

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

(Affiliated to the University of Calicut)



CURRICULUM & SYLLABI

FOR

B.Sc. Applied Mathematics Honours

**UNDER FOUR YEAR 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.

SYLLABUS

(w.e.f. 2024 admission onwards)

(FYUGP Regulations 2024)

B.Sc. APPLIED MATHEMATICS HONOURS PROGRAMME

Course Structure

Major A- Mathematics

Minor B

Minor C

Semester	Course Code	Course Title	Total Hours	Hours/Week	Credits			
						Internal	External	
1	AMA1CJ101	Major A-Course 1-Calculus I	75	5	4	30	70	100
	02	Minor B- Course	75	5	4	30	70	100
	03	Minor C- Course	75	5	4	30	70	100
	04	Ability Enhancement Course 1(P) (E)	60	4	3	25	50	75
	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		
2	AMA2CJ101	Major A- Course 2—Calculus II	75	5	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	25	50	100
	05	Ability Enhancement Course 4(AL)	45	3	3	25	50	100
	06	Multi-Disciplinary Course 2(Other Department)	45	3	3	25	50	100
			Total		25	21		
3	AMA3CJ201	Major A- Course 3- Calculus III	75	5	4	30	70	100
	AMA3CJ202	Major A- Course 4 – Theory of Equations	60	4	4	30	70	100
	03	Minor B-Course 3-Introduction to Artificial Intelligence and Machine	75	5	4	30	70	100

		Learning						
	04	Minor C- Course 4-Statistical Inference (practical using R programming)	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-Calculus IV	75	5	4	30	70	100
	AMA4CJ204	Major A-Course 6-Differential Equations	75	5	4	30	70	100
	AMA4CJ205	Major A- Course 7- Linear Programming and Applications	75	5	4	30	70	100
	04	Skill Enhancement Course 1 (P) (E)	45	3	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		24	21			
5	AMA5CJ301	Major A-Course 8- Linear Algebra	75	5	4	30	70	100
	AMA5CJ302	Major A-Course 9-Real Analysis	75	5	4	30	70	100
	AMA5CJ303	Major A-Course 10- Abstract Algebra and 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			
6	AMA6CJ304	Major A-Course 11- Partial Differential Equations & Calculus of Variation	60	4	4	30	70	100
	AMA6CJ305	Major A-Course 12- Complex Analysis	75	5	4	30	70	100
	AMA6CJ306	Major A-Course 13 Discrete Mathematics 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-Functional Analysis	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- Mathematics of Wavelets	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 Mathematics	60	4	4	30	70	100		
	Total		25	24					
Total Credits for four years					177				

Choose any four elective courses (two in fifth and two in sixth semester)

from the basket of electives with specialization

ELECTIVE COURSES IN MATHEMATICS 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 and Algorithms	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	AMA5EJ301 (3)	Graph Theory and application	5	60	4	4	30	70	100
	2	AMA5EJ302 (3)	Lattice Theory	5	60	4	4	30	70	100
	3	AMA6EJ301 (3)	Fuzzy Mathematics	6	60	4	4	30	70	100
	4	AMA6EJ302 (3)	Coding Theory	6	60	4	4	30	70	100

4	OPTIMIZATION									
	1	AMA5EJ303 (4)	Financial Mathematics	5	60	4	4	30	70	100
	2	AMA5EJ304 (4)	Mathematical Modeling	5	60	4	4	30	70	100
	3	AMA6EJ303 (4)	Mathematical Economics	6	60	4	4	30	70	100
	4	AMA6EJ304 (4)	Operation Research	6	60	4	4	30	70	100

5	ACTUARIAL SCIENCES									
	1	AMA5EJ305 (5)	Introduction to Actuarial Science	5	60	4	4	30	70	100
	2	AMA5EJ306 (5)	Mathematics of Finance I	5	60	4	4	30	70	100
	3	AMA6EJ305 (5)	Principles of Insurance	6	60	4	4	30	70	100
	4	AMA6EJ306 (5)	Mathematics of Finance II	6	60	4	4	30	70	100

Elective course for VIII semesters.

Sl. No.	Course code	Title	Total Hrs	Hrs /week	Credits	Marks		
						Internal	External	Total
1	AMA8EJ401	Analytical Number Theory	60	4	4	30	70	100
2	AMA8EJ402	Numerical Method 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

GROUPING OF MINOR COURSES IN 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	AMA1MN102	BUSINESS MATHEMATICS	2	60	4	4	30	70	100
	3	AMA1MN201	MANAGEMENT SCIENCE	3	60	4	4	30	70	100

DISTRIBUTION OF GENERAL FOUNDATION COURSES IN 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

Semester	Major Courses	Minor Courses	General Foundation Courses	ternship/ 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 Mathematics are with only theory component. Out of the total 5 modules of the syllabus, one open-ended module with 20% content is designed by the faculty member teaching that course, and it is internally evaluated for 5 marks. The internal evaluation of the remaining 4 theory modules is for 20 marks.

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

1. MAJOR AND MINOR COURSES

1.1. INTERNAL EVALUATION OF THEORY COMPONENT

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

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

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

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

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

3	Evaluation of the Practical/Practicum records submitted for the end semester viva-voce examination by the teacher-in-charge and additional examiner	3	15%
Total Marks		20	

1.2.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. Mathematics Honours programme, institute/ industry visit or study tour is a requirement for the completion of Internship. Visit to minimum one national research institute, research laboratory and place of scientific importance should be part of the study tour. A brief report of the study tour has to be submitted with photos

and analysis.

5. The students should make regular and detailed entries in to a personal log book through the period of Internship. The log book will be a record of the progress of the Internship and the time spent on the work, and it will be useful in writing the final report. It may contain mathematical results, ideas, expressions, experimental conditions, rough work and calculation, computer file names etc. All entries should be dated. The Internship supervisor should periodically examine and countersign the log book.
6. The log book and the typed report must be submitted at the end of the Internship.
7. The institution at which the Internship will be carried out should be prior-approved by the Department Council of the college where the student has enrolled for the UG Honours programme.

2.2. VALUATION OF INTERNSHIP

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

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

8	Evaluation of the day-to-day records, the report of internship supervisor, and final report submitted for the end semester viva-voce examination before the committee internally constituted by the Department Council	8	15%
	Total Marks	50	

3. PROJECT

3.1. PROJECT IN HONOURS PROGRAMME

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

3.2. PROJECT IN HONOURS WITH RESEARCH PROGRAMME

- Students who secure 75% marks and above (equivalently, CGPA 7.5 and above) cumulatively in the first six semesters are eligible to get selected to Honours with Research stream in the fourth year.
- A relaxation of 5% in marks (equivalently, a relaxation of 0.5 grade in CGPA) is allowed for those belonging to SC/ ST/ OBC (non-creamy layer)/ Differently-Abled/ Economically Weaker Section (EWS)/ other categories of candidates as per the decision of the UGC from time to time.
- In Honours with Research programme, the student has to do a mandatory Research Project of 12-credits instead of three Core Courses in Major in semester 8.
- The approved research centres 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 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 Mathematics are with only theory component.

4.1. INTERNAL EVALUATION

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

4.2. EXTERNAL EVALUATION

External evaluation carries about 70% marks. Examinations will be conducted at the end of each semester. Individual questions are evaluated in marks and the total marks are converted into grades by the 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 10-point indirect grading system as per guidelines given below.
- The Semester Grade Point Average (SGPA) is computed from the grades as a measure of the student's performance in a given semester.
- The Cumulative GPA (CGPA) is based on the grades in all courses taken after joining the programme of study.
- Only the weighted grade point based on marks obtained shall be displayed on the grade card issued to the students.

LETTER GRADES AND GRADE POINTS

Sl. No.	Percentage of Marks (Internal & External Put Together)	Description	Letter Grade	Grade Point	Range of Grade Points	Class
1	95% and above	Outstanding	O	10	9.50 – 10	First Class with Distinction
2	Above 85% and below 95%	Excellent	A+	9	8.50 – 9.49	
3	75% to below 85%	Very Good	A	8	7.50 – 8.49	
4	65% to below 75%	Good	B+	7	6.50 – 7.49	First Class
5	55% to below 65%	Above Average	B	6	5.50 – 6.49	
6	45% to below 55%	Average	C	5	4.50 – 5.49	Second Class
7	35% to below 45% aggregate (internal and external put together) with a minimum of 30% in external valuation	Pass	P	4	3.50 – 4.49	Third Class
8	Below an aggregate of 35% or below 30% in external evaluation	Fail	F	0	0 – 3.49	Fail
9	Not attending the examination	Absent	Ab	0	0	Fail

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

5.1. COMPUTATION OF SGPA AND CGPA

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

The SGPA equals the product of the number of credits (C_i) with the grade points (G_i) 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,

$$\text{i.e. SGPA } (S_i) = \frac{\sum_i (C_i \times G_i)}{\sum_i (C_i)}$$

where C_i is the number of credits of the i^{th} course and G_i 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 (C_i) of the course by the grade point (G_i) 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	The course covers fundamental concepts in calculus, including functions, shifting of graphs, limits, continuity, differentiation, extreme values, the Mean Value Theorem, graphing with derivatives, and limits at infinity with asymptotes. Students learn techniques for evaluating limits, finding extrema, and graphing functions using derivatives, preparing them for further studies in calculus and related fields.			

COURSE OUTCOME(CO)

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used
CO1	To show how these ideas of differential calculus can be applied in the problem of sketching of curves and in the solution of some optimization problems of interest in real life.	Ap	P	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO2	To understand the geometric problem of finding out the area of a planar region and practical way of evaluating the definite integral which establishes the close connection between the two branches of Calculus.	U	C	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO3	To find the arc length of a plane curve, volume, and surface areas of solids and so on.	Ap	F	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam

CO4	To use integration as a powerful tool in solving problems in physics, chemistry, biology, engineering, economics, and other fields.	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)				

Text Book	Calculus: Soo T Tan Brooks/Cole, Cengage Learning (2010).			
Module	Unit	Content	Hours (45+30)	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. 15
	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, Finding the Relative Extrema of a Function, first derivative test.		
II	4	3.4: Concavity and Inflection points- Concavity, Inflection Points, The Second Derivative Test.	10	Min. 15
	5	3.5: Limits involving Infinity; Asymptotes- Infinite Limits, Vertical Asymptotes, Limits at Infinity, Horizontal Asymptotes, Infinite Limits at Infinity.		
	6	3.6: Curve Sketching- The Graph of a Function, Guide to Curve Sketching, Slant Asymptotes.		
	7	3.7: Optimization Problems- guidelines for finding absolute extrema.		
III	8	4.1: Indefinite integrals- Basic Rules of Integration, a few basic integration formulas and rules of integration, Differential Equations, Initial Value Problems.	17	Min. 15
	9	4.4: The Definite Integral- Definition of the Definite Integral, Properties of the Definite Integral, More General Definition of the Definite Integral.		
	10	4.5: The Fundamental Theorem of Calculus- The Mean Value Theorem for Definite Integrals, The Fundamental Theorem of Calculus: Part I, inverse relationship between differentiation and integration, Fundamental Theorem of Calculus: Part 2, Evaluating Definite Integrals Using Substitution, Definite Integrals of Odd and Even Functions.		
IV	11	5.1: Areas between Curves- The Area Between Two Curves.	10	Min. 15
	12	5.2: Volume- Solids of revolution, Volume by Disk Method, Region revolved about the x-axis, Region revolved about the y-axis, Volume by the Method of		

		Cross Sections ['Washer Method' omitted]		
	13	5.4: Arc Length and Areas of surfaces of revolution- Definition of Arc Length, Length of a Smooth Curve, arc length formula, Surfaces of Revolution, surface area as surface of revolution		
V		<p>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.</p> <p>Overview of limits and continuity of functions (Chapter 1)</p> <p>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</p> <p>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 $(0, \pi)$ $f(x) = \frac{x}{(x + 1)(x - 2)}$</p>	30	
Practical				
<p>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).</p>				

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

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	✓	✓	✓	✓	✓
CO3	✓	✓			✓

Programme	B.Sc. Applied Mathematics Honours			
Course Code	AMA2CJ102			
Course Title	Calculus II			
Type of Course	Major			
Semester	2			
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 Functions, Limits, Continuity and Differentiation (Calculus I)			
Course Summary	The course provides a comprehensive exploration of integral calculus, covering techniques such as indefinite integrals, Riemann sums, definite integrals, properties of integrals, the Fundamental Theorem, L'Hopital's Rule, basic integration formulas, and applications in finding areas between curves, volumes of solids, lengths of plane curves, and areas of surfaces of revolution. Through these topics, students gain proficiency in solving a wide range of mathematical problems involving integration and its applications in various fields.			

