective(Specialization – Applied Algebra)			
Semester	V			
Academic Level	300-399			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	4
Pre-requisites	Basic Linear Algebra			
Course Summary	Linear codes involve encoding data into a sequence of bits using mathematical operations to correct errors during transmission. Cyclic codes are special type of linear codes facilitating efficient encoding and decoding.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used
CO1	Understand and apply various source coding techniques to improve transmission efficiency and examine different error detection mechanism.	**Ap**	**P**	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam
CO2	Construct the encoder and decoder of linear block codes.	**C**	**P**	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam
CO3	Analyze the generation and implementation of cyclic codes	**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: Semester **Course Name: CODING THEORY**

TEXTBOOK	San Ling and Chaoping Xing, Coding Theory, A First Course, Cambridge University Press, 2004.

MODULE	UNIT	CONTENT	Hrs	MARKS
				Ext:70
I	**Introduction to Coding theory**		**13**	
	1	- Error Detection and Correction		
	2	- Maximum likelihood decoding and Nearest neighbor decoding		
	3	- Basics of Finite Fields and Vector		
		space		
II	**Linear Codes**		**20**	
	4	4.2, 4.3 - Linear Codes and Hamming Weight		
	5	4.5 - Generator matrix and paritycheck matrix		
	6	4.6 - Equivalence of linear codes		
	7	4.8 - Decoding of linear codes		
III	**Cyclic Codes**		**14**	
	8	7.2 - Generator polynomials		
	9	7.4 - Decoding of cyclic codes		
	10	7.5 - Burst-error correcting codes		
IV	**Some Special Codes**		**13**	
	11	5.3.2 - q-ary Hamming codes		
	12	5.3.3 - Golay codes		
	13	Reed Solomon codes		
	14	6.2 - Reed Muller codes		
	MODULE V (Open Ended)			

V	Source coding- Classification of codes, Kraft inequality, coding efficiency, Shannon-Fano coding Huffman coding, Shannon-Fanco- Elias coding, Arithmetic coding, the Lempel-Ziv coding, Runlength encoding Convolution and turbo codes	**12**	

References:

1. R. Lidl and H. Neiderreiter, Introduction to Finite Fields and their Applications, Cambridge University Press, 1983.
2. F.J.MacWilliams and N.J.A.Sloane, The Theory of Error Correcting Codes, North Holland, Amsterdam, 1998.
3. Shu Lin and Daniel J.Costello, Error Control Coding -Fundamentals and Applications, Pearson Education India, 2011.
4. SimonHaykin, Communication System, 4th edition,Wiley Publications, 2001
5. Thomas M.Cover, Joy A Thomas, Elements of Information Theory, 2nt edition, Wiley,2015
6. **Bose, Ranjan.** Information theory, coding and Cryptography, 2nd Edition, Tata McGraw- Hill Education, 2008
7. R P Singh, S.D.Sapre, Communication system, 2nd Edition, Tata McGraw- Hill Education 2008
8. K. Deergha Rao, Channel coding Technique for Wireless Communications 2nd edition, Springer, 2019
9. Biswas, Nripendra N. Logic design theory, Prentice Hall, Inc,1993

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	2	3	2	3	3	3	0	2
CO 2	2	3	2	2	3	2	3	2	2	0	2
CO3	2	3	2	2	2	2	2	2	2	0	3

Correlation Levels:

Assessment Rubrics:

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

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	✓	✓	✓	✓	✓
CO3	✓	✓		✓	✓

Program	B. Sc. Applied Mathematics Honours			
Course Code	AMA6EJ302(1)			
Course Title	**CODING THEORY**			
Type of Course	Elective(Specialization – Applied Algebra)			
Semester	V			
Academic Level	300-399			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	4
Pre-requisites	Basic Linear Algebra			
Course Summary	Linear codes involve encoding data into a sequence of bits using mathematical operations to correct errors during transmission. Cyclic codes are special type of linear codes facilitating efficient encoding and decoding.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used

CO1	Understand and apply various source coding techniques to improve transmission efficiency and examine different error detection mechanism.	**Ap**	**P**	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam
CO2	Construct the encoder and decoder of linear block codes.	**C**	**P**	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam
CO3	Analyze the generation and implementation of cyclic codes	**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: Semester **Course Name: CODING THEORY**

TEXTBOOK	San Ling and Chaoping Xing, Coding Theory, A First Course, Cambridge University Press, 2004.			
MODULE	**UNIT**	**CONTENT**	**Hrs**	**MARKS** **Ext:70**
I	**Introduction to Coding theory**		**13**	
	1	- Error Detection and Correction		
	2	- Maximum likelihood decoding and Nearest neighbor decoding		
	3	- Basics of Finite Fields and Vector space		
II	**Linear Codes**		**20**	
	4	4.2, 4.3 - Linear Codes and Hamming Weight		
	5	4.5 - Generator matrix and paritycheck matrix		
	6	4.6 - Equivalence of linear codes		
	7	4.8 - Decoding of linear codes		
III	**Cyclic Codes**		**14**	
	8	7.2 - Generator polynomials		
	9	7.4 - Decoding of cyclic codes		
	10	7.5 - Burst-error correcting codes		
IV	**Some Special Codes**		**13**	
	11	5.3.2 - q-ary Hamming codes		
	12	5.3.3 - Golay codes		

	13	Reed Solomon codes		
	14	6.2 - Reed Muller codes		
V	**MODULE V (Open Ended)**		12	
	Source coding- Classification of codes, Kraft			
	inequality, coding efficiency, Shannon-Fano coding Huffman coding, Shannon-Fanco- Elias coding, Arithmetic coding, the Lempel-Ziv coding, Runlength encoding Convolution and turbo codes			

References:

1. R. Lidl and H. Neiderreiter, Introduction to Finite Fields and their Applications, Cambridge University Press, 1983.
2. F.J.MacWilliams and N.J.A.Sloane, The Theory of Error Correcting Codes, North Holland, Amsterdam, 1998.
3. Shu Lin and Daniel J.Costello, Error Control Coding -Fundamentals and Applications, Pearson Education India, 2011.
4. SimonHaykin, Communication System, 4th edition,Wiley Publications, 2001
5. Thomas M.Cover, Joy A Thomas, Elements of Information Theory, 2nt edition, Wiley,2015
6. **Bose, Ranjan.** Information theory, coding and Cryptography, 2nd Edition, Tata McGraw- Hill Education, 2008
7. R P Singh, S.D.Sapre, Communication system, 2nd Edition, Tata McGraw- Hill Education 2008
8. K. Deergha Rao, Channel coding Technique for Wireless Communications 2nd edition, Springer, 2019
9. Biswas, Nripendra N. Logic design theory, Prentice Hall, Inc,1993

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	2	3	2	3	3	3	0	2
CO 2	2	3	2	2	3	2	3	2	2	0	2

CO3	2	3	2	2	2	2	2	2	2	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	✓	✓	✓	✓	✓
CO3	✓	✓		✓	✓

Program	B. Sc. Applied Mathematics Honours				
Course Code	AMA5EJ307(4)				
Course Title	**Financial Mathematics**				
Type of Course	**Elective (Specialisation- OPTIMIZATION)**				
Semester	V				
Academic Level	300 - 399				
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours	
	4	4	-	60	
Pre-requisites	Basics of integration and differentiation ,Probability				
Course Summary	This course provides the basics of Black-Scholes option pricing and some applications of integration in various financial modelling situations.				

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	To acquire knowledge of the role of risk neutral probability measures the use of some elements of stochastic calculus in mathematical finance.	Ap	F	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam

CO2	To study the concepts of The Arbitrage theorem to form a pricing model for the stocks.	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)				

Text Book	1. Frank Verner and Yuri N Sotskov, Mathematics of Economics and Business, Routledge Publications, 2006. 2. Timothy J Biehler, The Mathematics of Money, The McGraw Hill Company, 2008. 3. SHELDON M. ROSS. An elementary introduction to mathematical finance, Cambridge University Press 2011			
Module	**Unit**	**Content**	**Hours**	**Marks**
				Ext:70
I	**1**	2.3 Finance (2.3.1-2.3.5 of Text 1)		
	2	5.6 Some Applications of Integration (5.6.1-5.6.3 of Text 1)		
II	**3**	12.4 Linear difference equations (12.4.1- 12.4.3 of Text 1) 10 Consumer Mathematics (10.1 -10.4 of Text 2)		
III	**4**	6 The Arbitrage Theorem (6.1-6.3 of Text3)		
	5	7 The Black–Scholes Formula (7.1-7.3 of Text 3)		
IV	**6**	10 Stochastic Order Relations (10.1-10.5 of Text 3)		
V-Open Ended		Problems of all the four modules using any of the 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)				

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	2	3	2	3	3	3	0	2
CO 2	2	3	2	2	3	2	3	2	2	0	2
CO3	2	3	2	2	2	2	2	2	2	0	3

Correlation Levels:

Assessment Rubrics:

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

- 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	✓	✓	✓	✓	✓
CO3	✓	✓		✓	✓

Program	B. Sc. Applied Mathematics Honours			
Course Code	AMA5EJ308(4)			
Course Title	**Mathematical Modelling**			
Type of Course	**Elective (OPTIMIZATION)**			
Semester	V			
Academic Level	300 - 399			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites	Basic statistics and calculus			
Course Summary	The main objective of this course is to introduce- compartmental models and real- life case studies through differential equations, their applications and mathematical modeling. choosing the most appropriate model from competing types that have been fitted			

COURSE OUTCOME:

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Learn basic of differential equations and compartmental models.	U	C	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam
CO2	Formulate differential equations for various mathematical models	C	C	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam
CO3	Construct normal equation of best fit and predict future values	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)				

Text Book	Text 1 Mathematical modelling using studies using MAPLE and MATLAB – B Barnes and G R Fulford (3rd edition) Text 2- A First Course in Mathematical Modelling (5th edition)- Frank R. Giordano, William P Fox, Steven B. Horton			
Module	**Unit**	**Content**	**Hours**	**Marks** **Ext:70**

I	**1**	Text 1: Introduction to mathematical modelling 1.1 Mathematical models 1.3 some modelling approaches 1.4 Modeling for decision- making	**15**	**20**
	2	2-Compartmental models 2.1 Introduction 2.2 Exponential Decay and Radioactivity		
	3	2.5 Lake Pollution models 2.6 Case Study: Lake Burley Griffin		
	4	2.7 Drug Assimilation into the blood 2.8 Case study: Dull dizzy or dead?		
II	**5**	3.1Exponential growth 1.2 Density – Dependent growth	**8**	**15**
	6	3.3 Limited growth with harvesting 3.7 discrete population growth and chaos		
III	**7**	5.1 Introduction 5.2 Model for an influenza outbreak	**10**	**15**
	8	5.4 Predators and prey		
	9	5.7 Competing species 5.9 Model of a battle		
IV		Text 2: Chapter 3 Model Fitting 3.1 Fitting Models to Data Graphically	**15**	**20**
		3.2 Analytic methods of Model Fitting		
		3.3 Applying the Least Squares Criterion		
		4.1 Harvesting the Chesapeake Bay and Other One – Term models		

		5.2 Generating Random Numbers		
V-Open Ended		Text 1: 5.3 Case Study: Cholera 5.6 Case Study: It's a dog's life: More on the control of stray dogs 5.8 Scenario: Aggressive protection of lerps and nymphs 5.10 Case Study: Rise and fall of civilisations Text 2: 3.4 Choosing a Best Model	**12**	

References

1. Albright, Brian, & Fox, William P. (2020). Mathematical Modeling with Excel (2nd ed.). CRC Press, Taylor & Francis Group.
2. Edwards, C. Henry, Penney, David E., & Calvis, David T. (2015). Differential Equations and Boundary Value Problems: Computing and Modeling (5th ed.). Pearson.

