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

(Affiliated to the University of Calicut)

CURRICULUM & SYLLABI

FOR

B.Sc. Computer Science & Mathematics (Double Major)

UNDER FOUR YEAR UNDER GRADUATE PROGRAMME (FYUGP) SYSTEM 2024

(EFFECTIVE FROM 2024 ADMISSION)

PROGRAMME OUTCOMES (PO):

At the end of the graduate programme at Calicut University, a student would:

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

PROGRAMME SPECIFIC OUTCOMES (PSO):

At the end of the BSc Computer Science and Mathematics Honours(Double Major) programme at Calicut University, a student would:

PSO1	Understand the theoretical and mathematical foundations of Computer Science and Mathematics
PSO2	Understand the concepts of system architecture, hardware, software and network Configuration. Apply mathematical techniques to solve complex problem situations across various domains and interpret the result, demonstrating critical thinking and analytical skills.
PSO3	Acquire logical thinking and problem-solving skills to find solutions in the software domain. Apply mathematical understanding to solve problems and explicitly work out step by step either by self or by software based computational tools.
PSO4	Design, analyse and develop code-based solutions for the algorithm. Demonstrate a strong understanding of mathematical principles and problem solving.
PSO5	Address the industry demands and assimilate technical, logical and ethical skills needed for the industry
PSO6	Integrate Mathematics with relevant disciplines to develop more holistic approaches to solve problems, leading to innovative solutions and advancements in various fields.

COURSE STRUCTURE FOR BATCH A1(B2)IN PATHWAY 5: DOUBLE MAJOR

A1: 68 credits in COMPUTER SCIENCE (Major A)
B2: 53 credits in MATHEMATICS (Major B)
The combinations available to the students: (A1 & B2)

Semester	Course Code	Course Title	Total Hours	Hours/ Week	Credits	Marks		
						Internal	External	Total
1	CSC1CJ101	Core Course 1 in Major A Fundamentals of Computers & Computational Thinking/Minor in Computer Science	75	5	4	30	70	100
	MAT1CJ101	Core Course 1 in Major B – Differential Calculus	60/ 75	4/ 5	4	30	70	100
	CSC1CJ102	Core Course 2 in Major A- Database Management System	75	5	4	30	70	100
		Ability Enhancement Course 1	60	4	3	25	50	75
		Ability Enhancement Course 2	45	3	3	25	50	75
	CSC1FM105	Multi-Disciplinary Course 1 in Major A– Data Analysis and VisualizationThrough Spreadsheets	45	3	3	25	50	75
		Total		**24/ 25**	**21**			**525**
2	CSC2CJ101	Fundamentals of Programming (CLanguage)	75	5	4	30	70	100
	MAT2CJ101	Core Course 2 in Major B – Integral Calculus	60/ 75	4/ 5	4	30	70	100
	MAT6CJ305	Core Course 3 in Major B – Elementary Number Theory	60/ 75	4/ 5	4	30	70	100
		Ability Enhancement Course 3	60	4	3	25	50	75
		Ability Enhancement Course 4	45	3	3	25	50	75
	CSC2FM106	Multi-Disciplinary Course 2 in Major A – Digital Empowerment ThroughEthical Standards	45	3	3	25	50	75

		Total		**23 – 25**	**21**			**525**
3	CSC3CJ201	Core Course 4 in Major – Software Project Management	60	4	4	30	70	100
	CSC3CJ202	Core Course 5 in Major – Data Structures and Algorithms	75	5	4	30	70	100
	MAT3CJ201	Core Course 4 in Major B- Multivariable Calculus	60/ 75	4/ 5	4	30	70	100
	MAT3CJ202	Core Course 5 in Major B – Matrix Algebra	60/ 75	4/ 5	4	30	70	100
	MAT2FM106(1)	Multi-Disciplinary Course 1 in B – Mathematics for Competitive Examinations - Part II	45	3	3	25	50	75
	CSC3FV108(1)	Value-Added Course 1 in Major A Introduction to cyber laws	45	3	3	25	50	75
		Total		**23 – 25**	**22**			**550**
4	CSC3CJ204	Core Course 6 in Major A– PythonProgramming	75	5	4	30	70	100
	MAT4CJ203	Core Course 6 in Major B- Real Analysis I	60/ 75	4/ 5	4	30	70	100
	CSC4CJ205	Core Course 7 in Major A–Computer networks	75	5	4	30	70	100
	CSC4FV109(2)	Value-Added Course 2 in Major A- Introduction to content management system	45	3	3	25	50	75
	MAT4FV110(1)	Value-Added Course 1 in B- Statistics and Mathematics with R	45	3	3	25	50	75
	CSC4FS112	Skill Enhancement Course 1 in Major A - Introduction to Digital Marketing	45	3	3	25	50	75
		Total		**23/ 24**	**21**			**525**
5	CSC5CJ302	Core Course 8 in Major – Object Oriented Programming	75	5	4	30	70	100
	MAT5CJ302	Core Course 7 in Major B – Abstract Algebra I	60/ 75	4/ 5	4	30	70	100
	CSC5CJ303	Core Course 9 in Major – Full Stack Development	60	4	4	30	70	100
		Elective Course 1 in Major A	60	4	4	30	70	100
		Elective Course 1 in Major B	60	4	4	30	70	100
	MAT5FS112	Skill Enhancement Course 1 in B-	45	3	3	25	50	75

		Mathematical Type Setting System – Latex						
		Total		**24/ 25**	**23**			**575**
6	CSC6CJ305	Core Course 10 in Major A –Operating System	75	5	4	30	70	100
	MAT6CJ304	Core Course 8 in Major B – Complex Analysis II	60/ 75	4/ 5	4	30	70	100
	MAT6CJ306	Core Course 9 in Major B – Methods of Differential Equations	60	4	4	30	70	100
		Elective Course 2 in Major A	60	4	4	30	70	100
		Elective Course 2 in Major B	60	4	4	30	70	100
	CSC6FS113	Skill Enhancement Course 3 Major A –Project Implementation	45	3	3	25	50	75
	CSC6CJ349	Internship in Major Computer Science (Credit for internship to be awarded only at the end of Semester 6)	60		2	50	-	50
		Total		**24/ 25**	**25**			**625**
Total Credits for Three Years					**133**			**3325**

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

ELECTIVE COURSES IN COMPUTER SCIENCE WITH SPECIALISATION

Group No.	Sl. No.	Course Code	Title	Semester	Total Hrs	Hrs/ Week	Credits	Marks		
								Internal	External	Total
1		**DATA SCIENCE**								
	1	CSC5EJ305a	Mathematical and Statistical Foundation for Data Science	5	60	4	4	30	70	100
	2	CSC5EJ306a	Exploratory Data Analysis	5	60	4	4	30	70	100
	3	CSC6CJ311a	Introduction to Data Warehousing and Big Data	6	60	4	4	30	70	100
	4	CSC6CJ312a	Advanced Python for Data Science	6	60	4	4	30	70	100
2		**AI and ML**								
	1	CSC5EJ305b	Machine Learning Algorithms	5	60	4	4	30	70	100
	2	CSC5EJ306b	Knowledge Engineering	5	60	4	4	30	70	100
	3	CSC5EJ311b	Soft Computing	6	60	4	4	30	70	100
	4	CSC5EJ312b	Deep Learning	6	60	4	4	30	70	100
3	**Cloud Computing**									
	1	CSC5EJ305c	Cloud Computing	5	60	4	4	30	70	100
	2	CSC5EJ306c	Security and Privacy in Cloud	5	60	4	4	30	70	100
	3	CSC6CJ311c	Storage Technologies	6	60	4	4	30	70	100
	4	CSC6CJ312c	Virtualization	6	60	4	4	30	70	100

ELECTIVE COURSES IN MATHEMATICS WITH SPECIALISATION

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

DISTRIBUTION OF GENERAL FOUNDATION COURSES IN COMPUTER SCIENCE

Semester	Course Code	Course Title	Total Hours	Hours / Week	Credits	Marks		
						Internal	External	Total
1	CSC1FM105	Data Analysis and Visualization Through SpreadSheet	45	3	3	25	50	75
2	CSC2FM106	Digital Empowerment Through Ethical Standards	45	3	3	25	50	75
3	CSC3FV108(1)	Introduction to cyber laws	45	3	3	25	50	75
4	CSC4FV109(2)	Introduction to ContentManagement Systems	45	3	3	25	50	75
5	CSC5FS112	Introduction to DigitalMarketing	45	3	3	25	50	75
6	CSC6FS113	Project Implementation	45	3	3	25	50	75

DISTRIBUTION OF GENERAL FOUNDATION COURSES IN MATHEMATICS

Semester	Course Code	Course Title	Total Hours	Hours / Week	Credits	Marks		
						Internal	External	Total
1	MAT1FM105(1)	Multi-Disciplinary Course 1 - Matrices and Basics of Probability theory	45	3	3	25	50	75
1	MAT1FM105(2)	Multi-Disciplinary Course 2 -Mathematics for Competitive Examinations - Part I	45	3	3	25	50	75
2	MAT2FM106(1)	Multi-Disciplinary Course 3 -Graph Theory and LPP	45	3	3	25	50	75
2	MAT2FM106(2)	Multi-Disciplinary Course 4 – Mathematics for Competitive Examinations - Part II	45	3	3	25	50	75
3	MAT3FV109(1)	Value-Added Course 1 - History of Mathematics	45	3	3	25	50	75
3	MAT3FV109(2)	Value-Added Course 2 - Computational Logic	45	3	3	25	50	75
4	MAT4FV110(1)	Value-Added Course 3 - Statistics and Mathematics with R	45	3	3	25	50	75
4	MAT4FV110(2)	Value-Added Course 4 - The Mathematical Practices of Medieval Kerala	45	3	3	25	50	75

5	MAT5FS112	Skill Enhancement Course 2 - Mathematical Type Setting System - LaTeX	45	3	3	25	50	75
6	MAT6FS113	Skill Enhancement Course 3 - Data Science with Python	45	3	3	25	50	75

CREDIT DISTRIBUTION FOR BATCH A1(B2)
IN PATHWAY 5: DOUBLE MAJOR

Semester	Major Courses in Computer Science	General Foundation Courses in Computer Science	Internship/ Project in Computer Science	Major Courses in Mathematics	General Foundation Courses in Mathematics	AEC	Total
1	4 + 4	3	-	4	-	3 + 3	21
2	4	3	-	4 + 4	-	3 + 3	21
3	4 + 4	3	-	4 + 4	3	-	22
4	4 + 4	3 + 3	-	4	3	-	21
5	4 + 4 + 4	-	-	4 + 4	3	-	23
6	4 + 4	3	2	4 + 4 + 4	-	-	25
Total for Three Years	**48**	**18**	**2**	**44**	**9**	**12**	**133**
	68			**53**		**12**	**133**

1. EVALUATION SCHEME

2. 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.

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

- In 4-credit courses with only theory component, out of the total 5 modules of the syllabus, one open-ended module with 20% content is designed by the faculty member teaching that course, and it is internally evaluated for 10 marks. The internal evaluation of the remaining 4 theory modules is for 20 marks.
- In 4-credit courses with 3-credit theory and 1-credit practical components, out of the total 5 modules of the syllabus, 4 modules are for theory and the fifth module is for practical. The practical component is internally evaluated for 20 marks. The internal evaluation of the 4 theory modules is for 10 marks.

4. All the 3-credit courses (General Foundational Courses) in Computer Science 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	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	20	10	70	100
3	3-credit course	only theory (5 modules)	5	20	50	75

1.1. INTERNAL EVALUATION OF THEORY COMPONENT

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

* Refer the table in section 1.2 for the evaluation of practical component

1.2. EVALUATION OF PRACTICAL COMPONENT

The evaluation of practical component in Major and Minor courses is completely by internal evaluation.

- Continuous evaluation of practical by the teacher-in-charge shall carry a weightage of 50%.
- The end-semester practical examination and viva-voce, and the evaluation of practical 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 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 component shall be as given below:

Sl. No.	Evaluation of Practical Component of Credit-1 in a Major / Minor Course	Marks for Practical	Weightage
1	Continuous evaluation of practical/ exercise performed in practical 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 records submitted for the end semester viva–voce examination by the teacher-in-charge and additional examiner	3	15%
	Total Marks	20	

1.3. EXTERNAL EVALUATION OF THEORY COMPONENT

External evaluation carries 70% marks. Examinations will be conducted at the end of each semester. Individual questions are evaluated in marks and the total marks are converted into grades by the 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	Marks for Each	Ceiling Of
			Answered	Question	Marks
2 Hours	Short Answer	10	8 – 10	3	24
	Paragraph/ Problem	8	6 – 8	6	36
	Essay	2	1	10	10
				Total Marks	70

2. INTERNSHIP

- All students should undergo Internship of 2-credits during the first six semesters in a firm, industry 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 Computer Science 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 BSc. Computer Science 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 experimental

conditions and results, ideas, mathematical expressions, rough work and calculation, computer file names etc. All entries should be dated. The Internship supervisor should periodically examine and countersign the log book.

6. The log book and the typed report must be submitted at the end of the Internship.
7. The institution at which the Internship will be carried out should be prior-approved by the Department Council of the college where the student has enrolled for the UG (Honours) programme.

2.2. EVALUATION OF INTERNSHIP

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

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

3. GENERAL FOUNDATION COURSES

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

3.1. INTERNAL EVALUATION

Sl. No.	Components of Internal Evaluation of a General Foundation Course in Computer Science and Mathematics	Internal Marks of a General Foundation Course of 3-credits in Computer Science and 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
		20	5
	Total	25	

3.2. 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 .

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

4. MINI PROJECT WORK (Skill Enhancement Course 3)

A mandatory mini-project (SEC 3) is scheduled in the VI Semester of the BSc Computer Science and Mathematics(Double Major) program. It is designed to cultivate students' research and software development skills. It will serve as a capstone experience, allowing students to bridge the gap between theoretical knowledge acquired in the classroom and its practical application to real-world problems.

4.1.Project Selection and Approval:

- Student groups (at most four members) can propose projects in computer science or related disciplines.
- Projects can be experimental (building a prototype), theoretical (a research paper), or

computational (implementing an algorithm).

- Project proposals must be submitted for **prior approval** from the Department Council.
- Each project team will be assigned a project supervisor for guidance.

Project Duration:

- The mini-project duration is one semester.
- **Minimum engagement:** 90 hours per student.

Project Deliverables**:**

- Two hard copies and one softcopy of a well-structured typed report outlining:
    - Project objectives and requirements analysis
    - System design and architecture
    - Implementation details (including sample code snippets)
    - Test cases and results
    - Conclusion and future work
- A signed undertaking by the student declaring the originality of the work and the absence of plagiarism.
- A certificate from the project supervisor confirming the same.

4.2.Evaluation Criteria and Rubrics:

1. **Internal Evaluation (25 Marks)** - Conducted by the project supervisor throughout the semester. This could involve:
    - **Project Proposal and Planning**
        - Clarity of project goals and objectives.
        - Feasibility of the chosen approach.
        - Quality of system study/literature review and proposed methodology.
        - Clarity of project schedule and division of tasks within the team.
    - **Project Progress and Implementation**
        - Regular code reviews and adoption of feedback provided by the supervisor.
        - Attendance and active participation in project meetings.
        - Completion of project milestones as planned.
        - Quality of code documentation and adherence to coding standards.
    - **Interim Presentations**
        - Effectiveness of communication and presentation skills.
        - Clarity of technical details and progress made.
        - Ability to answer questions about the project effectively.

Sl. No	Components of Evaluation of Project	Marks for the Internal Evaluation of Mini project
1	Project Proposal and Planning	5
2	Project Progress and Implementation	10
3	Interim Presentations	10
	Total Marks	25

2. **External Evaluation (50 Marks)** - Conducted by an external examiner appointed by the University. This will take place at the end of the VIth semester:

- **Project Report:**
  - **Content:** Completeness, organisation, clarity, and technical accuracy.
  - **Structure:** Introduction, System Design/literature review, methodology, implementation details, results, discussion, conclusion, future work, and references.
  - **Presentation:** Quality of writing, grammar, and formatting.
- **Project Demonstration**
  - **Demonstration:** Ability to showcase the functionality of the project or present the research findings effectively.
- **Viva-voce**
  - **Viva-voce:** Understanding of project concepts, ability to answer questions confidently, and critical thinking skills.

Sl. No	Components of Evaluation of Project	Marks for the End Semester Evaluation of Mini project
1	Project Report	15
2	Project Demonstration	20
3	Viva-voce	15
Total Marks		50

4. PROJECT

4.1. 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 or any other higher educational institution (HEI) or research center.
- A faculty member of the respective institution, where the student does the Project, should be the supervisor of the Project.

4.2. 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.
- In Honours with Research programme, the student has to do a mandatory Research Project of 12-credits 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 getprior approval from the University to offer the Honours with Research programme. Such departments should have minimum one faculty member 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 four students in Honours with Research stream.

4.3. GUIDELINES FOR THE PROJECT IN HONOURS PROGRAMME AND HONOURS WITH RESEARCH PROGRAMME

1. Project can be in Computer Science or allied disciplines.
2. Project should be done individually.
3. Project work can be of experimental/ theoretical/ computational in nature.
4. There should be minimum 240 hrs. of engagement from the student in the Project work in Honours programme.
5. There should be minimum 360 hrs. of engagement from the student in the Project work in Honours with Research programme.
6. The various steps in project works are the following:
    - Wide review of a topic.
    - Investigation on a problem in systematic way using appropriate techniques.
    - Systematic recording of the work.
    - Reporting the results with interpretation in a standard documented form.
    - Presenting the results before the examiners.
7. During the Project the students should make regularnd detailed entries in to a personal log book through the period of investigation. The log book will be a record of the progress of the Project and the time spent on the work, and it will be useful in writing the final report. It may contain experimental conditions and results, ideas, mathematical expressions, rough work and calculation, computer file names etc. All entries should be dated. The Project supervisor should periodically examine and countersign the log book.
8. During the Project the students should make regularnd detailed entries in to a personal log book through the period of investigation. The log book will be a record of the progress of the Project and the time spent on the work, and it will be useful in writing the final report. It may contain experimental conditions and results, ideas, mathematical expressions, rough work and calculation, computer file names etc. All entries should be dated. The Project supervisor should periodically examine and countersign the log book.

9. 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.
10. It is desirable, but not mandatory, to publish the results of the Project in a peer reviewed journal.
11. 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.
12. 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.

4.4. 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/ 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:

Components of Evaluation of Project	Marks for the Research Project(Honours)/ (Honours with Research) 12 Credits	Weightage
Continuous evaluation of project work through interim presentations and reports by the committee internally constituted by the Department Council	90	30%
End-semester viva-voce examination to be conducted by the external examiner appointed by the university	150	50%
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 Research Project (Honours programme) /(Honours with Research programme) 12 credits

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 Research Project (Honours programme) / (Honours with Research programme) 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

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 indirectgrading 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 theprogramme of study.
- Only the weighted grade point based on marks obtained shall be displayed on the grade card issued to the students.