Course outcome

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used
CO1	To exponentially model a wide variety of phenomenon of interest in science, engineering, mathematics, and economics.	U	C	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO2	To practically apply several different tests 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/Seminar/ Viva/Report/ End Sem Exam
CO3	To get the idea of parametrization of curves; how to calculate the arc length, curvature etc.	U	F	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO 4	To recognize and evaluate the area of surface of revolution of a parametrized plane curve.	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)				

Text Book		Calculus: Soo T Tan Brooks/Cole, Cengage Learning (2010).		
Module	Unit	Content	Hours	Marks
			(45+30)	Ext:70
I	1	6.1: The Natural logarithmic function-Definition, 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' Hôpital 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^∞ .		
	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).		
	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;		

II		proofs are omitted).	10	
	8	9.2: Series- defining the sum, convergence and divergence, Geometric Series, The Harmonic Series, The Divergence Test, Properties of Convergent Series. (Only statements are needed; proofs are omitted).		
	9	9.3: The Integral Test- investigation of convergence, integral test, The p Series, its convergence and divergence. (Only statements are needed; proofs are omitted).		
	10	9.4: The Comparison Test- test series, The Comparison Test, The Limit Comparison Test. (Only statements are needed; proofs are omitted).		
III	11	9.5: Alternating Series- definition, the alternating series test, its proof, examples, Approximating the Sum of an Alternating Series by S_n . (Only statements are needed; proofs are omitted).	12	
	12	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).		
	13	9.7: Power Series- definition, Interval of Convergence, radius of convergence, Differentiation and Integration of Power Series. (Only statements are needed; proofs are omitted).		
	14	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	15	10.2: Plane Curves and Parametric Equations- Why We Use Parametric Equations, Sketching Curves Defined by Parametric Equations.	13	
	16	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.		
	17	10.4: Polar coordinates- The Polar Coordinate System, Relationship between Polar and Rectangular Coordinates.		
	18	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.		
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 running group discussions, supervising class seminars and referring library books for self-study and note preparation.			

<p>Practical</p>	<p>6.4: Compound Interest</p> <p>10.4 , Graphs of Polar Equations, Symmetry, Tangent Lines to Graphs of Polar Equations.</p> <p>List of Practical (using any software): Plotting of graphs of function:</p> <p>$e^{ax+b}, \log(ax + b), \frac{1}{ax+b}, \sin(ax + b), \cos(ax + b), ax + b$ and be able to find the effect of a and b on the graph.</p> <p>Sketching parametric curves:</p> <ul style="list-style-type: none"> • $x = \sqrt{t}, y = t$ • $x = t, y = t^2$ • $x = \sin t, y = \sin 2t, 0 \leq t \leq 2\pi$ • $x = \theta - \sin \theta, y = 1 - \cos \theta, -\infty < \theta < \infty$ <p>Polar curves:</p> <ul style="list-style-type: none"> • $r = 2$ • $r = 1 + \cos \theta$ • $r = 2 \cos 2\theta$ • $r = 2\sqrt{\cos 2\theta}$ • $r = 1 - 2 \cos \theta$ • $r^2 = 4 \sin 2\theta$ • $r = \sin 3\theta$ • $r = 4 \sin 4\theta$ • $r = e^\theta$ • $r = \frac{1}{\theta}$ • $r = \theta$ 	<p>30</p>	
	<p>References:</p> <p>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).</p>		

***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	Calculus III			
Type of Course	Major			
Semester	3			
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 vectors, dot product, cross product, triple products, lines and planes in 3-dimensional space (Calculus II)			
Course Summary	The course covers fundamental concepts in calculus, including functions, shifting of graphs, limits, continuity, differentiation, extreme values, the Mean Value Theorem, graphing with derivatives, and limits at infinity with asymptotes. Students learn techniques for evaluating limits, finding extrema, and graphing functions using derivatives, preparing them for further studies in calculus and related fields.			

COURSE OUTCOME(CO)

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used
CO1	Understand several contexts of the appearance of multivariable functions and their representation using graph and contour diagrams.	U	F	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO2	Formulate and work on the idea of limit and continuity for functions of several variables.	Ap	F	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO3	Understand chain rule for calculating partial sums.	U	F	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO4	Understand the notion of partial derivatives, their computation and interpretation.	U	F	Internal Exam/ Assignment/Seminar/ Viva/Report/

				End Sem Exam
CO5	Get the idea of directional derivative, its evaluation, interpretation and relationship between partial derivatives.	An	C	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Text Book		Calculus: Soo T Tan Brooks/Cole, Cengage Learning (2010).		
Module	Unit	Content	Hours (45+30)	Marks Ext:70
I	1	11.5: Lines and Planes in Space- Equations of Lines in Space, parametric equation, symmetric equation of a line, Equations of Planes in Space, standard equation, Parallel and Orthogonal Planes, The Angle Between Two Planes, The Distance Between a Point and a Plane.	13	MIN 15
	2	11.6: Surfaces in Space- Traces, Cylinders, Quadric Surfaces, Ellipsoids, Hyperboloids of One Sheet, Hyperboloids of Two Sheets, Cones, Paraboloids, Hyperbolic Paraboloids (Sketching is included in module 5)		
	3	11.7: Cylindrical and Spherical Coordinates- The Cylindrical Coordinate System, converting cylindrical to rectangular and vice versa, The Spherical Coordinate System, converting spherical to rectangular and vice versa.		
II	4	12.1: Vector Valued functions and Space Curves- definition of vector function, Curves Defined by Vector Functions, ['Example 7' omitted]	10	MIN 15
	5	12.2: Differentiation and Integration of Vector-Valued Function- The Derivative of a Vector Function, Higher- Order Derivatives, Rules of Differentiation, Integration of Vector Functions.		
	6	12.3: Arc length and Curvature- Arc Length of a space curve, Smooth Curves, Arc Length Parameter, arc length function, Curvature, formula for finding curvature, Radius of Curvature.		
	7	12.5: Tangential and Normal Components of Acceleration- The Unit Normal, principal unit normal		

III		vector, [The subsections ‘Kepler’s Laws of Planetary Motion’, and ‘Derivation of Kepler’s First Law’ omitted].	12	MIN 15
	8	13.1: Functions of two or more variables- Functions of Two Variables, Level Curves, Functions of Three Variables and Level Surfaces.		
IV	9	13.3: Partial Derivatives- Partial Derivatives of Functions of Two Variables, geometric interpretation, Computing Partial Derivatives, Implicit Differentiation.	10	MIN 15
	10	13.5: The Chain rule- The Chain Rule for Functions Involving One Independent Variable, The Chain Rule for Functions Involving Two Independent Variables, The General Chain Rule, Implicit Differentiation.		
V		<p>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.</p> <p>11.6: Sketching 12.1 Limits and Continuity. 12.4: Velocity and Acceleration- Velocity, Acceleration, and Speed 12.5 Tangential and Normal Components of Acceleration 13.1 Graphs of Functions of Two Variables, 13.2: Limits and continuity-An Intuitive Definition of a Limit, existence and non-existence. of limit, Continuity of a Function of Two Variables, Continuity on a Set, continuity of polynomial and rational functions, continuity of composite functions, Functions of Three or More Variables, The Definition of a Limit Partial Derivatives of Functions of More Than Two Variables, Higher-Order Derivatives, Clairaut theorem, harmonic functions. 13.4: Differentials- Increments, The Total Differential, interpretation, Error in Approximating Δz by [only statement of theorem1 required; proof omitted] Differentiability of a Function of Two Variables, criteria, Differentiability and Continuity, Functions of Three or More Variables</p>	30	
<p>References:</p> <ol style="list-style-type: none"> 1. Joel Hass, Christopher Heil & Maurice D. Weir: Thomas’ Calculus (14/e) Pearson (2018). 2. Robert A. Adams & Christopher Essex: Calculus Single Variable (8/e) Pearson Education Canada (2013). 3. Jon Rogawski & Colin Adams: Calculus Early Transcendentals (3/e) W. H. Freeman and Company (2015). 				

4. Anton, Bivens & Davis: Calculus Early Transcendentals (11/e) John Wiley & Sons, Inc. (2016)
5. James Stewart: Calculus (8/e) Brooks/Cole Cengage Learning (2016).
6. 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
-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	BSc Applied Mathematics Honours			
Course Code	AMA3CJ202			
Course Title	Theory of Equations			
Type of Course	Major			
Semester	3			
Academic Level	200 - 299			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	4	-	60
Pre-requisites	Basic knowledge of operations and school level algebra			
Course Summary	Theory of Equations Main Theorems and Methods apply to root-finding and factorization of any polynomial			

COURSE OUTCOME(CO)

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used
CO1	Use different ways of solving equations and they begin to prove many properties in their own way regarding numbers.	Ap	P	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO2	Get idea of Complex numbers their properties, complex functions and special power functions.	AP	F	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO3	To analyse the limit of the roots and nature of roots	An	P	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam

CO4	To find the solutions of different kinds of equations	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 Book	1. Theory of Equations: J V Uspensky McGraw Hill Book Company, Inc. ISBN: 07-066735-7. 2. J.W. Brown and Ruel V. Churchill: Complex Variables and Applications, 8th Ed., McGraw Hill.			
Module	Unit	Content	60 Hours	Marks
I	1	Chapter II (Text 1) II.1 Integral rational functions or polynomials. II.2 Multiplication of polynomials.	10	
	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	10	
	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	IV.1 Limits of roots		
	12	IV.2 Method to find upper limit of positive roots IV.3 Limit for moduli of roots [only the method to find out upper limit from the auxiliary equation is required; derivation omitted]		
	13	IV.4 Integral roots		

	14	IV.5 Rational roots		
IV		Chapter V (Text 1) V.1 What is the solution of an equation?		
		V.2 Cardan's formulas		
		V.3 Discussion of solution		
		V.4 Irreducible case		
		V.5 Trigonometric solution		
		V.6 Solutions of biquadratic equations, Ferrari method		
V		The sign of a polynomial for small and large values of variables- locating roots of polynomial between two numbers having values of opposite sign geometric illustration only-[rigorous reasoning in the starred section omitted] Corollaries- roots of odd and even degree polynomial, number of roots in an interval counted according to their multiplicity Rolle's Theorem [proof omitted], use in separating roots Descartes's rule of signs-only statement and illustrations are required		

References

1. Dickson L.E.: Elementary Theory of Equations John Wiley and Sons, Inc. NY (1914)
2. Turnbull H.W.: Theory of Equations (4/e) Oliver and Boyd Ltd. Edinburg (1947)
3. Todhunter I.: An Elementary Treatise on the Theory of Equations (3/e) Macmillan and Co. London(1875)
4. William Snow Burnside and Arthur William Panton: The Theory of Equations with An Introduction to Binary Algebraic Forms Dublin University Press Series (1881)
5. James Ward Brown, Ruel Vance Churchill: Complex variables and applications (8/e), McGraw- Hill Higher Education, (2009) 13 | Page
6. Alan Jeffrey: Complex Analysis and Applications (2/e), Chapman and Hall/CRC Taylor Francis Group (2006).
7. Swaminathan Ponnusamy, Herb Silverman: Complex Variables with Applications Burkhouse Boston (2006).
8. John H. Mathews & Russell W. Howell: Complex Analysis for Mathematics and Engineering (6/e) 9
9. H A Priestly: Introduction to Complex Analysis (2/e), Oxford University Press, (2003),
10. Jerrold E Marsden, Michael J Hoffman: Basic Complex Analysis (3/e) W.H Freeman,

***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	✓				✓

Program	B.Sc. Applied Mathematics Honours			
Course Code	AMA4CJ203			
Course Title	Calculus IV			
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 vectors, dot product, cross product, triple products, lines and planes in 3-dimensional space (Calculus II)			
Course Summary	The course covers fundamental concepts in calculus, including functions, shifting of graphs, limits, continuity, differentiation, extreme values, the Mean Value Theorem, graphing with derivatives, and limits at infinity with asymptotes. Students learn techniques for evaluating limits, finding extrema, and graphing functions using derivatives, preparing them for further studies in calculus and related fields.			