***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	3	3	3	3	2	2	2	2	1	2
CO 2	2	3	3	3	3	2	2	2	2	1	2
CO 3	2	3	3	3	2	2	1	1	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. Applied Mathematics Honours				
Course Code	AMA6EJ307(4)				
Course Title	**Mathematical Economics**				
Type of Course	**Elective (OPTIMIZATION)**				
Semester	V I				
Academic Level	300 - 399				
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours	
	4	4	-	60	
Pre-requisites	Integration and basic mathematics				
Course Summary	This course includes properties of market equilibrium, applications to Market and National Income Models and applications of Integration				

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	To analyse the properties equilibrium in Economics.	An	P	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam
CO2	To understand some Economic Applications of Integrals	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)				

Text Book	Alpha C Chiang, Kevin Wainwright, Fundamental Methods of Mathematical Economics, 4^{th} Edition, 2005			
Module	**Unit**	**Content**	**Hours**	**Marks**
				Ext:70
I	**1**	Equilibrium Analysis in Economics 3.1 The Meaning of Equilibrium	**10**	
	2	3.2 Partial Market Equilibrium- A linear Model		
II	**3**	3.3 Partial Market Equilibrium- A non-linear Model	**13**	
	4	3.4 General Market Equilibrium	**15**	
	5	3.5 Equilibrium in National Income Analysis		
	6	Matrix Analysis 5.6 Applications to Market and National Income Models		
III	**7**	5.7 Leontif Input-Output Model		
	8	– Further topics in Optimization 13.1 Non-linear Programming and KuhnTucker Conditions		

	9	13.2 The Constraint Qualification		
	10	13.3 Economic Applications		
		13.4 Sufficiency Theorems in Non-linear Programming		
IV	**11**	Applications of Integration 14.5 Some Economic Applications of Integrals	**10**	
		14.6 Domar Growth Model		
V-Open Ended		Problems of all the four modules using any of the software	**12**	

Reference:

1. **Chiang, C., Fundamental Methods of Mathematical Economics, McGraw Hills, *(Latest Edition).***
1. **Baumol W. J., Economic Dynamics, Macmillan, *(Latest edition).***
2. **Budnick, Frank, Applied Mathematics for Business, Economics and Social Sciences.**
3. **Dowling E. T., Mathematics for economists, Schum Series (latest edition).**
4. **Weber E. Jean, Mathematical Analysis, Business and Economic Applications (Latest Edition) Harper and Row Publishers, New**

***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	2	2	2	2	0	1	0	2
CO 2	2	1	1	2	2	2	2	0	1	0	2

Correlation Levels:

Assessment Rubrics:

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

 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. Applied Mathematics Honours			
Course Code	AMA6EJ308(4)			
Course Title	**Operations Research**			
Type of Course	**Elective (OPTIMIZATION)**			
Semester	VI			
Academic Level	300-399			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites	Graphs and basic linear algebra			
Course Summary	This course gives an idea of application graph theory in optimization. It also explains the methods to solve integer programming problem, Kuhn-tucker Theory and Nonlinear Programming, game theory.			

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Apply various methods to solve integer programing problem	Ap	P	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam

CO2	Use Kuhn-tucker Theory and Nonlinear Programming	An	C	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam
CO3	Gives knowledge about strategies in game theory	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)				

Text Book	Optimization Methods By Mittal			
Module	**Unit**	**Content**	**Hours 60**	**Marks** **Ext:70**
I		5 – Flow And Potential In Networks 5.1 – Introduction	**12**	
		5.2 – Graphs: Definitions And Notations		
		5.3 – Minimum Path Problem		
		5.4 – Spanning Tree Of Minimum Length		
		5.5 – Problem Of Minimum Potential Difference		
		5.6 – Scheduling Of Sequential Activities		
		5.7 – Maximum Flow Problem		

		6 Integer Programming 6.1 - Introduction	**12**	
		6.2 - ILP in two- dimensional space		
		6.3 - General ILP And MILP Problems		
II		6.4 - Examples of section 2		
		6.5 - Cutting Planes		
		6.6 - Examples		
		6.8 - Branch and Bounded Method - examples		
III		8 Kuhn-tucker Theory and Nonlinear Programming 8.1 - Introduction	**12**	
		8.2 - Lagrangian function: saddle Point		
		8.3 - Relation between saddle point of $F(X, Y)$ and minimal point of $f(X)$		
		8.4 - Kuhn-Tucker conditions		
		8.5 - Primal and dual problems		
		8.6 - Quadratic Programming		
		8.7 - Separable programming		
IV		12 – Theory Of Games 12.1 – Introduction	**12**	
		12.2 – Matrix (Or Rectangular) Games		
		12.3 - Problem Of Game Theory		
		12.4 – Minimax Theorem, Saddle Point		
		12.5 – Strategies And Pay Off		
		12.6 – Theorems Of Matrix Games		
V-Open Ended		5.8 – Duality In the Maximum Flow Problem 5.9 – Generalized Problem of Maximum Flow 6.7 - Remarks On Cutting Plane Methods	**12**	

	6.9 - Branch And Bounded Method; General Description 12.7 – Graphical Solution 12.8 – Notion Of Dominance 12.9 – Rectangular Games as An LP Problem Queuing theory		

References

1. Robert J. Vanderbei: Linear Programming: Foundations and Extensions (2/e) Springer Science+Business Media LLC (2001)
2. Frederick S Hiller, Gerald J Lieberman: Introduction to Operation Research(10/e) McGraw-Hill Education, 2 Penn Plaza, New York 2015)
3. Paul R. Thie, G. E. Keough: An Introduction to Linear Programming and Game Theory(3/e) John Wiley and Sons,Ins. (2008)
4. Louis Brickman: Mathematical Introduction to Linear Programming and Game Theory UTM, Springer Verlag, N Y (1989)
5. Jiri Matoušek, Bernd Gartner: Understanding and Using Linear Programming Universitext, Springer-Verlag Berlin Heidelberg (2007)

***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	3	3	2	3	2	3	0	2	0	2
CO 2	3	2	3	2	3	2	3	1	2	0	2
CO 3	3	2	3	2	2	2	2	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. Applied Mathematics Honours			
Course Code	AMA5EJ309(5)			
Course Title	**Introduction to Actuarial Science**			
Type of Course	**Elective (Specialisation-Actuarial Science)**			
Semester	V			
Academic Level	300 - 399			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites				
Course Summary	Knowledge about population study and actuarial science			

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Impart Basic concepts in population studies, actuarial science and vital statistics.	Ap	P	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam
CO2	Learn about the life tables and its characteristics	An	C	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam

CO3	Prepare students to take up a career in Actuarial Practice.	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)				

Text Book	1.Shailaja R Deshmukh (2009), Actuarial Statistics:An Introduction using R, Universities Press			
Module	**unit**	**Content**	**Hours**	**Marks**
I	**1.**	Sources of vital statistics in India-functions of vital statistics	**15**	
	2.	Rates and ratios- mortality rates-crude, age specific and standard death rates-fertility and reproduction rates crude birth rates-general and specific fertility rates-gross and net reproduction rates		
	3.	Practical's based on statistical analysis of data related to medical/biological fields using R software which include the statistical tool birth rate, death rate, fertility rate,		
II	**4.**	Life Tables-complete life tables and its characteristics	**10**	
	5.	Abridged life tables and its characteristics, principal methods of construction of abridged life tables-Reed Merrel's method		
III	**6**	Actuarial Science: What is an Actuarial Science?	**15**	
	7	Insurance companies as Business organizations		
	8	Concept of Risk, Speculative and pure risk, Characteristics of insurable risks		
	9	how does the Insurance business operates?		

	10	Role of Statistics in Insurance, History of Insurance business in India.		
IV	**11**	Fundamentals of Insurance: Insurance, Features Of a contract, Principles of insurance	**10**	
	12	Peril, Hazard, Types of Hazard, Costs and benefits of insurance to Society		
	13	Insurance Business classification Life (Whole life, term assurance, endowment, money back, ULIP) and non-life (Fire, Marine, Miscellaneous)		
	14	Difference between life and non-life insurance.		
V		Actuarial Profession Overview, Self-Regulatory Measures in Actuarial profession, Role of Actuaries	**10**	

References.

2. S.C. Gupta and V K Kapoor, Fundamentals of applied Statistics, Sulthan Chand and Sons
3. Benjamin B, Health and Vital Statistics, Allen and Unwin
4. Mark S Dorfman, Introduction to Risk Management and Insurance, Prentice Hall
5. C.D. Daykin, T. Pentikainen et al, Practical Risk Theory of Actuaries, Chapman and Hill

***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	3	3	3	1	3	1	2	1	3

CO 2	3	1	3	3	3	1	3	1	2	1	3
CO 3	3	3	3	3	3	3	3	1	2	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. Applied Mathematics Honours			
Course Code	AMA5EJ310(4)			
Course Title	**Financial Mathematics 1**			
Type of Course	**Elective (Specialisation-Actuarial Science)**			
Semester	V			
Academic Level	300 - 399			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites				
Course Summary	Introduces the students to provide basic grounding in basic financial mathematics like simple interest, compound interest, loan calculation and their simple applications.			