LETTER GRADES AND GRADE POINTS

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

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

5.1. COMPUTATION OF SGPA AND CGPA

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

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

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

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

$$\text{SGPA} = \frac{\text{Sum of the credit points of all the courses in a semester}}{\text{Total credits in that semester}}$$

ILLUSTRATION – COMPUTATION OF SGPA

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

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

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

$$\text{CGPA} = \frac{\text{Sum of the credit points of all the courses in six semesters}}{\text{Total credits in six semesters (133)}}$$

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

$$\text{CGPA} = \frac{\text{Sum of the credit points of all the courses in eight semesters}}{\text{Total credits in eight semesters (177)}}$$

Syllabus of Major Courses in Computer Science

Programme	B. Sc. Computer Science and Mathematics(Double Major)				
Course Code	**CSC1CJ101**				
Course Title	**Fundamentals of Computers and Computational Thinking**				
Type of Course	Major				
Semester	I				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	1. Fundamentals of electronic components 2. Basic mathematical operations				
Course Summary	This course provides a comprehensive overview of computing, covering historical milestones, hardware components, software systems, and computational thinking principles. Students will explore the evolution of computing systems, from early pioneers to modern processors and quantum units. The curriculum delves into hardware intricacies, software distinctions, and essential concepts in computer science, emphasizing problem-solving skills and algorithmic thinking. Practical aspects include hands-on experiences with hardware assembling, operating system installation, algorithm and flowchart visualization.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Develop a foundational knowledge of computing systems, encompassing their historical development, evolutionary milestones, and the notable contributions of key figures in the field.	U	F	Instructor-created exams / Quiz
CO2	Acquire familiarity with diverse hardware components constituting a computer system.	U	C	Practical Assignment / Observation of Practical Skills
CO3	Gain practical expertise by engaging in hands-on activities focused on the installation and configuration of diverse hardwarecomponents within a computer system.	Ap	P	Practical Assignment / Observation of Practical Skills

CO4	Explore the spectrum of software types, and actively participate in the partitioning, installation, and configuration of operating systems to cultivate a comprehensive understanding of software systems.	Ap	P	Practical Assignment / Observation of Practical Skills
CO5	Develop a foundational understanding of computer science as a discipline, examining problems through the lens of computational thinking and cultivating analytical skills to address challenges in the field.	An	C	Instructor-created exams / Quiz
CO6	Represent complex problems using algorithmic approaches and enhance problem-solving skills by visualizing solutions through the utilization of various software tools.	Ap	P	Practical Assignment / Observation of Practical Skills
* - 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:

Fundamentals of Computers and Computational Thinking

Module	Unit	Content	Hrs	Marks
I		**History and Evolution of Computing System**	**9**	**15**
	1	**Evolution of Computers** – History, Generations	1	
	2	**Overview of Computer System**- Von Neumann Model, Number Systems(Binary, Hexa, Octal, Decimal)	2	
	3	**Number Conversion and Digital Codes-** Conversion from one number system to another, Digital Codes (Gray, Excess-3, BCD)	2	
	4	**Pioneers and Contributors of Computing Systems** - First Mechanical computer - Charles Babbage, Stored-Program Architecture - John von Neumann, Turing machine - Alan Turing, First General-Purpose Electronic Digital Computer -	2	
		John Mauchly and J. Presper Eckert, Artificial Intelligence- John McCarthy (Contributions only).		
	5	**Computing Systems: Past to Present** - Single Core, Dual-Core and Multi-Core Processors, Graphics Processing Unit (GPU), Accelerated Processing Unit, Quantum Processing Units (QPU) (Concept only).	2	

II	**Hardware**		**11**	**20**
	6	**Electronic Components** – Active Components - Diode, Transistor, Integrated Circuits (Definition, Symbol and Function).	1	
	7	**Electronic Components** - Passive Components – Resistors, Capacitors, Inductors (Definition, Symbol and Function).	1	
	8	**Motherboard Components –** CPU and Cooling Fan, RAM, Expansion Slots (PCIe), Input/Output Ports, Chipset (Concept only).	2	
	9	**Motherboard Components –** BIOS/UEFI Chip, SATA/NVMe Slots, Network Interface, Ports- Ethernet, VGA, HDMI, USB (Concept only).	3	
	10	**Computer Components** – SMPS, Motherboard, Storage Devices (HDD, SSD, NVMe)(Concept only).	2	
	11	**Computer Components** – RAM (DRAM, SRAM, DDR SDRAM), ROM, Cache (Concept only).	2	
III	**Software**		**10**	**15**
	12	**Softwares** - Application Software, System Software, Examples	1	
	13	**Operating Systems** – Need of OS, Types – Proprietary and Open Source, Hardware Software Compatibility, POST, Booting.	4	
	14	**OS Installation –** Bootable Media, UEFI / Legacy BIOS, Disk Partitioning, Dual Booting, Boot Manager – BOOTMGR, Grub, File Systems- FAT, NTFS, ext4.	4	
	15	**Device Drivers –** Need of Device Drivers, Driver Interactions (Basic concept only).	1	
IV	**Computer Science and Computational Thinking**		**15**	**20**
	16	**Computer Science**- Introduction, Role of Computer Science in the Modern Era	1	
	17	**Problem Solving -** Defining the Problem, Systematic Approach.	2	
	18	**Computational Thinking** – Problem Decomposition, Pattern Identification, Abstraction, Generalization.	2	
	19	**Logical Thinking** – Inductive and Deductive Reasoning, Logical Expressions.	2	
	20	**Algorithmic Thinking** – Intuition vs Precision, Defining algorithms.	2	
	21	**Algorithm** – Need of Algorithm, Qualities of a Good Algorithm, Examples.	3	
	22	**Flowchart** - Flowchart Symbols, Examples. Raptor.	3	
V	**Lab Activities**		**30**	**30**

		Some of the suggested lab activities are given below. 1. Identify, categorize and list out specifications of given **electronic components**. 2. Identify and list out specifications of given **motherboard components**. 3. Identify and Describe various **ports and connectors on the motherboard**. **4.** Installation of various **components on the motherboard** (Processor, Fan, Heat Sink, RAM etc.) 5. Hands-on experience in **assembling and disassembling** a computer system (SMPS, Motherboard, Storage Device etc.). 6. Accessing and configuring the **Basic Input/ Output System (BIOS) or Unified Extensible Firmware Interface (UEFI)** settings. 7. Preparation of **Bootable media** with software like ***Rufus***. 8. Check the hardware compatibility and **Install operating system** (single booting) on given computer. 9. Check the hardware compatibility and **Install operating systems** (dual booting – Windows and Linux) on a given computer. **Develop algorithms and implement** the solutions using ***RAPTOR*** flowchart execution tool for the following problems. 10. Read and print a number. 11. Read the price of three items and print the total bill amount. 12. Read the ages of two persons and print the elder one. 13. Read the number of units of electricity consumed and print the bill amount for various slabs. 14. Read a year and check whether it is a leap year. 15. Print first N numbers (using loop).		

References:

1. Gary B. Shelly, Thomas J. Cashman, and Misty E. Vermaat. “Introduction to Computers”, Cengage Learning, 2008.

2. Pradeep K. Sinha and Priti Sinha, Computer Fundamentals: Concepts, Systems & Applications. BPB Publications.

3. Kevin Wilson, Computer Hardware: The Illustrated Guide to Understanding Computer Hardware. Amazon Digital Services LLC – KDP, 2018.

4. John Hanna, OS Installation 101: A Step-by-Step Approach for Newbies.

5. David Riley and Kenny Hunt, Computational thinking for modern solver, Chapman & Hall/CRC, 2014

6. R.G. Dromey, How to solve it by Computer, PHI, 2008

Course Code & Title	CSC1CJ102	Database Management System			
Type of Course	**Major**	Academic Level	200 – 299		
Pre-requisites	Programming Basics				
Semester	I				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Course Summary	This course introduces database management systems. The topics covered include the concept of Database Management System, ER Model, Relational model, SQL, Database design, Transactions, concepts of other data model-NoSQL and practical session to implement Database Concepts.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	A comprehensive understanding of fundamental concepts in database management systems and its application	U	C	Instructor-created exams / Quiz
CO2	Understand concepts of Relational Data Model and Normalization Techniques	U	C	Instructor-created exams / Quiz
CO3	Apply principles of entity-relationship modeling and normalization techniques to design efficient and well-structured databases that meet specified requirements.	Ap	P	Practical Assignment / Observation of Practical Skills
CO4	Acquire expertise in crafting and executing SQL queries for the retrieval, updating, and manipulation	Ap	p	Practical Assignment /
	of data, showcasing adept skills in database querying and data manipulation			Observation of Practical Skills
CO5	Comprehend and apply strategies for managing transactions and implementing mechanisms for controlling concurrency, ensuring the database's consistency and reliability in environments with multiple users.	Ap	P	Practical Assignment / Observation of Practical Skills
CO6	Explore and analyze recent trends in database management systems, with a focus on unstructured databases, NoSQL technologies	An	P	Practical Assignment / Observation of Practical Skills

Detailed Syllabus:

Module	Unit	Content	Hrs	Mark
I	**Database System- Concept**		**10**	**15**
	1	Introduction, Characteristics of the Database Approach	2	
	2	Actors on the Scene, Workers behind the Scene, Advantages of Using the DBMS Approach, File system vs Database	2	
	3	Data Models, Schemas, and Instances , Three-Schema Architecture and Data Independence	3	
	4	Database Languages and Interfaces	2	
	5	Structured, Semi Structured and Unstructured Database	1	
II	**Database Design**		**14**	**20**
	6	ER Model- Basic concepts, entity set & attributes, notations	2	
	7	Relationships and constraints, cardinality, participation, notations, weak entities	2	
	8	Relational Model Concepts-Domains, Attributes, Tuples, and Relations, Values and NULLs in the Tuple	2	
	9	Relational Model Constraints and Relational Database Schemas	2	
	10	Relational Database Design- Atomic Domain and Normalization-INF, 2NF,3NF,BCNF	4	
	11	4NF,5NF	2	
III	**Query Languages**		**11**	**20**
	12	SQL-, introduction to Structured Query Language (SQL)	1	
	13	Data Definition Language (DDL), Table definitions and operations	2	
	14	SQL DML (Data Manipulation Language) - SQL queries on single and multiple tables	4	
	15	Nested queries (correlated and non-correlated), Aggregation and grouping, Views, assertions, Triggers, SQL data types.		
	16	Introduction to NoSQL Databases	2	
	17	Main characteristics of Key-value DB (examples from: Redis), Document DB (examples from: MongoDB)	2	
IV	**Transaction Processing,Concurrency Control**		**10**	**15**
	18	Transaction Processing: Introduction, Transaction and System Concepts	3	
	19	Desirable Properties of Transactions	1	
	20	Characterizing Schedules Based on Recoverability & Serializability	2	
	21	Transaction Support in SQL.	1	
	22	Introduction to Concurrency Control: Two-Phase Locking Techniques	3	
V	**DBMS LAB**		**30**	
	1	Students should decide on a case study and formulate the problem statement.	3	
	2	Based on Identified problem Statement, Design ER Diagram (Identifying entities, attributes, keys and relationships between entities, cardinalities, generalization, specialization etc.) Note: Student is required to submit a document by drawing ER Diagram to the Lab teacher.	3	
	3	Converting ER Model to Relational Model (Represent entities and relationships in Tabular form, Represent attributes as columns, identifying keys) Note: Student is required to submit a document showing the database tables created from ER Model.	2	

	4	Normalization -To remove the redundancies and anomalies in the above relational tables, Normalize up to Third Normal Form	3	
	5	Creation of Tables using SQL- Overview of using SQL tool, Data types in SQL, Creating Tables (along with Primary and Foreign keys), Altering Tables and Dropping Tables	3	
	6	Practicing DML commands-Insert, Select, Update, Delete	2	
	7	Experiment 7:Practicing Queries using ANY, ALL, IN, EXISTS, NOT EXISTS, UNION, INTERSECT, CONSTRAINTS etc.	2	
	8	Practicing Sub queries (Nested, Correlated) and Joins (Inner, Outer and Equi).	2	
	9	Practice Queries using COUNT, SUM, AVG, MAX, MIN, GROUP BY, HAVING, VIEWS Creation and Dropping.	4	
	10	Install and Configure MongoDB to execute NoSQL Commands.	6	

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	2	-	-	-	-						
CO 2	3	2	1	-	-	-						
CO 3	1	-	2	3	-	-						
CO 4	-	-	-	3	3	-						
CO 5	-	-	-	3	3	-						
CO 6	-	-	-	-	2	3						

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3		✓	✓	✓
CO 4		✓	✓	✓
CO 5	✓	✓		✓
CO 6		✓	✓	✓

Text books

1. Database System Concepts (Sixth Edition) Avi Silberschatz, Henry F. Korth, S. Sudarshan McGraw-Hill 2011 ISBN 978-0071325226/ 0-07-352332-1
2. Database Management Systems, Third Edition Raghu Ramakrishnan and Johannes Gehrke McGraw-Hill ©2003 ISBN: 978-0072465631/ 0-07-246563-8

Programme	B. Sc. Computer Science and Mathematics(Double Major)				
Course Code	**CSC2CJ101**				
Course Title	**Fundamentals of Programming (C Language)**				
Type of Course	Major				
Semester	II				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	1. Fundamentals of Algorithms and Flowcharts 2. CSC1CJ101 – Fundamentals of Computers and Computational Thinking				
Course Summary	The objectives of this course are to make the student understand programming language, programming, concepts of Loops, reading a set of Data, stepwise refinement, Functions, Control structure, Arrays, Structures, Unions, and Pointers. After completion of this course the student is expected to analyze the real life problem and write a program in 'C' language to solve the problem. The main emphasis of the course will be on problem solving aspect i.e. developing proper algorithms.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Remember the program structure of C with its syntax and semantics	U	C	Instructor-created exams / Quiz
CO2	Use the various constructs of a programming language viz. conditional, iteration and recursion.	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Implement the algorithms in C language.	Ap	P	Practical Assignment / Observation of Practical Skills
CO4	Use simple data structure like array in solving problems.	Ap	C	Practical Assignment / Observation of Practical Skills
CO5	Handling pointers and memory management functions in C.	Ap	P	Practical Assignment / Observation of Practical Skills
CO6	Develop efficient programs for solving a problem.	Ap	P	Viva Voce

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

Detailed Syllabus:

Module	Unit	Content	Hrs
I	**Introduction to C Language**		**10**
	1	History of C, Importance of C, and sample programs	2
	2	Character set, Tokens, Constants, Variables, and Data types	2
	3	Operators - Arithmetic, Relational, logical, assignment, increment, decrement, conditional, bitwise and special operators. Arithmetic expressions, operator precedence, type conversions, mathematical functions	3
	4	Managing Input and Output Operators: Reading and writing a character, formatted input, formatted output.	3
II	**Decision Making Branching and Looping**		**10**
	5	Decision making with If - simple If, If else, nested If else, else If ladder	3
	6	Switch statement, conditional operator, Goto statement	2
	7	Loops: while, do while, for statements and nested loops	3
	8	Jumps in loops – break, continue	2
III	**Arrays and Functions**		**15**
	9	One dimensional array – declaration, initialization and accessing	2
	10	Two dimensional array – declaration, initialization and accessing	2
	11	Multi dimesnsional array, dynamic array	1
	12	Strings – Reading, Writing. Arithmetic operations on characters, Comparisons and string handling functions	2
	13	Functions – Need, Elements of user defined functions and definition	2
	14	Return values and their types, function call and declaration, call by value and call by reference	2
	15	Categories of functions, Nesting of functions	1
	16	Recursion and command line arguments	1
	17	Passing arrays to functions and passing strings to functions	2
IV	**Storage Classes, Structure and Union, Pointers**		**10**
	18	Storage classes – The scope, visibility and lifetime of variables. Auto, Extern, Static and Register storage classes. Storage classes in a single source file and multiple source files	2
	19	Structure and Union - Defining, giving values to members, initialization and comparison of structure variables, arrays of structure, arrays within structures, structures within structures, structures and functions, unions	2
	20	Pointers definition, declaring and initializing pointers, accessing a variable through address and through pointer, pointer expressions, pointer increments and scale factor	2
	21	Pointers and arrays, pointers and functions, pointers and structure	2
	22	Dynamic memory allocation and memory management functions	2
V	**Hands-on Problem Solving Using C** **Practical Applications, Case Study and Course Project**		**30**

	1	Implement the following: **1. Variables, Data types, Constants and Operators:** 1.Evaluation of expression ex: ((x+y) ^2 * (x+z))/w 2.Temperature conversion problem (Fahrenheit to Celsius) 3.Program to convert days to months and days (Ex: 364 days = 12 months and 4 days) 4. Salesman salary (Given: Basic Salary, Bonus for every item sold, commission on the total monthly sales) **2. Decision making (Branch / Loop) Statements:** 5. Solution of quadratic equation 6. Maximum of three numbers 7. Calculate Square root of five numbers (using goto statement) 8. Pay-Bill Calculation for different levels of employee (Switch statement) 9. Fibonacci series 10.Armstrong numbers 11.Pascal 's Triangle **3. Arrays, Functions and Strings:** 12. Prime numbers in an array 13. Sorting data (Ascending and Descending) 14. Matrix Addition and Subtraction 15. Matrix Multiplication 16.Transpose of a matrix 17Function with no arguments and no return value 18. Functions with argument and return value 19.Functions with argument and multiple return values 20.Function that convert lower case letters to upper case 21. Factorial using recursion. 22. Perform String Operations using Switch Case	30
		23. Largest among a set of numbers using command line argument **4. Structures and Union:** 24. Structure that describes a Hotel (name, address, grade, avg room rent, number of rooms) Perform some operations (list of hotels of a given grade etc.) 25. Using Pointers in Structures. 26. Cricket team details using Union. **5. Pointers:** 27.Evaluation of Pointer expressions 28.Function to exchange two pointer values 29. Reverse a string using pointers 30.Insertion, deletion, and searching in an array	

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	-	1	1	-	-						
CO 2	-	1	2	2	-	-						
CO 3	-	1	3	3	-	-						
CO 4	1	1	2	2	-	-						
CO 5	-	2	2	2	-	-						
CO 6	-	1	3	3	1	1						

Correlation Levels:

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

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6			✓	

Programme	B. Sc. Computer Science and Mathematics(Double Major)				
Course Code	**CSC3CJ201**				
Course Title	**SOFTWARE PROJECT MANAGEMENT**				
Type of Course	**Major**				
Semester	III				
Academic Level	200 – 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	1. Computer Science knowledge 2. Understanding fundamental computer science concepts. 3. Basic knowledge of project planning and scheduling				
Course Summary	Students are introduced to the concepts, procedures, and resources of software project management in this course. Project scheduling, budgeting, quality assurance, risk management, and teamwork are among the subjects covered. The goal of the course is to equip students with the skills necessary for efficient project management in software development settings.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used

CO1	Define and explain the fundamental concepts, principles, and terminologies related to software project management. Differentiate between various software engineering process models. Understand the agile principle and methodologies and appreciate the need for iterative approaches to software Development	U	C	Instructor-created exams / Quiz
CO2	Master various design concepts used during project development life cycle.	U	P	Assignments/ Test papers/ Viva Voce
CO3	Master various SPM techniques	U	P	Seminar Presentation / Group Tutorial Work/ Viva Voce
CO4	Develop project plans, Create project schedules using tools like Gantt charts and network diagrams	Ap	C	Instructor-created exams / Home Assignments
CO5	Understand the importance of quality in software development by mastering quality assurance processes, methodologies, and testing strategies.	U	P	Writing assignments/ Exams
CO6	Prepare and deliver effective project presentations.	Ap	P	Case Study/ mini Project/ Seminar Presentation/ Group Presentations

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)

- Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (48+12)	Marks (70)
I	**Introduction to Software Engineering and Process Models**		**10**	**12**
	1	Software and Software Engineering- nature of software, Software Engineering, Software Process	2	
	2	Software Development Life Cycle (SDLC)	2	
	3	Prescriptive Process Model- Water fall model, Incremental Model, Evolutionary Process Model	2	
	4	Agile Development- What is Agility, What is agile Process?	2	
	5	Extreme Programming	2	
II	**Software requirements and Design Concepts**		**16**	**22**
	6	Understanding requirements- requirement engineering process	3	
	7	Feasibility studies	1	
	8	Design Concepts- Design process, Design Concepts	2	
	9	Design Model Elements- Data design elements, Architectural design elements, Interface Design Elements, Component-Level Design Elements, Deployment-Level Design Elements	2	
	10	Architectural design using DFD	2	
	11	Component level design guidelines	2	
	12	Modelling with UML – Class diagram Use Case Diagram, State chart Diagram, Activity Diagram,	4	
III	**Software Project Management**		**11**	**18**
	13	Introduction to Software Project Management- Overview of software project management, Importance of project management in software engineering, Role of a project manager	2	
	14	Project Planning and Scope Management- Work breakdown structure (WBS) and project estimation techniques	2	
	15	Project Scheduling and Resource Allocation- Gantt charts and network diagrams,	2	
	16	Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT)	2	
	17	Risk Management-reactive vs proactive risk strategies, Risk identification, risk projection, RMMMM plan	3	
IV		**Software Quality Assurance**	**11**	**18**

	18	Quality Concepts- Software quality, Achieving Software quality,	2	
	19	Testing Strategies	2	
	20	Software testing- levels of software testing	1	
	21	Types of software test- Unit testing, Integration testing, Black box testing, white box testing, System testing	4	
	22	Art of debugging	2	
V	**Open Ended Module- Trends in Software Engineering**		**12**	
	1	• Case study of CASE tools • Prepare a project report • Analysis of real-world software project management case studies • Group project presentations		

References

- Roger S, "Software Engineering – A Practitioner's Approach", seventh edition, Pressman, 2010.
- Pearson Education, "Software Engineering by Ian Sommerville", 9th edition, 2010.
- Pankaj Jalote, An Integrated Approach to Software Engineering, 3rd Edition, Narosa Publishing House.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	1	-	-	3	-						
CO 2	1	1	2	-	3	-						
CO 3	1	1	-	-	3	-						
CO 4	1	1	-	-	3	-						
CO 5	1	1	-	-	3	-						
CO 6	1	1	-	-	3	-						

Correlation Levels:

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

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam

- Programming Assignments (20%) Final Exam (70%)

Programme	B. Sc. Computer Science and Mathematics(Double Major)				
Course Code	**CSC3CJ202**				
Course Title	**DATA STRUCTURES AND ALGORITHM**				
Type of Course	**Major**				
Semester	III				
Academic Level	200 – 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	1. Fundamental Mathematics Concepts: Set, Functions, Logic 2. CSC2CJ101 – Fundamentals of Programming				
Course Summary	This course explores implementations of linked list and array-based data structures, delving into the inner workings of basic data structures including lists, stacks, queues, trees, and graphs.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Differentiate basic data structures (arrays, linked lists, stacks, queues) based on their characteristics, operations, and real-world applications.	U	C	Instructor-created exams / Quiz
CO2	Perform basic operations (e.g., insertion, deletion, search) on fundamental data structures using a chosen programming language.	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Identify the properties and applications of advanced data structures (trees, graphs).	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Investigate the properties of various searching and sorting Techniques	U	C	Practical Assignment / Seminar
CO5	Demonstrate critical thinking and problem-solving skills by applying data structures and algorithms to address complex computational challenges.	Ap	P	Viva Voce/ Observation of Practical Skills
CO6	Implement and analyse different data structure algorithms (to solve practical problems.	Ap	P	Case study/ Project

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

Detailed Syllabus:

Module	Unit	Content	Hrs (45+30)	Marks (70)
I	**Introduction to Data Structures and Basic Algorithms**		**9**	**15**
	1	Overview of Data Structures: Data type Vs. Data structure, ADT, Definition of Data structure, Data structure Classification – Linear, Non- Linear (Array, Linked List, Stack, Queue, Tree, Graph)	1	
	2	Introduction to Arrays: Definition, Types (1 Dimensional, 2 Dimensional, Multi-Dimensional, Sparse matrix), Different Array Operations with Algorithm (insertion, deletion, traversal)	3	
	3	Structures and Self-referential structures	1	
	4	Introduction to Linked list: Definition, Types (Single linked list, Doublelinked list, Circular linked list- concept only).	2	
	5	Singly Linked List Operations with Algorithm (insertion, deletion, traversal)	2	
II	**Stack and Queue**		**10**	**20**
	6	Introduction to Stack: Definition, stack operations with Algorithm, Applications: recursion, infix to postfix - example and Algorithm	3	
	7	Implementation of Stack: using array (overflow & underflow) and Linkedlist (with algorithm)	2	
	8	Introduction to Queue: Definition, queue operations with Algorithm, Types: Double ended queue (Input Restricted and Output restricted), Circular queue, Applications	2	
	9	Implementation of Queue: using array and Linked list (with algorithm)	3	
III	**Non- Linear Data Structures**		**16**	**20**
	10	Introduction to Trees: Basic terminology, Types (Binary tree-complete,full, skewed etc., Expression Tree)	2	
	11	Properties of Binary tree, Applications.	2	
	12	Binary tree representations- using array and linked list	2	
	13	Operations on Binary tree- Insertion, Deletion, Traversal- inorder, preorder, postorder - (concepts with examples)	3	
	14	Algorithm of non-recursive Binary tree traversal	3	
	15	Introduction to Graph: Definition, Basic terminology, Types (Directed, Undirected, Weighted).	2	
	16	Graph representation –Adjacency list and Adjacency Matrix, Applications.	2	
IV	**Sorting and Searching**		**10**	**15**
	17	Introduction to Sorting: Definition, Classification (Internal, External)	1	
	18	Internal Sorting Algorithms: Selection sort- Selection sort algorithm, Exchange sort- Bubble sort algorithm	2	
	19	External Sorting Algorithms: Merge sort- Demonstrate with example.(NoAlgorithm needed)	1	
	20	Advanced sorting Algorithm-: Quick sort- Demonstrate with example. (NoAlgorithm needed)	1	
	21	Introduction to Searching: Linear search and Binary search(Algorithm needed) with example.	2	