COURSE OUTCOME(CO)

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used
CO1	To explain the notion of a vector field, the idea of curl and divergence of a vector field, their evaluation and interpretation.	U	C	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO2	To optimize vector valued functions using Critical point and Lagrange Multipliers	E	P	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO3	To apply Green's theorem, Gauss's theorem and Stokes' theorem of multivariable calculus	Ap	P	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO4	To solve problems involving geometry of lines, curves, planes and surfaces in space and to sketch curves in plane and space given in vector valued form.	Ap	P	Internal Exam/ Assignment/S

				eminar/ 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	13.6: Directional Derivatives and Gradient vectors- The Directional Derivative, The Gradient of a Function of Two Variables, Properties of the Gradient, Functions of Three Variables.	10	
	2	13.7 Tangent Planes and Normal Lines- Geometric Interpretation of the Gradient, Tangent. Planes and Normal Lines. Using the Tangent Plane off to approximate the Surface $z = f(x, y)$ Problems of Greens theorem, Stokes theorem, Divergence Theorem.		
II	4	14.1 Double integrals- An Introductory Example, Volume of a Solid between a Surface and a Rectangle, The Double Integral over a Rectangular Region, Double Integrals over General Regions, Properties of Double Integrals.	12	
	5	14.2 Iterated Integrals-Iterated Integrals over Rectangular Regions, Fubini's Theorem for Rectangular Regions, Iterated Integrals over Nonrectangular Regions- simple and simple regions, advantage of changing the order of integration.		
	6	14.3 Double integrals in polar coordinates- Polar Rectangles, Double Integrals over Polar		

		Rectangles, Double Integrals over General Regions, r-simple region, method of Evaluation		
III	8	14.6 Triple integrals- Triple Integrals over a Rectangular Box, definition, method of evaluation as iterated integrals, Triple Integrals over General Bounded Regions in Space, Evaluating Triple Integrals over General Regions, evaluation technique	10	
	9	14.7 Triple Integrals in cylindrical and spherical coordinates- evaluation of integrals in Cylindrical Coordinates, Spherical Coordinates.		
	10	14.8 Change of variables in multiple integrals- Transformations, Change of Variables in Double Integrals [only the method is required; derivation omitted], illustrations, Change of Variables in Triple Integrals.		
	11	15.1 Vector Fields- V.F. in two and three dimensional space, Conservative Vector Fields		
	12	15.2 Divergence and Curl- Divergence-idea and definition, Curl- idea and definition.		
IV	13	15.3 Line Integrals- Line integral w.r.t. arc length, basic idea and definition, Line Integrals with Respect to Coordinate Variables, orientation of curve Line Integrals in Space, Line Integrals of Vector Fields.		
	15	15.5 Green's Theorem- Green's Theorem for Simple Regions, proof of theorem for simple regions, finding area using line integral, Green's Theorem for More General Regions, Vector Form of Green's Theorem(Proof omitted)		
	17	15.7 Surface Integrals-Surface Integrals of Scalar Fields, evaluation of surface integral for surfaces that are graphs, [derivation of formula omitted; only method required]	13	

		Parametric Surfaces, evaluation of surface integral for parametric surface, Oriented surfaces.		
	18	15.8 The Divergence Theorem- divergence theorem for simple solid regions (statement only), illustrations (Interpretation of Divergence omitted)		
	19	15.9 Stokes Theorem- generalization of Green's theorem- Stokes Theorem, illustrations, (Interpretation of Curl omitted).		
V		<p>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.</p> <p>13.8 Extrema of Functions of two variables- Relative and Absolute Extrema, Critical Points- Candidates for Relative Extrema, The Second Derivative Test for Relative Extrema, Finding the Absolute Extremum Values of a Continuous Function on a Closed Set</p> <p>13.9 Lagrange Multipliers- Constrained Maxima and Minima, The Method of Lagrange Multipliers, Lagrange theorem, Optimizing a Function Subject to Two Constraints</p> <p>14.5 Surface Area- Area of a Surface $z = x$, Area of Surfaces with Equations $y = (x,)$ and $x = h(y, z)$.</p> <p>15.4 Independence of Path and Conservative Vector Fields-path independence through example, definition, fundamental theorem for line integral, Line Integrals Along Closed Paths, work done by conservative vector field, Independence of Path and Conservative Vector Fields, Determining Whether a Vector Field Is Conservative, test</p>	30	

	<p>for conservative vector field Finding a Potential Function,(conservative field physics problem & Conservation of Energy omitted).</p> <p>15.6 Parametric Surfaces-(Why We Use Parametric Surfaces,omitted)) Finding Parametric Representations of Surfaces, Tangent Planes to Parametric Surfaces, Area of a Parametric Surface [derivation of formula omitted].</p> <p>15.7, Surface Integrals of Vector Fields- definition, flux integral, evaluation of surface integral for graph [method only], Parametric Surfaces, evaluation of surface integral of a vector field for parametric surface [method only, flux and conservative field physics problem omitted]</p>		
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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	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
CO 4	3	2	1	1	3	2	1	1	1	-	1

Correlation Levels:

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

Assessment Rubrics:

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

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Seminar	Report	End Semester Examinations
CO 1	√	√	-	-	√
CO 2	√	-	√	√	√
CO 3	√	-	√	√	√
CO4	√	√	-	-	√

Program	B.Sc. Applied Mathematics Honours			
Course Code	AMA4CJ404			
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
CO 1	Students could identify a number of areas where the modelling process results in a differential equation	U	F	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO 2	They will learn what an ODE is, what it means by its solution, how to classify DEs, what it means by an IVP and so on.	AP	C	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO 3	They will learn to solve DEs that are in linear, separable and in exact forms and also to analyse the solution. They	An	P	Internal Exam/ Assignment/S

	will become familiar with the theory and method of solving a second order linear homogeneous and nonhomogeneous equation with constant coefficients.			eminar/ Viva/Report/ End Sem Exam
CO 4	Students acquire the knowledge of solving a differential equation using Laplace method which is especially suitable to deal with problems arising in the engineering field.	Ap	P	Internal Exam/ Assignment/S eminar/ Viva/Report/ End Sem Exam
CO 5	Students will acquire knowledge of Fourier Transform, Sine and cosine transform. Inverse Fourier Transform and their applications	U	P	Internal Exam/ Assignment/S eminar/ 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	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: Introduction, Some Basic Mathematical Models, Direction Fields, Solutions of some Differential Equations, Classification of Differential Equations. (Chapter 1, Sec: 1.1,1.2,1.3)	12	
	2	First order differential equations-Linear equations with variable coefficients, Separable equations, Differences between linear and nonlinear equations, Exact equations and integrating factors. (Chapter 2 – Sec. 2.1, 2.2, 2.4, 2.6)		
II	3	Second Order Linear Differential Equations Homogeneous equation with constant coefficients, Fundamental solutions of Linear Homogeneous equations, Linear independence and Wronskian, Complex roots of characteristic equations, Repeated roots; Reduction of order, Non homogeneous equations; Method of Undetermined	10	

		coefficients, Variation of parameters, (Chapter 3; Sec:3.1-3.7)		
III	5	Definition of Laplace Transforms, Solution of Initial Value Problem, Step functions, Impulse functions, The Convolution Integral (Chapter 6- Sec. 6.1, 6.2, 6.3, 6.5, 6.6).	10	
IV	6	Text2 1.1 Brief Historical Introduction 1.2 Fourier Series and Fourier Transforms 1.4 Basic Concepts and Definitions	13	
	7	2.1 Introduction 2.2 The Fourier Integral Formulas 2.3 Definition of the Fourier Transform and Examples 2.4 Fourier Transforms of Generalized Functions 2.5 Basic Properties of Fourier Transforms		
		2.11 Solutions of Integral Equations 2.13 Fourier Cosine and Sine Transforms with Examples		
V		<p>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.</p> <p>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</p>	30	

	<p>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.</p> <p>Numerical computation of following methods using Python;</p> <p>Euler Method, Runge-Kutta Method, Picard's Method.</p>		
<ol style="list-style-type: none"> 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). 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	AMA5CJ303			
Course Title	Linear Programming and Applications			
Type of Course	Major			
Semester	5			
Academic Level	300-399			
Course Details	Credit	Lecture/Tutorial per week	Practical/Practicum per week	Total Hours
	4	3	2	5
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	Study different methods to solve Linear Programming Problems.	E	P	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO2	Study to convert real life problems as mathematical models	AP	P	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO3	Students experience the classical way of doing and enjoying mathematics in a much more logical way	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)				

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, mathematical formulation, Canonical Forms for Linear Programming Problems, objective functions, constraint set, feasible solution, optimal solution, Polyhedral Convex Sets, convex set, extreme point, theorems asserting existence of optimal solutions, The Two Examples Revisited, graphical solutions to the problems, A Geometric Method for Linear Programming, the difficulty in the method, Concluding Remarks	8	Min. 10
II	2	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. 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, The Simplex Algorithm for Maximum Basic Feasible Tableaus, The Simplex Algorithm for Maximum Tableaus, Negative Transposition; The Simplex Algorithm for Minimum Tableaus, Cycling, Simplex Algorithm Anti cycling Rules, Concluding Remarks.	16	Min. 15
III	3	Chapter 4: Duality Theory: Duality in Canonical Tableaus, The Dual Simplex Algorithm, The Dual Simplex Algorithm for Minimum Tableaus, The Dual Simplex Algorithm for Maximum Tableaus, Matrix Formulation of Canonical Tableaus ,The Duality Equation, The Duality theorem, Concluding Remarks.	10	Min. 15
IV	4	Chapter 6: Transportation and Assignment Problems: The Balanced Transportation Problem, The Vogel Advanced-Start Method (VAM), The Transportation Algorithm, Another Example, Unbalanced Transportation Problems, The Assignment Problem, The Hungarian Algorithm, Concluding Remarks, The Minimum-Entry Method, The Northwest-Corner	12	Min. 15

		Method.		
V-Open Ended		Labs of the above discussed topics using Python.	12	
References:				
<ol style="list-style-type: none"> 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) McGraw-Hill 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

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	AMA5CJ301			
Course Title	LINEAR ALGEBRA			
Type of Course	Major			
Semester	V			
Academic Level	300 – 399			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	4	--	75
Pre-requisites	Familiarity with system of equations and their solutions. 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	Understand and apply concepts related to vector spaces and subspaces, including determining whether a set forms a subspace and finding the span of a set.	U	C	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
CO2	Demonstrate proficiency in analysing null spaces, column spaces, and linear transformations, including understanding the kernel and range of a linear transformation and contrasting the properties of null space and column space.	Ap	P	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam

CO3	Evaluate and apply concepts related to bases, dimensionality, and rank of vector spaces, including understanding bases for null space and column space, determining dimensions of subspaces, and applying the rank theorem to systems of equations.	E	C	Internal Exam/ Assignment/ Seminar/ Viva/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Text Book	Elementary Linear Algebra: Application Version(11/e): Howard Anton & Chris Rorres, Wiley (2014) ISBN 9781118434413.				
Module	Unit	Content	Hrs (45+30)	External Marks (70)	
I	Module I				
	1	1.1: Introduction to Systems of Linear Equations: Linear equation in n variables, linear system of m equations in n variables, solution, Linear Systems in Two and Three Unknowns, solution by geometric analysis, consistent and inconsistent systems, linear system with no, one, and infinite number of solutions, augmented matrix and elementary row operations.	9	Min 15	
	2	1.2: Gaussian elimination: Considerations in Solving Linear Systems, Echelon Forms, reduced row echelon form, Elimination Methods, Gauss–Jordan elimination, Gaussian elimination, Homogeneous Linear Systems, Free Variables, Free Variable Theorem for Homogeneous Systems, (Gaussian Elimination and Back Substitution, Some Facts about Echelon Forms are omitted)			
3	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, Solution of a Linear System by Matrix inversion (All other topics are omitted).				
II	Module II				
	4	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 are omitted) 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 is omitted) Properties of Invertible Matrices, equivalent statements for unique solution of $Ax = b$, determining consistency.		Min 15	