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Describe how to use a generalized cash flow model in financial transaction. Describe how a loan may be repaid by regular instalments of interest and capital.	Ap	P	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam
CO2	Apply different kinds of interest rates expressed in different time periods.	AP	C	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam

CO3	Recall and use the more important compound interest functions, including annuities certain.	R	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)

Text Book	Bower, N. L., Gerber, H. U., Hickman, J. C., Jones, D. A., & Nesbitt, C. J. (1997). Actuarial Mathematics			
Module	**unit**	**Content**	**Hours**	**Marks**
I	**1**	Cash flow models**:** Cash flow process -- Examples of cash flow scenarios -- Zero coupon bond, Fixed interest securities, Index linked securities, Cash on deposit, Equity, Annuity, An interest only Loan and Repayment loan.	**10**	
	2	Insurance contracts: Pure endowment - An endowment assurance - Term assurance - Contingent annuity - Car insurance policy - Health cash plans		
	3	Time value of money**:** Interestsimple interest, Compound interest, Accumulation factors --The principle of consistency		

	4	Present Values -- Discount rates -- Simple discount -- Compound discount -- Effective rates of interest and discount -- Equivalent rates		
II	**5**	Interest Rates: Nominal rates of Interest and discount – Accumulating and discounting using nominal interest and discount rates	**15**	
	6	The Force of interest: Accumulating and discounting using force of interest -- Derivation.		
	7	Relationship between effective, nominal and force of interest – The force of interest as a function of time -- Present values		
	8	Real and money rates of interest: Definition of real and money interest rates -- Deflationary conditions -- Usefulness of real and money interest rates.		
III	**9**	Discounting and accumulating: Present values of cash flows -- Discrete cash flows -- Continuous cash flows -- Valuing cash flows - Constant interest rates and sudden changes in interest rates -Interest income.	**15**	
	10	Level Annuities-- Present values – Payments made in arrear - Payment made in advance- Accumulations – Perpetuities – Continuously payable annuities		

	11	Annuities payable pthly: Present values, Accumulations and Perpetuities -- Annuities payable pthly where p is less than 1 – Non integer value of n		
	12	Deferred annuities - Annual payments - Continuously payable annuities - Annuities payable pthly - Non integer values of n - Deferred annuities		

IV		Increasing annuities --Varying annuities -- Annual payments -- Continuously payable annuities - Decreasing annuities – Special cases -- Irregular payments and Compound increasing annuities	**8**	
		Equations of value: The equation of value and the yield on a transaction - The theory – Solving for an unknown quantity – Uncertain payment or receipt – Probability of cash flows -- Higher Discount rate		
		Loan schedule: Calculating the capital outstanding – Introduction - The theory prospective and retrospective loan calculation – Calculating the interest and capital elements		
V		The Loan schedule -- Installments payable more frequently than	**12**	
		annually, Consumer credit: Flat rates and APRs		

1. ActEd Study Material: Subject - CT1
2. Mathematical basis of life insurance – IC81 – Insurance Institute of India maShare
3. An Elementary Introduction to Mathematical Finance – Sheldon Ross
4. An Undergraduate Introduction to Financial Mathematics – by Robert Buchanan
5. Business Mathematics - by Lerner and Zima (Schaum's Outline Series)
6. Corporate Finance by Brealy and Myers
7. Fundamentals of Actuarial Mathematics by David Promislow
8. Investment by Sharpe and Bailey Upper Saddler River, N.J. Prentice Hall, c1999. 9. Investment Science by Luenberger (Indian Edition), Oxford University Press
10. Investments by Bodie, Kane and Marcus, McGraw-Hill Irwin, c2005.
11. Lecture Notes on Actuarial Mathematics – by Jerry Veeh
12. Actuarial Mathematics by Bowers et al, Society of Actuaries, USA.

NPTEL Financial Mathematics
By Prof. Pradeep Kumar Jha | IIT Roorkee

https://youtu.be/No1j4gUerDI

1. Actuarial Mathematics. Bowers, Newton L et al. – 2nd ed.

***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	2	1	2	1	2	0	2
CO 2	2	2	3	1	2	1	2	1	2	0	2

CO 3	2	2	3	1	2	1	2	1	2	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. Applied Mathematics Honours			
Course Code	AMA6EJ39(5)			
Course Title	**Principles of Insurance**			
Type of Course	**Elective (Specialisation- Actuarial)**			
Semester	V I			
Academic Level	300 - 399			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites				
Course Summary	This course provides a basic understanding of the Insurance Mechanism, relationship between Insurers and their Customers and the importance of Insurance Contacts, gives an overview of major Life Insurance and General Insurance Products.			

CO	**CO Statement**	**Cognitive Level***	**Knowledge Category#**	**Evaluation Tools used**
CO1	Classify the various types of risks faced by the insurance industry and solving them using appropriate risk management tools	Ap	P	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam
CO2	Understand the basic knowledge of insurance and its different types	An	C	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam

CO3	Identify the functions of insurance company, role of regulatory body for the insurance industry, role of insurance in economic development	E	P	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam
CO4	Estimation of future exposure in insurance industry, calibration of general insurance and analyze how the insurance market function in current scenario.	E	M	

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

Text Book	**Principles of Insurance – IC 01 – III.**			
Module	**unit**	**Content**	**Hours**	**Marks**
I	1	The concept of insurance and its evolution Concept of insurance – Insurance (evolved and works)	**10**	
	2	Types of insurance		
	3	Importance of insurance industry		
	4	The Business of Insurance: how risk is managed by individuals and insurers		
	5	Premium Importance of reinsurance-Role of insurance in economic and social development		
II	6	**The insurance contract** Introduction – Insurable interest	**15**	
	7	Principle of indemnity		

	8	Subrogation and contribution- Utmost good faith- Proximate cause		
	9	**Life insurance products** Traditional products – Linked products – Annuities and group policies		
III	10	**General Insurance:** Concept and scope	**15**	
	11	Nationalization of general Insurance in India in 1972 structure of General Insurance in India		
	12	Privatization and Globalization of General Insurance in India.		
IV	13	**Types of General Insurance** Fire insurance – Definition – Causes of fire	**10**	
	14	Essential characteristics of fire insurance contracts		
	15	Procedures – Rate fixation		
	16	Kind of fire insurance policies – Policy conditions - Claim settlement		
V	Insurance and Retirement Benefits		10	

Reference:

1. Dorfman S. Mark, introduction to risk management and insurance Prentice Hall India 2005

2. George E. Rejda, Principles of Risk Management and Insurance.

3. Emmett J. Vaughan, Therese M. Vaughan, Essentials of Risk Management and Insurance

4. Risk management by Hull Edition 2002 Jr., C. Arthur C Williams, Peter C Young, Michael L. Smith “Risk Management & Insurance”

***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	2	3	3	3	3	2	2	2
CO 2	0	3	2	0	2	3	2	2	2	0	0
CO 3	0	0	0	2	2	3	3	2	0	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. Applied Mathematics Honours			
Course Code	AMA6EJ310(5)			
Course Title	**Mathematics of Finance II**			
Type of Course	**Elective (Specialization-Actuarial science)**			
Semester	VI			
Academic Level	300 - 399			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites				
Course Summary	Introduce the student's concepts of cost, nature of production and its relationship to business operations, to understand marginal analysis to the "firm" under different market conditions and to integrate the concept of price and output decisions of firms under various market structure.			

CO	**CO Statement**	**Cognitive Level***	**Knowledge Category#**	**Evaluation Tools used**
CO1	Under stand the working and application of advanced financial products like stocks and derivatives	Ap	P	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam

CO2	Knowledge about how duration and convexity are used in the immunization of a portfolio of liabilities	An	C	Internal Exam/Assignment /Seminar/ Viva / End Sem Exam
CO3	To Concept of equation of value to solve bond, equity and property according to tax liability	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)

Text Book	1. Bower, N. L., Gerber, H. U., Hickman, J. C., Jones, D. A., & Nesbitt, C. J. (1997). Actuarial Mathematics			
Module	**unit**	**Content**	**Hours**	**Marks 70**
I	**1**	Project Appraisal I: Introduction – Estimating cash flows – Fixed interest rates -- Accumulated value, Net present value and internal rate of return	**12**	
	2	The comparison of two investment projects – Different interest rates for lending and borrowing – Payback period - Other considerations		

	3	Project Appraisal II: Definition of a capital project – Definition of project – Evaluation of cash flows -- Methods of project evaluation – Annual capital charge -- Payback period – Nominal returns – Strategic fit – Opportunity cost -- Hurdle rates		
	4	Evaluation of risky projects: Simulation -- Sensitivity analysis – Scenario testing – Monte Carlo stimulation – Probability trees – Certainty equivalents		

	5	Uncertain income securities: Equities – Property - Real rate of interest.	**12**	

II	**6**	Inflation adjusted cash flows – Calculating real yield using an inflation index – Calculating real yields given constant inflation assumption – Payments related to the rate of inflation – The effects of inflation –Index-linked bonds		
III	**7**	Term structure of interest rates: Discrete time – Discrete time spot	**10**	
		rates -- Discrete time forward rates.		
	8	Theories of time-term structure of interest rates – Why interest rates vary over time -- Theories --Yields to maturity – Par yields.		

IV	**9**	Weighted Average Cost Of Capital: Introduction – The importance of the discount rate -- Defining the weighted average cost of capital -- Modigliani and miller -- Their view	**14**	
	10	CAPM: Cost of equity – CAPM and risk – Systematic risk – Beta as a measure of systematic risk – Measuring beta – Market derived real discount rate.		
	11	Cost of debt -- Marginal or average cost -- Determinants – Calculation of WACC.		
V		Bonds Equity And Property -- Fixed interest securities – Calculating the price-- Allowing for income tax-- Capital gains tax -- Capital gains test -- Calculating yields -- Deferred income tax. Duration, convexity and immunization - Interest rate risk-- Effective duration – Duration – Convexity – Immunization	**12**	

References:

1. Promislow, S. D. (2014). Fundamentals of Actuarial Mathematics. John Wiley & Sons.
2. Booth, P., Haberman, S., Chadburn, R., James, D., Khorasanee, Z., Plumb, R. H., &Rickayzen, B. (2004). Modern actuarial theory and practice. Chapman and Hall/CRC.
3. Harrison, F., & Lock, D. (2017). Advanced project management: a structured approach. Routledge.
4. Ingersoll, J. E. (1987). Theory of Financial decision making (Vol. 3). Rowman& Littlefield.