	22	Hashing: Hash Tables, Hash Functions, Different Hash Functions – Division method, Multiplication method, Mid square method, Folding Method, Collision and Collision resolution Techniques: Open hashing- Chaining, Closed hashing- Probing	2	
V	**Hands-on Programming in Data Structures: Practical Applications, Case Study and Course Project**		**30**	
	1	**Implement the following:** **1.** Basic Operations in a single linked list (Menu driven) **2.** Sort the elements in given singly linked list **3.** Stack using array. **4.** Stack using Linked list **5.** Queue using Array **6.** Queue using Linked list **7.** Sorting algorithms- Selection, Bubble Sort **8.** Searching Algorithms- Linear and Binary search	25	
	2	Project/ Case study	5	

REFERENCES

1. Seymour Lipschutz, "Data Structures with C", McGraw Hill Education (Schaum'sOutline Series)
2. Reema Thareja, " Data Structures Using C", Oxford University Press

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	1	1	-	-	-						
CO 2	2	1	2	3	-	-						
CO 3	2	1	2	3	-	-						
CO 4	2	-	2	3	-	-						
CO 5	1	1	2	3	1	-						
CO 6	1	1	3	3	1	-						

Correlation Levels:

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

Assessment Rubrics:

- Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam

- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	InternalExam	Assignment	Practical Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5		✓		✓
CO 6			✓	

Programme	B. Sc. Computer Science and Mathematics(Double Major)				
Course Code	CSC3CJ204				
Course Title	**PYTHON PROGRAMMING**				
Type of Course	**Major**				
Semester	IV				
Academic Level	200 – 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	1. CSC2CJ101 – Fundamentals of Programming				
Course Summary	This course explores the versatility of Python language in programming and teaches the application of various data structures using Python. The course also gives an introduction to scientific computing using popular Python packages.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the basic concepts of Python programming language.	U	C	Instructor-created exams / Quiz
CO2	Apply problem-solving skills using the basic constructs in Python Programming	Ap	P	Coding Assignments/ Code reading and review
CO3	Apply modular programming using functions in Python	Ap	P	Coding Assignments/ Code reading and review
CO4	Analyse the various data structures and operations on it using Python	An	C	Instructor-created exams / Case studies
CO5	Apply various packages available in Python	Ap	P	Coding Assignments/ Case studies
CO5	Apply visualization tools in Python	Ap	P	Coding Assignments/ Case studies

* - 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
I	**Fundamentals of Python**		**12**
	1	Features of Python, Identifiers, Keywords, Variables, Operators, Operands, Expressions and Data types	3
	2	Precedence and Associativity, Indentation, Comments	1
	3	Input, Output and Import functions, Mathematical functions, range function, Type Conversions	1
	4	Decision-making Structures	3
	5	Looping Structures	3
	6	Control Statements	1
II	**Functions & Modules**		**8**
	7	Function Definition, Function Calling, Flow of Execution, Parameters and Arguments	2
	8	Types of Function Arguments – Required, Keyword, Positional and Variable length arguments	2
	9	Scope and lifetime of variables	1
	10	Types of Functions – Recursive, Anonymous, Functions with more than one return value, Void Functions	2
	11	Built in modules, User defined modules and packages	1
III	**Data Structures in Python**		**15**
	13	Strings - Indexing, Traversal, Slicing, Joining, and Splitting of Strings, Formatting Strings, Operation and Methods of Strings	5
	14	Lists- Indexing and Traversal, Slicing, Joining, and Splitting of Lists, Operations and Methods of Lists	4
	15	Tuples – Indexing and Traversal, Operations and Methods of Tuples	2
	16	Dictionaries – Accessing and Modifying *key-value* pairs in Dictionary, Operations and Methods	3
	17	Sets - Creation and Operations of Sets	1
IV	**Introduction to Scientific Computing in Python**		**10**
	18	Introduction to NumPy Arrays – Advantage of NumPy Arrays, Creation of NumPy Arrays	2
	19	Computation on NumPy Arrays - Universal Functions, Broadcasting, Fancy Indexing	3
	20	Introduction to Pandas - Pandas Series and Pandas Data Frames. Series - Construction from arrays, explicit indices, and dictionaries. **Data Frames-** Construction from arrays and dictionaries.	3
	21	Introduction to Matplotlib Basic plotting - Line plots, Scatter plots, Bar plots ,Histograms and Pie charts.	2
V	**Hands-on Data Structures: Practical Applications, Case Study and Course Project**		**30**
	1	**Basics of Python** 1. Demonstrate basic data types in python using interactive Interpreter. 2. Write a Python script that reads two integers and perform all	20

		arithmetic operations on these two numbers. 3. Write a program to compute distance between two points. 4. Write a program to calculate the area of a circle. **Control Structures** 5. Write a program to check whether a number is odd or even. 6. Write a program that reads a positive integer, *n*, from the user and then displays the sum of the first n natural numbers.	
		7. Write a Python program to check whether a given year is a leap year or not. 8. Develop a program that reads a four-digit integer from the user and displays the sum of the digits in the number. For example, if the user enters 2151 then your program should display 2+1+5+1=9. **Function** 9. Write a program to find the largest of three numbers using functions. The program should pass three numbers as arguments and should return the result. 10. Write a function to check whether a given number is prime or not. 11. Write a recursive function to find the factorial of a number. **Python Data Structures: Strings, Sets, Lists , Tuples and Dictionaries** 12. Create a program that checks whether a given string is a palindrome or not. 13. Write a program to check whether an item exists in a tuple. 14. Write a program to create intersection, union, set difference, and symmetric difference of sets. 15. Write a program to create a telephone directory using a dictionary and display its contents. Also check for a specific phone number in the dictionary. **NumPy, Pandas and Matplotlib** 16. Write a program to implement matrix multiplication using NumPy. 17. Create a pandas series from a dictionary of values, and an ndarray. 18. Write a program to draw a line plot for the given heights and weights of a group of people. height=[145,155,165,175,185,195] weight=[43, 56, 60,69, 78,95]	
	2	**Case Study**	3
	3	**Capstone (/Course) Project:** Build a practical application using any one package and demonstrate using visualization tools.	7

Mapping of COs with PSOs and POs :

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

CO 3	2	-	2	1	-	-						
CO 4	1	-	1	-	-	-						
CO 5	-	2	2	2	2	2						
CO 6	-	2	2	-	2	2						

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Reference Books:

1. Jose, Jeeva. Taming Python By Programming. Khanna Book Publishing, 2017. Print.
2. S, Gowrishankar, and A, Veena. Introduction to Python Programming. Chapman & Hall/CRCPress, 2018.
3. Downey, Allen. Think Python. Green Tea Press, 2nd ed. 2009
4. VanderPlas, Jake. Python Data Science Handbook: Essential Tools for Working with Data. United States, O'Reilly Media, 2016.
5. Stephenson, Ben. *The Python Workbook*. SPRINGER INTERNATIONAL PU, 2016.

Programme	B. Sc. Computer Science and Mathematics(Double Major)				
Course Code	CSC4CJ205				
Course Title	**COMPUTER NETWORKS**				
Type of Course	**Major**				
Semester	IV				
Academic Level	200 – 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	1. Knowledge in Operating System.				
Course Summary	This course covers the concepts of data communication and computer networks. It comprises of the study of the standard models for the layered protocol architecture to communicate between autonomous computers ina network and also the main features and issues of communication protocols for different layers. Topics covered comprise of introduction to OSI and TCP/IP models also.				

Sl. NO:	Course Outcome	Cognitiv elevel *	Knowledg ecategory #	Evaluation Toolsused
CO1	To understand the fundamentals of computer networks including concepts likedata communication ,network topologies and the reference models	U	C	Instructor-CreateExams or Quiz
CO2	Proficiency in Transmission Media and Multiplexing Techniques:	A	P	Discussions andQuizzes
CO3	To familiarise with the common networking protocols and standards	U	F	Instructor created exams orHome assignments
CO4	Describe ,analyse and compare differentdata link, network and transport layer protocols	A, E	P	Discussions ,Quizzes
CO5	Design/implement data link and network layer protocols in simulated networking environment	Ap	P	Viva Voce Observation ofpractical skills
CO6	To understand the need of various Application layer protocols	U	M	Instructor Created -Exams, Assignments

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

(M)

Module	Unit	Content	Hrs	Marks
I	**Introduction to Computer networks and Network models**		**12**	**17**
	1	*Types of computer networks, Internet, Intranet, Network topologies, Network classifications.*	2	
	2	*Network Architecture Models: Layered architecture approach, OSI Reference Model, TCP/IP*	2	
	3	*Physical Layer: Analog signal, digital signal, Analog to Digital, Digital to Analog, maximum data rate of a channel Transmission*	4	
	4	*Transmission media (guided - unguided transmission media)*	2	
	5	*multiplexing (frequency division multiplexing, time division multiplexing, wavelength division multiplexing)*	2	
II	**Data Link Layer**		**11**	**18**

	6	*Data link layer services, error-detection* Types of errors, Single bit error and Burst error, Vertical redundancy check (VRC), longitudinal redundancy Check (LRC), Cyclic Redundancy Check (CRC),Check sum Error correction - Single bit error correction, Hamming code	2	
	7	*Error correction techniques,* *error recovery protocols (stop and wait, go back n, selective repeat),*	3	
	8	*multiple access protocols, (TDMA/FDP, CDMA/FDD/CSMA/CD, CSMA/CA),*	2	
	9	*Datalink and MAC addressing, Ethernet, Polling*	1	
	10	IEEE Standards- Wireless LANS,Ethernet,Bluetooth	3	
III	**Network layer**		**11**	**18**
	11	*Networking and Internetworking devices - Repeaters, Bridges, Routers, Gateways, Firewall*	2	
	12	*Logical addressing - IPv4 & IPv6 addresses, Network Address Translation (NAT), Internet protocols, internetworking, Datagram,*	2	
	13	*Transition from IPv4 to IPv6*	1	
	14	*Address Mapping-Error reporting and multicasting - Delivery,*	2	
	15	*Forwarding and Routing algorithms, Distance Vector Routing,*	2	
	16	*Link State Routing. Dijkstra*	2	
IV	**Transport Layer and Application layer**		**11**	**17**
	17	*Transport layer, Process-to-process Delivery: UDP, TCP*	2	
	18	*Congestion control and Quality of Service,*	2	
	19	*Domain Name Systems-Remote Login, Email*	2	
	20	*FTP, WWW, HTTP*	2	
	21	*Introductory concepts on Network management & Mailtransfer: SNMP,*	2	
	22	*SMTP*	1	
V	**Hands-on Computer Networks:** **Practical Applications,**		**30**	

	1	Lab 1: identifying Networking Hardware components(Jacks,Cables, Tools) Lab 2 IP address - configuring.Lab3. crimping Lab 4: Configuring network host - setting hostname -assigning IP address Lab 5: configuring the Network Interface card – Lab 6: Setup a Wired LAN with more than two systems Lab 7:Setup a Wireless LAN with more than two systems Lab 8: Setting up Internet services File TransferProtocol(FTP), Lab 9: Simple Mail Transfer Protocol(SMTP) and Post Office Protocol(POP) Lab 10: Setting up Intranet Services - Network FileSystem(NFS),	20	
	2	Case study	3	
	3	**Capstone (/Course) Project:** Build a practical applicationusing Wired Network	7	

References:

1. *Behurouz A Forozan, Introduction to Data Communications & Networking, TMH*
2. *Andrew S. Tanenbaum, Computer Networks, PHI*
3. *William Stallings, Data and Computer Communications, VIIth Edition, Pearson Education*

Programme	B. Sc. Computer Science and Mathematics(Double Major)				
Course Code	CSC5CJ302				
Course Title	**OBJECT ORIENTED PROGRAMMING (JAVA)**				
Type of Course	**Major**				
Semester	V				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	1. Knowledge in basic programming 2. Knowledge in OOP Concepts				
Course Summary	The aim of this course is to provide students with an understanding of the basic concepts in Java programming. This course will help students create GUI applications in Java and establish database connectivity.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	To understand the concepts and features of Object Oriented Programming(OOPs)	U	C	
CO2	To practice programming in Java	Ap	P	
CO3	To learn java's exception handling mechanism, I/O operations and multithreading.	Ap	P	
CO4	To learn java's O operations and multithreading.	Ap	P	
CO5	Implement programs using Java Database Connectivity	Ap	P	
CO6	Students will be capable of developing Graphical User Interface (GUI) applications using Swing, understanding layout management, and implementing basic event handling.	Ap	P	
* - 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	Mark (70)
I	**Review of OOPs and Introduction to Java**		**17**	**20**
	1	Overview of OOPs Concept	1	
	2	History of Java and Java Virtual Machine	1	
	3	Basic Structure of Java Programming : Data Types, Operators, Expression and Control Statement	2	
	5	Arrays and String: One Dimensional Array, Multidimensional Array, String Operations	2	
	6	Scanner, Type Conversion and Casting	2	
	7	Introduction to Class and Objects: Definition of Class and Objects, Access Modifier	2	
	8	Constructor and Inheritance: Types of Constructors, Types of Inheritance, use of extends, super, final, this keyword	3	
	9	Method Overriding, Method Overloading and Dynamic Method Dispatch : Programming implementation of Method Overriding and Overloading	2	
	10	Interface, Abstract Class and Packages ; Programming implementation of Interface, Abstract class and Packages	2	
II	**Exception and I/O Operations**		**8**	**15**
	11	Exception: Baic Concept of exception and Exception Hierarchy	2	
	12	Managing Exception: Use of try….catch ….. finally blocks, throw and throws keyword	2	
	13	Managing Input/Output files in Java : Importance of I/O Operations, BufferedInputStream, BufferedOutputStream	2	
	14	File Operations : Programming implementation of FileInputStream, FileOutputStream, FileReader, FileWriter	2	
III	**Multithreading and Database Connectivity**		**9**	**20**
	15	Thread : Concept of Thread and Thread state	2	
	16	Programming Implementation of Thread : Using extending thread class and Runnable interface, Thread Priorities	2	

	17	Database Programming : Basic Concept of Database and JDBC Driver, Connecting with Database	2	
	18	Querying Database: Programming implementation of creating table, insert and update values to the table using	3	
		preparedStatement, Statement object and querying the values using ResultSet and ResultSetMetadata		
IV	**GUI Programming**		**11**	**15**
	19	Introduction to GUI Application : AWT Basics, Introduction to IDE	2	
	20	Swing Programming : Introduction of Model-View-Controller Pattern	2	
	21	Introduction to layout Management : Fundamental controls used in SWING	4	
	22	Event Handling : Basic Knowledge of Event Handling(Event Class and Event Listener)	3	
V	**Hands-on Programming in Java(Using IDE NetBeans, Eclipse, VSCode):**		**30**	**30**
	Practical Applications, Case Study and Course Project			
	1	Implement the following:		
		1. String and Arrays:	20	
		Write a program to perform various String operations in Java(Hint: charAt, substring, concat, equals,, isEmpty..)		
		Write a program to implement Multi-Dimensional Array(Hint : Matrix multiplication)		
		2. Object Oriented Programming Concept:		
		Write a program to implement the concept of class and object.(Hint: Complex Number addition)		
		Write a program to demonstrate the order in which constructors are invoked in multilevel inheritance.		
		Write a program to implement method overloading		
		Write a program to implement method overriding.		
		3. Exception Handling and Multithreading:		
		Write a program to implement try…cath, finally block (Hint: Arithmetic and ArrayOutOfBoundException)		

		Write a multi thread java program for displaying odd numbers and even numbers up to a limit (Hint :Create thread by inheriting Thread class).		
		Write a multi thread java program for displaying odd numbers and even numbers up to a limit (Hint : Implement thread using Runnable interface).		
		4. GUI Application with Database:		
		Write a swing program to track mouse & key events		
		Write a swing program to fetch data from TextFiled and display it in Label		
		Write a swing program to perform form validation		
		Write a swing program to display data in tabular form		
		Write a simple login program without database connectivity		
		Write a swing program to create a registration form (Hint : Create table student in any database and link the registration form with database using JDBC)		
	2	Case Study	2	
	3	**Project:** Build a application for shop management system (Eg: Admin Login, Product registration, stock management, product selling, employee salary)	8	

Text Book :

1. Herbert Scheldt, Java: The Complete Reference, 12th Edition, Tata McGraw-Hill Edition, ISBN:9781260463415.

References :

1. C. Thomas Wu, An introduction to Object-oriented programming with Java, 5e, McGraw-Hill,2009.
2. Y. Daniel Liang, Introduction to Java programming, Comprehensive Version, 10e, Prentice HallIndia, 2013.
3. K. Arnold, J. Gosling, David Holmes, The JAVA programming language, 4e, Addision- Wesley,2005.

Mapping of COs with PSOs and POs :

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

CO 4	-	-	2	3	-	-						
CO 5	-	-	3	3	2	3						
CO 6			3	3	3							

Correlation Levels:

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

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓

Programme	B. Sc. Computer Science and Mathematics(Double Major)				
Course Code	CSC5CJ303				
Course Title	**FULL STACK WEB DEVELOPMENT**				
Type of Course	**Major**				
Semester	V				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	1. Fundamental of Web Pages and web servers 2. Basics of HTML				

Course Summary	This course provides the ideas, techniques, and applications for efficien Web Development. The advanced industry demand and emerging trend are covered in this syllabus.

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the concepts to create responsive web pages using HTML and CSS	U	C	Instructor-created exams / Quiz
CO2	Familiarization with Client-side Scripting using JavaScript	U	C	Practical Assignment / Observation of Practical Skills
CO3	Understand Node.JS and equip learners with a comprehensive understanding of NodeJS and its functionalities.	U	F	Seminar Presentation / Group Tutorial Work/ Viva Voce
CO4	Understanding and building interactive web pages using React JS.	U	P	Instructor-created exams / Home Assignments
CO5	Familiarization with SQL and NoSQL	Ap	P	Writing assignments/ Instructor-created exams/ practicals

CO6	Explore MongoDB and Develop real-world web applications using various technologies learned in the Course	Ap	P	Case Study/ mini Project/ practicals

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)

- Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45+30)	Marks (70)
I	**HTML & CSS**		**9**	**12**
	1	Introduction to HTML5 Tags, Attribute and Elements Doctype Element, Comments	2	2
	2	Semantic tags Headings, Paragraphs, and Formatting Text Lists, Links, Images-	1	2
	3	Forms and Tables Introduction CSS Applying CSS to HTML.	2	2
	4	Selectors, Properties and Values CSS Colors and Backgrounds CSS Box Model	3	5
	5	CSS Margins, Padding, and Borders CSS Text and Font Properties Webpage Layout Responsive web design	1	1
II	**JavaScript & Node.JS**		**11**	**15**
	6	Introduction to JavaScript Applying JavaScript (internal and external) Understanding JS Syntax	1	2
	7	Introduction to Document and Window Object Variables and Operators Data Types and Num Type Conversion	1	2
	8	Math and String Manipulation Objects and Arrays Date and Time Conditional Statements	2	3
	9	Switch Case Looping in JS Functions	2	2

	10	Node.JS Overview Node.JS - Basics and Setup Node.JS Console Node.JS Command Utilities Node.JS Modules	3	3
	11	Node.JS Concepts Node.JS Events Node.JS with Express js Node.JS Database Access	2	3
III	**React.JS**		**12**	**15**
	12	Introduction Templating using JSX	2	3
	13	Components, State and Props Lifecycle of Components Rendering List and Portals	3	3
	14	Redux and Redux Saga Immutable.js Service Side Rendering	2	3
	15	Unit Testing	2	3
	16	Webpack	3	3
I V		**MongoDB**	**13**	**20**
	17	SQL and NoSQL Concepts	3	4
	18	Create and Manage MongoDB	2	3
	19	Migration of Data into MongoDB	1	3
	20	MongoDB with PHP	1	3
	21	MongoDB with NodeJS.	2	4
	22	Services Offered by MongoDB	3	3
V	**Practical Implementations of Full Stack Web Development**		**30**	**20**
	1	● Webpage Development using HTML And CSS	25	
		● Webpage Development using Javascript & Node.JS ● Webpage Development using React.JS With Backend MongoDB		
	2	Case Study/ Project	**5**	

References Books

1. Hawramani, Ikram. HTML, CSS and JavaScript for Complete Beginners: A Step by Step Guide to Learning HTML5, CSS3 and the JavaScript Programming Language. United States, Amazon Digital Services LLC - KDP Print US, 2018.

2. Soni, Ravi Kant. Full Stack AngularJS for Java Developers: Build a Full-Featured Web Application from Scratch Using AngularJS with Spring RESTful. United States, Apress, 2017.

3. Northwood, Chris. The Full Stack Developer: Your Essential Guide to the Everyday Skills Expected of a Modern Full Stack Web Developer. Germany, Apress, 2018.

4. Sharma, Aneeta. Full-Stack Web Development with Vue. Js and Node: Build Scalable and Powerful Web Apps with Modern Web Stack: MongoDB, Vue, Node. Js, and Express. United Kingdom, Packt Publishing, Limited, 2018.