	5	1.8: Matrix transformations: Definition, Properties of Matrix Transformations, standard matrix, A Procedure for Finding Standard Matrices.	12	
	6	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, Solution Spaces of Homogeneous Systems as subspace, The Linear Transformation Viewpoint, kernel, different set of vectors spanning the subspace. (Example 8 omitted).		
III	Module III		12	Min 15
	7	4.3: Linear Independence: Linear Independence and Dependence, illustrations, A Geometric Interpretation of Linear Independence. (All other topics are omitted)		
	8	4.4: Coordinates and basis: Coordinate Systems in Linear Algebra, Basis for a Vector Space, finite and infinite dimensional vector spaces, illustrations, Coordinates Relative to a Basis, Uniqueness of Basis Representation.		
	9	4.5: Dimension: Number of Vectors in a Basis, dimension, Some Fundamental Theorems, dimension of subspaces.		
	10	4.7: Row space, Column space and Null space: Vector spaces associated with matrices, consistency of linear system, Bases for Row Spaces, Column Spaces, and Null Spaces, basis from row echelon form, Basis for the Column Space of a Matrix, row equivalent matrices and relationship between basis for column space, Bases Formed from Row and Column Vectors of a Matrix.		
IV	Module IV		12	Min 15
	11	4.8: Rank, Nullity, and the Fundamental Matrix Spaces: Equality of dimensions of row and column spaces, Rank and Nullity, Dimension Theorem for Matrices, The Fundamental Spaces of a Matrix, rank of a matrix and its transpose. (All other topics are omitted)		
	12	4.10: Properties of matrix transformations: Compositions of Matrix Transformations, One to One Matrix Transformations, Kernel and Range, fundamental relationship between invertibility of a matrix and its matrix transformation, Inverse of a One-to-One Matrix Operator.		
	13	5.1: Eigen values and Eigen Vectors: Definition, Computing Eigenvalues and Eigenvectors, characteristic equation, alternative ways of describing eigen values, Finding Eigenvectors and Bases for Eigenspaces, Eigenvalues and Invertibility, Eigenvalues of General		

	Linear Transformations. (Example 9 is Omitted)		
V	<p style="text-align: center;">OPEN ENDED</p> <p>The goal is for the students to learn the following selected topics in 10 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 preparations.</p>		
	<ul style="list-style-type: none"> • 1.2: Gaussian Elimination and Back Substitution, Some Facts about Echelon Forms • 1.4: Properties of Inverses (Only this topic) • 1.5: A Method for Inverting Matrices, Inversion Algorithm, illustrations (Only this topic) • 1.6: Linear Systems with a Common Coefficient Matrix (Only this topic) • 1.7: Diagonal, Triangular and Symmetric matrices: Diagonal Matrices, Inverses and Powers of Diagonal Matrices, Triangular Matrices. Properties of Triangular Matrices, Symmetric Matrices, algebraic properties of symmetric matrices, Invertibility of Symmetric Matrices. • 2.1: Determinants by cofactor expansion: Definition of a General Determinant, A Useful Technique for Evaluating 2×2 and 3×3 Determinants; (All other topics are omitted) • 2.2: Evaluating determinants by row reduction: Examples and problems to find determinant by row reduction (Theory omitted); • 2.3: Properties of Determinants; Cramer's Rule: Cramer's Rule (Only problems), Inverse of matrices using adjoint formula (Only problems). • 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. • 4.9: Basic matrix transformations in \mathbb{R}^2 and \mathbb{R}^3: Reflection Operators, Projection Operators, Rotation Operators, Rotations in \mathbb{R}^3, Dilations and Contractions, Expansions and Compressions, Shears, Orthogonal Projections onto Lines Through the Origin, Reflections About Lines Through the Origin. 	30	

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

Mapping of COs with PSOs and POs:

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

Correlation Levels:

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

Assessment Rubrics:

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

Mapping of COs to Assessment Rubrics:

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

Programme	B. Sc. Applied Mathematics Honours			
Course Code	AMA5CJ302			
Course Title	REAL ANALYSIS			
Type of Course	Major			
Semester	V			
Academic Level	300 – 399			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	3	2	75
Pre-requisites	1. Mathematical Logic and necessary exposure to set theory. 2. Basic Calculus			
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 Weierstrass 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

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

Detailed Syllabus:

Text	Introduction to Real Analysis, 4/e, Robert G Bartle, Donald R Sherbert John Wiley & Sons (2011)				
Module	Unit	Content	Hrs (45+30)	External Marks (70)	Internal Marks
I	Module 1		12	Min 15	
	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 3.2 – Limit theorems. (Proofs of the Theorems 3.2.3, 3.2.9, 3.2.10 and 3.2.11 are omitted)			
	3	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)			
	4	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	10
	5	Section 3.7 - Introduction to Infinite Series (Proofs of the Theorems 3.7.7 and 3.7.8 are omitted)			
	6	Section 4.1- Limit of functions (Proofs of all Theorems are omitted).			
	7	Section 5.1 – Continuous functions.			
	8	Section 5.3 – Continuous functions on Intervals - 5.3.1 to 5.3.5			
III	Module III		10	Min 15	
	9	Section 5.3 – from 5.3.7 to 5.3.10			
	10	Section 5.4 – Uniform Continuity - 5.4.1 to 5.4.8(Proofs of the Theorems 5.4.3 and 5.4.8 are omitted)			
	11	Section 6.1 – The Derivative – 6.1.1 to 6.1.4			
	12	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	
	13	Section 6.2- The Mean Value Theorem - 6.2.1 to 6.2.4			
	14	Section 6.2- from 6.2.5 to 6.2.9(Proof of 6.2.8 is omitted)			
	15	Section 6.2- from 6.2.10 to 6.2.13 (Proof of Lemma 6.2.11 is omitted)			
	16	Section 8.1 – Pointwise and Uniform Convergence–8.1.1 to 8.1.6			

V	Practicum:	30	-	20
	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.			
	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	<ol style="list-style-type: none"> 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

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	AMA4CJ205			
Course Title	Abstract Algebra and Number Theory			
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	School level mathematics, sets, relations, functions, one to one and onto functions			
Course Summary				

COURSE OUTCOME(CO)

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used
CO1	To explain division algorithm and find g c d by Euclidean algorithm and express numbers using fundamental theorem of arithmetic	U	C	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO2	To use properties of congruences and apply Fermat's Little theorem and Wilson's Theorem	AP	P	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO3	To find sum and numbers of divisors of a number	E	P	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO4	The identity isomorphic binary structures and explain properties of groups, subgroups and cyclic groups.	An	C	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO5	To Explain Permutation groups, orbits, cycles and alternating groups.	U	C	Internal Exam/ Assignment/S

				eminar/ Viva/Report/ End Sem Exam
CO6	To use Lagrange theorem and express finitely generated abelian groups as direct products	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)

TEXTBOOK	Text 1: David M Burton: Elementary Number Theory, 7 th Edition, TMH Text 2: John B Fraleigh: A First Course in Abstract Algebra, 7 th Edition			
MODULE	UNIT	CONTENT	Hours (45+30) MARKS Ext:70	
I	MODULE I		12	Min 15
	2.2 (Text 1)	The division algorithm		
	2.3	The greatest common divisor		
	2.4	The Euclidean algorithm		
	3.1	The fundamental theorem of arithmetic		
II	MODULE II		13	Min 15
	4.2	Basic properties of congruence		
	4.4	Linear congruences		
	5.2	Fermat's little theorem and pseudo primes		
	5.3	Wilson's theorem		
	6.1	The sum and number of divisors		
III	MODULE III		8	Min 15
	2(Text 2)	Binary operations		
	3	Isomorphic binary structures		
	4	Groups		
	5	Subgroups		
	6	Cyclic groups		
IV	MODULE IV		12	Min 15
	8	Groups of permutations		
	9	Orbits, cycles, and Alternating groups		

	10	Cosets and Theorem of Lagrange	
	11	Directed products and finitely generated abelian groups	
V	MODULE V		3
	<p>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.</p> <p>Assignments using Sage Math of above modules (Not for examination purpose) 2.5 The Diophantine equation $ax + by = c$ 3.2 The sieve of Eratosthenes 4.4 the Chinese remainder theorem Text 2 Directed products and finitely generated abelian groups, Dihedral group, Plane Isometries.</p>		
<p>References:</p> <ol style="list-style-type: none"> 1. C.Y. Hsiung, Elementary Theory of Numbers, Allied Publishers. 2. N. Robbins, Beginning Number Theory, Second Edition. Narosa. 3. G.E. Andrews, Number Theory, HPC. 4. Joseph A. Gallian: Contemporary Abstract Algebra. Narosa Pub. House. 5. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul: Basic Abstract Algebra, 2nd ed., Cambridge University Press. 			

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

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	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	2	1	2	3	2	1	-	3	-	3
CO5	3	2	1	3	3	2	1	-	3	-	3
CO6	3	2	1	3	3	2	1	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	√				√
CO5	√	√			√
CO 6	√	√			√

Program	B.Sc. Applied Mathematics Honours			
Course Code	AMA6CJ304			
Course Title	Partial Differential Equations and Calculus of Variations			
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	0	4
Pre-requisites	Basic Knowledge of integration and differentiation			
Course Summary	Course contains first and second order partial differential equations and their solutions using different methods., Variational problems, Necessary condition for an Extrema, Euler Equation, A Simple Variable End Point Problem, variational problems with subsidiary condition			

COURSE OUTCOME(CO)

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools used
CO 1	Apply a range of techniques to solve first and second order partial differential equations	Ap	P	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO 2	Model physical phenomena using partial differential equations such as heat and wave equations	Ap	C	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO 3	Understand problems, methods and techniques of calculus of variations	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)				

TEXTBOOK	1. An Elementary Course in Partial Differential Equations- T. Amarnath (2nd edition) Jones and Bartlett Publishers 2. Calculus of Variations- M Gelfand and S V Fomin, Dover Publications Inc 2000			
MODULE	UNIT	CONTENT	Hrs.	MARKS
			60	Ext: 70
I	MODULE I		15	
	1	1.1 Curves and Surfaces Genesis of 1.2 First Order P.D.E		
	2	1.3 Classification of Integrals		
	3	1.4 Linear Equations of the First Order		
	4	1.7 Charpit's Method		
	5	1.8 Jacobi's Method		
	6	Quasi-Linear Equations		
	7	Non-linear First Order P.D.E.		
II	MODULE II		12	
	8	2.1 Genesis of Second Order PDE		
	9	2.2 Classification of Second Order PDE		
	10	2.3 One Dimensional Wave Equations 2.3.1 Vibrations of an Infinite String		
	11	2.3.2 Vibrations of a Semi - Infinite String		
	12	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)		
III	MODULE III		6	
	13	2.4.3 The Cauchy Problem		
	14	2.5.1 Heat Conduction – Infinite Rod Case		
	15	2.5.2 Heat Conduction – Finite Rod Case		
IV	MODULE IV		15	
	16	1 Elements of The Theory 1.1 Functionals, Some Variational Problems 1.2 Function Spaces		
	17	1.3 The Variation of a Functional, A Necessary condition for an		

	Extremum	
18	1.4 The Simplest Variational Problem, Euler's Equation	
19	1.5 The Case of Several Variables	
20	1.6 A Simple Variable End Point Problem	
21	1.7 The Variational Derivative	
22	1.8 Invariance of Euler's Equation, Problems	
23	2.12 Variational Problems with Subsidiary conditions, Problems	
V	MODULE V (Open Ended)	12
	1.5 Pfaffian Differential Equations 1.6 Compatible Systems 1.9 Integral Surfaces Through a Given Curve 2.4.1 Boundary Value Problems History of Calculus of Variations, Brachistochrone problem 14 End Points Lying on Two Given Curves 15 Broken Extremals. The Weierstrass-Erdmann Conditions, Problems or Surfaces Isoperimetric problems. Assignment using Sage Math of above modules	