***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	3	3	2	3	2	2	1	3
CO 2	3	2	3	3	3	2	3	2	2	1	3
CO 3	3	2	3	3	3	2	3	2	2	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	✓	✓	✓	✓	✓

Elective 4^{th} year

Program	B.Sc. Applied Mathematics Honours			
Course Code	AMA8EJ406			
Course Title	**Discrete Time Control System**			
Type of Course	**Major**			
Semester	VIII			
Academic Level	400-499			
Course Details	Credit	Lecture/Tutorial per week	Practical/Practicum per week	Total Hours
	4	4	-	
Pre-requisites	Differential Equations, Complex analysis			
Course Summary	This course is the follow-on to Continuous Control Systems and presents a comprehensive introduction to the theory and design of discrete-time control systems. Representation, modeling, and analysis of discrete-time / sampled-data systems are first discussed.			

COURSE OUTCOME(CO)

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used

Program	B.Sc. Applied Mathematics Honours			
Course Code	AMA8EJ401			
Course Title	**Analytical Number Theory**			
Type of Course	**Elective**			
Semester	VIII			
Academic Level	400-499			
Course Details	Credit	Lecture/Tutorial per week	Practical/Practicum per week	Total Hours
	4	4	-	
Pre-requisites	Algebra and Complex Analysis			
Course Summary	Topics covered might include: the prime number theorem, Dirichlet L-functions, zero-free regions, sieve methods, representation by quadratic forms, and Gauss sums. Including the use of zeta functions and L-functions to prove distribution results concerning prime numbers (e.g., the prime number theorem in arithmetic progressions).			

COURSE OUTCOME(CO)

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used
CO 1	Understand and analyse the properties of arithmetical functions, including the Mobius function, Euler totient function, and their relationships and products.	**An**	**C**	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO 2	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
CO 3	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), Analyze (An), Evaluate (E), Create (C) # - Factual Knowledge (F), Conceptual Knowledge (C), Procedural Knowledge (P), Metacognitive Knowledge (M)				

Text	1. Introduction to Analytic Number Theory– Tom.M.Apostol, Narosa.			
Module	Unit	Content	Hours75	Marks
I	1	**Arithmetical Functions and Dirichlet Multiplication**: Introduction-The mobius function μ(n) The Euler totient function ø(n) A relation connecting ø and μ A product formula for ø(n)	10	
	2	Dirichlet product of arithmetical functions Dirichlet inverse and mobius inversion formula The Mangoldt function *Λ(n)*		
II	5	Dirichlet product of arithmetical functions Dirichlet inverse and mobius inversion formula The Mangoldt function *Λ(n)*	10	
III	8	**Averages of Arithmetical functions:** Introduction The big oh notation. Asymptotic equality of functions Euler's summation formula Some elementary Asymptotic formulas The Average order of d(n) The Average order of the divisor functions The average order of ø(n) An application to the distribution of lattice points visible from the origin The average order of μ(n) and Λ (n) The partial sums of Dirichlet product.	10	
IV	10	**Some Elementary Theorems on the Distribution of Prime Numbers**: Introduction Chebyshev's functions Relations connecting υ(x) and π(x) Some equivalent forms of the prime number theorem Inequalities for π(n) and p_n Shapiro's Tauberian Theorem An Asymptotic formula for the partial sums $\sum_{p\le x}(1/p)$ The partial sums of the Mobius function.	10	

V		**Finite Abelian Groups and Their Characters**: Definition- Examples of groups and subgroups- Elementary properties of groups- Construction of subgroups- Characters of finite abelian groups. The character group- The orthogonality relations for characters- Dirichlet Characters- Sums involving	35	
		Dirichlet Characters- The non-vanishing of L(1 , x) for real non principal x.		

. **References:**

1. Analytic Number Theory – Raymond Ayoub, American Math. Society .
2. An Introduction to the Theory of Numbers – G.H Hardy, E. M Wright, Oxford University Press.

***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	2	0	3
CO 2	2	3	2	1	3	0	3	1	2	0	3
CO 3	3	2	3	2	3	0	3	1	2	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	✓	✓	✓	✓	✓

Program	B.Sc. Applied Mathematics Honours			
Course Code	AMA8EJ402			
Course Title	Numerical Methods for Partial Differential Equations			
Type of Course	**Elective**			
Semester	VIII			
Academic Level	400-499			
Course Details	Credit	Lecture/Tutorial per week	Practical/Practicum per week	Total Hours
	4	4	-	
Pre-requisites	B. Sc Mathematics			
Course Summary	This course contains numerical solution for parabolic, elliptic and hyperbolic equation with error approximations.			

COURSE OUTCOME(CO)

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used
CO 1	Gain a fundamental understanding of finite difference method for solving partial differential equation.	**Ap**	**C**	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO 2	To equip the students with the finite element analysis fundamentals	**AP**	**P**	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO 3	To train the students to use this knowledge in related research area.	**C**	**C**	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyze (An), Evaluate (E), Create (C) # - Factual Knowledge (F), Conceptual Knowledge (C), Procedural Knowledge (P), Metacognitive Knowledge (M)				

Text	1. Numerical Solution of Partial Differential Equations, Finite Differences methods - G.D. Smith, Brunel University, Clarandon Press Oxford.		
Module	Content	Hours75	Marks
I	Introduction to finite difference formula Parabolic equation – Explicit finite difference approximation to one dimensional equation Crank – Nicholson implicit method – Derivation boundary conditions	10	
II	Alternate direction implicit (ADI) method finite difference in cylindrical and spherical polar coordinates. **Convergence Stability and consistency**: Definitions of local truncation error and consistency convergence analysis – stability analysis by matrix method eigenvalue von Newmann stability methods, global rounding error – local truncation error – Iax's equation theorem.	10	
III	**Hyperbolic Equations**: Analytical solution of 1_{st} order quasi linear equation – Numerical Integration along a characteristic Iax wenderoff explicit method. CFL condition wenderoff implicit approximation – Propagation of discontinues – Numerical solution by the method of characteristics.	10	
IV	**Elliptic Equations**: Introduction – Finite differences in polar co-ordinates – formulas for derivative near a curved boundary analysis of the discretization error of the five point approximation to polman's equation over a rectangle.	18	
	Systematic iterative methods for large linear systems – necessary and sufficient condition for convergence of iterative methods – stones implicit methods. Finite Element Method: weighted residual method – variations methods – division of the region into elements linear element – Galerkin formulation		
V	Practicals of above discussed methods using any software	12	

. **References:**

1. The Finite Finite Differences Methods in Partial Differential Equations – A. R. Mitchel and D.F. Grnra, John Wiley
2. Numerical Methods for Engineers and Scientists – Joe D.Hoffman, Mc Graw Hill.
3. Applied Finite Element Analysis – Larry J. Segerlind, John Wiley.

***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	1	3	2	2	1	3
CO 2	3	3	3	3	3	1	3	2	2	1	3
CO 3	3	2	2	3	3	2	3	2	2	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	✓	✓	✓	✓	✓

Program	B.Sc. Applied Mathematics Honours			
Course Code	AMA8EJ403			
Course Title	**Differential Equations and Dynamical System**			
Type of Course	**Elective**			
Semester	8			
Academic Level	400-499			
Course Details	Credit	Lecture/Tutorial per week	Practical/Practicum per week	Total Hours
	4	4	-	
Pre-requisites	Theory of Ordinary differential equations			
Course Summary	The course is designed to get knowledge of basic concepts and methods from the theory of differential equations and dynamical systems, including analytical and geometrical techniques for the study of qualitative properties of solutions. In particular, the student is familiar with linear and nonlinear systems, existence and uniqueness, continuous dependence, phase plane analysis, equilibria, limit cycles, stability, Lyapunov's Direct Method, index theory, the PoincaréBendixson theorem, the additional topics and examples of applications.			

COURSE OUTCOME(CO)

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used
CO1	The student is able to apply his or her knowledge to the study of concrete examples	**Ap**	**C**	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO2	The student masters central techniques of proof and is able to apply these to related problems	**AP**	**P**	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam

CO3	Students will Learn and use various tools for the analysis and control of nonlinear systems	**E**	**P**	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyze (An), Evaluate (E), Create (C) # - Factual Knowledge (F), Conceptual Knowledge (C), Procedural Knowledge (P), Metacognitive Knowledge (M)				

Text	Differential Equations, Dynamical Systems and an Introduction to Chaos- M.W.Hirsch, Stephens Snale, Rldevaney, ELSE WEAR Press			
Module	Unit	Content	Hours75	Marks
I	1	**Linear Systems**: Uncoupled Linear Systems Diagonalization Exponentials of Operators	10	
	2	The Fundamental Theorem for Linear Systems Linear Systems in R_2 Complex Eigen Values Multiple Eigen Values Jordan Forms- Stability Theorem Non homogeneous Linear Systems.		
II	3	**Nonlinear Systems: Local Theory** Some Preliminary Concepts and Definitions The Fundamental Existence Uniqueness Theorem Dependence on Initial Conditions and Parameters The Maximal Interval of Existence	10	
	4	The Flow Defined by a Differential Equation Linearization The Stable Manifold Theorem The Hartman Grobman Theorem Stability and Lyapunov Functions Saddle- Nodes- Foci and Centers Nonhyperbolic Critical Points in R_2 Gradient and Hamiltonian Systems.		