5. Sharma, Manu. Mongodb Complete Guide: Develop a Strong Understanding of Administering Mongodb, Crud Operations, and Mongodb Commands. India, Bpb Publications, 2021.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	1	3	2	2	3						
CO 2	-	1	3	3	3	2						
CO 3	-	1	3	3	3	2						
CO 4	-	1	3	3	3	2						
CO 5	-	1	3	3	3	2						
CO 6	-	1	3	3	3	2						

Correlation Levels:

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

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	End Semester Examinations	Practical
CO 1	✓		✓	
CO 2	✓	✓	✓	✓
CO 3	✓	✓	✓	✓
CO 4	✓	✓	✓	
CO 5	✓	✓	✓	✓
CO 6	✓		✓	✓

Programme	B. Sc. Computer Science and Mathematics(Double Major)				
Course Code	CSC6CJ305				
Course Title	**PRINCIPLES OF OPERATING SYSTEM**				
Type of Course	**Major**				
Semester	VI				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Knowledge in Basic System Architecture				
Course Summary	This course provides students with a comprehensive understanding of the fundamental principles, design concepts, and practical implementation aspects of operating systems. The course covers key topics such as Process Management, CPU Scheduling, Memory Management and Linux Shell Programming concepts.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Summarize the History, Objectives and Functions of an operating system	U	C	Instructor-created exams / Quiz
CO2	Understand process management concepts: Process Control Block, States, Scheduling, Operations, Inter process Communication	U	C	Instructor-created exams
CO3	Evaluate various processor scheduling strategies, algorithms	E	P	Seminar Presentation / Group Tutorial Work
CO4	Apply process synchronisation concepts for effective process management	Ap	P	Viva Voce
CO5	Analyse conditions for deadlock occurrence and methods of resolving.	An	C	Instructor-created exams/Assignments
CO6	Describe various memory management techniques, including paging , segmentation and virtual memory	U	C	Instructor-created exams / Home Assignments
CO7	Develop Shell Scripts using Linux	C	P	Practical Assignment / Observation of Practical Skills

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

Detailed Syllabus:

Module	Unit	Content	Hrs (45+30)	Marks (70)
I	**Introduction to Operating Systems & Process Management**		**10**	**15**
	1	Operating System: History, Types, Objectives and Functions	2	
	2	Process Concepts: Process States, Process Control Block	2	
	3	Types of Process Schedulers and Operations on Process	2	
	4	Co operating Processes	2	
	5	Inter Process Communication	2	
II	**CPU Scheduling, Process Synchronisation and Deadlocks**		**15**	**20**
	6	Basic Scheduling Concepts, Scheduling Criteria	1	
	7	CPU Scheduling Algorithms	2	
	8	Process Synchronisation: Critical Section	2	
	9	Semaphores	2	
	10	Classical Problems of Synchronisation: Reader Writer, Dining Philosopher	2	
	11	Introduction to Deadlock: Necessary Conditions, Resource Allocation Graph	2	
	12	Handling Deadlocks: Prevention, Avoidance, Detection & Recovery	4	
III	**Memory Management Techniques**		**10**	**20**
	13	Basic Concepts: Physical VS Logical Address, Continuous Memory Allocation	2	
	14	Fragmentation Problem and Solutions	1	
	15	Non contiguous Memory Allocation: Paging	2	
	16	Non contiguous Memory Allocation: Segmentation, Segmentation with Paging	2	
	17	Virtual Memory Concepts: Demand Paging and Page Replacement Algorithms, Thrashing	3	
IV	**Linux Shell Programming**		**10**	**15**
	18	Introduction: Types of Linux Shells, File Directory & File Management Commands:ls, cd,pwd,mkdir,rm,cp,mv, chmod,touch Input/Output Commands: read, echo, Text Processing Commands: grep , cat	2	
	19	Piping and Redirection operators: |,>,<,>>,<< Arithmetic, Logical and Relational Operator	2	
	20	Iterative and Conditional Commands : if, while, for, break, continue, case	2	
	21	Arrays and functions	2	
	22	Command line arguments, Network commands: ipconfig, ping, date and time commands, Informative commands: random, w, ps, free, uptime	2	
V	**Practical Applications using Linux Shell Programming**		**30**	

		Implement the following: 1. Write a Shell Script to find the roots of a quadratic equation. 2. Write a shell script for a menu driven program to perform file management (File creation, display content, remove, write content to a file). 3. Write a shell script to count no of line, words and characters of an input file. 4. Write a shell script to find the average of the number entered as command line arguments. 5. Write a shell script to copy the contents of file to another. Input file names through command line. The copy should not be allowed if second file exists. 6. Write a shell script to check network connectivity. 7. Write a shell script that analyzes a log file, extracting and summarizing relevant information such as error counts ,warning messages, info and debug messages using grep command. 8. Write a shell script to display current date and time, list all user account names, count of logged in user accounts, list all logged in user accounts with login time. 9. Write a simple game script using random function to implement number guessing game. 10. Write a shell script to display your system details (number of users, current processes, memory usage , system running time).	30	
		11. Write a shell script to implement and examine the effectiveness of the First Come First Serve CPU Scheduling algorithm. Find the average waiting time and turnaround time. 12. Write a shell script program to implement Inter Process Communication.		

References

1. Silberschatz, Galvin and Gagne, Operating System Concepts, John Willey & Sons

2. William Stallings, Operating Systems, Internals and Design Principles, PHI

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	-	-	-	-	-						
CO 2	-	2	-	-	-	-						
CO 3	-	3	-	1	-	-						
CO 4	-	2	2	-	-	-						
CO 5	-	3	-	-	-	-						
CO 6	-	3	-	-	-	-						

CO7	-	-	2	2	-	-						

Correlation Levels:

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

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Practical Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5	✓			✓
CO 6	✓			✓
CO7			✓	

Syllabus of Major Courses in Mathematics

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

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Analyse a function for its limits, continuity and differentiability and evaluate limits and derivatives.	An	F	Internal Exam/Assignment /Seminar/Viva/ End Sem Exam
CO2	Apply first and second derivatives and related theorems to find extrema of functions.	Ap	F	Internal Exam/Assignment /Seminar/Viva/ End Sem Exam
CO3	Sketch the graph of functions by analysing critical points and asymptotes	An	F	Internal Exam/Assignment /Seminar/Viva/ End Sem Exam

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

Detailed Syllabus:

Textbook	Calculus and Analytic Geometry, 9th Edition, George B. Thomas, Jr. Ross L. Finney, Pearson Publications, 2010, ISBN: 978-8174906168.

Module	Unit	Content	Hrs (48+12)	Marks Ext: 70
I		**Module I**	12	Min.15
	1	Preliminaries: Section 3 – Functions		
	2	Preliminaries: Section 4 - Shifting Graphs.		
	3	Section 1.1-Rates of Change and Limits - Limits of Function Values onwards.		
	4	Section 1.2 - Rules for Finding Limits. Topics up to and including Example 3.		
	5	Section 1.2 - Rules for Finding Limits. Rest of the section.		
	6	Section 1.4- Extensions of the Limit Concept. Topics up to and including Example 6.		
II		**Module II**	15	Min.15
	7	Section 1.5 - Continuity.		
	8	Section 2.1 - The Derivative of a Function (The topic Graphing f' from estimated values is optional).		
	9	Section 2.2 - Differentiation Rules.		
	10	Section 2.3 - Rates of Change. Topics up to and including Example 5.		
	11	Section 2.5 - The Chain Rule. Topics up to and including Example 6.		
	12	Section 2.6- Implicit Differentiation and Rational Exponents. Topics up to and including Example 5.		
III		**Module III**	11	Min.15
	13	Section 3.1 - Extreme Values of Functions. Topics up to Finding Extrema.		
	14	Section 3.1 - Extreme Values of Functions- Topics from Finding Extrema onwards.		
	15	Section 3.2 - The Mean Value Theorem -Topics up to and including Example 4. (Proof of Theorem 3 is optional).		
	16	Section 3.2 - The Mean Value Theorem- Increasing Functions and Decreasing Functions		
	17	Section 3.3 - The First Derivative Test for Local Extreme Values.		
IV		**Module IV**	10	Min.15
	18	Section 3.4 - Graphing with y' and y'' - Topics up to and including Example 5.		
	19	Section 3.4 - Graphing with y' and y''- Topics from The Second Derivative Test for Local Extreme Values onwards.		
	20	Section 3.5 - Limits as $x \to \pm\infty$, Asymptotes and Dominant Terms. - Topics up to and including Summary for Rational Functions.		
	21	Section 3.5 - Limits as $x \to \pm\infty$, Asymptotes and Dominant Terms- Topics from Horizontal and Vertical Asymptotes up to and including Example 12.		
	22	Section 3.5 - Limits as $x \to \pm\infty$, Asymptotes and		

		Dominant Terms-Topics from Graphing with Asymptotes and Dominant Terms onwards.		
V	**Module V (Open Ended)**	Trigonometric Functions, Target Values and Formal Definitions of Limits, Derivatives of Trigonometric Functions, Power Rule of Differentiation for rational powers, Optimization, Linearization and Differentials.	**12**	

References

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

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

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

Mapping of COs with PSOs and POs :

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

Correlation Levels:

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

Assessment Rubrics:

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

Mapping of COs to Assessment Rubrics:

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

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

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Solve indefinite and definite integrals of functions.	Ap	F	Internal Exam/Assignment /Seminar/Viva/ End Sem Exam
CO2	Learn logarithmic, exponential, inverse	U	F	Internal

	trigonometric functions and to evaluate derivatives and integrals of the above transcendental functions and use it for computations of other limits			Exam/Assignment /Seminar/Viva/ End Sem Exam
CO3	Apply integration formulas to find the area between two curves, the surface area and volume of a solid of revolution.	Ap	F	Internal Exam/Assignment /Seminar/Viva/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

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

	14	Section 7.1 - Basic Integration Formulas.		
	15	Section 7.2 - Integration by Parts		
	16	Section 7.3 Partial Fractions.		
IV	**Module IV**		**11**	**Min.15**
	17	Section 5.1 - Areas Between Curves. - Topics up to and including Example 2.		
	18	Section 5.1 - Areas Between Curves- Topics from Boundaries with Changing Formulas		
	19	Section 5.2 - Finding Volumes by Slicing. (Example 2 may be done as open ended).		
	20	Section 5.3 - Volumes of Solids of Revolution- Disks and Washers - Topics up to and including Example 4.		
	21	Section 5.5 - Lengths of Plane Curves. - Topics up to and including Example 2.		
	22	Section 5.6 - Areas of Surfaces of Revolution- Topics up to and including Example 2.		
V	**Module V (Open Ended)**		**12**	
	Inverse Functions and their Derivatives, a^x and $\log_a x$, Inverse Trigonometric Functions and their derivatives, Hyperbolic Functions, Integrals and their derivatives, Integration using trigonometric substitutions, Moments and Center of Mass.			

References

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

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

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

Mapping of COs with PSOs and POs:

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

Correlation Levels:

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

Assessment Rubrics:

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

Mapping of COs to Assessment Rubrics:

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

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

Course Outcomes:

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

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

Detailed Syllabus:

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

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

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

References

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

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

Mapping of COs with PSOs and POs :

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

Correlation Levels:

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

Assessment Rubrics:

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

Mapping of COs to Assessment Rubrics:

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

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

Course Outcomes (CO):

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

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

Detailed Syllabus:

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

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

	18	Section 13.1: Double Integrals	
		Double Integrals over Bounded Nonrectangular Regions, Finding the Limits of Integration.	
	19	Section 13.2: Areas, Moments and Centers of Mass Areas of Bounded Regions in the Plane, Average Value.	
	20	Section 13.3: Double Integrals in Polar Form Integrals in Polar Coordinates, Limits of Integration, Changing Cartesian Integrals into Polar Integrals.	
	21	Section 13.4: Triple Integrals in Rectangular Coordinates Triple Integrals, Properties of Triple Integrals, Volume of a Region in Space, Evaluation.	
	22	Section 13.4: Triple Integrals in Rectangular Coordinates Average Value of a Function in Space.	
V	**Practicum**		**30**
	Triple Integrals in Cylindrical Coordinates, Spherical coordinates Substitution in Multiple Integrals Vector Valued Functions and Space Curves Line Integrals Vector Fields, Work, Circulation and Flux Path Independence, Potential Functions and Conservative Fields. Green's Theorem in the Plane (Proof is Optional) Surface area and surface integrals Parametrized surfaces Stoke's theorem (Proof is optional) The Divergence theorem (Proof is Optional)		

References:

1. Anton, Bivens & Davis : Calculus Early Transcendentals (10/e) John Wiley & Sons, Inc.(2012) ISBN: 9780470647691
2. Arnold Ostebee & Paul Zorn: Multivariable Calculus (2/e) W. H. Freeman Custom Publishing, N.Y.(2008)ISBN: 9781429230339
3. James Stewart : Calculus (8/e) Brooks/Cole Cengage Learning(2016) ISBN:9781285740621
4. Jerrold E. Marsden & Anthony Tromba :Vector Calculus (6/e) W. H. Freeman and Company ,New York(2012) ISBN: 9781429215084
5. Joel Hass, Christopher Heil & Maurice D. Weir : Thomas' Calculus (14/e) Pearson(2018) ISBN 0134438981
6. Jon Rogawski: Multivariable Calculus Early Transcendentals (2/e) W. H. Freeman and Company(2012) ISBN: 1429231874
7. Robert A Adams & Christopher Essex : Calculus: A complete Course (8/e) Pearson Education Canada (2013) ISBN: 032187742X
8. William Wade: An Introduction to Analysis, (4/e) Pearson Education

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

Mapping of COs with PSOs and POs :

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

Correlation Levels:

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

Assessment Rubrics:

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

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Seminar	Report	End Semester Examinations

CO 1	√	√			√
CO 2	√		√	√	√
CO 3	√		√	√	√

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

Course Outcomes (CO):

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

Detailed Syllabus:

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

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

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

References

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

*Optional topics are exempted for end semester examination

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

Mapping of COs with PSOs and POs :

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

Correlation Levels:

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

Mapping of COs to Assessment Rubrics:

Assessment Rubrics:

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

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

Programme	B. Sc. Computer Science and Mathematics(Double Major)			
Course Code	MAT4CJ203			
Course Title	**REAL ANALYSIS I**			
Type of Course	**Major**			
Semester	IV			
Academic Level	200 – 299			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	3	2	75
Pre-requisites	1. Mathematical Logic and necessary exposure to set theory. 2. Basic Calculus			
Course Summary	After introducing the basic notions in set theory, the course develops into the construction of the Real number system. 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	Demonstrate Proficiency in Set Theory Fundamentals and Real Number Properties	An	C	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO2	Apply the completeness property of $\mathbb{R}$, and solve problems involving intervals and applications of the supremum property.	U	C	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO3	Analyse sequences and their limits, apply limit theorems, and demonstrate an understanding of concepts such as monotone sequences, sub-sequences, and the Cauchy Criterion, as well as their applications in solving problems related to sequences and limits.	An	C	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

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

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

References

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

Optional Programming References for Practicum:

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

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

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

Mapping of COs with PSOs and POs :

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

Correlation Levels:

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

Assessment Rubrics:

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

Mapping of COs to Assessment Rubrics:

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

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

Course Outcomes (CO):

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

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

Detailed Syllabus:

Text book	A first course in abstract algebra, Fraleigh, John B.. Seventh Edition, Pearson Education India, 2003

Module	Unit	Content	Hrs (48+12)	Marks Ext(70)
I		**Module I**	12	Min.15
	1	Section 2- Binary Operations (2.1 to 2.10)		
	2	Section 2- Binary Operations (2.11 to 2.25)		
	3	Section 3- Isomorphic Binary Structures (3.1 to 3.11).		
	4	Section 3- Isomorphic Binary Structures (3.12 to 3.17)		
	5	Section 4- Groups (4.1 to 4.14)		
	6	Section 4- Groups – Elementary Properties of Groups, Finite Groups and Group tables (4.15 onwards)		
II		**Module II**	14	Min.15
	7	Section 5- Subgroups (5.1 to 5.16)		
	8	Section 5 -Subgroup - Cyclic Subgroups (5.17 to 5.23)		
	9	Section 6 -Cyclic Groups (6.1 to 6.9) (Proof of Theorem 6.3 is optional)		
	10	Section 6- Cyclic Groups (6.10 to 6.17) (Proof of Theorem 6.14 is optional).1		
	11	Section 8-Groups of Permutations (up to 8.6)		
	12	Section 8- Groups of Permutations (8.7 to 8.18)		
III		**Module III**	10	Min.15
	13	Section 9 - Orbits, Cycles, and the Alternating Groups (Up to 9.10)		
	14	Section 9 - Orbits, Cycles, and the Alternating Groups (9.11 to 9.21) (Proof 2 of theorem 9.15 is optional).		
	15	Section 10- Cosets and the theorem of Lagrange (Up to 10.9)		
	16	Section 10- Cosets and the theorem of Lagrange (10.10 to 10.14)		
IV		**Module IV**	12	Min.15
	17	Section 13- Homomorphisms (13.1 to 13.10)		
	18	Section 13-Homomorphism (13.11 to 13.20)		
	19	Section 18-Rings and Fields (18.1 to 18.13)		
	20	Section 18-Rings and Fields (18.14 to 18.18)		
	21	Section 19-Integral Domains (19.1 to 19.8)		
	22	Section 19-Integral Domains (19.9 to 19.15)		
V		**Module V (Open Ended)**	12	-
		Generating Sets in Groups		
		Factor Groups		
		The Field of Quotients of an Integral Domain		

References

1. Herstein, Israel Nathan. *Topics in algebra*. John Wiley & Sons, 1991.
2. Gallian, Joseph. *Contemporary abstract algebra*. Chapman and Hall/CRC, 2021.

3. Wallace, David AR. *Groups, rings and fields*. Springer Science & Business Media, 2001
4. Reis, Clive. *Abstract algebra: an introduction to groups, rings and fields*. World Scientific Publishing Company, 2011.
5. Allan Clark, *Elements of Abstract Algebra,* Dover Publications, 1984

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

Suggested Programming Exercises for Open-Ended

1. Form congruence groups, their Cayley tables (Section 9.2, Ref (3)).
2. Form symmetric groups of various orders, list the elements, find the power of some elements, find out the product of some of the elements. Find the order of the elements. Form a group table using conditionals and loops. (Section 9.3, Ref (3) or Ref (1)).
3. List S_3. Find a subgroup from this group. How many distinct subgroups can be found from this group? List all of them.
4. Form the Dihedral group D_4, check if it is abelian using is_abelian(). Conduct the same experiments as listing the elements ,finding the orders etc as above. (Section 9.4, Ref (3) or Ref (1)).
5. Test the command is normal () on a few subgroups of S_3. (Ref (1)).
6. Create cyclic groups. (Section 9.5, Ref (3)).
7. Form finitely generated abelian groups. (Section 9.6, Ref (3)).
8. Form a subgroup of a group (say, S_3) (Section 9.8, Ref (3)).

References

1. Robert A. Beezer; Group Theory and SAGE: A Primer, http://people.reed.edu/~davidp/332/sage-group-theory.pdf
2. Group Theory and Sage - SageMath tutorial https://doc.sagemath.org/html/en/thematic_tutorials/group_theory.html
3. Ajit Kumar, Vikas Bist; Group Theory An Expedition with SageMath, Narosa Publishing House.
4. Thomas W. Judson, Robert A. Beezer; Abstract Algebra Theory and Applications with Sage Exercises for Abstract Algebra, http://abstract.ups.edu/download/ aata-20130816.pdf

Mapping of COs with PSOs and POs :

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

Correlation Levels:

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

Assessment Rubrics:

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

Mapping of COs to Assessment Rubrics:

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

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

Course Outcomes (CO):

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

Detailed Syllabus:

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

V	IVP and BVP Problem-solving using mathematical software like Sage/Python/ Mathematica/Matlab/ Maple/Scilab etc (Instructor may choose any software appropriately)	**12**	
	Suggestions: ● Plotting solution curves -2 hrs ● Solve first order initial value problems -2 hrs ● Solve second order initial value problems -2 hrs ● Plot Laplace transform of given function -2 hrs ● find Laplace transform and inverse Laplace transform - 2 hrs ● Solve the initial value problem using Laplace transform -2 hrs		

References

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

*Optional topics are exempted for end semester examination.

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

Mapping of COs with PSOs and POs :

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

Correlation Levels:

Level	Correlation
-	Nil

1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

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

Mapping of COs to Assessment Rubrics:

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

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

Course Outcomes (CO):

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

Detailed Syllabus:

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

	19	Section 6.6- Some Consequences of the Residue Theorem- Evaluation of Real Trigonometric Functions (up to and including example1 of 6.6.1)		
	20	Section 6.6 -Some Consequences of the Residue Theorem- Evaluation of Real Improper Integrals(up to and including Example 2)		**Min.15**
	21	Section 6.6 -Some Consequences of the Residue Theorem- Theorem 6.6.1 and Example 3.		
	22	Section 6.6 -Some Consequences of the Residue Theorem- Theorem 6.6.2 and Example 4.		
V	**Module V (Open Ended)**			
		Definite Integrals, Line Integrals in the Plane, Indented Contours	**12**	
		Integration along a Branch Cut, The Argument Principle		
		Rouche's Theorem and its applications		
References				
	1	Brown, James Ward, and Ruel V. Churchill. Complex variables and applications. McGraw-Hill,, 2009.		
	2	Stein, Elias M., and Rami Shakarchi. Complex analysis. Vol. 2. Princeton University Press, 2010.		
	3	Burckel, Robert B. An Introduction to Classical Complex Analysis: Vol. 1. Vol. 64. Birkhäuser, 2012.		
	4	Hormander, Lars. An introduction to complex analysis in several variables. Elsevier, 1973.		
	5	Priestley, Hilary A. Introduction to complex analysis. OUP Oxford, 2003.		
	6	Silverman, Richard A. Introductory complex analysis. Courier Corporation, 2013.		
	7	Bak, Joseph, Donald J. Newman, and Donald J. Newman. *Complex analysis*. Vol. 8. New York: Springer, 2010.		