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.
4. Differential Equations & Calculus of Variations- George Yankovsky-Mir Publishers

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

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	3	2	5
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	Evaluation Tools used
CO1	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
CO2	To understand necessary and sufficient condition for checking analyticity	AP	P	Intenal Exam/Viva/Assignment/Seminar/End Sem Exam
CO3	To know of harmonic functions and their connection with analytic functions.	U	C	Intenal Exam/Viva/Assignment/Seminar/End Sem Exam
CO4	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-	E	P	Intenal Exam/Viva/Assignment/Seminar/End Sem Exam

	Goursat theorem and their applications.			
CO5	To understand and apply Cauchy's integral formula and a few on sequences of it such as Liouville's theorem, Morera's theorem and so forth in various situations and to see the application of Cauchy's integral formula in the derivation of power series expansion of an analytic function	Ap	P	Internal Exam/Viva/Assignment/Seminar/End Sem Exam
CO6	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)				

Textbook	Complex Analysis: John M. Howie, Springer International Edition,			
Module	Unit	Content	Hrs (75)	Marks
				Ext : 80
I	Module I			
	1	2.1: Are complex numbers necessary?	15	
		2.2: Basic properties of complex numbers		
	2	3.1: Why is complex analysis possible?		
		3.2: Some useful terminology;		
		3.3: Functions and continuity;		
	3	4.1: Differentiability:		
4.2: Power series:				
4.3: Logarithms				
4.5: Singularities				
II	Module II			
	4	5.1: The Heine-Borel theorem	15	
		5.2: Parametric representation		
		5.3: Integration		
		5.4: Estimation		
		5.5: Uniform convergence		
III	Module III			
	5	6.1: Cauchy's theorem: A first approach:	15	
		6.2: Cauchy's theorem: A more general version		
		6.3: Deformation		
	6	7.1: Cauchy's integral formula		
		7.2: The fundamental theorem of algebra		
		7.3: Logarithms		
7.4: Taylor series				

		Module IV					
IV	7	8.1: Laurent series			15		
		8.2: Classification of singularities					
		8.3: The residue theorem					
		Module V (Open Ended)					
V	Real integrals: Semicircular contours, Integrals involving circular functions Lab work to be performed 1. Declaring a complex number and graphical representation. E.g. $Z_1=3+4i, Z_2=4-7i$ 2. Program to discuss the algebra of complex numbers $Z_1=3+4i, Z_2=4-7i$, then find $Z_1+Z_2, Z_1-Z_2, Z_1*Z_2$ and Z_1/Z_2 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. $f(z)=z, iz, z^2, e^z$ etc					15	
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 (2nd edn.), 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	3	3	3	-	3	-	1	-	1	-	1
CO 2	3	2	2	-	3	-	1	-	3	-	1
CO 3	3	2	1	-	3	-	1	-	1	-	1
CO 4	3	2	2	1	3	-	1	-	2	-	2
CO 5	3	2	2	1	3	-	1	-	2	-	2
CO 6	3	2	2	1	3	-	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	√		√	√	√
CO4	√	√			√
CO5	√	√			√
CO6	√	√			√

Program	B.Sc. Applied Mathematics Honours			
Course Code	AMA6CJ306			
Course Title	Discrete Mathematics 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	To explain basic definitions of Graphs and trees	U	F	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO 2	To identify Euler tour, cut vertices, connectivity, planar graphs and use Euler's formula	AP	p	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO 3	Understand the criteria for the evaluation of arguments and the scientific way of decision making using the laws of logic and the concept of algebraic structures in Mathematics	Ap	P	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO 4	Identify a given algebraic structure as belonging to a particular family of structures and to state the characteristic properties of the members of the family	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)				

Text Book	1. Discrete Mathematics with Applications: Thomas Koshy, Elsevier Academic Press (2004), 2. Theory and Problems of Discrete Mathematics: Third Edition, Seymour Lipschutz, Marc Lars Lipson, McGraw-Hill Companies 3. A First Look at Graph Theory: John Clark & Derek Allan Holton, Allied Publishers, First Indian Reprint 1995			
Module	unit	Content	Hours	Marks
I	1	(Text 1) 1.1 Propositions- definition, Boolean (logic) variables, Truth Value, Conjunction, Boolean expression, Disjunction (inclusive and exclusive), Negation, Implication, Converse, Inverse and Contra positive, Biconditional statement, Order of Precedence, Tautology Contradiction and Contingency	15	Min 15
	2	1.2 Logical equivalences- laws of logic		
	3	1.3 Quantifiers - universal & existential, predicate logic		
	4	1.4 Arguments - valid and invalid arguments, inference rules		
	5	1.5 Proof Methods- vacuous proof, trivial proof, direct proof, indirect proof- contrapositive & contradiction, proof by cases, Existence proof constructive & non constructive, counterexample.		
II	6	Lattices (Text 2) 14.2 Ordered Sets (Kleene Closure and Order omitted)	15	Min 15
	7	14.3 Hasse Diagrams of Partially Ordered Sets		
	8	14.4 Consistent Enumeration		
	9	14.5 Supremum and Infimum		
	10	14.6 Isomorphic (Similar) Ordered Sets		
	11	14.7 Well- ordered sets		
	12	14.8 Lattices		
	13	14.9 Bounded Lattices		
	14	14.10 Distributive Lattices		
15	14.11 Complements, Complemented Lattices			
III	16	Text 3: Graph Theory 1.1 Definition of a graph 1.2 Graphs as models	10	Min 15
	17	1.3 More definitions 1.4 Vertex degrees		
	18	1.5 Sub graphs		
	19	1.6 Paths and Cycles		

	20	1.7 Matrix representation of a graph [up to Theorem 1.6; proof of Theorem 1.5 is omitted]		
IV	21	2.1 Definitions and Simple Properties	10	Min 15
	22	2.2 Bridges [Proof of Theorem 2.6 and Theorem 2.9 are omitted]		
	23	2.3 Spanning Trees		
	24	2.6 Cut Vertices and Connectivity [Proof of Theorem 2.21 omitted]		
	25	3.1 Euler Tour [up to Theorem 3.2, proof of Theorem 3.2 omitted]		
		5.1 Plane and Planar graphs [Proof of Theorem 5.1 omitted]		
	26			
V		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, neighbourhoods, 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, 2 nd edition- Prentice Hall of India.		
Module	Unit	Content	Hrs (45+30)	External Marks (70)
I	Module I		11	Min.15
	1	Topological spaces		
	2	Basis for a Topology		
	3	The Order Topology		
II	Module II		12	Min.15
	4	The Product Topology on $X \times Y$		
	5	The Subspace Topology		
	6	Closed Sets and Limit Points		
III	Module III		12	Min.15
	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		
IV	Module IV		10	Min.15
	10	Compact Spaces		
	11	The Countability Axioms (Proofs of theorems are omitted)		
	12	The Separation Axioms (Example 3 is omitted)		
V Practicum	Open Ended		30	
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			
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	Functional Analysis			
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	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			15	Min 15
	1	Normed Spaces and Banach Spaces (15 Hours) 1. Introduction to Functional Analysis <ul style="list-style-type: none"> ○ Basic concepts of functional analysis. ○ Historical background and significance. 			
	2	4. Normed Spaces Definitions and examples. Normed space properties and the concept of norm. Equivalent norms			
	3	5. Banach Spaces Definition and examples. The concept of completeness. Subspaces, quotient spaces, and linear operators			
	4	6. 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 <ul style="list-style-type: none"> ○ Definitions and examples. ○ Properties of inner products. ○ Parallelogram law and polarization identity. 			

	6	1. Hilbert Spaces <ul style="list-style-type: none"> ○ Definition and properties. ○ Orthogonal complements. ○ Projection theorem and Riesz representation theorem. 	12	Min 15
	7	1. Orthonormal Sets and Sequences <ul style="list-style-type: none"> ○ Orthonormal sets, bases. ○ Gram-Schmidt orthogonalization process. ○ Bessel's inequality and Parseval's identity 		
III				
	8	Linear Operators (15 Hours) <p style="margin-left: 40px;">1. Bounded and Unbounded Operators (4 Hours)</p> <ul style="list-style-type: none"> ○ Definitions and examples. ○ Bounded linear operators. <p style="margin-left: 40px;">The concept of operator norm</p>	12	Min 15
	9	1. Adjoint Operators <ul style="list-style-type: none"> ○ Definition and properties. ○ Examples of adjoint operators. ○ Self-adjoint, unitary, and normal operators 		
	10	1. Compact Operators <ul style="list-style-type: none"> ○ Definition and properties. ○ Examples and spectral properties 		
IV				
	11	Spectral Theory (15 Hours) <p style="margin-left: 40px;">1. Spectral Theory of Bounded Operators</p> <ul style="list-style-type: none"> ○ Spectrum of an operator. ○ Point spectrum, continuous spectrum, and residual spectrum 	12	Min 15
	12	1. Spectral Theorems <ul style="list-style-type: none"> ○ Spectral theorem for compact operators. ○ Spectral theorem for bounded self-adjoint operators. ○ Applications of spectral theorems. 		
	13	1. Unbounded Operators <ul style="list-style-type: none"> ○ Basic concepts and definitions. ○ Closed operators and the closed graph theorem. 		

		<ul style="list-style-type: none"> ○ Spectral properties of unbounded operators. 		
V	Unit 5: Advanced Topics and Applications (15 Hours) <ol style="list-style-type: none"> 1. Weak Topologies and Reflexivity <ul style="list-style-type: none"> ○ Weak and weak* topologies. ○ Reflexivity in normed spaces. 2. Fixed Point Theorems <ul style="list-style-type: none"> ○ Banach fixed-point theorem. ○ Applications of fixed-point theorems in functional analysis. 3. Distributions and Sobolev Spaces <ul style="list-style-type: none"> ○ 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, Rochester 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	✓	✓	✓	✓	✓

Programme		B. Sc. Mathematics Honours		
Course Code		AMAT7CJ403		
Course Title		CRYPTOGRAPHY and Automata		
Type of Course		Major		
Semester		VII		
Academic Level		400-499		
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
4	4	-		60
Pre-requisites		Elementary number theory, algebra, combinatorics, basic linear algebra		
Course Summary		<p>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.</p>		
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 basic kinds of finite automata	U	F	Internal Exam/Assignm ent/ Seminar/ Viva / End Sem Exam

	and their capabilities			
* - 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	3.1 Definition of an Automaton		
	19	3.2 Description of a finite Automaton		
		3.3 Transition system 3.4 Properties of transition functions		
	20	3.5 Acceptability of a string by a finite automation 3.6 Nondeterministic finite state machines		
		21		
	22	3.9 Minimization 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: 3.8 Mealy and Moore Models 3.8.1 Finite Automata with Outputs 3.8.2 Procedure for transforming a Mealy Machine into a Moore Machine. 3.8.3 Procedure for transforming a Moore Machine into a Mealy Machine Formal Languages Regular Grammars	12	
<p>1. John E. Hopcroft, Rajeev Motwani, Jeffrey D. Ullman (2007), Introduction to Automata Theory Languages and Computation, 3rd edition, Pearson Education, India.</p> <p>2. Introductory theory of computer science by E.V. Krishna Murthy, East-West Press.</p> <p>3. Theory of Finite Automates with an introduction to formal languages by Carrel J and Lang D, PHI</p> <p>4. Linz P, An Introduction to Formal Languages and Automata, Narosa Publishing House Pvt. Ltd., New Delhi, ISBN: 9788173197819.</p> <p>5. Michael Sipser, Introduction to Theory of Computation, Cengage Learning India Private Limited, Indian Edition, ISBN: 8131505138.</p> <p>6. H.R. Lewis and C.H. Papadimitriou, Elements of Theory of Computation, 2nd Edition, Prentice Hall, ISBN: 0132624788.</p> <p>7. J. E. Savage, Models of Computation, Exploring the Power of Computing, Addison Wesley, 1998, Available at http://cs.brown.edu/~jes/book/.</p> <p>8. Martin J.C, Introduction to Languages and Theory of Computation, Tata McGraw Hill, 3rd Edition, ISBN: 9780070</p>				

****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	Mathematics of Wavelets			
Type of Course	Major			
Semester	VII			
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	1. 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		