III	5	**Nonlinear Systems: Global Theory**- Dynamical Systems and Global Existence Theorems Limit Sets and Attractors Periodic Orbits Limit Cycles and Separatrix Cycles The Poincare Map	18	
	6	The Stable Manifold Theorem for Periodic Orbits Hamiltonian Systems with Two Degrees of Freedom The Poincare Bendixson Theory in $R2$ Lienard Systems – Bendixon's Criteria The Poincare Sphere and separatrix		
IV	7	**Nonlinear Systems: Bifurcation Theory**- Structural Stability and Peixoto's Theorem Bifurcations at Non- Hyperbolic Equilibrium Points	10	
		Hopf Bifurcation and Bifurcation of Limit Cycles from a Multiple Focus.		
	8	Bifurcations at Non- Hyperbolic Periodic Orbits- One Parameter Families of Rotated Vector Fields		
V		Configurations Index Theory. The Global Behavior of One Parameter Families of Periodic Orbits- Homoclinic Bifurcations- Melnikov's Method.	12	
. **References:** 1. Differential Equations and Dynamical Systems- Lawrence Perko, Springer.				

***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	3	3	1	2	1	2	1	3
CO 2	3	2	3	3	3	1	2	1	2	1	3
CO 3	3	3	3	3	3	1	3	1	2	1	3

Correlation:

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	✓	✓	✓	✓	✓

Program	B.Sc. Applied Mathematics Honours			
Course Code	AMA8EJ404			
Course Title	Relativity and Cosmology			
Type of Course	Elective			
Semester	VIII			
Academic Level	400-499			
Course Details	Credit	Lecture/Tutorial per week	Practical/Practicum per week	Total Hours
	4	4	-	

COURSE OUTCOME(CO)

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used
CO 1	Describe the concept of Tensor and their properties.	**Ap**	**C**	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO 2	Describe the concepts flat space and space of constant curvature.	**AP**	**P**	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO 3	Explain the meaning and significance of the postulate of Special Relativity.	**U**	**P**	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO 4	Explain true nature of Lorentz transformation and their consequences	**U**	**C**	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam

CO 5	Explain relativistic transformation equations for mass, work and kinetic energy.	**U**	**C**	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyze (An), Evaluate (E), Create (C) # - Factual Knowledge (F), Conceptual Knowledge (C), Procedural Knowledge (P), Metacognitive Knowledge (M)				

Text	1. Barry Spain, Tensor Calculus-Radha Publishing House, Calcutta. 2. R.C. Tolman, Relativity, Thermodynamics and Cosmology, Clarendon Press, Oxford.			
Module	Unit	Content	Hours75	Marks
I	1	Tensor Analysis: N-dimensional space, covariant and contravariant vectors, contraction, second & higher order tensors, quotient law, fundamental tensor, associate tensor, angle between the vectors, principal directions, Christoffel symbols, covariant and intrinsic derivatives, geodesics (Chapters 1 to 4 of Text book.1).	12	
II	2	Riemann Christoffel Tensor, covariant curvature tensor and its properties, Ricci Tensor, Curvature invariant, Einstein space, Bianchi's identity, Riemannian Curvature, Einstein space, flat space, space of constant curvature, Schur's Theorem (Chapter V of Text book.1).	12	
III	3	Space-time continuum, the three plus one dimensions of space-time, the geometry corresponding to space-time, the signature of the line element and the three kinds of interval, Lorentz rotation of axes, transformation to proper coordinates (Chapter II, Articles 13-18 of Text book 2).	12	

IV	4	The mass of a moving particle, the transformation equations for mass, work and kinetic energy, the relations between mass, energy and momentum, Four-dimensional expressions of the mechanics of a particle (Chapter III, Articles 23-28 of Text book 2).	12	
V		The Maxwell-Lorentz Field Equations, The transformation equations for E, H and Q. The force on a moving charge, The energy and momentum of electromagnetic field, electromagnetic stresses, Four dimensional expressions for electron theory (Chapter IV, Articles 39-43 & 46 of Text book 2).	12	
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***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	2	3	1	2	0	2	0	3
CO 2	3	2	3	3	3	1	3	0	2	0	3
CO 3	3	3	1	2	2	1	1	0	2	0	3
CO4	3	2	2	2	2	2	1	0	2	0	3
CO5	3	3	2	2	2	2	2	0	2	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:

Mapping of course outcomes with the program outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	√	√	√	-	-
CO2	√	√	√	-	-
CO3	√	-	√	√	-
CO4	√	-	√	√	-
CO5	√	-	√	√	-

Program	B.Sc. Applied Mathematics Honours			
Course Code	AMA8EJ405			
Course Title	**Elasticity**			
Type of Course	**Elective**			
Semester	8			
Academic Level	400-499			
Course Details	Credit	Lecture/Tutorial per week	Practical/Practicum per week	Total Hours
	4	4	-	
Pre-requisites				
Course Summary	The main objective of this course- To make students understand the principles of elasticity. To familiarize students with basic equations of elasticity. To expose students to two dimensional problems in Cartesian and polar coordinates. To make students understand the principle of torsion of prismatic bars.			

COURSE OUTCOME(CO)

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used
CO1	To apply elastic analysis to study the fracture mechanics.	**Ap**	**C**	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO2	To apply linear elasticity in the design and analysis of structures such as beams, plates, shells and sandwich composites.	**Ap**	**P**	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO3	To apply hyper elasticity to determine the response of elastomer-based objects.	**Ap**	**P**	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam

CO4	To analyze the structural sections subjected to torsion.	**An**	**C**	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyze (An), Evaluate (E), Create (C) # - Factual Knowledge (F), Conceptual Knowledge (C), Procedural Knowledge (P), Metacognitive Knowledge (M)				

Text	1. Hetnarski R.B. and Ignaczak J. "Mathematical Theory of Elasticity", Taylor & Francis, London, 2004. 2. Sokolnikoff I.S. "Mathematical Theory of Elasticity", Tata-McGraw Hill, New Delhi, 1974. 3. Achenbach J.D. "Wave Propagation in Elastic Solids", North-Holland Pub. Co., Amsterdam, 1973.			
Module	Unit	Content	Hours75	Marks
I	1	ANALYSIS OF STRAIN 9 Deformation, strain tensor in rectangular Cartesian coordinates, Geometric interpretation of infinitesimal strain, rotation, compatibility of strain components, properties of strain tensor, strain in spherical and cylindrical polar coordinates.	10	
	2			
II	5	ANALYSIS OF STRESS 9 Stresses, laws of motion, Cauchy's formula, equations of equilibrium, transformation of coordinates, Plane state of stresses, Cauchy's stress quadric, shearing stress, Mohr's circle, stress deviation, stress tensor in general coordinates, physical components of a stress tensor in general coordinates, equation of equilibrium in curvilinear coordinates.	10	
III	8	LINEAR THEORY OF ELASTICITY 8 Generalized Hooke's law, Stress-Strain relationship for an isotropic elastic material, Basic equation of elasticity for homogeneous isotropic bodies, boundary value problems, the problem of equilibrium and the uniqueness of solution of elasticity, Saint-Venant's principle.	10	
IV	10	TORSION 7 Torsion of prismatic bars, torsion of circular, elliptic and rectangular bars, membrane analogy, torsion of rectangular section and hollow thin walled sections.	10	

	11	SOLUTION OF TWO AND THREE DIMENSIONAL PROBLEMS IN ELASTICITY 12 Bending of a cantilever beam, simply supported beam with simple loadings. Semi-infinite medium subjected to simple loadings. Plane elastic waves, Rayleigh surface waves, Love waves, Vibration of an infinite isotropic solid cylinder.		
V		Applied problems of all modules	35	

1. Srinath L.S., “Advanced Mechanics of Solids”, Tata McGraw Hill, New Delhi, 3 rd Edition, 2008
2. . 2. Fung Y.C., “Foundations of Solid Mechanics”, Prentice Hall Inc., New Jercy, 1965.

AM 9026 ALGORITHMIC GRAPH THEORY L T P C

***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	3	3	3	1	1	0	2	0	3
CO 2	3	1	3	3	3	1	2	0	2	0	3
CO 3	3	3	3	3	3	1	1	0	3	0	3
CO4	3	2	1	3	2	1	2	0	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	✓	✓	✓	✓	✓
CO4	✓				✓

Program	B.Sc. Applied Mathematics Honours			
Course Code	AMA8EJ406			
Course Title	**Discrete Time Control System**			
Type of Course	Elective			
Semester	VIII			
Academic Level	400-499			
Course Details	Credit	Lecture/Tutorial per week	Practical/Practicum per week	Total Hours
	4	4	-	
Pre-requisites	Differential Equations, Complex analysis			
Course Summary	This course is the follow-on to Continuous Control Systems and presents a comprehensive introduction to the theory and design of discrete-time control systems. Representation, modeling, and analysis of discrete-time / sampled-data systems are first discussed.			

COURSE OUTCOME(CO)

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used
CO 1	To train and motivate the students towards mathematical modeling	**Ap**	**C**	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO 2	To understand various real world problems which use applications of mathematics	**AP**	**P**	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyze (An), Evaluate (E), Create (C) # - Factual Knowledge (F), Conceptual Knowledge (C), Procedural Knowledge (P), Metacognitive Knowledge (M)				

Text				
Module	Unit	Content	Hours75	Marks
I	1	**Introduction to Discrete Time Control Systems**: Introduction - Digital Control Systems - Quantizing and	10	
		Quantization Error - Data Acquisition, Conversion and Distribution Systems.		
	2	**Z Transform**: Introduction - Z Transforms of Elementary Functions – Important properties and theorems - The Inverse Z transform- Method for solving difference equations.		
II	5	**Z-Plane Analysis of Discrete - Time Control Systems**: Introduction - Impulse Sampling and data hold - Obtaining the Z Transform by the Convolution integral Method - The pulse transfer function.	10	
III	8	**Design of Discrete-Time Control Systems by Conventional Methods**: Introduction - Mapping between the S plane and the Z plane - Stability analysis of closed Loop systems in the Z plane.	10	
IV	10	**State-Space Analysis**: Introduction - State - Space representations of discrete time systems - Solving discrete-time state Space equations - Pulse-transferfunction matrix - Discretization of continuous-time state - space equations - Liapunov stability analysis.	10	
	11	**Pole placement and observer design**: Introduction - Controllability - Observability - Useful transformations in state - Space analysis and design - Design via pole placement - State observers.		
V		Applied problems of all modules	35	
1. Discrete - Time Control Systems- Katsuhiko, Ogata Prentice, Hall of India Pvt,2nd edition- New Delhi. **References**: 1. Digital Control using Digital Signal Processing- FarzadNekoogar& G Moriarty Prentice Hall PTR- Upper Saddle Rover- New Jersey.				