*Optional topics are exempted for end semester examination.

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

Mapping of COs with PSOs and POs :

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

Correlation Levels:

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

Assessment Rubrics:

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

Mapping of COs to Assessment Rubrics:

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

ELECTIVE COURSES IN COMPUTER SCIENCE WITH SPECIALISATION

Group No.	Sl. No.	Course Code	Title	Semester	Total Hrs	Hrs/ Week	Credits	Marks		
								Internal	External	Total
1		**DATA SCIENCE**								
	1	CSC5EJ305a	Mathematical and Statistical Foundation for Data Science	5	60	4	4	30	70	100
	2	CSC5EJ306a	Exploratory Data Analysis	5	60	4	4	30	70	100
	3	CSC6CJ311a	Introduction to Data Warehousing and Big Data	6	60	4	4	30	70	100
	4	CSC6CJ312a	Advanced Python for Data Science	6	60	4	4	30	70	100
2		**AI and ML**								
	1	CSC5EJ305b	Machine Learning Algorithms	5	60	4	4	30	70	100
	2	CSC5EJ306b	Knowledge Engineering	5	60	4	4	30	70	100
	3	CSC5EJ311b	Soft Computing	6	60	4	4	30	70	100
	4	CSC5EJ312b	Deep Learning	6	60	4	4	30	70	100
3	**Cloud Computing**									
	1	CSC5EJ305c	Cloud Computing	5	60	4	4	30	70	100
	2	CSC5EJ306c	Security and Privacy in Cloud	5	60	4	4	30	70	100
	3	CSC6CJ311c	Storage Technologies	6	60	4	4	30	70	100
	4	CSC6CJ312c	Virtualization	6	60	4	4	30	70	100

Programme	B. Sc. Computer Science and Mathematics(Double Major)
Course Code	**CSC5EJ305a**
Course Title	**Mathematical and Statistical Foundations for Data Science**
Type of Course	Elective
Semester	V
Academic Level	300-399

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	1. Basic Mathematics and Statistics 2. Python basics (If Python implementation is preferred in module V by the course tutor)				
Course Summary	This undergraduate course provides the fundamental mathematical and statistical tools necessary for understanding and analyzing data in the context of data science. The course covers topics ranging from basic algebraic operations to advanced statistical techniques.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Apply Vector and Matrix operations to solve computational problems.	Ap	P	Instructor-created exams / Assignment
CO2	Students will evaluate eigenvalues and eigenvectors to decompose matrices, enabling them to analyze and interpret data transformations effectively.	An	P	Instructor-created exams / Assignment
CO3	Students will apply fundamental probability concepts to solve real-world problems.	Ap	P	Assignment / Quiz
CO4	Students will utilize statistical techniques for data interpretation and decision-making	Ap	P	Instructor-created exams / Assignment
CO5	Students will apply sampling techniques and hypothesis tests to make inferences aboutpopulations from sample data, using one-tailed, two-tailed tests, and ANOVA for analysis	Ap	Q	Assignment / Case Studies
CO6	Students will apply PCA to reduce data dimensionality, identify principal components, and interpret results in data science application.	Ap	R	Assignment / Case Studies

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

Detailed Syllabus:

Module	Unit	Content	Hrs (48+12)	Marks 70
I	**Linear Algebra**		**14**	**20**
	1	Scalars, Vectors, Matrices and Tensors Vectors:- Vector Arithmetic - Vector Addition, Vector Subtraction, Vector Multiplication, Vector Division; Vector Dot Product; Vector Scalar Multiplication	2	
	2	Matrix Multiplication, Identity and Inverse Matrices, Linear dependence and Span , Norms, Diagonal and Orthogonal Matrices	4	
	3	Eigenvectors and Eigenvalues , Eigen Decomposition	2	
	4	Singular Value Decomposition	2	
	5	The Trace Operator , The Determinant	2	
	6	Principal Component Analysis	2	
II	**Probability**		**14**	**20**
	7	Random Variables , Probability Distributions	3	
	8	Marginal Probability , Conditional Probability,	1	
	9	The Chain Rule of Conditional Probabilities	3	
	10	Independence and Conditional Independence	2	
	11	Expectation, Variance and Covariance	1	
	12	Common Probability Distributions - Bernoulli Distribution	3	
		Binomial, Normal and Poisson Distribution		
	13	Bayes' Rule	1	
III	**Basic Statistics**		**8**	**15**

	14	Measures of Central Tendency	3	
	15	Measures of Dispersion	2	
	16	Skewness, Kurtosis	1	
	17	Correlation and Regression	2	
IV	**Sampling and Hypothesis Testing**		**12**	**15**
	18	Sampling distributions of the sample mean and the sample variance for a normal population	2	
	19	Point and interval estimation	1	
	20	Sampling distributions (Chi-square, t, F, Z)	3	
	21	Hypothesis testing	1	
	22	One tailed and two-tailed tests, Analysis of variance, ANOVA, One way and two way classifications.	5	
V	**Application oriented module**		**12**	
	Solve the following problems mathematically. Or Try to implement these problems using Python.			
	1	**Linear Algebra** Concepts to be learned:- • Vector arithmetic (a) Define a vector *a* and *b* with the length of 3 and the integer values 1, 2 and 3. (b) Perform addition, subtraction, multiplication, division and dot product of the two vectors *a* and	1	

2	**Linear Algebra**	1 Concepts to be learned: - • Matrix arithmetic (a) Create two 2 row, 3 column matrices, say *A* and *B*. Perform matrix addition, subtraction, division and multiplication (element-wise matrix multiplication or the Hadamard product). (b) Create a matrix *A* with 3 rows and 2 columns, anda matrix *B* with 2 rows and 2 columns. Perform matrix dot product of matrices *A* and *B*.		
3	**Linear Algebra**	2 Concepts to be learned: - • Singular Value Decomposition • Orthogonal Matrices • Diagonal Matrix • Singular Value • Eigen values and Eigen Vectors • Matrix Multiplication Find the singular value decomposition of the matrix [2 2 -1 1]		
	4	**Basic Statistics**Concepts to be learned: - Measures of Central Tendency - Mean, Median, ModeFind the mean, the median, and the mode for the number of vehicles owned in a s survey of 52 households.	1	

x	0	1	2	3	4	5	6	7
f	2	12	15	11	6	3	1	2

<table>
<tr>
<td></td>
<td>5</td>
<td>Basic Statistics
Concepts to be learned: -
• Measures of Dispersion - Range, Variance, Standard Deviation
Find the range, the variance and the standard deviation for the sample of ten IQ scores randomly selected from a school for academically gifted students.
142 152 138 145 148 139 147 155 150 153</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Application of Probability
Concepts to be learned: -
• Probability basics
• Combinations
• Mutually exclusive events
• Complementary events
Of 10 girls in a class, 3 have blue eyes. If two of the girls are chosen at random, what is the probability that (i) both have blue eyes, (ii) neither has blue eyes, (iii) at least one has blue eyes?</td>
<td>1</td>
<td></td>
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<td>7</td>
<td>Application of Probability
Concepts to be learned: -
• Probability Basics
• Contingency Tables
• Marginal and Joint Probabilities
• Conditional Probability
The following two-way contingency table gives the breakdown of the population in a particular locale according to age and tobacco usage.
<table>
<tr><td rowspan="2">Age</td><td colspan="2">Tobacco Use</td></tr>
<tr><td>Smoker</td><td>Non-smoker</td></tr>
<tr><td>Under 30</td><td>0.05</td><td>0.20</td></tr>
<tr><td>Over 30</td><td>0.20</td><td>0.55</td></tr>
</table>
</td>
<td>1</td>
<td></td>
</tr>
</table>

		A person is selected at random. Find the probability of each of the following events. (a) The person is a smoker. (b) The person is under 30. (c) The person is a smoker who is under 30.		
	8	**Application of Probability** Concepts to be learned: - • Understand the characteristics of a normal distribution. • Calculating and interpreting z-scores. Suppose the heights H of 800 students are normally distributed with mean 66 inches and standard deviation 5 inches. Find the number N of students with heights (a) between 65 and 70 inches, (b) greater than or equal to 6 feet(72inches).	1	
	9	**Application of Probability** Concepts to be learned: - • Bayes' Theorem A patient goes to see a doctor. The doctor performs a test with 99 percent reliability--that is, 99 percent of people who are sick test positive and 99 percent of the healthy people test negative. The doctor knows that only 1 percent of the people in the country are sick. If the patient tests positive, what are the chances the patient is sick?	1	
	10	**Sampling and Hypothesis Testing** Concepts to be learned: - • Hypothesis testing Contingency tables, and • Chi-square analysis	1	

		A die is suspected of being biased. It is rolled 25 times with the following result: Outcome Frequency 1 9 2 4 3 1 4 8 5 3 6 0 Conduct a significance test to see if the die is biased. (a) What Chi Square value do you get and how many degrees of freedom does it have? (b) What is the p value?		
	11	**Sampling and Hypothesis Testing** Concepts to be learned: - • Central Limit Theorem • Sampling distribution of the Sample Mean • Standard Error of the Mean • Z-score • Normal Distribution Properties • Probability Calculation Suppose scores on an IQ test are normally distributed, with a mean of 100. Suppose 20 people are randomly selected and tested. The standard deviation in the sample group is 15. What is the probability that the average test score in the sample group will be at most 110?	1	

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO 1	3	-	2	2	2	2
CO 2	3	-	2	3	2	2
CO 3	3	-	3	3	2	2
CO 4	3	-	3	3	2	2
CO 5	3	-	3	3	2	2
CO 6	3	-	3	3	2	2

Correlation Levels:

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

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5	✓	✓	✓	✓
CO 6	c✓	✓	✓	

References

1. Ian Goodfellow, Yoshua Bengio, and Aaron Courville. Deep Learning. MIT Press, 2017.
2. Gilbert Strang. Introduction to Linear Algebra. 5th ed. Wellesley-Cambridge Press, 2016.
3. S. Ross, Introduction to Probability and Statistics for and Engineers and Scientists, Third Edition, Elsevier, 2004.

Programme	B. Sc. Computer Science and Mathematics(Double Major)
Course Code	**CSC5EJ306a**
Course Title	**Exploratory Data Analysis**
Type of Course	**Elective**

Semester	V				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	1. Basic Statistical Knowledge 2. Python Programming including knowledge in Pandas library				
Course Summary	This course explores the different visualization tools and techniques and teaches the application of these techniques using Python packages.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the importance of data visualization for business intelligence and decision making.	U	C	Instructor-created exams / Quiz
CO2	Understand different types of charts and plots such as line, area, histograms, bar, pie, box, scatter, and bubble.	U	C	Instructor-created exams / Quiz
CO3	Learn about categories of visualization and application areas.	R	C	Instructor-created exams / Quiz
CO4	Familiarize with the data visualization tools and techniques.	Ap	P	Assignments/ Case Studies
CO5	Familiarise with the Python libraries, such as Matplotlib, Seaborn, Folium, Bokeh and learn how to to tell a stimulating story.	Ap	P	Assignments/ Case Studies
CO6	Create advanced visualizations for geo spatial data.	Ap	P	Assignments/ Case Studies

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

Detailed Syllabus:

Module	Unit	Content	Hrs 48+12	Marks 70
	Introduction to Data Visualization		**15**	**20**

I	1	Data:- Types of Data-Structured and Unstructured Data, Qualitative and Quantitative Data, Continuous and Discrete Data, Primary and Secondary Data, Data Attributes - Types of Data Attributes - Nominal, Ordinal, Interval, Ratio	3	
	2	Introduction to Data Visualization:- Data Visualization, The Importance of Data Visualization, Overview of popular data visualization libraries in Python - Matplotlib, Seaborn, Folium, Bokeh	1	
	3	Plots:- Comparison Plots: Line Chart, Bar Chart and Radar Chart	2	
	4	Relation Plots: Scatter Plot, Bubble Plot, Correlogram and Heatmap	2	
	5	Composition Plots: Pie Chart, Stacked Bar Chart, Stacked Area Chart, Venn Diagram	3	
	6	Distribution Plots: Histogram, Density Plot, Box Plot, Violin Plot	2	
	7	Geo Plots: Dot Map, Choropleth Map, Connection Map	2	
II	**Data Visualization with Matplotlib**		**10**	**20**
	8	Introduction, Overview of Plots in Matplotlib Pyplot Basics: Creating Figures, Closing Figures, Format Strings, Plotting, Plotting Using pandas DataFrames, Displaying Figures, Saving Figures	3	
	9	Basic Text and Legend Functions: Labels, Titles, Text, Annotations, Legends	1	
	10	Basic Plots: Bar Chart, Pie Chart, Stacked Bar Chart, Stacked Area Chart, Histogram, Box Plot, Scatter Plot, Bubble Plot	3	
	11	Layouts: Subplots, Tight Layout, Radar Charts, GridSpec	2	
	12	Images: Basic Image Operations, Writing Mathematical Expressions	1	
III	**Simplifying Visualizations using Seaborn**		**12**	**15**
	13	Introduction, Advantages of Seaborn, Plot a Relation Plot, Line Plot, Box Plot and, a Heat Map	2	
	14	Controlling Figure Aesthetics: Seaborn Figure Styles, Removing Axes Spines, Contexts	2	
	15	Color Palettes: Categorical Color Palettes, Sequential Color Palettes, Diverging Color Palettes	4	

	16	Interesting Plots in Seaborn: Bar Plots, Kernel Density Estimation, Plotting Bivariate Distributions, Visualizing Pairwise Relationships, Violin Plots	4	
IV	**Plotting Geospatial Data**		**11**	**15**
	17	Introduction to Geoplotlib, The Design Principles of Geoplotlib	1	
	18	Geospatial Visualizations - Choropleth Plot, GeoJSON File	2	
	19	Introduction to Folium	1	
	20	Visualizing Data: Building a Google map from geocoded data	2	
	21	Making Things Interactive with Bokeh : Introduction to Bokeh, Concepts of Bokeh, Interfaces in Bokeh, Output	3	
	22	Bokeh Server, Presentation, Integrating, Adding Widgets	2	
V	**Hands-on Data Visualization:** Practical Applications - Implement any 10 programs		**12**	
		Comparison Plots: Line Chart, Bar Chart, and Radar Chart 1. Write a Python script to create a line chart comparing the sales performance of two products over different months using Matplotlib. 2. Create a bar chart using Seaborn to visualize the average scores of students in different subjects. 3. Implement a radar chart using Matplotlib to compare the performance of multiple candidates in different skills.	2	
		Relation Plots: Scatter Plot, Bubble Plot, Correlogram, and Heatmap 4. Generate a scatter plot using Seaborn to analyze the relationship between the height and weight of individuals in a dataset. 5. Create a line graph with bokeh using Annotations and Legends. 6. Plot a correlogram heatmap using Seaborn to visualize the correlation matrix of variables in a dataset.	2	

		Composition Plots: Pie Chart, Stacked Bar Chart, Stacked Area Chart, Venn Diagram 7. Implement a pie chart using Matplotlib to represent the distribution of expenses in a budget. 8. Create a stacked bar chart using Seaborn to visualize the sales performance of different product categories over multiple quarters. 9. Generate a stacked area chart using Matplotlib to display the cumulative distribution of COVID-19 cases over time in different regions. 10. Use the matplotlib-venn library to create a Venn diagram illustrating the intersection of sets in a survey dataset.	2	
		Distribution Plots: Histogram, Density Plot, Box Plot, Violin Plot 11. Write a Python function to generate a histogram using Matplotlib for analyzing the distribution of exam scores in a class. 12. Create a density plot using Seaborn to visualize the distribution of income levels in a population. 13. Implement a box plot using Matplotlib to compare the distribution of salaries across different job roles. 14. Generate a violin plot using Seaborn to compare the distribution of ages between male and female participants in a study.	3	
		Geo Plots: Dot Map, Choropleth Map, Connection Map 15. Use Folium to create a dot map representing the locations of earthquake occurrences around the world. 16. Generate a choropleth map using Folium to visualize the population density of different countries. 17. Create a connection map using Matplotlib to illustrate flight routes between various cities.	3	

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO 1	-	-	2	2	2	2
CO 2	-	-	2	2	2	2
CO 3	-	-	-	2	2	2

CO 4	-	-	2	2	2	2
CO 5	-	-	2	2	2	2
CO 6	-	-	2	2	2	2

Correlation Levels:

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

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓		✓	✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5	✓	✓	✓	✓
CO 6	✓	✓		✓

References

1. Data Visualization workshop, Tim Grobmann and Mario Dobler, Packt Publishing
2. Kristen Sosulski, “Data Visualization Made Simple”, Taylor & Francis, 2019.
3. Pooja, Dr. Data Visualization with Python: Exploring Matplotlib, Seaborn, and Bokeh for Interactive Visualizations. BPB Online, 2023.
4. Wilke, Claus O. Fundamentals of data visualization: a primer on making informative and compelling figures. O'Reilly Media, 2019.
5. VanderPlas, Jake. Python data science handbook: Essential tools for working with data. " O'Reilly Media, Inc.", 2016.

Online Learning Resources

1. https://www.coursera.org/courses?query=data%20visualization

2. https://www.simplilearn.com/free-data-visualization-course-online-skillup

Programme	B. Sc. Computer Science and Mathematics(Double Major)				
Course Code	**CSC6EJ311a**				
Course Title	**Introduction to Data Warehousing and Big Data**				
Type of Course	**Elective**				
Semester	VI				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	0	75
Pre-requisites	1. Data Science Concepts 2. RDBMS				
Course Summary	This course provides insight into the basic concepts of data warehousing and its architecture. The various OLAP operations are also discussed in this syllabus to understand the summarisation and retrieval of the data. The fundamentals of big data technology are also introduced in this syllabus following the data warehousing concepts. An overview of the storage, retrieval and processing of big data is also provided here.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the concepts of data warehouse and its architecture	U	C	Instructor-created exams / Quiz
CO2	Analyse the differences between OLTP and OLAP operations	An	C	Instructor-created exams / Quiz
CO3	Understand the various operations performed in the data warehouse to process the data	U	C	Modelling Assignments/ Case Studies
CO4	Understand Big Data and the importance of cloud and distributed computing in the real world	U	C	Instructor-created exams / Quiz
CO5	Understand the Map Reduce concepts of the jobs	U	C	Modelling Assignments/ / Case studies
CO5	Understand the Hadoop ecosystem	U	C	Instructor-created exams / Quiz

* - 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	Marks
I	**Introduction to Data Warehousing**		**8**	**10**
	1	Overview of databases and need for normalisation. Databases vs data warehouse	2	
	2	Introduction to Data warehousing, Need for data warehousing	2	
	3	Architecture of data warehousing	3	
	4	Data Marts vs Data Lakes	1	
II	**Concepts and techniques in Data Warehousing**		**13**	**20**
	6	Data warehouse Schema - Stars, snowflakes and fact constellations	3	
	7	OLAP (Online analytical processing) definitions// Difference between OLAP and OLTP	2	
	8	Dimensional analysis - What are cubes?	2	
	9	Drill-down and roll-up - slice and dice or rotation	2	
	10	OLAP models, ROLAP versus MOLAP	4	
III	**Big Data Technology**		**16**	**25**
	11	Fundamentals of Big Data, 3V's of big data. Structured Data and its sources; Unstructured data and its sources; integrating data types to big data	2	
	12	Big Data Stack: Layers 1 to 4; Big data analytics and applications	4	
	13	Role of Distributed computing and virtualizations in big data	3	
	14	Hypervisor and implementing virtualizations in big data	1	
	15	Cloud in big data; cloud deployment models	2	
	16	Cloud delivery models; advantages of using cloud	2	
	17	Cloud Providers for Big Data	2	
IV	**Big Data Management**		**11**	**15**
	18	Fundamentals of Map Reduce: Map and reduce functions	2	
	19	Putting Map and Reduce together	2	
	20	Hadoop: Name nodes, Data Nodes, Hadoop MapReduce	3	
	21	Hadoop ecosystem: Yarn, HBase and Hive Interactive tools: Pig, Pig Latin, SQOOP, ZooKeeper	4	
	22	Big Data Analytics: Basic, Advanced, Operationalized	1	
V	**Hands-on data and Data warehousing: Practical Applications, Case Study and Course Project**		**12**	
	1	Data warehousing case studies	4	
	2	Case studies on Big Data Analytics and Big Data Solutions in the Real World	5	
	3	Assignments on Security in Big Data Environments	3	

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	-	-	-	-	1						
CO 2	1	-	2	-	-	-						
CO 3	-	-	2	-	-	-						
CO 4	-	2	3	3	-	1						

CO 5	-	2	3	3	-	1						
CO 6	-	-	-	-	-	2						

Correlation Levels:

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

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1		✓		✓
CO 2	✓	✓		✓
CO 3		✓		✓
CO 4	✓			✓
CO 5	✓		✓	✓
CO 6	✓		✓	✓

References

1. O'Neil, Cathy, and Rachel Schutt. *Doing data science: Straight talk from the frontline*. " O'Reilly Media, Inc.", 2013.
2. Han, Jiawei, et al. Data Mining: Concepts and Techniques. Netherlands, Elsevier Science, 2011.
3. Shah, Chirag. A Hands-On Introduction to Data Science. United Kingdom, Cambridge University Press, 2020.
4. Chopra, Rohan, et al. Data Science with Python: Combine Python with Machine Learning Principles to Discover Hidden Patterns in Raw Data. United Kingdom, Packt Publishing, 2019.