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

	20	4.5 Two Dimensional Wavelets		
	21	4.6 Nonseparable Multidimensional Wavelets (including Problems at the end of the chapter)		
	22	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. Raghuvver 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, Jean-Michel Poggi, John, "Wavelets and their Applications", Wiley & Sons, 2010.
8. J S Walker, "A primer 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-signal-processing/mallat/978-0-12-466606-1> 2. <https://www.pearson.com/us/higher->

education/program/Rao-Wavelet-Transforms-Introduction-to-Theory-andApplications/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	AMA7CJ405			
Course Title	Advanced Abstract Algebra			
Type of Course	Major			
Semester	VII			
Academic Level	400-499			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	5	..	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 etc			

Course Outcome

CO	CO Statement	Cognitive level*	Knowledge category#	Evaluation Tools used
CO1	To analyse the structure of groups	An	C	Internal Exam/Viva/ Assignment/Seminar /End Sem Exam
CO2	Distinguish the properties among ring structures	E	C	Internal Exam/Viva/ Assignment/Seminar /End Sem Exam
CO3	Understand extension of fields and their constructions	U	F	Internal Exam/Viva/ Assignment/Seminar /End Sem Exam
CO4	Apply the concepts and results to solve problems of modern algebra	Ap	P	Internal Exam/Viva/ Assignment/Seminar /End Sem Exam

TEXTBOOK	John B Fraleigh: A First Course in Abstract Algebra, 7 th Edition			
MODULE	UNIT	CONTENT	Hrs	MARKS
				Ext:70
I	MODULE I		10	
	12	Homomorphisms		
	13	Factor Groups		
	34	Isomorphism Theorems		
	36	Sylow Theorems		
II	MODULE II		15	
	18	Rings and Fields		
	19	Integral Domains		
	20	Fermat's and Euler theorems		

	21	The field of Quotients of an Integral Domain		
III	MODULE III		20	
	22	Rings of Polynomials		
	23	Factorization of Polynomials over a field		
	26	Homomorphisms and Factor Rings		
	27	Prime and Maximal ideals		
IV	MODULE IV		15	
	29	Introduction to Extension Fields		
	31	Algebraic Extensions		
	33	Finite Fields		
V	MODULE V (Open Ended)		10	
	Assignments using Sage Math of above modules (Not for examination purpose)			
References: <ol style="list-style-type: none"> 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	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	1	2	2	3	1	-	-	3	1	2
CO 2	3	1	2	2	3	1	-	-	3	1	2
CO 3	3	1	2	2	3	1	1	-	3	1	2
CO 4	3	1	2	2	3	1	1	-	3	1	2

Correlation Levels:

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

Assessment Rubrics:

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

Mapping of COs to Assessment Rubrics:

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

Programme	B Sc 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 continuous 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), evaluate (E), Create (C)
- Factual Knowledge (F), Conceptual Knowledge (C), Procedural 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	1	Module I		15
		1.1 Basic set theory		
		1.2 Functions and limits		
		1.3 Measures and mass distributions		
II	2	Module II		15
		2.1 Box-counting dimensions		
		2.2 Properties and problems of box-counting dimension		
		3.1 Hausdorff measure		
III		3.2 Hausdorff dimension		15
		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)				

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	

		<p>2. Z.U.A. Warsi: Fluid Dynamics, Theoretical and Computational Approaches, C.R.C. Press</p> <p>3. S.W. Yuan: Foundation of Fluid Mechanics, Prentice Hall of India Pvt. Ltd. New Delhi</p> <p>4. N. Curle and H J Davies: Modern fluid dynamics</p> <p>5. G. K. Batchelor: An Introduction to Fluid Dynamics. Cambridge University Press. London.</p> <p>6. R.W. Fox, P.J. Pritchard and A.T. McDonald: Introduction to Fluid Mechanics, Seventh Edition, John Wiley & Sons, 2009.</p> <p>7. Mechanics, Seventh Edition, John Wiley & Sons, 2009.</p> <p>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</p>		
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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	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	VII			
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	Hours	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-Coloring 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:			
<ol style="list-style-type: none"> 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 Vesztegombi, 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.			

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		<i>Algorithms</i> by Sanjoy Dasgupta, Christos H. Papadimitriou, Umesh Vazirani. McGraw- Hill Education, 2006. ISBN: 978-0073523408.		
Module	Unit	Content	Hrs (48+12)	Ext. Marks (70)
I	Introduction		12	
	1	Computing Fibonacci Numbers: Exponential and Polynomial Algorithms		
	2	Efficiency of Algorithms: Asymptotic Analysis, Big-O Notation		
	3	Algorithms with Numbers : Efficiency of classical Addition and Multiplication algorithms		
	4	Algorithms for Modular Arithmetic		
	5	Euclid's Algorithm for GCD		
	6	Primality Testing		
	<i>Sections from Text: 0.2, 0.3, 1.1, 1.2, 1.3</i>			
	II	Divide and Conquer Algorithms and Graph Search		
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		
<i>Sections from Text: 2.1, 2.2, 2.3, 3.1-3.3.</i>				
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	
	<i>Sections from Text: 3.4, 4.1 to 4.4, 4.5, 4.7</i>		
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	
	<i>Sections from Text: 5.1, 5.4, 6.1, 6.6.</i>		
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:			
<ol style="list-style-type: none"> 1. <i>The Design and Analysis of Algorithms</i> by Dexter C Kozen. Texts and Monographs in Computer Science, Springer, 1992. ISBN:0-387-97687-6. 2. <i>Introduction to Algorithms</i> (3rd Edition) by Thomas H. Cormen, Charles E. Leiserson, Ronald L Rivest, Clifford Stein. PHI Learning, 2009. ISBN:978-81-203-4007-7. 3. <i>Algorithm Design</i> by Jon Kleinberg and Eva Tardos. Pearson, 2015. ISBN:978-93-325-1864. 			

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

Mapping of COs with PSOs and POs :

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

Correlation Levels:

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

Assessment Rubrics:

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

Mapping of COs to Assessment Rubrics:

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

Programme	B. Sc. 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.			

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 Transcendental equations (Text 1)		12
	1	2.1 Introduction	
	2	2.2 Bisection Method	
	3	2.4 Iteration Method (Derivation of Condition for Convergence and Acceleration of Convergence are optional)	
	4	2.5 Newton- Raphson Method (Generalized Newton's Method is optional)	
	5	2.7 Secant Method	
II	Interpolation(Text 1)		12
	6	3.1 Introduction, 3.3.1 Forward differences, 3.3.2 Backward differences	
	7	3.6 Newton's formulae for interpolation (up to and including Example 3.5)	
	8	3.6 Newton's formulae for interpolation (From Example 3.6)	
	9	3.9.1 Lagrange'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 Langtagn, 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%)

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	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	<p>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.</p>			

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		
	<i>Sections from Text (i): Chapter 1 – 1.1, 1.2, 1.3</i>			
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		
	<i>Sections from Text (i): Chapter 2 – 2.1, 2.2, 2.3, 2.4, 2.5</i>			
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		
<i>Sections from Text (i): Chapter 3, Chapter 4 – 4.1, 4.2, 4.3</i>				
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	
	<i>Sections from Text (i): Chapter 5 – 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8</i>		
V (Open Ended)	Advanced Topics (Practical)		12
	26	Basic Syntax and Scalar arithmetic operations and calculations by Using MATLAB	
	27	Arithmetic operations in matrix data & Reading an Image File by Using MATLAB	
References:			
1. Baldock R and Graham J (2000) Image Processing and analysis, a practical approach, Oxford University Press			
2. Gonzalez R C and Woods R E (1993) Digital Image Processing, Addison-Wesley			

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

Mapping of COs with PSOs and POs :

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

Correlation Levels:

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

Assessment Rubrics:

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

Mapping of COs to Assessment Rubrics:

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

Programme	B. Sc. Applied Mathematics Honours			
Course Code	AMA5EJ301(1)			
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 play an important role to solve the technology driven research-oriented 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 Beginner'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), (Macmillian)
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/Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

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

CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	BSc Applied Mathematics Honours			
Course Code	AMA5EJ302(1)			
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
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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	10	

		2.4.1: Definition and Introduction		
	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	3.2 Semigroups 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		
		4.1.2 Some properties of Lattices		
		4.1.4 Sub lattices		
		4.2 Boolean algebra 4.2.1 Definition and examples		
		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, Chintamani 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
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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	AMA5EJ301(1)			
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
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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	10	
	11	3.5 Combinations of Operations		
	12	3.6 Aggregation Operations		
	13	4.1 Fuzzy Numbers		
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	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 parity-check matrix		
	6	4.6 - Equivalence of linear codes		
III	Cyclic Codes		14	
	7	4.8 - Decoding of linear codes		
	8	7.2 - Generator polynomials		
	9	7.4 - Decoding of cyclic codes		
IV	Some Special Codes		13	
	10	7.5 - Burst-error correcting codes		
	11	5.3.2 - q-ary Hamming codes		
	12	5.3.3 - Golay codes		
V	MODULE V (Open Ended)		12	
	13	Reed Solomon codes		
	14	6.2 - Reed Muller codes		
V	Source coding- Classification of codes, Kraft		12	

	inequality, coding efficiency, Shannon-Fano coding Huffman coding, Shannon-Fanco- Elias coding, Arithmetic coding, the Lempel-Ziv coding, Run- length encoding Convolution and turbo codes		
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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, 2nd 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	AMA5EJ303(2)
Course Title	Financial Mathematics
Type of Course	Elective (Specialisation- MODELLING)

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	<ol style="list-style-type: none"> 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:

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	AMA5EJ304(2)			
Course Title	Mathematical Modelling			
Type of Course	Elective (Specialization- MODELLING)			
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			

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 (3 rd edition) Text 2- A First Course in Mathematical Modelling (5 th 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	AMA6EJ301(1)			
Course Title	Mathematical Economics			
Type of Course	Elective (Specialisation- MODELLING)			
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		
	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	15	
	8	– Further topics in Optimization 13.1 Non-linear Programming and Kuhn-Tucker 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:

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	AMA6EJ304(2)			
Course Title	Operations Research			
Type of Course	Elective (Specialisation- MODELLING)			
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 programming 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		
II		6 Integer Programming 6.1 - Introduction	12	
		6.2 - ILP in two- dimensional space		
		6.3 - General ILP And MILP Problems		
		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		
<p>References</p> <ol style="list-style-type: none"> 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	Applied Mathematics			
Course Code	AMA5EJ305(3)			
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	Applied Mathematics			
Course Code	AMA5EJ306(3)			
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: Interest-simple 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		
<p>1. ActEd Study Material: Subject - CT1</p> <p>2. Mathematical basis of life insurance – IC81 – Insurance Institute of India maShare</p> <p>3. An Elementary Introduction to Mathematical Finance – Sheldon Ross</p> <p>4. An Undergraduate Introduction to Financial Mathematics – by Robert Buchanan</p> <p>5. Business Mathematics - by Lerner and Zima (Schaum’s Outline Series)</p> <p>6. Corporate Finance by Brealy and Myers</p> <p>7. Fundamentals of Actuarial Mathematics by David Promislow</p> <p>8. Investment by Sharpe and Bailey Upper Saddle River, N.J. Prentice Hall, c1999.</p> <p>9. Investment Science by Luenberger (Indian Edition), Oxford University Press</p> <p>10. Investments by Bodie, Kane and Marcus, McGraw-Hill Irwin, c2005.</p> <p>11. Lecture Notes on Actuarial Mathematics – by Jerry Veeh</p> <p>12. Actuarial Mathematics by Bowers et al, Society of Actuaries, USA.</p> <p>NPTEL Financial Mathematics By Prof. Pradeep Kumar Jha IIT Roorkee</p> <p>https://youtu.be/No1j4gUerDI</p> <p>1. Actuarial Mathematics. Bowers, Newton L et al. – 2nd ed.</p>				