***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	3	3	3	1	3	1	2	1	3
CO 2	3	1	3	3	3	1	3	1	2	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	✓	✓	✓	✓	✓

Program	B.Sc. Applied Mathematics Honours			
Course Code	AMA8EJ407			
Course Title	**Differential Geometry**			
Type of Course	Elective			
Semester	VII			
Academic Level	400-499			
Course Details	Credit	Lecture/Tutorial per week	Practical/Practicum per week	Total Hours
	4	4	-	
Pre-requisites	Calculus			

COURSE OUTCOME(CO)

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used
CO1	To recognize the concept of curves and surfaces	**Ap**	**C**	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO2	To understand the concept of curvature of a surface and able to compute the curvature of space curves.	**AP**	**P**	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO3	To understand geodesic as a distance minimizing curves on surfaces and find the geodesic of various surfaces	**U**	**P**	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyze (An), Evaluate (E), Create (C) # - Factual Knowledge (F), Conceptual Knowledge (C), Procedural Knowledge (P), Metacognitive Knowledge (M)				

Text	John A. Thorpe, Elementary Topics in Differential Geometry, Springer, 1979.

Module	Unit	Content	Hours75	Marks
I	1	Chapter 1 Graphs and Level Sets	15	
	2	Chapter 2 Vector Fields		
II	5	Chapter 3The Tangent Space	10	
		Chapter 4Surfaces		

III	8	Chapter 5 Vector Fields on Surfaces; Orientation	13	
		Chapter 7 Geodesics		
IV	10	Chapter 8 Parallel Transport	10	
	11	Chapter 9 The Weingarten Map		
V		Curve sketching of above discussed using any software	12	

. References

1. W.L. Burke: Applied Differential Geometry Cambridge University Press (1985)
2. M. de Carmo: Differential Geometry of Curves and Surfaces Prentice Hall Inc Englewood Cliffs NJ (1976).
3. V. Grilleman and A. Pollack: Differential Topology Prentice Hall Inc Englewood Cliffs NJ (1974).
4. B. O'Neil: Elementary Differential Geometry Academic Press NY (1966).
5. M. Spivak: A Comprehensive Introduction to Differential Geometry, (Volumes 1 to 5) Publish or Perish, Boston (1970, 75).
6. R. Millmen and G. Parker: Elements of Differential Geometry Prentice Hall Inc Englewood Cliffs NJ (1977).
7. I. Singer and J.A. Thorpe: Lecture Notes on Elementary Topology and Geometry UTM, Springer Verlag, NY (1967)

***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	3	2	0	1	1	2	0	3
CO 2	2	1	3	3	2	0	1	1	2	0	3
CO 3	3	3	3	3	2	0	1	1	2	0	3

Program	B.Sc. Applied Mathematics Honours			
Course Code	AMA8EJ408			
Course Title	**Rings and modules**			
Type of Course	Elective			
Semester	VIII			
Academic Level	400-499			
Course Details	Credit	Lecture/Tutorial per week	Practical/Practicum per week	Total Hours
	4	4	-	
Pre-requisites				
Course Summary	The aim of this course is to introduce commutative algebra. This theory has developed not just as a standalone area of algebra, but also as a tool to study other important branches of Mathematics including Algebraic Geometry and Algebraic Number Theory.			

COURSE OUTCOME(CO)

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used
CO 1	Learn basic properties of commutative rings, ideals and modules over commutative rings	**U**	**C**	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO 2	Learn the basic theory of Noetherian and Artin Rings	**U**	**C**	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyze (An), Evaluate (E), Create (C) # - Factual Knowledge (F), Conceptual Knowledge (C), Procedural Knowledge (P), Metacognitive Knowledge (M)				

Text	Siegrried Bosch, Algebraic geometry and commutative algebra, 2nd edition			
Module	Unit	Content	Hours60	Marks 70+30
I	1	Rings and ideals, local rings and localization of rings, Radicals (sections 1.1-1.3 from chapter 1 text 1)	12	

II	2	Modules, Finiteness conditions and the Snake lemma (Sections 1.4and 1.5 from chapter 1)	12	
III	3	The theory of Noetherian Rings, Primary Decomposition of ideals, Artinian Rings and	12	
		Modules (sections 2.1and 2.2 from Chapter 2)		
IV	4	The Artin-Rees lemma, Krull Dimension (section2.3and 2.4) Integral extensions, integral dependence, Noether Normalization and Hilbert's Nullstellensatz, The Cohen-Seidenberg Theorems (sec 3.1-3.3)	12	
V		Extensions of coefficients and Descent, tensor products, flat modules, extension of coefficients(sec 4.1-4.3)	12	
. 1. M. F. Atiyah and I. G. MacDonald, Introduction to Commutative Algebra, Addison Wesley (1969). 2. N. S. Gopalakrishnan, Commutative Algebra, Oxonian Press (1984). 3. M. Reid, Undergraduate Commutative Algebra, LMS Student Texts (29), Cambridge Univ. Press (1995). 4. Matsumura, H., Commutative Ring Theory, Cambridge Studies in Advanced Mathematics, 1989				

***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	3	3	3	1	1	0	2	0	3
CO 2	3	1	3	3	3	1	2	0	2	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	✓	✓	✓	✓	✓

Programme	B Sc Applied Mathematics Honours			
Course Code	AMA8EJ409			
Course Title	**Mathematics of Wavelets**			
Type of Course	**ELECTIVE**			
Semester	**VIII**			
Academic Level	400-499			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	5	..	75
Pre-requisites	Real analysis and linear algebra			
Course Summary	To expose the students to the basics of wavelet theory and to illustrate the use of wavelet processing for data compression and noise suppression.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the concepts of continuous wavelet transform.	U	C	Internal Exam/Assignment/Seminar/ Viva/Report/ End Sem Exam
CO2	Improve problem solving skills using discrete wavelet transform and filter banks.	Ap	P	Internal Exam/Assignment/Seminar/ Viva/Report/ End Sem Exam
CO3	Understand the concepts of Multiresolution analysis. Learn the various applications of wavelet.	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)				

Text Book	R. M. Rao and Ajit S. Bopardikar, "Wavelet Transform, Introduction to theory and Applications", Addison-Wesley, 1998.			
Module	**Unit**	**Content**	**Hours**	**Marks**
				Ext:70
I	**1**	Continuous Wavelet Transform 1.1 Introduction 1.2 Continuous -Time Wavelets(including Problems at the end of the chapter)	**20**	
	2	1.3 Definition of the CWT(including Problems at the end of the chapter		
	3	1.4The CWT as a Correlation(including Problems at the end of the chapter		
	4	1.5Constant Q-Factor Filtering interpretation and Time -Frequency Resolution(including Problems at the end of the chapter		
	5	1.6The CWT as an Operator(including Problems at the end of the chapter		
	6	1.7Inverse CWT(including Problems at the end of the chapter	**20**	
II	**7**	2.1 Introduction 2.2Approximation of Vectors in Nested Linear Vector Subspaces 2.21Examples of Approximating Vectors in Nested subsequence of an Infinite -Dimensional linear Space(including Problems at the end of the chapter)		
	8	Example of an MRN 2.3.1 Bases for the Approximation Subspace and Harr Scaling Function 2.3.2 Bases for the Detail Sunspace of Harr Wavelet(including Problems at the end of the chapter)		
	9	2.3.3 Digital Filter Implementation of the 20Harr Wavelet Decomposition (including Problems at the end of the chapter)		

	10	3 MRA, Orthogonal Wavelets and Their Relationship to Filter Banks		
	11	3.1Introduction 3.2Formal Definition of an MRN(including Problems at the end of the chapter)		
	12	3.3Construction of an MRN 3.3.1Scaling Functions and Subspaces 3.3.2Implications of Dilation Equation and Orthogonality(including Problems at the end of the chapter)		
III	**13**	3.4 A wavelet Basis for MRN	**20**	
		3.4.1 Two-Scale Relation for y(t) 3.4.2Basis for the Detail subspaces 3.4.3Direct Sum Decomposition(including Problems at the end of the chapter)		
	14	3.5Digital Filtering Interpretation 3.5.1Decomposition Filters 3.5.2Reconstructing the signal(including Problems at the end of the chapter)		
	15	Examples of Orthogonal Basis – Generating Wavelets(including Problems at the end of the chapter)		
	16	3.6.1 Daubechies D4 Scaling Function and Wavelet 3.6.2Bandlimited Wavelets(including Problems at the end of the chapter)		
	17	Interpreting Orthonormal MRAs for Discrete-Time Signals 3.7.1Continuous – Time MRN Interpretation for DTWT 3.7.2Discrete- Time MRA 3.7.3Basis Function for the DTWT(including Problems at the end of the chapter)		
IV	**18**	4 Alternative Wavelet Representations 4.1Introduction 4.2Biorthonormal Wavelets(including Problems at the end of the chapter	**20**	
	19	4.3Filtering Relationship for Biorthogonal Filters(including Problems at the end of the chapter)		
	20	4.4 Examples of Biorthogonal Scaling Functions Wavelets(including Problems at the end of the chapter)		

	21	4.5Two Dimensional Wavelets		
	22	4.6Nonseparable Multidimensional Wavelets(including Problems at the end of the chapter		
	23	Wavelet Packets(including Problems at the end of the chapter		
V		Wavelet Transform and Data compression, Transform Coding, DTWT for image compression, Audio Compression, other applications of wavelet Transforms	**15**	

References

1. Gilbert Strang and Truong Nguyen, "Wavelets and Filter banks", Wellesley Cambridge Press, 1996.

2. K. P. Soman, K. I. Ramachandran, “Insight into Wavelets: From Theory to Practice”, Third Edition, PHI, 2004.

3. S. Mallat , “A Wavelet Tour of Signal Processing”, 2nd edition, Academic Press, 1999.

4. M. Vetterli, J. Kovacevic , “Wavelets and Sub band Coding”, Prentice Hall, 1995.

5.Raghuveer rao ,Ajit S.Bopardikar, “ Wavelet transforms: Introduction, Theory and applications”, Pearson Education Asia, 2000.