Programme	B. Sc. Computer Science and Mathematics(Double Major)				
Course Code	**CSC6EJ312a**				
Course Title	**Advanced Python for Data Science**				
Type of Course	**Elective**				
Semester	VI				
Academic Level	300 – 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	1. Data Science Concepts 2. Python basics				
Course Summary	This course provides insight into the basic concepts of Python required for Data Science. It includes array fundamentals, array transformations, and matrices fundamentals. The analysis of data using Pandas will help the students to understand the basics of data analysis				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the concepts of arrays, matrices and their transformations	U	C	Instructor-created exams / Quiz
CO2	Create informative plots using Python packages	Ap	P	Modelling Assignments/ Case Studies
CO3	Understand the loading mechanism of different types of data and manipulate them	U	C	Instructor-created exams / Quiz
CO4	Analyse the data using Pandas and Data Frames	An	P	Modelling Assignments/ Case Studies
CO5	Understand the concepts of random tensors and generate tensors from various distributions	U	C	Instructor-created exams / Quiz
CO6	Familiarize with various TensorFlow operations needed for Data Science	U	C	Instructor-created exams / Quiz

* - 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	Marks
I	**Arrays, Matrix manipulation using NumPy**		**10**	**12**
	1	Array creation, sorting, concatenating	2	
	2	Shape and size of an array, basic arithmetic operations on an array, broadcasting	2	
	3	Aggregate functions on arrays, Unique and count operations	2	
	4	Matrices using NumPy	2	
	5	Transpose, reverse, flatten and ravel	2	
II	**Data Analysis and Manipulation using Pandas**		**12**	**18**
	6	Series - constructing from an array, using explicitly defined indices, using a dictionary.	2	
	7	Data Frame - constructing from arrays, dictionaries, structured arrays, and series, Indexing of data frames	3	
	8	Arithmetic and Binary operations on Data frame	3	
	9	Broadcasting operations	2	
	10	Universal functions, melt() and pivot()	2	
III	**Other Python packages for data science**		**10**	**14**
	11	Scipy, Scikit-learn, PyTorch, Seaborn, Scrapy, and Beautiful Soup.	3	
	12	Python Data Operations: Importing and Exporting Data, Data Cleansing	3	
	13	Processing CSV Data, Processing JSON Data, Processing XLS Data.	2	
	14	Data Analysis: Measuring Central Tendency, Measuring Variance, and Correlation in Python	2	
IV	**TensorFlow Fundamentals**		**16**	**26**
	15	Tensors, creation of tensors and random tensors, Tensors from the Normal distribution, Poisson distribution, set_seed()	2	
	16	Tensor attributes, size, rank and reshaping of a tensor	2	
	17	Tensor arithmetic, relational, logical operations. Shuffle()	2	
	18	Reduce operations on tensor Dimension-wise	2	
	19	Ragged tensors, TensorArray, dynamic arrays,	2	
	20	unique(), fill(), concat(), gather(), ones(), ones_like(), zeros(),	2	
	21	eye(), range(), repeat, reverse(), roll(), slice(), sort(),	2	
	22	split(),squeeze(), tile(), stack(), unstack(), tensordot()	2	
V	**Hands-on Data Structures:** **Practical Applications, Case Study and Course Project**		**12**	

	1	Use Pandas and NumPy to efficiently process and analyze CSV, Excel, or JSON data	4	
	2	Create compelling visual insights using Matplotlib, Seaborn, or Plotly	3	
	3	Case studies with Tensor flow	5	

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	-	2	2	2						
CO 2	-	1	-	-	2	2						
CO 3	-	-	2	-	2	2						
CO 4	-	1	1	2	2	2						
CO 5	1	-	-	-	2	2						
CO 6	-	-	2	2	2	2						

Correlation Levels:

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

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓	✓	✓
CO 3	✓		✓	✓
CO 4	✓	✓	✓	✓
CO 5	✓			✓
CO 6	✓			✓

References

1. VanderPlas, Jake. Python Data Science Handbook: Essential Tools for Working with Data. United

States, O'Reilly Media, 2016.
2. Rogel-Salazar, Jesus. Data Science and Analytics with Python. United Kingdom, CRC Press, 2018.
3. https://numpy.org/doc/
4. https://pandas.pydata.org/docs/
5. https://www.tensorflow.org/guide

AI and ML									
No	**Course Code**	**Course Name**	**C**	**Marks**			**Hrs/wk**		
				I	**E**	**T**	**L**	**P**	**T**
29	CSC5EJ305b	Machine Learning Algorithms	4	30	70	100	4	0	4
30	CSC5EJ306b	Knowledge Engineering	4	30	70	100	4	0	4
35	CSC6EJ311b	Soft Computing	4	30	70	100	4	0	4
36	CSC6EJ312b	Deep Learning	4	30	70	100	4	0	4

Programme	B. Sc. Computer Science and Mathematics(Double Major)				
Course Code	**CSC5EJ305b**				
Course Title	**Machine Learning Algorithms**				
Type of Course	**Elective**				
Semester	V				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	1. Understanding of basic mathematics and statistics (linear algebra, calculus, probability)				
Course Summary	This course introduces the fundamental concepts, algorithms, and applications of machine learning				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand basic concepts of machine learning, including supervised learning, unsupervised learning, and reinforcement learning	U	C	Instructor-created exams / Quiz
CO2	Understand the mathematical foundations of machine learning algorithms, including concepts such as optimization, linear algebra, probability, and statistics	U	C	Assignment / Seminar presentations/ Exams

CO3	Demonstrate proficiency in various machine learning algorithms, such as linear regression, logistic regression, decision trees, support vector machines, k-nearest neighbors, clustering algorithms, and neural network	U	P	Seminar Presentation / Group Tutorial Work/ Viva Voce
CO4	Explore techniques for feature engineering and feature selection to improve the performance of machine learning models.	U	P	Instructor-created exams / Home Assignments
CO5	Evaluate machine learning models using appropriate metrics and techniques, including cross-validation, precision, recall, F1 score, ROC curves, and confusion matrices.	Ap	P	Writing assignments/ Exams/ Seminar Presentations
CO6	Develop critical thinking skills to analyze and solve complex problems using machine learning approaches.	Ap	P	Case Study/ Group discussions/ Presentations
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48+12)	Marks (70)
I		**Mathematical Foundation for Machine learning**	**14**	**20**
	1	Introduction to key concepts: features, labels, training, and testing	2	
	2	Designing a Learning system	1	
	3	Types of learning; supervised, unsupervised and reinforcement	2	
	4	Introduction to linear algebra- Vector :-Vector operations: addition, subtraction, scalar multiplication	2	
	5	Matrices- Matrix operations	2	
	6	Eigenvalues and Eigenvectors	2	
	7	Foundations of Probability for ML:- Introduction to probabilty	1	
	8	Random Variable, Probability distributions (Normal and gaussian-basics only), Naïve bayes	2	
II		**Feature Engineering and Preprocessing**	**12**	**15**
	9	Data Preprocessing and Feature Engineering: Data Representation, Data Preprocessing	2	
	10	Features and Types	3	
	11	Dimensionality Reduction – Feature Identification	2	
	12	Feature selection	2	
	13	Feature extraction - Feature Importance	3	
III		**Regression and Classification**	**12**	**20**
	14	Regression: Linear Regression – Non-Linear regression	2	
	15	Evaluation metrics for regression	1	
	16	Classification: Binary, multi-class, and multi-label classification	1	

	17	lazy leaners- (KNN) - tree-based techniques (Decision Tree)- kernel based techniques (SVM) - probabilistic techniques (Naïve bayes)- and ensembled techniques (bagging, boosting, voting)	7	
	18	Evaluation metrics for classification.	1	
IV	**Clustering and Rule Mining**		**10**	**15**
	19	Clustering: Partitioning based (K Means)	2	
	20	Hierarchical based (Divisive)	2	
	21	Rule mining: Apriori algorithm, FB Growth - association rules.	4	
	22	Outlier Detection - LOF	2	
V	**Open Ended Module**		**12**	
	1	Ethical considerations in machine learning	3	
	2	McCulloch-Pitts neurons, Hebb's networks	3	
	3	Hopfield networks, Boltzmann machines	2	
	4	Reinforcement Learning: Markov Decision Processes (MDPs), Q-learning.	4	

References

- Ethem Alpaydin, Introduction to Machine Learning- 3rd Edition, PHI
- Machine Learning by Mitchell, Tom M. (Tom Michael), McGraw-Hill
- Mathematics For Machine Learning, Marc Peter Deisenroth A. Aldo Faisal Cheng Soon Ong
- "Pattern Recognition and Machine Learning" by Christopher M. Bishop.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	1	-	-	1	-						
CO 2	3	-	-	-	1	-						
CO 3	1	3	1	1	2	3						
CO 4	1	-	1	1	2	3						
CO 5	1	-	-	-	2	3						
CO 6	1	2	2	2	3	3						

Correlation Levels:

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

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	End Semester Examinations
CO 1	✓		✓
CO 2	✓		✓
CO 3	✓		✓
CO 4	✓	✓	✓
CO 5	✓	✓	✓
CO 6		✓	

Programme	B. Sc. Computer Science and Mathematics(Double Major)				
Course Code	**CSC5EJ306b**				
Course Title	**Knowledge Engineering**				
Type of Course	**Elective**				
Semester	V				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	2. Understanding of basic mathematics and statistics 3. Basic understanding of computer science concepts				
Course Summary	This course introduces students to the principles, techniques, and tools used in Knowledge Engineering. It covers the design and development of knowledge-based systems, including knowledge representation, reasoning, and acquisition.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand basics of Knowledge Engineering	U	C	Instructor-created exams / Quiz
CO2	Apply methodologies and modelling for agent design and development	Ap	P	Assignment / Seminar presentations/ Exams

CO3	Design and develop ontologies	Ap	P	Seminar Presentation / Group Tutorial Work/ Viva Voce
CO4	Apply reasoning with ontologies and rules	Ap	P	Instructor-created exams / Home Assignments
CO5	Understand learning and rule learning	U	C	Writing assignments/ Exams/ Seminar Presentations
CO6	Develop theoretical knowledge to design a knowledge based system	Ap	P	Case Study/ Group discussions/ Presentations
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48+12)	Marks (70)
I	**Reasoning under uncertainity**		**15**	**15**
	1	Understanding the World through Evidence-based Reasoning: - Evidence, Data, and Information, Evidence and Fact, Evidence and Knowledge	2	
	2	Abductive Reasoning	1	
	3	Probabilistic Reasoning: - Enumerative Probabilities: Obtained by Counting, Subjective Bayesian View of Probability	2	
	4	Belief Functions	1	
	5	Baconian Probability, Fuzzy Probability	3	
	6	Evidence-based Reasoning	2	
	7	Artificial Intelligence: - Intelligent Agents, Mixed-Initiative Reasoning	2	
	8	Knowledge Engineering: - An Ontology of Problem-Solving Tasks, Building Knowledge-based Agents	2	
II	**Methodologies and Tools for Agent Design and Development ,Modelling the Problem-Solving Process**		**12**	**20**
	9	A Conventional Design and Development Scenario	2	
	10	Development Tools and Reusable Ontologies	2	
	11	Agent Design and Development Using Learning Technology	2	
	12	Problem Solving through Analysis and Synthesis	1	
	13	Inquiry-driven Analysis and Synthesis for Evidence-based Reasoning	2	
	14	Evidence-based Assessment, Believability Assessment	3	
III	**Ontologies**		**11**	**20**
	15	What Is an Ontology? Concepts and Instances, Generalization Hierarchies	2	
	16	Object Features, Defining Features, Defining Features, Representation of N-ary Features	2	
	17	Transitivity, Inheritance, Ontology Matching	3	
	18	Ontology Design and Development Methodology- Steps in Ontology Development, Domain Understanding and Concept Elicitation, Modeling-based Ontology Specification	4	

IV	**Reasoning with Ontologies and Rules**		**10**	**15**
	19	Production System Architecture	1	
	20	Complex Ontology-based Concepts	1	
	21	Reduction and Synthesis Rules and the Inference Engine, Evidence-based Hypotheses Analysis, Rule for Ontology Matching	4	
	22	Partially Learned Knowledge, Reasoning with Partially Learned Knowledge	4	
V	**Open Ended Module- Learning for Knowledge-based Agents**		**12**	
	1	Generalization and Specialization Rules	4	
	2	Types of Generalizations and Specializations	4	
	3	Analogy-based Generalization	4	

References

- “Knowledge Engineering”, Gheorghe Tecuci, Dorin Marcu, Mihai Boicu, David A. Schum
- "Artificial Intelligence: A Modern Approach" by Stuart Russell and Peter Norvig
- "Knowledge Representation and Reasoning" by Ronald J. Brachman and Hector J. Levesque.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	1	-	-	1	1						
CO 2	3	-	-	-	1	1						
CO 3	1	3	1	1	2	3						
CO 4	1	-	1	1	2	3						
CO 5	1	-	-	-	2	3						
CO 6	1	2	1	1	3	3						

Correlation Levels:

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

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)

- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	End Semester Examinations
CO 1	✓		✓
CO 2	✓		✓
CO 3	✓		✓
CO 4	✓	✓	✓
CO 5	✓	✓	✓
CO 6	✓	✓	

Programme	B. Sc. Computer Science and Mathematics(Double Major)				
Course Code	**CSC6EJ311b**				
Course Title	**Soft Computing**				
Type of Course	**Elective**				
Semester	VI				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	1. Fundamental Mathematics Concepts: Set, Functions, Logic 2. CSC2CJ101 – Fundamentals of Programming				
Course Summary	This course explores implementations of linked list and array-based data structures, delving into the inner workings of basic data structures including lists, stacks, queues, trees, and graphs.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the foundational principles of soft computing and the historical factors influencing its development.	U	C	Instructor-created exams / Quiz
CO2	Analyze the properties of Fuzzy sets and Fuzzy relations	Ap, U	P	Assignment/ Seminar
CO3	Apply fuzzy logic concepts to solve real-world problems, showcasing proficiency in designing and implementing fuzzy systems.	Ap, U	C	Seminar Presentation / Quiz
CO4	Master the concepts of Genetic algorithms and their operations	U	C	Practical Assignment / Seminar

CO5	Design and implement solutions using fuzzy logic, neural networks, and genetic algorithms for diverse applications.	Ap	P	Practical Assignment/ Seminar
CO6	Evaluate and present real-world scenarios where soft computing techniques can be effectively applied	Ap	P	Case study/ Project
* - 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
I		**Introduction to Soft Computing**	**7**
	1	Overview of Soft computing, Hard Computing, and Hybrid Computing	2
	2	Areas and Applications of Soft Computing	1
	3	Basic Tools of Soft Computing- Fuzzy Logic, Neural Networks and Evolutionary computing	2
	4	Introduction to Fuzzy logic, Neural Networks, Genetic Algorithm, and Hybrid systems (Concepts only)	2
II		**Introduction to Fuzzy Logic**	**14**
	6	Introduction to Fuzzy Logic	2
	7	Fuzzy sets and crisp sets	2
	8	Fuzzy relations and Crisp relations	2
	9	Tolerance and Equivalence Relations	2
	10	Fuzzy membership functions	3
	11	Fuzzification and Defuzzification	3
III		**Advanced Fuzzy Logic**	**14**
	12	Fuzzy Rules and Fuzzy Reasoning	3
	13	Fuzzy Inference Systems- Mamdani and Sugeno models	4
	14	Fuzzy Control Systems	3
	15	Fuzzy Clustering (Concepts only)	2
	16	Fuzzy Neural Networks (Concepts only)	2
IV		**Genetic Algorithm**	**13**
	17	Introduction to Genetic Algorithm	2
	18	Operators in genetic algorithm - coding - selection - cross over – mutation,	2
	19	Stopping condition for genetic algorithm flow.	2
	20	Constraints in Genetic Algorithm	2
	21	Classification of Genetic Algorithm	3
	22	Genetic Programming (Concepts)	2
V		**Open Ended Module**	**12**
		• Understand the different optimization techniques used. • Explore the real-life applications of soft computing techniques • Discuss hybrid soft computing techniques	

REFERENCES

1. S.N.Sivanandam and S.N.Deepa, "Principles of Soft Computing", Wiley India Pvt Ltd
2. D.K. Pratihar, “Soft Computing: Fundamentals and Applications”, Alpha Science International Ltd

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	-	-	-	1	1						
CO 2	2	-	-	1	1	1						
CO 3	2	-	-	2	2	1						
CO 4	2	-	-	1	1	1						
CO 5	1	-	2	3	2	3						
CO 6	1	-	3	3	2	3						

Correlation Levels:

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

Assessment Rubrics:

- Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Practical Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5		✓		✓
CO 6			✓	

Programme	B. Sc. Computer Science and Mathematics(Double Major)				
Course Code	**CSC6EJ312b**				
Course Title	**Deep Learning**				
Type of Course	**Elective**				
Semester	VI				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	4. Introduction to Artificial Intelligence 5. Basic understanding of linear algebra, calculus, and probability. 6. Basics of Machine learning				
Course Summary	The theoretical groundwork for comprehending the fundamentals of deep learning is supplied by this course. Theoretical frameworks, optimisation techniques, and mathematical ideas that support deep neural network building and training will be examined by students.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Master key concepts of machine learning, understanding various layers of neural network.	U	C	Instructor-created exams / Quiz
CO2	Understand and implement the backpropagation algorithm for training neural networks, demonstrating the ability to compute gradients and update weights.	Ap, U	P	Assignment / Seminar presentations/ Exams
CO3	Analyze and compare different activation functions used in neural networks, explaining their role in the learning process.	U	P	Seminar Presentation / Group Tutorial Work/ Viva Voce
CO4	Design and implement feedforward neural networks for various applications, considering aspects such as model architecture, activation functions, and initialization methods.	Ap	C	Instructor-created exams / Home Assignments
CO5	Master the principles of convolutional neural networks, including convolutional layers, pooling layers, and their applications in computer vision. Master various regularization techniques, such as dropout, batch normalization, and weight regularization, to improve the generalization of neural networks	U	P	Writing assignments/ Exams/ Seminar Presentations

CO6	Apply deep learning concepts to solve real-world problems, demonstrating the ability to choose appropriate architectures and hyperparameters.	Ap	P	Case Study
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48+12)	Marks (70)
I	**Machine Learning Basics**		**10**	**15**
	1	Learning Algorithms -Supervised learning- regression, classification, Unsupervised learning, Reinforcement learning (Introduction only)	2	
	2	Terms - Capacity, Overfitting and Underfitting, Hyperparameters and Validation Sets, Estimators, Bias and Variance	2	
	3	Maximum Likelihood estimation, Bayesian statistics, Stochastic Gradient Descent	3	
	4	Building a Machine Learning Algorithm	1	
	5	Challenges Motivating Deep Learning	2	
II	**Optimisation and Neural Networks**		**15**	**20**
	6	Neural Networks –Perceptron, Gradient Descent solution for Perceptron, Multilayer perceptron	3	
	7	Activation Functions- Sigmoid, Softmax, Relu, LeakyRelu, ERELU	2	
	8	Chain rule, back propagation- Backpropagation Algorithm	3	
	9	Gradient based learning.	2	
	10	Introduction to optimization– Gradient based optimization, linear least squares. Stochastic gradient descent	2	
	11	Regularisation techniques- Drop out, Batch Normalisation, weight regularisation	3	
III	**Convolutional Neural Network**		**12**	**20**
	12	Convolutional Neural Networks – convolution operation, motivation	2	
	13	Pooling	2	
	14	Variants of convolution functions	2	
	15	Structured outputs, data types	2	
	16	CNN Architecture- Alexnet, VGG16	4	
IV	**Deep learning Architectures**		**11**	**15**
	17	Sequence Modeling: Recurrent and Recursive Nets- Basics of Recurrent Neural Networks	2	
	18	Encoder – Decoder Sequence to Sequence Architectures,	2	
	19	Deep Recurrent Networks, Recursive Neural Networks	2	
	20	The Long Short-Term Memory	2	
	21	GRU	2	
	22	Basics of transfer learning techniques (Concept only)	1	
V	**Open ended Module**		**12**	

	1	• Master students Basics of Mathematics required for Machine learning and deep learning- Linear Algebra (Scalars, Vectors, Matrices and Tensors, Eigen values, Eigen Vectors)- concepts only • Probability awareness- Why probability, random variable, probability distributions)- concepts only • Discuss advanced topics in deep learning, including transfer learning, autoencoders, adversarial training, and stay informed about recent developments in the field.)- concepts only		

References

- "Deep Learning" by Ian Goodfellow, Yoshua Bengio, and Aaron Courville.
- Aston Zhang, Zachary C. Lipton, Mu Li, and Alexander J. Smola, "Dive into Deep Learning", August 2019.
- Neural Networks and Deep Learning: A Textbook by Charu C. Aggarwal. Springer.1st edition, 2018.
- "Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow" by Aurélien Géron.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	-	-	2	3						
CO 2	2	-	1	1	2	3						
CO 3	2	-	-	-	2	1						
CO 4	2	-	1	1	2	2						
CO 5	2	-	2	1	2	3						
CO 6	2	-	2	1	2	3						

Correlation Levels:

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

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	End Semester Examinations
CO 1	✓		✓
CO 2	✓		✓
CO 3	✓		✓
CO 4		✓	✓
CO 5		✓	✓
CO 6		✓	

Cloud Computing									
No	**Course Code**	**Course Name**	**C**	**Marks**			**Hrs/wk**		
				I	**E**	**T**	**L**	**P**	**T**
29	CSC5EJ305c	Cloud Computing	4	30	70	100	4	0	4
30	CSC5EJ306c	Security and Privacy in Cloud	4	30	70	100	4	0	4
35	CSC6EJ311c	Storage Technologies	4	30	70	100	4	0	4
36	CSC6EJ312c	Virtualization	4	30	70	100	4	0	4

Programme	B. Sc. Computer Science and Mathematics(Double Major)				
Course Code	**CSC5EJ305c**				
Course Title	**Cloud Computing**				
Type of Course	**Elective**				
Semester	V				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	7. Basic understanding of computer networks, operating systems, and programming.				
Course Summary	This course introduces students to the fundamental concepts, technologies, and practices of cloud computing. It covers the basics of cloud infrastructure, deployment models, and service models.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand fundamentals of cloud Computing	U	C	Instructor-created exams / Quiz
CO2	Describe and compare Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS)	U	C	Assignment / Seminar presentations/ Exams
CO3	Analyze various deployment models such as public, private, and hybrid clouds.	U	P	Seminar Presentation / Group Tutorial Work/ Viva Voce
CO4	Understand the principles of virtualization and its role in cloud computing.	U	C	Instructor-created exams / Home Assignments
CO5	Compare and contrast different virtualization technologies, including hypervisors and containerization.	U	P	Writing assignments/ Exams/ Seminar Presentations
CO6	Explore various cloud platforms in industry	U	F	Case Study/ Exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48+ 12)	Marks (70)
I	**Introduction to cloud computing**		**8**	**12**
	1	Cloud computing in a glance	2	
	2	Historical context and evolution	1	
	3	Building cloud computing environments- Cloud components	2	
	4	Desired features of cloud	2	
	5	Advantages of Cloud	1	
II	**Cloud computing architecture**		**14**	**20**
	6	Cloud reference model	4	
	7	Types of cloud- private, public, hybrid, community	3	
	8	Cloud service models (IaaS)	2	
	9	Cloud service models (PaaS)	2	
	10	Cloud service models (SaaS)	2	
	11	Open Challenges	1	
III	**Virtualization Technologies**		**16**	**23**
	12	Virtual machine basics	2	