***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	Applied Mathematics			
Course Code	AMA6EJ305(3)			
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 Contracts, 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	Applied Mathematics			
Course Code	AMA6EJ306(3)			
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		
II			12	
	5	Uncertain income securities: Equities – Property - Real rate of interest.		
	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	
<p>References:</p> <ol style="list-style-type: none"> Promislow, S. D. (2014). Fundamentals of Actuarial Mathematics. John Wiley & Sons. 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. Harrison, F., & Lock, D. (2017). Advanced project management: a structured approach. Routledge. 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 4th 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
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	1			
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-transfer-function 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	
<p>1. Discrete - Time Control Systems- Katsuhiko, Ogata Prentice, Hall of India Pvt,2nd edition- New Delhi. References:</p> <p>1. Digital Control using Digital Signal Processing- FarzadNekoogar& G Moriarty Prentice Hall PTR- Upper Saddle Rover- New Jersey.</p>				

***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	AMA8EJ401			
Course Title	Analytical Number Theory			
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	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 $\mu(n)$ The Euler totient function $\phi(n)$ A relation connecting ϕ and μ A product formula for $\phi(n)$	10	
	2	Dirichlet product of arithmetical functions Dirichlet inverse and mobius inversion formula The Mangoldt function $\Lambda(n)$		
II	5	Dirichlet product of arithmetical functions Dirichlet inverse and mobius inversion formula The Mangoldt function $\Lambda(n)$	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 $\phi(n)$ An application to the distribution of lattice points visible from the origin The average order of $\mu(n)$ and $\Lambda(n)$ The partial sums of Dirichlet product.	10	
IV	10	Some Elementary Theorems on the Distribution of Prime Numbers: Introduction Chebyshev’s functions Relations connecting $\psi(x)$ and $\pi(x)$ Some equivalent forms of the prime number theorem Inequalities for $\pi(n)$ and P_n Shapiro’s Tauberian Theorem An Asymptotic formula for the partial sums $\sum_{p \leq x} (1/p)$ 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 $L(1, \chi)$ for real non principal χ .		
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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	Major			
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, Clarendon Press Oxford.		
Module	Content	Hours	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 co-ordinates. Convergence Stability and consistency: Definitions of local truncation error and consistency convergence analysis – stability analysis by matrix method eigenvalue von Neumann 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. 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	18	
V	Practicals of above discussed methods using any software	12	
<p>. References:</p> <ol style="list-style-type: none"> 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 Poincaré-Bendixson 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 R^2 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 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	AMA8EJ407			
Course Title	Differential Geometry			
Type of Course	Major			
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	Hours	Marks
I	1	Chapter 1 Graphs and Level Sets	15	
	2	Chapter 2 Vector Fields		
II	5	Chapter 3 The Tangent Space	10	
		Chapter 4 Surfaces		

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

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	AMA8EJ404			
Course Title	Relativity and Cosmology			
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	-	

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	Hours	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	

***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	Major 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	Hours	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 Jercey, 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	AMA8EJ408			
Course Title	Rings and modules			
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				
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	Siegfried Bosch, Algebraic geometry and commutative algebra, 2 nd 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 2.1 and 2.2 from Chapter 2)		
IV	4	The Artin-Rees lemma, Krull Dimension (sections 2.3 and 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	
<p>. 1. M. F. Atiyah and I. G. MacDonal, Introduction to Commutative Algebra, Addison Wesley (1969).</p> <p>2. N. S. Gopalakrishnan, Commutative Algebra, Oxonian Press (1984).</p> <p>3. M. Reid, Undergraduate Commutative Algebra, LMS Student Texts (29), Cambridge Univ. Press (1995).</p> <p>4. Matsumura, H., Commutative Ring Theory, Cambridge Studies in Advanced Mathematics, 1989</p>				

***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	✓	✓	✓	✓	✓

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	
		<p>LaTeX</p> <p>9.4 How to create and typeset a simple LATEX document</p> <p>9.5 How to add basic information to your document</p> <p>9.6 How to do elementary mathematical typesetting</p> <p>9.7 How to do advanced mathematical typesetting</p> <p>9.8 How to use graphics</p>		
		PsTricks		
		<p>10.1 What is PSTricks?</p> <p>10.2 How to make simple pictures</p> <p>10.3 How to plot functions</p> <p>10.4 How to make pictures with nodes</p>		
		<p>Beamer</p> <p>11.1 What is Beamer?</p> <p>11.2 How to think in terms of frames</p> <p>11.3 How to set up a Beamer document</p> <p>11.4 How to enhance a Beamer presentation</p>		
V	OPEN ENDED (General Mathematical Research)		12	

	<p>Lecturer's choices from the following</p> <p>Reference 1 (Princeton Companion), Section 1.4: General Goals of Mathematical Research, p.48 to 78.</p> <ol style="list-style-type: none"> 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? <p>Reference 2 (Math Unlimited), any chapters of the lecturer's choices.</p> <p>Reference 3 (Krantz, Mathematical Writing), any topics of lecturer's choice.</p>		
Reference	<ol style="list-style-type: none"> 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

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	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: 978-0-36764373-7, 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		9	Min 10
	7	Section 21.1 - Solution of simultaneous equations by matrices		
	8	Section 21.2 - Solution of simultaneous equations by determinants		
	9	Section 21.3 - Solution of simultaneous equations using Cramer's rule		

	10	Section 21.4 - Solution of simultaneous equations using the Gaussian elimination method.		
III	Basic Statistics From Text 2			
	11	Section 1.1 to 1.2 - An Overview of Statistics, Data Classification		
	12	Section 2.1 - Frequency Distributions and their Graphs	9	Min 10
	13	Section 2.3 - Measures of Central Tendency		
	14	Section 2.4 - Measures of Variation		
	15	Section 2.5 - Measures of Position		
IV	Basics of Probability (from text 2)		9	Min 10
	16	Section 3.1 - Basic Concepts of Probability and Counting.		
	17	Section 3.2 - Conditional Probability and the Multiplication Rule.		
	18	Section 3.3 - The Addition Rule.		
	19	Section 3.4 - Additional topics in probability and counting.		
V	Open Ended		9	
	Data Collection and Experimental Design, More Graphs and Displays (for instance refer sections from Text 2: 1.3 and 2.2)			

References:

1. Advanced engineering mathematics, 10/e, Erwin Kreyszig, Wiley, 2011.
2. Introduction to Linear Algebra with Applications, Jim DeFranza and Daniel Gagliardi, Waveland Press, 2015.
3. Elementary Statistics, 13/e, Mario F. Triola, Pearson Education, 2018.
4. Elementary Statistics, 8/e, Neil A. Weiss, Pearson Education, 2012.

Mapping of COs with PSOs and POs :

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

Correlation Levels:**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.Applied 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			
II	Basic Arithmetic Operations		9	Min 10
	6	Simplification		
	7	Average		
	8	Ratio and Proportion		
	9	Problems based on ages		
10	Percentage			
III	Financial Mathematics		9	Min 10
	11	Profit and Loss		
	12	Discount		
	13	Simple Interest		
	14	Compound Interest		
15	Work and Time			
IV	Time, Speed, and Distance		9	Min 10
	16	Speed, Time and Distance		
	17	Problems based on trains		

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

Mapping of COs with PSOs and POs :

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

Correlation Levels:

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		
I	1	Similarity of Pairs	9	Min 10
	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 symbols- Tutorial 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 2 ϵ (Online Link:- [The Not So Short Introduction to LaTeX \(oetiker.ch\)](http://www.oetiker.ch))
- 2) Harvey J. Greenberg, A simplified introduction to LaTeX (Online version)
- 3) Leslie Lamport (second edition. Addison Wesley,1994)- LaTeX, a Document Preparation System.
- 4) Donald Knuth (Addison-Wesley, 1984), The TeX book 5) Frank Mittelbach and Michel Goossens (second edition, Addison-Wesley, 2004).

Mapping of COs with PSOs and POs :

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

Correlation Levels: 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	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	Various forms of distribution, A normal distribution, A normal distribution from a binomial distribution.	12	Min 10
	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)			
	18	What is data mining? Presenting an analysis.	8	Min 10
	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	<ol style="list-style-type: none"> 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/exploreanalyze-data-with-python/1-introduction 9 https://onlinecourses.nptel.ac.in/noc24_cs54/preview 10 https://onlinecourses.nptel.ac.in/noc20_cs46/preview 			

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

Roadmap:

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

Mapping of COs with PSOs and POs :

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

Mapping of COs to Assessment Rubrics:

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

**Correlation Levels:
Rubrics:**

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

Assessment

- 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/Assignme nt/ 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/Assignme nt/ 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, 3 rd 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 <i>Arithmetica Infinitorum</i> 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		
<p>References:</p> <ol style="list-style-type: none"> 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	Propositional Logic (Chapter 1 of Text Book).		10	Min 10
	1	Syntax and Semantics, Truth Tables, Satisfiability and Validity.		
	2	Equivalence and Normal Forms, Substitution Theorem		
	3	DNF and CNF forms		
	4	Horn Formulas,		
	5	Compactness Theorem for Propositional Calculus		
	6	Resolution Theorem and Resolution Algorithm		
II	Introduction to Predicate Logic: Section 2.1, 2.2, Subsection on Mathematical Theories of Section 2.3		9	Min 10
	7	Syntax of Predicate Logic		
	8	Semantics - Structures and Models, Satisfiability and Validity		
	9	Equivalence of formulas - Substitution, Variable Renaming.		
	10	Skolem Normal Form		
	11	Mathematical Theories - Axioms and Models.		
III	Herbrand Theory for Predicate Logic: Section 2.4		9	Min 10
	12	Herbrand Universe and Structures		
	13	Herbrand Model and Satisfiability Theorem		
	14	Skolem Lowenheim Theorem		

	15	Herbrand Expansion and Godel-Herbrand-Skolem Theorem		
	16	Compactness and Herbrand's Theorem		
IV	Resolution for Predicate Logic: Section 2.5			
	17	Ground Resolution and Resolvants	8	Min 10
	18	Ground Resolution Theorem		
	19	Robinson's Unification Theorem and Algorithm		
	20	Lifting Lemma		
	21	Resolution Theorem for Predicate Logic		
V	Logic Programming		9	
	1	Unsolvability of Predicate Logic (Section 2.3 on Text Book)		
	2	SLD Resolution (Section 2.6 of Text Book)		
	3	Introduction to Logic Programming		
	4	Horn Clause Programs		
	5	Evaluation Strategies for Horn Clause Programs.		
References:				
1. J. H. Gallier, Logic for Computer Science - Foundations of Automatic Theorem Proving, Dower, 2015.				
2. S. Reeves, M Clarke, Logic for Computer Science, Addition Wesley, 1990. coding				

Mapping of COs with PSOs and POs :

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

Correlation Levels:

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, 3 rd 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	
	<p>Suggestions:</p> <p>Section 3.2 - 3.4: Higher Level Graphics with ggplot</p> <p>Section 4.6: Debugging and Maintenance</p> <p>Section 4.7: Efficient Algorithms.</p> <p>Section 6.1: Monte Carlo, 6.2: Pseudo-Random Numbers</p> <p>Appendix A: Overview of Random Variables and Distributions</p> <p>Section 6.3: Simulation of Random Variables</p> <p>Section 8.3: Newton-Raphson</p> <p>Section 8.5: Linear Programming</p>			

Reference	<ol style="list-style-type: none"> 1. Roger D. Peng, R Programming for Data Science, LeanPub, 2022, ISBN 9781365056826. https://bookdown.org/rdpeng/rprogdatascience/ 2. Garrett Golemund, 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
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Mapping of COs with PSOs and POs :

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

Detailed Syllabus:

Text Book		1. Lilavati of Bhaskaracarya Translated by K.S.Patwardhan, S.A.Naimpally and S.L.Singh, Motilal Banarsidass Publishers, Delhi. 2006. 2. Ganita Yukti Bhasa of Jyesthadeva. Volume I. English Translation by K.V.Sarma with explanatory notes by K.Ramasubramanian, M.D.Srinivas and M.S.Sriram. Hindustan Book Company, 2008.		
Module	Unit	Content	Hours (36 + 9)	Ext. Marks (50)
I	Measurement of sides and areas of triangles, quadrilaterals and circles.		9	14
	1	Computation of sides of a right triangle when one side is given.		
	2	Computation of area of triangles and quadrilaterals.		
	3	Computation of the perpendicular below the intersection of diagonals.		
	4	Approximating the surface area and volume of spheres.		
	5	Computation of sides of polygons inscribed in a circle.		
	6	Computation of the arcs and chords of circles.		
	Chapter 28 from Text I (Treatment based on English translations of Sanskrit verses in Lilavati).			
II	Rules concerned with Solids, Shadow of Gnomon and Pulverizer.		9	12
	7	Volume of Solids		
	8	Volume of a heap of Grain		
	9	Shadows of Gnomon.		
	10	Pulverization		
	Chapters 29, 30, 31, 32 and 33 from Text I (Treatment based on English translations of Sanskrit verses in Lilavati).			
III	Circle and Circumference as in Yuktibhasa.		10	14
	11	Circumference of a circle approximated by regular polygons.		
	12	Circumference of a circle without calculating square roots.		
	13	Circumference of a circle in terms of the hypotenuses.		
	14	Summation of Series.		
	15	Calculation of circumference.		
	16	Conversion of the Rsine to Arc.		
	Sections 6.1 to 6.6 of Chapter 6 from Text II.			
IV	Sine and Cosine series as in Yuktibhasa.		8	10
	17	Some technical terms and derivation of Rsines.		
	18	Computation of Rsines.		
	19	Computation of Jya and Sara by sankalita and accurate circumference.		
	Sections 7.1 to 7.6 of Chapter 7 from Text II.			
V	From Ancient Mathematical Rules to Modern Computer Algorithms.		9	

(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. Yukthibhasa. Rama Varma Maru Thampuran and A.R.Akhileswara Iyer (Editors)}, Mangalodayam Press, Trichur 1948.
5. Tantrasangraha of Nilakantha Somayaji with Yuktidipika and Laghuvivrti of Sankara. K.V.Sarma, Vishveshvaranand Visva Bandhu Institute of Sanskrit and Indological Studies, Punjab University, Hoshiarpur 1977.
6. Colebrook's translation of the Lilavati with Notes by Haran Chandra Banerji. The Book Company, Calcutta, 1927.
7. Mathematical Treasures – Lilavati of Bhaskara. Frank J.Swetz and Victor J.Katz. Loci. 2011.

Mapping of COs with PSOs and POs :

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

Correlation Levels: 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	✓	✓	✓	✓	✓

MINOR COURSES

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	C	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Implement functions, matrices, and combinatorics	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

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		12	Min. 15
	7	2.1 The Concept of a Set - up to and including example 2.7 (Example 2.6 is optional).		
	8	2.1 The Concept of a Set - finite and infinite sets (Topics from the Hilbert Hotel paradoxes onwards are optional).		
	9	2.2 Operations with Sets – up to and including example 2.21.		
	10	2.2 Operations with Sets – Cartesian product (Fuzzy sets, Fuzzy subsets and operations on fuzzy sets are optional).		

	11	2.4 The Cardinality of a Set (Theorem 2.2 and Algorithm subsets are optional).		
III	Functions and Matrices			
	12	3.1. The Concept of Functions - up to and including example 3.2	10	Min. 15
	13	3.1. The Concept of Functions – Piecewise definition, sum and product (Example 3.7 is optional).		
	14	3.2 Special Functions – up to and including example 3.13 (Proof of Theorems 3.1 and 3.2 are optional).		
	15	3.2 Special Functions- Characteristic function, Mod and Div functions (Theorem 3.3, Code dealing and The two Queens Puzzle are optional).		
	16	3.7 Matrices (Proof of theorem 3.12, algorithm product are optional).		
IV	Combinatorics and Discrete Probability		11	Min. 15
	17	6.1 The Fundamental Counting Principles (Example 6.7 is optional)		
	18	6.2 Permutations - up to and including example 6.13 (Proof of theorem 6.4 is optional)		
	19	6.2 Permutations - Cyclic permutations (Theorem 6.7 and Fibonacci numbers revisited are optional)		
	20	6.4 Combinations (Proof of theorem 6.10, example 6.22, theorem 6.12 and example 6.26 are optional)		
	21	6.8 Discrete Probability- up to and including example 6.49 (Examples 6.45 and 6.47 are optional)		
	22	6.8 Discrete Probability- Mutually exclusive events (Proof of theorem 6.20 is optional)		

V	Open Ended	12	
	<p>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.</p>		
<p>References:</p> <ol style="list-style-type: none"> 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	Analyse Graph Structures and Properties	E	C	Internal Exam/Assignment/Seminar/ Viva / End Sem Exam
CO2	Apply Algorithms to Eulerian and Hamiltonian Graphs	Ap	P	Internal Exam/Assignment/Seminar/ Viva / End Sem Exam
CO3	Explore Formal Languages and Finite State Automata	E	C	Internal Exam/Assignment/Seminar/ Viva / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Text: Discrete Mathematics with Applications, Thomas Koshy, Academic Press (2003), ISBN: 978-0124211803.

Module	Unit	Content	Hrs (48 +12)	Ext. Marks (70)
I	Graphs		14	Min. 15
	1	8.1 Graphs - Graph, Simple Graph (Example 8.3 is optional).		
	2	8.1 Graphs - Adjacency and Incidence, Degree of a Vertex, Adjacency Matrix (Example 8.5 and proof of Theorem 8.2 are optional).		
	3	8.1 Graphs – Subgraph of a Graph.		
	4	8.1 Graphs - Complete Graph, Cycle and Wheel Graphs (Fibonacci and Paraffins, Lucas and Cycloparaffins are optional).		
	5	8.1 Graphs - Bipartite graph, Complete Bipartite Graph, Weighted Graph (Graphs and Telecommunications, Graphs and Local Area Networks and A Generalised Handshake Problem are optional).		
	6	8.3 Isomorphic Graphs.		
II	Eulerian and Hamiltonian graphs		10	Min. 15
	7	8.4 Paths, Cycles and Circuits – Path, Independent Subsets of the Vertex set, Cycle and Circuit (Proof of theorem 8.3, 8.5, example 8.20 and example 8.21 are optional).		
	8	8.4 Paths, Cycles and Circuits – Connected Graphs (Proof of theorem 8.3, 8.5, example 8.20 and example 8.21 are optional).		

	9	8.5 Eulerian and Hamiltonian graphs- Eulerian Graph (Proof of theorem 8.7, example 8.26, Algorithm Eulerian graph, example 8.27, Algorithm Eulerian circuit, proof of theorem 8.8, example 8.31).		
	10	8.5 Eulerian and Hamiltonian graphs- Hamiltonian Graph (Knight's tour problem, example 8.34, Travelling Salesperson Problem, Example 8.35 are optional)		
III	Planar Graphs and Trees		11	Min. 15
	11	8.6 Planar Graphs- Planar Graph (Proofs of theorems 8.11 and 8.12 are optional).		
	12	8.6 Planar Graphs- Degree of a Region, Homeomorphic Graphs.		
	13	8.7 Graph Coloring- Graph Coloring, Chromatic Number, The Four-Color Problem (Example 8.27 is optional).		
	14	9.1 Trees- Trees (Proof of theorem 9.1 and 9.2 are optional).		
	15	9.2 Spanning Trees - Spanning Trees, Kruskal's Algorithm for a Spanning Tree.		
IV	Automata		13	Min. 15
	16	2.1 The Concept of Sets – Alphabet, Length of a Word, Language, Concatenation.		
	17	11.1 Formal Languages - Equality of Words, Concatenation of Languages (Examples 11.2, 11.3, 11.5 and Proof of Theorem 11.1 are optional).		
	18	11.1 Formal Languages – Kleene Closure.		
	19	11.2 Grammars – Grammars, Phase Structure Grammar.		
	20	11.2 Grammars – Derivation and Language.		

	21	11.3 Finite State Automata – up to and including Example 11.30 (Example 11.27 is optional).	
	22	11.3 Finite State Automata – Equivalent Finite State Automata up to and including example 11.35.	
V	Open Ended Module		12
	Computer representation of graphs, minimal spanning trees, rooted trees, Digraphs and Finite state machines		

References:

1. Discrete Mathematics and Its Applications (7/e), Kenneth H. Rosen, McGraw-Hill, NY (2007).
2. Discrete Mathematics with Applications (4/e), Susanna S Epp, Brooks/ Cole Cengage Learning (2011).
3. A First Look at Graph Theory, John Clark and Allan Holton, Allied Publishers (1991).

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

Mapping of COs with PSOs and POs :

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

Correlation Levels: 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	MAT1MN203 and MAT2MN203			
Course Summary	This course comprises four main modules: Lattice, Boolean Algebra, System of Equations, and Eigenvalue and Eigenvectors. Module I introduce concepts like ordered sets and lattices, while Module II explores Boolean Algebra and its applications. Module III covers linear systems of equations, including Gauss elimination and determinants. Finally, Module IV delves into Eigenvalue and Eigenvectors, offering insights into matrix properties and applications.			

Course Outcome

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Analyse Lattices and Boolean Algebra	E	C	Internal Exam/Assignment/Seminar/ Viva / End Sem Exam
CO2	Apply Matrix Operations and Linear Systems	Ap	P	Internal Exam/Assignment/Seminar/ Viva / End Sem Exam
CO3	Investigate Eigenvalue and Eigenvector Problems	An	P	Internal Exam/Assignment/Seminar/ Viva / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Textbook	1. Theory and Problems of Discrete mathematics (3/e), Seymour Lipschutz, Marc Lipson, Schaum's Outline Series. 2. Advanced Engineering Mathematics (10/e), Erwin Kreyzsig, Wiley India.			
Module	Unit	Content	Hrs (48 +12)	Ext. Marks (70)
I	Lattice (Text 1)		12	Min 15
	1	14.2 Ordered set		
	2	14.3 Hasse diagrams of partially ordered sets		
	3	14.5 Supremum and Infimum		
	4	14.8 Lattices		
	5	14.9 Bounded lattices, 14.10 Distributive lattices		
	6	14.11 Complements, Complemented lattices		
II	Boolean Algebra (Text 1)		10	Min 15
	7	15.2 Basic definitions		
	8	15.3 Duality		
	9	15.4 Basic theorems		
	10	15.5 Boolean algebra as lattices		
	11	15.8 Sum and Product form for Boolean algebras		
	12	15.8 Sum and Product form for Boolean algebras - Complete Sum and Product forms		
III	System of Equations (Text 2)		14	Min 15
	13	7.1 Matrices, Vectors: Addition and Scalar Multiplication		
	14	7.2 Matrix Multiplication (Example 13 is optional)		
	15	7.3 Linear System of Equations- Gauss Elimination		

	16	7.4 Linear Independence- Rank of a matrix- Vector Space (Proof Theorem 3 is optional)		
	17	7.5 Solutions of Linear Systems- Existence, Uniqueness (Proof of Theorem 1, Theorem 2 and Theorem 4 are optional)		
IV	Eigen Value and Eigen Vectors (Text 2)		12	Min 15
	18	7.6 Second and Third Order Determinants- up to and including Example 1		
	19	7.6 Second and Third Order Determinants- Third order determinants		
	20	7.7 Determinants- Cramer's Rule (Proof of Theorem 1, Theorem 2, Theorem 3 and Theorem 4 are optional)		
	21	7.8 Inverse of a Matrix- Gauss- Jordan Elimination (Proof Theorem 1, Theorem 2, Theorem 3 and Theorem 4 are optional)		
	22	8.1 The Matrix Eigenvalue Problem- Determining Eigenvalues and Eigenvectors (Proof of Theorem 1 and Theorem 2 are optional)		
V	Open Ended Module		12	
	Relation on a set, Equivalence relation and partition, Isomorphic ordered sets, 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 Gratzner, 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			
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	
<p>References:</p> <ol style="list-style-type: none"> 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	AMA1MN102			
Course Title	BUSINESS MATHEMATICS			
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 interest- Types 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): Calculus Limits- Differentiation- Methods of differentiation- Second order derivative- Maxima and Minima.	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
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Course Code	AMA1MN201			
Course Title	MANAGEMENT SCIENCE			
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, Indefinite Integral and constant of integration. Integration of different functions- Integration by substitution -Definite integrals: Evaluation of standard integrals, Integration by substitution.		
V-Open Ended		Problems on business application.	12	
References:				
<ol style="list-style-type: none"> 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	✓	✓	✓	✓	✓