6. J.C. Goswami, A.K. Chan, “ Fundamentals of Wavelets: Theory, Algorithms, and Applications”, 2nd ed., Wiley, 2011.

7. Michel Misiti, Yves Misiti, Georges Oppenheim, JeanMichel Poggi, John , “Wavelets and their Applications”, Wiley & Sons, 2010 .

8. J S Walker, “A premier on Wavelets and their scientific applications”, CRC press, 2002.

9. Stark, “Wavelets and signal processing: An application based introduction”, Springer, 2005.

10. Gerald keiser, “A friendly guide to Wavelets”, Springer, 2011.

Web References: 1.https://www.elsevier.com/books/a-wavelet-tour-of-signalprocessing/mallat/978-0-12-466606-1 2.https://www.pearson.com/us/highereducation/program/Rao-Wavelet-Transforms-Introduction-to-TheoryandApplications/PGM39927.html 3. http://www.wavelet.org/

E-Text Books: 1. http://users.rowan.edu/~polikar/WAVELETS/WTtutorial.html

2 http://www.math.hawaii.edu/~dave/Web/Amara's%20Wavelet%20Page.htm

MOOC Course

1. nptel.ac.in/courses/103106114/48

2. https://ocw.mit.edu/.../18-327-wavelets-filter-banks-and-applications-spring-2003/

**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	2	3	1	-	-	3	1	2
CO 2	3	2	2	2	3	1	-	-	3	1	2
CO 3	3	2	2	2	3	1	-	-	3	1	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. Applied Mathematics Honours
Course Code	AMA8EJ410
Course Title	**Functional Analysis**
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
Course Summary	The course is aimed to provide a thorough understanding of functional analysis The focus of the course is on the study of normed linear space, Hilbert space and spectral theory.

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	To learn the concept of normed linear spaces and Hilbert spaces.	An	C	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO2	To learn various properties operators defined on both normed and Hilbert spaces.	An	C	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO3	To understand the concept dual space.	U	C	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam

CO4	To learn the completeness of the space bounded linear operators	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

Text Book	**Introductory Functional Analysis with Applications' by E.Kreyszig**			
Module	**Unit**	**Content**	**Hrs (60)**	**External Marks (70)**
I		**Module I**		
	1	**Normed Spaces and Banach Spaces (15 Hours)** 1. **Introduction to Functional Analysis** ○ Basic concepts of functional analysis. ○ Historical background and significance.	**15**	**Min 15**
	2	2. **Normed Spaces** Definitions and examples. Normed space properties and the concept of norm. Equivalent norms		
	3	3. **Banach Spaces** Definition and examples. The concept of completeness. Subspaces, quotient spaces, and linear operators		
	4	4. **Finite Dimensional Normed Spaces** The Heine-Borel theorem. Riesz lemma		
II		**Module II**		

	5	**Inner Product Spaces and Hilbert Spaces (15 Hours)** 1. **Inner Product Spaces** ○ Definitions and examples. ○ Properties of inner products. ○ Parallelogram law and polarization identity.		

			12	Min 15
	6	1. **Hilbert Spaces** ○ Definition and properties. ○ Orthogonal complements. ○ Projection theorem and Riesz representation theorem.		
	7	1. **Orthonormal Sets and Sequences** ○ Orthonormal sets, bases. ○ Gram-Schmidt orthogonalization process. ○ Bessel's inequality and Parseval's identity		
III				Min 15
	8	**Linear Operators (15 Hours)** 1. **Bounded and Unbounded Operators (4 Hours)** ○ Definitions and examples. ○ Bounded linear operators. The concept of operator norm	12	
	9	1. **Adjoint Operators** ○ Definition and properties. ○ Examples of adjoint operators. ○ Self-adjoint, unitary, and normal operators		
	10	1. **Compact Operators** ○ Definition and properties. ○ Examples and spectral properties		
IV				

	11	**Spect al Theory (15 Hours)** 1. **Spectral Theory of Bounded Operators** ○ Spectrum of an operator. ○ Point spectrum, continuous spectrum, and residual spectrum	12	**Min 15**
	12	1. **Spectral Theorems** ○ Spectral theorem for compact operators. ○ Spectral theorem for bounded self-adjoint operators. ○ Applications of spectral theorems.		
	13	1. **Unbounded Operators** ○ Basic concepts and definitions. ○ Closed operators and the closed graph theorem.		
		○ Spectral properties of unbounded operators.		
V				
	Unit 5: Advanced Topics and Applications (15 Hours) 1. **Weak Topologies and Reflexivity** ○ Weak and weak* topologies. ○ Reflexivity in normed spaces. 2. **Fixed Point Theorems** ○ Banach fixed-point theorem. ○ Applications of fixed-point theorems in functional analysis. 3. **Distributions and Sobolev Spaces** ○ Introduction to distributions. ○ Sobolev spaces and their properties		**12**	

	References: [1] B. V. Limaye: Functional Analysis, New Age International Ltd, New Delhi, 1996. [2] G. Bachman and L. Narici: Functional Analysis; Academic Press, NY; 1970 [3] J. B. Conway: Functional Analysis; Narosa Pub House, New Delhi; 1978 [4] J. Dieudonne: Foundations of Modern analysis; Academic Press; 1969 [5] W. Dunford and J. Schwartz: Linear Operators - Part 1: General Theory; John Wiley & Sons; 1958 [6] Kolmogorov and S.V. Fomin: Elements of the Theory of Functions and Functional Analysis (English translation); Graylock Press, Rochaster NY; 1972		

***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	2	3	1	1	-	3	-	3
CO 2	3	2	1	2	3	1	1	-	3	-	2
CO 3	3	2	1	2	3	1	1	-	3	-	3
CO 4	3	2	1	2	3	1	1	-	3	-	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	✓	✓	✓	✓	✓

RESEARCH METHODOLOGY

Programme	B. Sc. Applied Mathematics Honours			
Course Code	AMA8CJ489			
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.	An	F	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.	C	P	Internal examination/ Seminar/ Assignment/ End Sem examination

RESEARCH METHODOLOGY

Programme	B. Sc. Applied Mathematics Honours				
Course Code	AMA8CJ489				
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.	An	F	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.	C	P	Internal examination/ Seminar/ Assignment/ End Sem examination
CO3	Mathematical typesetting: to use LaTeX to create and typeset documents. Beamer Presentations and PSTricks also included.	Ap	F	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 good mathematical 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.			

Reference	1. The Princeton companion to mathematics, Timothy Gowers, Ed., Princeton University Press, 2008, ISBN ISBN 978-0-691-11880-2. 2. Math Unlimited, Essays in Mathematics, Editors: R. Sujatha, H N Ramaswamy, C S Yogananda, CRC Press, 2012, ISBN: 978-1-57808-704-4. 3. A Primer of Mathematical Writing, Steven G. Krantz, 2nd Ed., 2017, ISBN 9781470436582.

Mapping of COs with PSOs and POs :

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

CorrelationLevels:

Assessment Rubrics:

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

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

Mapping of COs to Assessment Rubrics:

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

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:

Texts:

1. John Bird, Bird's Higher Engineering Mathematics 9/e, Routledge, ISBN: 978-036764373-7, 2021.
2. Ron Larson & Betsy Farber, Elementary Statistics, Picturing the World 6/e, Pearson Education, ISBN: 978-0-321-91121-6, 2015.

Module	Unit	Content	Hrs (36+ 9)	Ext. Marks (50)
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**		
	7	Section 21.1 - Solution of simultaneous equations by matrices		
	8	Section 21.2 - Solution of simultaneous equations by determinants	**9**	**Min 10**
	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)**		
	16	Section 3.1 - Basic Concepts of Probability and Counting.	**9**	**Min 10**

	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

CorrelationLevels:

Assessment Rubrics:

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

- 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. Applied Mathematics Honours			
Course Code	AMA2FM106(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 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 modeling, 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:

Assessment Rubrics:

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

- 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.Appled Mathematics Honours			
Course Code	AMA1FM105(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		
		Basic Arithmetic Operations		
	6	Simplification		

II	7	Average	**9**	**Min 10**
	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:

Assessment Rubrics:

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

- 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. Applied Mathematics Honours				
Course Code	AMA2FM106(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:

Assessment Rubrics:

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

- 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. Applied Mathematics Honours
Course Title	**MATHEMATICAL TYPE SETTING SYSTEM - LATEX**
Course Code	AMA5FS112

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:

Textbook	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 (5^{th} Edition),			
Module	**Unit**	**Content**	**Hrs (36+ 9)**	**Ex. Marks (50)**
I	**Getting Started with LaTeX (Text-1)**		**8**	**Min 10**
	1	The basics- Tutorial I		
	2	The documents – Tutorial II		
	3	Bibliographic Database- Tutorial III & IV		
	4	Table of contents and Index- Tutorial V(Omit glossary)		
II	**Styling Pages**		**6**	**Min 10**
	5	Displayed Text – Tutorial VI		
	6	Rows and columns – Tutorial VII		
	7	Tables – Tutorial VII .2		
III	**Typesetting Mathematics**		**10**	**Min 10**
	8	Basic Mathematical equation- Tutorial VIII.1, VIII.2		
	9	Groups of Equations and numbering – Tutorial VIII.3		
	10	Matrices, dots, delimiters and affixing symbolsTutorial VIII.4		
	11	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)		
IV	**Theorems, figures, Cross references and Presentation(Text-1 and 2)**			
	12	Theorem in Latex – Tutorial IX.1		

	13	The AMS theorem package- Tutorial IX.2 (Omit IX.2.2 , IX.2.3)	**12**	**Min 10**
	14	Boxes – Tutorial X (Section X.1 , X.2 Only)		
	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 Weley,1994)- LaTeX, a Dcument Preparation System.
4) Donald Knuth (Addison-Wesley, 1984), The TeX book 5) Frank Mittelbach and Michel Goossens (second edition,A 6) ddison-Wesley, 2004).