	13	hypervisor	2	
	14	Virtualisation structure	3	
	15	Implementation levels of virtualisation	2	
	16	Virtualisation types- Full Virtualisation, Para Virtualisation, Hardware Virtualisation	3	
	17	Virtualisation of CPU, Memory	2	
	18	Virtualisation of I/O devices	2	
IV	**Virtualisation infrastructure & Dockers**		**10**	**15**
	17	Desktop Virtualisation, Network Virtualisation & Storage Virtualisation	2	
	18	Containers vs Virtual Machines	2	
	19	Basics of Dockers	2	
	20	Docker Components	2	
	21	Docker Containers	1	
	22	Docker Images and repositories	1	
V	**Open Ended Module**		**12**	
	1	• Cloud platforms in Industry ✓ **Amazon web services**- computation services, storage services, communication services ✓ **Google AppEngine**- Architecture and core concepts ✓ **Microsoft Azure**- Azure core concepts		

References

1. “Mastering cloud computing”. Rajkumar Buyya
2. “Cloud Computing: Principles and Paradigms”, Rajkumar Buyya, James Broberg, Andrzej Goscinski
3. "Cloud Computing: Concepts, Technology & Architecture" by Thomas Erl
4. “Introduction to Cloud Computing”, William Voorsluys, James Broberg, Rajkumar Buyya
5. "Cloud Computing: A Hands-On Approach" by Arshdeep Bahga and Vijay Madiset

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	2	--	-	1	1						
CO 2	-	2	-	-	1	1						
CO 3	-	1	-	-	1	1						
CO 4	-	1	-	-	2	1						
CO 5	-	1	-	-	2	1						
CO 6	-	1	-	-	2	2						

Correlation Levels:

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

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	End Semester Examinations
CO 1	✓		✓
CO 2	✓		✓
CO 3	✓		✓
CO 4		✓	✓
CO 5		✓	✓
CO 6		✓	

Programme	B. Sc. Computer Science and Mathematics(Double Major)				
Course Code	**CSC5EJ306c**				
Course Title	**Security and Privacy in Cloud**				
Type of Course	**Elective**				
Semester	V				
Academic Level	300 – 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	8. Basic understanding of computer networks, operating systems, databases, Cloud computing				
Course Summary	This course explores the security and privacy challenges in cloud computing environments. Students will learn about the fundamental principles, technologies, and best practices for ensuring the confidentiality, integrity, and availability of data in the cloud. The course also covers legal and ethical considerations related to privacy in cloud computing.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand fundamentals of security concepts (encryption, decryption)	U	C	Instructor-created exams / Quiz
CO2	Understand security design principles.	U	C	Assignment / Seminar presentations/ Exams
CO3	Analyze various threats to cloud security	U	P	Seminar Presentation / Group Tutorial Work/ Viva Voce
CO4	Understand various cloud security design patterns.	U	C	Instructor-created exams / Home Assignments
CO5	Explore various access control mechanisms and management schemes to ensure security in cloud.	U	P	Writing assignments/ Exams/ Seminar Presentations
CO6	Explore various levels of security in cloud infrastructure	U	F	Case Study/ Exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48+12)	Marks (70)
I		**Fundamentals of Security in Cloud**	**14**	**22**
	1	Overview of Cloud Security- Security services- Confidentiality, Integrity, Authentication, Non repudiation, Access control	2	
	2	Basics of Cryptography	2	
	3	Conventional and public key cryptography	4	
	4	Hash functions	2	
	5	Authentications	2	
	6	Digital Signature	2	
II		**Security Design and Architecture for Cloud**	**12**	**18**
	7	Security design principles for cloud computing- comprehensive data protection, end to end access control	2	
	8	Common attack vectors and threats	1	
	9	Network and storage- Secure Isolation strategies, Virtualisation strategies, inter- tenant network segmentation strategies, data protection strategies	3	
	10	Data retention, detection and archiving procedures for tenant data	2	
	11	Encryption, Redaction, Tokenisation, Obfuscation	2	
	12	PKI and key	2	
III		**Access Control and Identity Management**	**12**	**18**

	13	Access control requirements for Cloud infrastructure- user identification, authentication and authorization	2	
	14	Role based access control- multi-factor authentication, single Sign-on	2	
	15	Identity providers and service consumers	2	
	16	Storage and network access control options- OS Hardening and minimization	3	
	17	Intruder detection and prevention	3	
IV	**Cloud Security Design patterns**		**10**	**12**
	18	Introduction to design patterns	2	
	19	Cloud bursting	2	
	20	Geo-tagging	2	
	21	Secure cloud interfaces	2	
	22	Cloud resource access control	2	
V	**Open Ended Module**		**12**	
	1	Infrastructure security: Network level, host level, application level	4	
	2	Security management in the cloud	4	
	3	Audit and compliance	4	

References

1. "Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance" by Tim Mather, Subra Kumaraswamy, and Shahed Latif
2. “Cloud computing: Principles and Paradigms”. Rajkumar Buyya, James Broberg, Andrzej M. Goscinski, Willey Publications

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	2	--	-	1	1						
CO 2	-	2	-	-	1	1						
CO 3	-	1	-	-	1	1						
CO 4	-	1	-	-	2	1						
CO 5	-	1	-	-	2	1						
CO 6	-	1	-	-	2	2						

Correlation Levels:

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

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam

- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	End Semester Examinations
CO 1	✓		✓
CO 2	✓		✓
CO 3	✓		✓
CO 4		✓	✓
CO 5		✓	✓
CO 6		✓	

Programme	B. Sc. Computer Science and Mathematics(Double Major)				
Course Code	**CSC6EJ311c**				
Course Title	**Storage Technologies**				
Type of Course	**Elective**				
Semester	VI				
Academic Level	300 – 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	9. Basic knowledge of computer systems and architecture 10. Fundamental understanding of data structures and algorithms				
Course Summary	This course introduces students to various storage technologies, storage network technologies, storage and virtualization technologies. Course also discuss various back up and recovery strategies.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand fundamentals of Information storage	U	C	Instructor-created exams / Quiz
CO2	Examine features of various storage architectures	U	C	Assignment / Seminar presentations/ Exams
CO3	Understand features of Intelligent storage systems	U	P	Seminar Presentation / Group Tutorial Work/ Viva Voce
CO4	Identify features of various Storage technologies	U	C	Instructor-created exams / Home Assignments

CO5	Identify need of backup and recovery and various recovery mechanisms	U	P	Writing assignments/ Exams/ Seminar Presentations
CO6	Infer security needs and management needs for storage technologies	U	F	Case Study/ Exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48+12)	Marks (70)
I		**Storage System**	**12**	**18**
	1	**Introduction to Information Storage-** Information Storage, Evolution of Storage Architecture	2	
	2	Data Center Infrastructure and characteristics	1	
	3	Third platform technologies- Cloud storage and its characteristics	2	
	4	Cloud services and deployment models	3	
	5	Storage Architectures- Direct-Attached Storage (DAS) Network-Attached Storage (NAS) (Introduction only)	2	
	6	Storage Area Network (SAN) Cloud storage architectures(Introduction only)	2	
II		**Intelligent Storage Systems & RAID**	**12**	**18**
	7	RAID Implementation Methods, RAID Array Components, RAID Techniques	2	
	8	RAID Levels, RAID Impact on Disk Performance	3	
	9	RAID Comparison	1	
	10	Components of an Intelligent Storage System	1	
	11	Storage Provisioning	2	
	12	Types of Intelligent Storage Systems	3	
III		**Storage Networking Technologies - Fibre Channel Storage Area Networks**	**12**	**18**
	13	Block based stored system, File based storage system, object oriented based storage system (Introduction)	2	
	14	Fibre Channel Storage Area Networks- Components of FC SAN,	2	
	15	Fibre Channel Architecture	2	
	16	Fabric Services	2	
	17	FC SAN Topologies	2	
	18	Virtualization in SAN	2	
IV		**Backup and Archive**	**12**	**16**
	19	Backup Purpose, Backup Considerations, Back up Granularity	3	
	20	Recovery Considerations , Backup Methods	3	
	21	Backup Architecture, Backup Topologies	3	

	22	Backup and Restore Operations	3	
V	**Open Ended Module**		**12**	
	1	Storage Security Domains	3	
	2	Security Implementations in Storage Networking	3	
	3	Securing Storage Infrastructure in Virtualized and Cloud Environments	3	
	4	Storage Infrastructure Management Activities	3	

References

- Information Storage and Management: Storing, Managing, and Protecting Digital Information in Classic, Virtualized, and Cloud Environments, 2nd Edition, Willey Publications

Mapping of Cos with PSOs and Pos :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	2	--	-	1	1						
CO 2	-	2	-	-	1	1						
CO 3	-	1	-	-	1	1						
CO 4	-	1	-	-	2	1						
CO 5	-	1	-	-	2	1						
CO 6	-	-	-	-	2	2						

Correlation Levels:

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

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	End Semester Examinations
CO 1	✓		✓
CO 2	✓		✓
CO 3	✓		✓
CO 4	✓	✓	✓
CO 5	✓	✓	✓
CO 6	✓	✓	

Programme	B. Sc. Computer Science and Mathematics(Double Major)				
Course Code	**CSC6EJ312c**				
Course Title	**Virtualization**				
Type of Course	**Elective**				
Semester	VI				
Academic Level	300 – 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	11. Basic understanding of cloud computing				
Course Summary	This course introduces students to the fundamental concepts, technologies, virtualization, various virtualization tools and virtualization in storage, desktop, network and server				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools Used
CO1	Understand basics of virtualization	U	C	Instructor-created exams / Quiz
CO2	Understand how hypervisors work and their role in virtualization.	Ap	P	Assignment / Seminar presentations/ Exams
CO3	Understand Differences between various types of virtualization, including server virtualization, desktop virtualization, network virtualization, and storage virtualization	Ap	C	Seminar Presentation / Group Tutorial Work/ Viva Voce
CO4	Explore how virtualization technologies are used in the context of cloud services.	U	P	Instructor-created exams / Home Assignments
CO5	Understand the potential risks and vulnerabilities associated with virtualization and learn how to mitigate them.	U	P	Writing assignments/ Exams/ Seminar Presentations
CO6	Compare and analyse various virtualization tools	U	F	Case Study/ Exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48+12)	Mark (70)
I		**Introduction to Virtualisation**	**12**	**18**
	1	Virtualization and computing- need for virtualisation,	2	
	2	Cost, administration,	2	
	3	Fast deployment, reduce infrastructure cost	2	
	4	Limitations	1	
	5	Types of hardware virtualization: full virtualisation, partial virtualization, paravirtualization	3	
	6	Types of hypervisors	2	
II		**Server and Desktop virtualization**	**14**	**20**
	7	Virtual machine basics	2	
	8	Types of virtual machines	2	
	9	Understanding server virtualisation- types of server virtualization	3	
	10	Business cases for server virtualization	2	
	11	Uses of virtual server consolidation,	2	
	12	Selecting server virtualisation platform	1	
	13	Desktop virtualisation- types of desktop virtualization	2	
III		**Network Virtualisation**	**12**	**18**
	14	Introduction to network virtualisation	2	
	15	Advantages, functions	2	
	16	Tools for network virtualization	3	
	17	VLAN-WAN architecture	2	
	18	WAN Visualization	3	
IV		**Storage Virtualization**	**10**	**16**
	19	Introduction to memory virtualization	2	
	20	Types of storage virtualization	3	
	21	Risk of storage virtualization	2	
	22	SAN-NAS-RAID	3	
V		**Open Ended Module- Virtualization tools (Any 3- $ hours each)**	**12**	
		VMWare-Amazon AWS Microsoft HyperV Oracle VM Virtual box IBM PowerVM Google Virtualization		

References

- **Cloud Computing a practical approach- Anthony T Velte, Toby T Velte, Robert Elsenpeter, TataMcGraw Hill**
- **Virtualization from Desktop to the Enterprise, Chris Wolf, Eric M Halter**

Mapping of COs with PSOs and POs :

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

CO 2	-	2	-	-	1	1						
CO 3	-	1	-	-	1	1						
CO 4	-	1	-	-	2	1						
CO 5	-	1	-	-	2	1						
CO 6	-	1	-	-	2	2						

Correlation Levels:

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

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	End Semester Examinations
CO 1	✓		✓
CO 2	✓		✓
CO 3	✓		✓
CO 4		✓	✓
CO 5		✓	✓
CO 6	✓	✓	

ELECTIVE COURSES IN MATHEMATICS WITH SPECIALISATION

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

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

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

Detailed Syllabus:

TextBook	(I) Jiří Matoušek and Jaroslav Nešetřil, Invitation to Discrete Mathematics, (2/e) Oxford University Press (II) Robin J Wilson, Introduction to Graph Theory (4/e), Prentice Hall			
Module	**Unit**	**Content**	**Hrs (48+12)**	**Ext. Marks (70)**
I	**Combinatorial Counting (Text 1)**		**12**	
	1	1.1 An Assortment of problems		
	2	1.3 Mathematical Induction (Proof of Theorem 1.3.1 is optional)		
	3	1.5 Relations, 1.6 Equivalences and other special type of relation		
	4	3.1 Functions and subsets, 3.2 Permutations and factorials		
	5	3.3 Binomial Coefficients-		

	6	3.7 Inclusion-Exclusion Principle. (Third proof of Theorem 3.7.2 is optional)		
II	**Basics of Graph Theory (Text 1)**		**12**	
	7	4.1 The notion of a graph; Isomorphism		
	8	4.2 Subgraphs, Components, Adjacency Matrix		
	9	4.3 Graph Score (Proof of Theorem 4.3.3 is optional)		
	10	4.4 Eulerian Graphs (Second proof of Theorem 4.4.1 and lemma 4.4.2 are optional)		
	11	4.5 Eulerian Directed Graph		
	12	5.1 Definition and characterizations of trees		
III	**Matching and Colouring (Text 2)**		**12**	
	13	12. Planar Graphs (Proof of Theorem 12.2 and Theorem 12.3 are optional)		
	14	13. Euler's formula (up to Corollary 13.4)		
	15	13. Euler's formula (from Corollary 13.4)		
	16	17. Coloring Graphs		
	17	19. Coloring Maps (Proof of Theorem 19.2 and Theorem 19.4 are optional)		
	18	25 Hall's Marriage theorem		
IV	**Probabilistic Method (Text 1)**		**12**	
	19	10.1 Proofs by Counting (2-Coloting revisited and related topics are optional)		
	20	10.2 Finite Probability Spaces (up to Random graphs)		
	22	10.2 Finite Probability Spaces (From Random graphs)		
	22	10.3 Random Variables and their Expectations		
V	**Open Ended**		**12**	
	Hamiltonian Graphs, 2-Connectivity, Examples of applications of Probabilistic Method, Ramsey Theory, Generating Functions, simulating random experiments in python and calculating expectations. Brook's Theorem.			

References:

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

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

2) 70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.

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

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	✓	✓	✓	✓	✓

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Analyse and compare the efficiency of algorithms for computing Fibonacci numbers, distinguishing between exponential and polynomial approaches.	E	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Demonstrate proficiency in asymptotic analysis to assess the efficiency of algorithms.	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Apply classical algorithms for number operations, including addition, multiplication, and modular arithmetic, to solve computational problems efficiently.	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam

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

Detailed Syllabus:

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

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

References:

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

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

Mapping of COs with PSOs and POs :

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

Correlation Levels:

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

Assessment Rubrics:

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

Mapping of COs to Assessment Rubrics:

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

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

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

Detailed Syllabus:

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

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

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

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

Mapping of COs with PSOs and POs:

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

Correlation Levels:

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

Assessment Rubrics:

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

Mapping of COs to Assessment Rubrics:

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

Programme	B. Sc. Computer Science and Mathematics(Double Major)			
Course Code	MAT6EJ302(1)			
Course Title	**MATHEMATICS FOR DIGITAL IMAGES**			
Type of Course	**Elective (Specialisation- Mathematical Computing)**			
Semester	VI			
Academic Level	300 - 399			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	4	4	-	60
Pre-requisites	Basic Geometry and Algebraic Structures			
Course Summary	The focus of this paper is mathematics underlying patterns which in converse can be used to produce patterns automatically by computer, allocating some design decisions to the user. We begin with isometries, those transformations of the plane which preserve distance and hence shape. These fall into two classes: the direct ones are rotations or translation, and the indirect ones reflections or glides. We			

	derive the rules for combining isometries, and introduce groups, and the dihedral group in particular. We also apply this to classifying all 1-dimensional or 'braid' patterns into seven types. Our next focus is on symmetries; that is, those isometries which send a pattern onto itself, each part going to another with the same size and shape. A plane pattern is one having translation symmetries in two non-parallel directions. These are made up of parallelogram shaped cells, falling into five types. Finally, we deduce the existence of 17 pattern types, each with its own set of interacting symmetry operations.

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

Detailed Syllabus:

Text Book	MATHEMATICS FOR DIGITAL IMAGES : Creation, Compression, Restoration, Recognition. S G Hoggar- Cambridge University Press.			
Module	**Unit**	**Content**	**Hrs (48+12)**	**Ext. Marks (70)**
I		**Introduction**	**12**	
	1	Isometries and their sense		
	2	The plane and vectors		
	3	Isometries – Translation, Rotation, Reflection		
	4	The sense of an isometry		
	5	The Classification of isometries		
	6	Composing isometries		
	Sections from Text (i): Chapter 1 – 1.1, 1.2, 1.3			
II		**How Isometries Combine**	**12**	
	7	Reflections are the key		
	8	Some useful compositions		

	9	The Image of a line of symmetry		
	10	The dihedral group		
	11	Appendix on groups		
	Sections from Text (i):Chapter 2 – 2.1, 2.2, 2.3, 2.4, 2.5			
III	**The Seven Braid Patterns, Plane Patterns & Symmetries**		**12**	
	12	Classification of braids		
	13	Constructing braid patterns		
	14	Translations and nets		
	15	Cells		
	16	The five net types		
	17	Nets allowing a reflection		
	Sections from Text (i): Chapter 3, Chapter 4 – 4.1, 4.2, 4.3			
IV	**The 17 Plane Patterns**		**12**	
	18	Preliminaries		
	19	The general parallelogram net		
	20	The rectangular net		
	21	The centred rectangular net		
	22	The square net		
	23	The hexagonal net		
	24	Examples of the 17 plane pattern types		
	25	Scheme for identifying pattern types		
	Sections from Text (i): Chapter 5 – 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8			
V (Open Ended)	**Advanced Topics (Practical)**		**12**	
	26	Basic Syntax and Scalar arithmetic operations and calculations by Using MATLAB		
	27	Arithmetic operations in matrix data & Reading an Image File by Using MATLAB		

References:

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

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

Mapping of COs with PSOs and POs :

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

Correlation Levels:

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

Assessment Rubrics:

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

Mapping of COs to Assessment Rubrics:

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

General Foundation Courses in Computer Science

Programme	B. Sc. Computer Science and Mathematics(Double Major)				
Course Code	CSC1FM105				
Course Title	Data Analysis and Visualisation Through Spread sheets				
Type of Course	**MDC**				
Semester	I				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-	-	45
Pre-requisites	● Basic understanding of computers ● Familiarity with basic mathematical operations				
Course Summary	This course provides a comprehensive introduction to Spreadsheets, focusing on understanding formulas, functions, data organization, analysis techniques, and data visualization. Participants will gain skills in spreadsheet management, data cleansing, analysis, and visualization using Excel's various tools and features.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Students will demonstrate proficiency in managing spreadsheets, including creating, formatting, and manipulating data within Excel workbooks. They will be able to effectively navigate Excel's interface and utilize toolbars.	U	P	Instructor-created exams / Quiz
CO2	Learners will understand the importance of data organization and cleansing in Excel. They will be able to import, export, filter, sort, validate, and remove duplicates from datasets. Students will develop skills to ensure data integrity and consistency, enhancing their ability to work with clean and organized data sets.	U	P	Instructor-created exams/ Home Assignments
CO3	Participants will acquire advanced data analysis skills like pivot	Ap	P	Instructor-created exams

	tables, what-if analysis, and goal seek. They will be able to apply various Excel functions and tools to perform complex calculations, analyze trends, and make informed decisions based on data analysis.			
CO4	Students will gain proficiency in data visualization techniques using Excel. They will be able to create a variety of charts, design pivot charts, dashboards for effectivedata analysis. Additionally,learners will be able to implement form controls for interactive data manipulation in their visualizations.	Ap	P	Instructor-created exams
CO5	Learners will develop skills in advanced features of Excel like macros, protect data sheets and workbooks, utilize split, freeze,and hide options effectively, incorporate add-ins for extended functionalities, and manage printing options in Excel for professional presentation of data.	Ap	P	Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (36+9)	Marks (50)
I		**Introduction to Excel & Understanding Formulas, Functions**	**9**	**15**
	1	Features of Spreadsheet	1	
	2	Parts of Excel Window, Tool bars, Work sheet and Work book, Insertion and Deletion of cells, columns, rows	2	
	3	Formatting in Excel (Merge, Warp, Font Formatting, Number Formatting, Borders and Shading, Colouring)	2	
	4	Range, Autofill, Autosum, Relative, Absolute and Mixed Referencing in Excel, Linking data between worksheets	2	
	5	Formulas and Functions in Excel: Use of Formula Bar, Functions: SUM,ROUND, CEIL, FLOOR,IF, AND,	2	