Mapping of COs with PSOs and POs :

Correlation Levels: Assessment Rubrics:

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

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

	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

Mapping of COs to Assessment Rubrics:

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

Programme	B. Sc. Applied Mathematics Honours				
Course Code	AMA6FS113				
Course Title	**DATA SCIENCE WITH PYTHON**				
Type of Course	**SEC**				
Semester	VI				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	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/exploreanalyzedata-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. Applied Mathematics Honours			
Course Code	AMA3FV109(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, 7th 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:

Assessment Rubrics:

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

- 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. Applied Mathematics Honours			
Course Code	AMA3FV109(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		**sitional 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**		**8**	**Min 10**
	17	Ground Resolution and Resolvants		
	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:

Assessment Rubrics:

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

- 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. Applied Mathematics Honours
Course Code	AMA4FV110(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: Assessment Rubrics:

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

- 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. Applied Mathematics Honours				
Course Code	AMA4FV110(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)				

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 (Treatement 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	**From Ancient Mathematical Rules to Modern Computer Algorithms.**		**9**	

Detailed Syllabus:

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: Assessment Rubrics:

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

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

(Open Ended)	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 to Assessment Rubrics:

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

CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

MINOR

Programme	B.Sc Applied Mathematics Honours				
Course Code	AMA1MN104				
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	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Implement functions, matrices, and combinatorics	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam

CO4	Understand the Fundamental Counting Principle, permutations, combinations, and discrete probability.	U	C	
* - 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, (1/e), Thomas Koshy, Academic Press (2003), ISBN: 978-0124211803.

Module	Unit	Content	Hrs (48 +12)	Ext. Marks (70)
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**			
	7	2.1 The Concept of a Set - up to and including example 2.7 (Example 2.6 is optional).	**12**	**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**			

	17	6.1 The Fundamental Counting Principles (Example 6.7 is optional)	11	**Min. 15**
	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: Assessment Rubrics:

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

- 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 Applied Mathematics Honours				
Course Code	AMA2MN104				
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	**Remember** the definitions and fundamental properties of graphs, including simple graphs, adjacency and incidence, degree of a vertex, adjacency matrix, subgraphs, complete graphs, cycle and wheel graphs, bipartite graphs, complete bipartite graphs, weighted graphs, and isomorphic graphs.	R	F	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	? **Analyze** the structure of planar graphs and trees, identifying their components and understanding their interrelationships. ?	An	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO4	**Apply** graph coloring techniques to determine chromatic numbers and utilize Kruskal's Algorithm to find minimum spanning trees in various graphs.	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO5	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
CO4	2	1	2	1	1	2	2	0	0

Correlation Levels: Assessment Rubrics:

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

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. Applied Mathematics Honours
Course Code	AMA3MN204
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	AMA1MN203 and AMA2MN203
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	**Uni t**	**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, Wellordered 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: Assessment Rubrics:

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

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. Applied Mathematics Honours			
Course Code	AMA1MN101			
Course Title	COMMERCIAL ARITHMETIC			
Course Type	Minor			
Semester	1			
Academic Level	100-199			
Course Details	Credit	Lecture/Tutorial per week	Practical/Practicum per week	Total Hours
	4	4	0	4
Pre- requisites	Basic arithmetic			
Course Summary	The course covers basic concepts of Sets, Matrices and their operations, Relations and Functions. This course also covers the methods of solving Linear Equations and basic concepts of Arithmetic and Geometric progressions.			

COURSE OUTCOME(CO)

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used
CO 1	Understand numerical equations, matrix, progression, financial mathematics.	U	F	Internal Exam/Assignment /Seminar/Viva/End Sem Exam
CO 2	The student will be able to understand basic concepts in Mathematics and will be able to appreciate wide applications in business.	U	F	Internal Exam/Assignment /Seminar/Viva/End Sem Exam

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

COURSE OUTCOME(CO)

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used
CO 1	Understand numerical equations, matrix, progression, financial mathematics.	U	F	Internal Exam/Assignment /Seminar/Viva/End Sem Exam
CO 2	The student will be able to understand basic concepts in Mathematics and will be able to appreciate wide applications in business.	U	F	Internal Exam/Assignment /Seminar/Viva/End Sem Exam

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

Module	Unit	Content	Hours	Marks
				Ext:70
I	1	Sets and Set Operation: Venn Diagrams-Theorems on number of Elements in a set.	15	
	2	Relations, types of relation and equivalence relation. Functions -Type of functions.		
	3	Elements of Co- ordinate system.		
II	4	Progressions: Arithmetic progressions - Finding the “n”th term of an AP and also sum to „n‟terms of an AP-Insertion of Arithmetic means in given terms of AP and representation of AP- Geometric progression: Finding n‟th term of GP. Insertion of GMs in given GP and also representation of GP	10	
III	5	Matrices -Definition, Order of Matrices, Types of Matrices, Operations on Matrices– addition, subtraction, Scalar multiplication and Matrix multiplication -Transpose-Determinant- Inverse of square matrices (not more than 3rd order) - Solving system of simultaneous liner equations.	15	
IV	6	Theory of Equations: Meaning - Types of equations – Simple linear and simultaneous equations (only two variables) eliminations and substitution method only. Quadratic equation factorization and formula method ($ax^2 + bx + c = 0$ form only)	8	
V-Open Ended		Problems on business application.	12	

References:

1. Goldstein, L.J., Schneider, D.I., & Siegal, M.J. (2010). Finite mathematics and Applications. New Jersey: Pearson Publication.
2. Dr. A K Arte & R V Prabhakar - A Text Book of BusinessMathematics.
3. Dr Jagbir Singh, Business Mathematics- Maharshi Dayanand University Press 2021
4. Sundaresan and Jayaseelan – An Introduction to Business Mathematics and Statistical Methods.

***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:**

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

Programme	B.Sc. Applied Mathematics Honours			
Course Code	AMA2MN102			
Course Title	BUSINESS MATHEMATICS			
Course Type	Minor			
Semester	2			
Academic Level	100-199			
Course Details	Credit	Lecture/Tutorial per week	Practical/Practicum per week	Total Hours
	4	4	0	4
Pre- requisites	Basic arithmetic, Basic Knowledge about Interest, Set theory and Calculus			
Course Summary	The course covers concepts of Lines, Interest and Time values, Probability, and also basic concepts of Differential calculus.			

COURSE OUTCOME(CO)

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used
CO 1	Student will able to understand difference between mathematical equations and inequalities and their solutions.	U	P	Internal Exam/Assignment/Seminar/Viva/End Sem Exam
CO 2	Student will be able to appreciate uses of Mathematical models in real life situations	Ap	P	Internal Exam/Assignment/Seminar/Viva/End Sem Exam
CO 3	To be able to calculate present worth of money spent and annuity in real life situations.	Ap	C	Internal Exam/Assignment/Seminar/Viva/End Sem Exam
***-Remember®, Understand (U), Apply (Ap), Evaluate(E), Create(C) #-Factual Knowledge (F), Conceptual Knowledge (C), Procedural Knowledge(P), Metacognitive Knowledge(M)**				

Module	Unit	Content	Hours	Marks Ext:70
I	**1**	Linear Models: Linear equations and inequalities in one variable, Linear functions, slope and equations of a line	**8**	

II	**2**	Interest and Time value: Concept of interestTypes of interest: Simple interest and compound interest – nominal, real and effective rate of interest. Future value and Present Value; Annuity and Perpetuity. Computing future and present values of annuity (regular and immediate) - multi and growing period perpetuity. Compound annual growth rate- computation of Equated Monthly	**12**	
		Instalments (EMI).		
III	**3**	Theory of Probability: Permutation and Combination- Probability: Concept and definitions- Approaches to probability- Theorems of probability- Addition Theorem, Multiplication Theorem- Conditional probability- Inverse probability- Baye's Theorem- Random variable- Mathematical expectation.	**13**	
IV	**4**	Basic Calculus (excluding trigonometric - functions): :ulus Limits- Differentiat Methods of - Second orde differentiation ima and Minima. derivative-	**15**	
V-Open Ended		Linear mathematics models, constructing mathematical models. Application to commerce and Economics- Revenue Function- Cost function- Profit function- Elasticity of demand- Breakeven point. Problems on business application.	**12**	

References:

1. Goldstein, L.J., Schneider, D.I., & Siegal, M.J. (2010). Finite mathematics and Applications. New Jersey: Pearson Publication.
2. Business Mathematics with Calculus - Daniel Ashlock and Andrew McEachern
3. G K Ranganath& T V Narasimha Rao. *Business Mathematics*. New Delhi: Himalaya Publishing House.

***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:

	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7

CO 1	3	2	2	-	2	-	2	-	1
CO 2	2	1	3	1	3	-	3	1	3
CO 3	3	2	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. Applied Mathematics Honours			
Course Code	AMA3MN201			
Course Title	MANAGEMENT SCIENCE			
Course Type	Minor			
Semester	3			
Academic Level	200-299			
Course Details	Credit	Lecture/Tutorial per week	Practical/Practicum per week	Total Hours
	4	4	0	4
Pre- requisites	Basic arithmetic, Basic Knowledge about Matrices and Calculus			
Course Summary	The course covers concepts of Linear Programming Problem, Transportation problem, Assignment problem and also basic concepts of Integral calculus.			

COURSE OUTCOME(CO)

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used
CO 1	Student will able to understand commercial arithmetic and calculus and its applications.	U	P	Internal Exam/Assignment/Seminar /Viva/End Sem Exam
CO 2	Students will understand common techniques used in Operation Management Decisions	U	F	Internal Exam/Assignment/Seminar /Viva/End Sem Exam
CO 3	Students will understand calculus and its applications	U	P	Internal Exam/Assignment/Seminar /Viva/End Sem Exam

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

Module	Unit	Content	Hours	Marks
				Ext:70

I	**1**	Linear Programming: Problems Definition- Linear Programming Problem- Formulation- Solution by Graphical method- simplex method- minimization and maximization problems.	**15**	
II	**2**	Transportation Problems: Different Initial Allocation Methods- Move towards Optimality- MODI Method of Solving Transportation Problems.	**12**	
III	**3**	Assignment Problems- Solutions- Variations in Assignment Problems- Travelling Sales-man problem.	**8**	
IV	**4**	Integral Calculus (excluding trigonometric	**13**	
		functions) : Integration as antiderivative, Integral and constant of integration. n of different functions- Integration by substitution -Definite integrals: Evaluation of ntegrals, Integration by substitution.		
V-Open Ended		Problems on business application.	**12**	

References:

1. Business Mathematics with Calculus - Daniel Ashlock and Andrew McEachern
2. Goldstein, L.J., Schneider, D.I., & Siegal, M.J. (2010). Finite mathematics and Applications. New Jersey: Pearson Publication.
3. J.K. Sharma, Operation Research, Theory and Applications Macmillan India Limited.

***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:

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