		OR,AVERAGE, MIN, MAX ,COUNT, COUNTIF, SUMIF, VLOOKUP,HLOOKUP		
II	**Cleansing and Organising Data in Excel**		**9**	**10**
	6	Importance of Data Cleansing and Organisation	1	
	7	Data Import and Export	2	
	8	Filtering and Sorting	2	
	9	Data Validation and remove Duplicates	1	
	10	Group, Ungroup, Subtotal	2	
	11	Conditional Formatting – Highlight Cell Rules, Top/Bottom Rules	1	
III	**Advanced Techniques for Data Analysis**		**8**	**10**
	12	Features of Pivot table	1	
	13	Pivot Table creation	2	
	14	What-if Analysis	2	
	15	Goal Seek	2	
	16	Watch Window	1	
IV	**Data Visualisation Techniques**		**10**	**15**
	17	Creating Charts, Different types of charts	2	
	18	Formatting Chart Objects, Changing the Chart Type, Showing and Hiding the Legend, Showing and Hiding the Data Table	2	
	19	Pivot Chart	2	
	20	Dashboards	1	
	21	Form Controls	3	
V	**Open Ended Module: More about Excel**		**9**	
	1. Recording and Running Macros 2. Protecting Data Sheets and Workbooks 3. Split, Freeze and Hide options 4. Add-ins 5. Printing options in Excel			

References

1. "Excel 2019 Bible" by Michael Alexander and Richard Kusleika
2. "Excel Formulas & Functions For Dummies" by Ken Bluttman and Peter Aitken

3. "Excel with Microsoft Excel: Comprehensive & Easy Guide to Learn Advanced MS Excel" by Naveen Mishra

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Final Exam

Programme	B. Sc. Computer Science and Mathematics(Double Major)				
Course Code	CSC2FM106				
Course Title	Digital Empowerment through Ethical Standards				
Type of Course	**MDC**				
Semester	II				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-	-	45
Pre-requisites	Basic understanding of computers				
Course Summary	This course explores the evolution from pre-digital challenges to the current digital landscape, covering historical milestones, key technologies, and the vision of Digital India. It emphasizes the benefits and importance of digital revolution while addressing ethical and security considerations. Participants engage with digital tools for personal and professional growth and examine case studies on digital infrastructure, missions, and services to understand real-world applications.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Students will be able to analyze the challenges of the pre-digital age and comprehend the importance and benefits of digital revolution, facilitating a deeper understanding of technological evolution.	An	F	Instructor-created exams / Quiz

CO2	Participants will gain familiarity with key digital technologies like Cloud Computing, IoT, AI, and Blockchain, equipping them with the knowledge to identify their applications and potential benefits in different sectors.	U	C	Instructor-created exams/ Home Assignments
CO3	Students will develop insights into Digital India initiatives and emergence of Kerala as Digital Society	U	C	Instructor-created exams
CO4	Through exploration of digital tools	Ap	P	Instructor-
	for personal and professional growth, students will enhance their digital literacy and ability in utilizing tools for data sharing, online learning, networking, and content creation, empowering them to thrive in the digital age.			created exams
CO5	Learners will become aware of ethical and security considerations in the digital age, including privacy concerns, Intellectual Property Rights, key terminologies related to cyber security, and an introduction to cyber laws in India, fostering responsible digital citizenship.	U	C	Instructor-created exams
CO6	Students will analyze real-world case studies of digital infrastructure projects, digital missions, and digital services to demonstrate a comprehensive understanding of the practical applications and implications of digital technologies in various contexts, fostering critical thinking and strategic decision-making skills in digital transformation initiatives.	An	C	Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs 36+9	Marks (50)
I		**Transition to Digital World**	**7**	**8**

	1	Challenges of Pre-Digital Age	1	
	2	Importance and Benefits of Digital Revolution	2	
	3	Key concepts: digitization, digitalization, digital transformation	1	
	4	Introduction to Key Digital Technologies: Cloud Computing, IoT, AI, Block Chain	3	
II	**Perspective of Digital India & Digital Innovations in Kerala**		**11**	**15**
	5	Understanding Digital India: Concept, Objectives, and Evolution	1	
	6	Overview of Digital Infrastructure: Broadband Connectivity, Digital Literacy, and Access to Information	2	
	7	Vision of Digital India: DigiLocker, E-Hospitals, e-Pathshala, BHIM, , e-Health Campaigns	3	
	8	Kerala-Emergence as Digital Society : Internet & Mobile Penetration in Kerala, 4 Pillars of Digital Emergence in Kerala (Akshaya Project, IT@School Project, Digital Infrastructure Availability, State Data Centre & allied Applications),	2	
	9	Role of K-DISC in Digital Empowerment	1	
	10	Kerala State IT Mission: Core IT Infrastructure, e-Governance Applications, Service Delivery Platforms,	2	
III	**Digital Tools for Personal and Professional Growth**		**9**	**12**
	11	Digital Tools for Data Sharing: Google Drive, Google Sheets	2	
	12	Digital Tools for Data Sharing: Google Docs, Google Classroom	3	
	13	Online learning platforms and resources (e.g., Coursera, Khan Academy, MOOCs, Duolingo)	2	
	14	Networking Tools: LinkedIn	1	
	15	Content Creation and Management: Canva	1	
IV	**Ethical and Security Considerations in the Digital Age**		**9**	**15**
	16	Understanding privacy in the digital age	1	
	17	Legal and ethical considerations in data collection and processing: Intellectual Property Rights (IPR)	2	
	18	Key Terminologies: Cyber Security, Cyber Crime, Cyber Attack, Cyber Espionage, Cyber Warfare	2	
	19	Authentication, Authorisation	1	
	20	Cyber Crimes and Classification	2	
	21	Introduction to Cyber Laws in India	1	

V	**Open Ended Module: Case Study (One from each set)**		**9**	
	1	Case Study on Digital Infrastructure Projects: (Bharat Broadband Network (BBNL) , Submarine Cable Project, Google Data Center)	3	
	2	Case Study on Digital Mission:	3	
		(Digital Literacy Missions in Kerala, SmartDubai Project, China's Digital Silk Road)		
	3	Case Study on Digital Services: (MyGov.in , Moodle LMS, Digital Payment Services)	3	

References

1. "Digital India Importance Needs and Values" by S K Kaushal
2. "Cyber Security in India: Government, Law Enforcement and Corporate Sector" by Vipin M. Chaturvedi and Shivani Kapoor
3. "Information Security: Principles and Practices in Indian Context" by R.S. Pressman, G. Sharma, and G. Sridhar
4. "Introduction to Computer Security" by Michael Goodrich and Roberto Tamassia
5. https://kdisc.kerala.gov.in/
6. https://itmission.kerala.gov.in/

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Final Exam

Programme	B. Sc. Computer Science and Mathematics(Double Major)				
Course Code	CSC3FV108(1)				
Course Title	Introduction to Cyber laws				
Type of Course	VAC				
Semester	III				
Academic Level	100 - 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-	3	45
Pre-requisites	1. Basic Computer Literacy 2. Familiarity with Online Platforms 3. Willingness to Learn				
Course Summary	Introduction to Cyber laws provides students with a foundational understanding of various concepts Cyber Crimes and Cyber laws against them.				

Course Code		Course Title Introduction to Cyber Laws		
Credit 3		Duration 45 hrs		
Sl. NO:	Course Outcome	Cognitive level *	Know ledge catego ry #	Evaluation Tools used
CO1	To understand the concept of Cyber Space ,Cyber Crimes and cyber laws	U	C	Instructor-Create Exams or Quiz
CO2	To understand details of cyber crimes and criminals	A	P	Discussions and Quizzes
CO3	To examine various provisions in IT Act 2000	U	F	Instructor created exams or Home assignments
CO4	To Identify Intellectual Property right and E-commerce related issues.	A ,E	P	Discussions, Quizzes
CO5	To get overall idea of cyber laws and its	Ap	P	Viva Voce
	enforcement mechanisms in India			Observation of practical skills
CO6	To get to know about Penalties and legal implications associated with cyber crimes under Indian law	U	M	Instructor Created - Exams, Assignments
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Module	Unit	Content	Hrs	Marks
I		Introduction to cyber space	**9**	**12**
	1	Cyber Space- Fundamental definitions	2	
	2	Jurisprudence and-Jurisdiction in Cyber Space	2	
	3	Need for IT act - Enforcement agencies	3	
	4	Introduction to cyber law and its relevance in the Indian context	2	
II		**Cyber Crimes and Criminals**	**9**	**12general**

	5	Cyber crimes	2	
	6	Cyber Criminals and their Objectives	2	
	7	Cyber stalking; cyber pornography	2	
	8	Forgery and fraud; crime related to IPRs;	2	
	9	Phishing and Identity Theft	1	
III	**Indian Cyber law**		**9**	**14**
	10	Introduction to Indian Cyber Law	2	
	11	Cyber Crime vs Conventional Crime	2	
	12	Electronic Commerce and related issues	2	
	13	Overview of Intellectual Property rights	2	
	14	Computer Software and related IPR Issues	1	
IV	**Basics of IT law and its regulatory mechanisms**		**9**	**12**
	13	Key provisions of the Information Technology Act, 2000 related to cyber crimes and offenses	2	
	14	Regulatory Mechanisms and Enforcement	2	
	15	Overview of the Cyber Crime Investigation Cell (CCIC)	2	
	16	Understanding the process of reporting cyber crimes	2	
	17	Penalties and legal implications associated with cyber crimes under Indian law (basics only)	1	
V	**Hands-on : Practical Applications, Case Study and Course Project**		**9**	
	1	Social Media based Cyber crimes	2	
	2	Discussion on Emerging issues	2	
	3	Recent trends in digital marketing	3	
	4	Demonstrate how to use google web masters Indexing Using API	2	

References:

1. Cyber law –The Indian perspective by Pavan Duggal
2. Justice Yatindra Singh: Cyber Laws, Universal Law Publishing Co., New Delhi
3. Farouq Ahmed, Cyber Law in India, New Era publications, New Delhi

Correlation Levels:

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

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Practical Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4	✓			✓
CO 5		✓		✓
CO6				✓

Programme	B. Sc. Computer Science and Mathematics(Double Major)				
Course Code	CSC4FV109(2)				
Course Title	Introduction to Content Management System				
Type of Course	VAC				
Semester	IV				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-	-	45
Pre-requisites	1. Familiarity with web content management systems (CMS). 2. Basic knowledge of internet technologies provides a foundation for learning web design.				
Course Summary	The course covers fundamental web design concepts including HTML and CMS principles, focusing on Drupal as a robust Content Management System. Students will learn to create and customize websites using Drupal, exploring its features such as content types, themes, and modules to build dynamic and interactive web pages.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Cultivate a robust understanding of web design fundamentals, laying a strong foundation for their journey into the dynamic world of digital design and development.	U	C	Assignment / Instructor-created exams / Quiz
CO2	Attain comprehensive knowledge and practical proficiency in Content Management Systems (CMS), empowering to navigate and excel in the ever-evolving landscape of digital content creation and management.	U	C	Assignment / Instructor-created exams / Quiz
CO3	Develop expertise in Drupal, a widely used CMS platform, gaining comprehensive understanding of its features, configuration, and installation processes, thus preparing them for proficient and innovative web development endeavors.	Ap	P	Practical Assignment / Instructor-created exams / Quiz
CO4	Impart a comprehensive understanding of website development using Drupal and facilitate the acquisition of expertise across various options within the Drupal ecosystem.	Ap	P	Practical Assignment / Instructor-created exams / Quiz
CO5	Gain an understanding of how to apply web design concepts to real-world scenarios, effectively designing and developing functional and aesthetically	C	P	Practical Assignment / Instructor-created exams /

	pleasing websites utilizing the Drupal CMS.			Quiz
CO6	Develop proficiency in advanced website management skills, including installing and configuring modules, managing menus, and more, to effectively navigate and optimize the functionality of websites built on the Drupal platform.	C	P	Practical Assignment / Instructor-created exams / Quiz
* - 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	Marks
I		**Introduction to Web Designing**	**8**	**10**
	1	Basics of Web Designing -World Wide Web (WWW), W3C, Web Browser	1	
	2	Web Server, Web Hosting, Web Pages	1	
	3	DNS, URL	2	
	4	Overview of HTML (Concept only) and its role in Web Development	2	
	5	Open Source S/W, Open Source vs Closed Source Software, Open Source Licenses (Concept only)	2	
II		**Introduction to CMS**	**6**	**10**
	6	Introduction to Content Management Systems (CMS) - Features of CMS	2	
	7	Web Content Management System	2	
	8	Components of Content Management System	2	
III		**Introduction to Drupal**	**10**	**15**
	10	Drupal - Features, Advantages and Disadvantages	1	
	11	Installation and Configuration	1	
	12	Content types and Field	2	
	13	Drupal Architecture	1	
	14	User Management, Managing Comments	2	
	15	Creating and Customizing Themes	3	
IV		**Building Website**	**12**	**15**
	16	Website Development - Working with Templates and Template files	2	
	17	Articles, Creating Web Forms	2	
	18	Managing blocks, Add Links to Blocks, Moving Elements within Block	2	
	19	Blocks and Regions	2	
	20	Creating and Customizing Views	1	
	21	Installing and Configuring Modules	1	
	22	Static Pages, Creating Pages, Menu Management.	2	
V		**Open Ended Module – Website Development**	**9**	
	23	Develop a simple Website using Drupal.	9	

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	3	1	1	3	1						
CO 2	1	3	2	1	3	1						
CO 3	1	3	1	1	3	2						
CO 4	1	3	3	1	3	2						
CO 5	3	3	3	1	3	2						
CO 6	1	3	3	1	3	2						

Correlation Levels:

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

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Practical Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6	✓	✓		✓

References:

1. Jennifer Campbell, Jennifer T Campbell, Web Design: Introductory, Course Technology.

2. Jason Beaird and Alex Walker, The Principles of Beautiful Web Design, SitePoint.

3. Bob Boiko, Content Management Bible, Wiley.

4. Daniel Sipos, Drupal 9 Module Development, Packt Publishing Limited.

Programme	B. Sc. Computer Science and Mathematics(Double Major)				
Course Code	CSC5FS112				
Course Title	Introduction to Digital Marketing				
Type of Course	SEC				
Semester	V				
Academic Level	100 - 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-	3	45
Pre-requisites	1. Basic Computer Literacy 2. Familiarity with Online Platforms 3. Willingness to Learn				
Course Summary	Introduction to Digital Marketing" provides students with a foundational understanding of key concepts and techniques in the rapidly evolving field of digital marketing. Through engaging lectures. Students will explore various digital marketing channels, including search engine optimization (SEO), social media marketing, email marketing, and content marketing				

Course Code		Course Title Introduction to Digital Marketing		
Credit 3		Duration 45 hrs		
Sl. NO:	Course Outcome	Cognitive level *	Knowledge category #	Evaluation Tools used
CO1	To understand the concept of digital marketing and its integration with traditional marketing	U	C	Instructor-Create Exams or Quiz
CO2	To understand customer value journey in digital context and behaviour of online consumers	A	P	Discussions and Quizzes

CO3	To examine various tactics for enhancing a website's position and ranking with search engines	U	F	Instructor created exams or Home assignments
CO4	To Identify and differentiate between various digital marketing channels, including SEO, social media, email, and content marketing.	A ,E	P	Discussions, Quizzes
CO5	To get overall idea in implementing basic digital marketing strategies to enhance online visibilityand engagement.	Ap	P	Viva Voce Observation of practical skills
CO6	To get to know about ethical considerations and best practices in digital marketing, including privacy, data protection, and consumer trust	U	M	Instructor Created - Exams, Assignments
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus

Module	Unit	Content	Hrs	Marks
I		Digital Marketing Basics	**9**	**12**
	1	Overview of digital marketing	2	
	2	Importance of digital marketing for businesses	2	
	3	Introduction to key digital marketing channels (SEO, social media, email marketing)	3	
	4	Basics of creating a digital marketing strategy	2	
II		**Content Marketing & Social Media**	**9**	**12**
	5	Content Marketing Fundamentals	2	
	6	Content Strategy Development	2	
	7	Content Creation for Different Platforms	2	
	8	Introduction to Social Media Marketing & keyword Optimization	2	
	9	Social Media Strategy & Community Management	1	
III		**Search Engine Optimization (SEO) & Paid Advertising**	**9**	**14**
	10	Introduction to Search Engine Optimization	2	

	11	On-page and Off-page SEO Techniques	2	
	12	Search Engine Marketing (SEM) Fundamentals	2	
	13	Pay-Per-Click (PPC) Advertising with Google Ads	2	
	14	Social Media Advertising Platforms	1	
IV	**Web Analytics & Emerging Trends**		**9**	**12**
	13	Introduction to Web Analytics & Key Metrics	2	
	14	Using Analytics Tools for Data-Driven Decision Making	2	
	15	Conversion Tracking & Optimization	2	
	16	Emerging Trends in Digital Marketing	2	
	17	The Future of Marketing	1	
V	**Hands-on : Practical Applications, Case Study and Course Project**		**9**	
	1	**S**ocial Media Marketing-Social media Channels	2	
	2	Leveraging social media for brand conversions and buzz	2	
	3	Recent trends in digital marketing	3	
	4	Demonstrate how to use google web masters Indexing Using API	2	

References:

1. Digital Marketing for Dummies by Ryan DeWald
2. MARKETING 4.0 Moving from Traditional to Digital PHILIP KOTLER HERMAWAN KARTAJAYA IWAN SETIAWAN
3. Ryan, D. (2014). Understanding Digital Marketing: Marketing Strategies for Engaging the Digital Generation, Kogan Page Limited
4. Taxmanns - Digital Marketing - Satinder Kumar, Supereet Kaur
5. Social Media Marketing 2024 - Mastering New Trends & Strategies for Online Success - Robert Hill

Correlation Levels:

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

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Practical Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4	✓			✓
CO 5		✓		✓
CO6				✓

General Foundation Courses in Mathematics

Programme	B. Sc. Computer Science and Mathematics(Double Major)			
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: 978-0-367-64373-7, 2021.
2. Ron Larson & Betsy Farber, Elementary Statistics, Picturing the World 6/e, Pearson Education, ISBN: 978-0-321-91121-6, 2015.

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:

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. Computer Science and Mathematics(Double Major)			
Course Code	MAT2FM106(1)			
Course Title	**GRAPH THEORY AND LPP.**			
Type of Course	**MDC**			
Semester	II			
Academic Level	100 - 199			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	3	3	-	45
Pre-requisites	Basic Arithmetic and Geometry.			
Course Summary	The course "Graph Theory and Linear Programming" introduces fundamental concepts in graph theory focusing initially on graph definitions, properties, and structures such as vertex degrees, subgraphs, paths, and cycles. The discussion extends to trees, bridges, spanning trees, cut vertices, and connectivity, emphasizing essential properties and theorems while 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:

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

Course Outcomes (CO):

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

Detailed Syllabus:

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

	19	Clock and Calendar		
V	**Open Ended**		**9**	
	Mixture or Allegation, Partnership, Pipes and Cisterns			

References: 1. Fast Track Objective Arithmetic, Rajesh Verma, Arihant Publications India limited, 2018 (Primary Reference).
2. Objective Arithmetic for Competitive Examinations, Dinesh Khattar, Pearson Education, 2020.
3. Quicker Objective Arithmetic, Dr Lal, Jain, Upkar's publication, 2010.

Mapping of COs with PSOs and POs :

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

Correlation Levels:

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

Assessment Rubrics:

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

Mapping of COs to Assessment Rubrics:

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

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

Course Outcomes (CO):

CO	**CO Statement**	**Cognitive Level***	**Knowledge Category#**	**Evaluation Tools used**
CO1	Apply mathematical methods to solve problems	Ap	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO2	Understand the basic concepts of logical reasoning Skills	U	P	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam
CO3	Manage time in competitive examinations	C	M	Internal Exam/Assignment/ Seminar/ Viva / End Sem Exam

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)

- Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

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

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

References:

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

Mapping of COs with PSOs and POs :

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

Correlation Levels:

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

Assessment Rubrics:

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

Mapping of COs to Assessment Rubrics:

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

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

Course Outcomes (CO):

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

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

Detailed Syllabus:

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 (5th 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**	**Min 10**
	12	Theorem in Latex – Tutorial IX.1		
	13	The AMS theorem package- Tutorial IX.2 (Omit IX.2.2 , IX.2.3)		
	14	Boxes – Tutorial X (Section X.1 , X.2 Only)		

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

References:

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

Mapping of COs with PSOs and POs :

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

Correlation Levels:

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

Assessment Rubrics:

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

Mapping of COs to Assessment Rubrics:

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

Programme	B. Sc. Computer Science and Mathematics(Double Major)				
Course Code	MAT6FS113				
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.

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

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

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

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

Roadmap:

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

Mapping of COs with PSOs and POs :

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

Mapping of COs to Assessment Rubrics:

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

Correlation Levels:

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

Assessment Rubrics:

- Internal Exam
- Assignment
- Quiz
- End Semester Examinations

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

Course Outcomes (CO):

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

Detailed Syllabus:

<table>
<tr><td>Textbook</td><td colspan="4">Mathematics & Its History, 3rd Edition, John Stillwell, Springer (2010) ISBN: 978-1-4419-6052-8.</td></tr>
<tr><td>Module</td><td>Unit</td><td>Content</td><td>Hrs
(36+9)</td><td>Ext. Marks
(50)</td></tr>
<tr><td rowspan="14">I</td><td colspan="2">Ancient Origins & Foundations</td><td rowspan="14">9</td><td rowspan="14">Min 10</td></tr>
<tr><td colspan="2">Quick Review of Ancient Mathematics</td></tr>
<tr><td>1</td><td>Chapter 1: Pythagoras Theorem</td></tr>
<tr><td>2</td><td>Chapter 2: Greek Geometry</td></tr>
<tr><td>3</td><td>Chapter 3: Greek Number Theory</td></tr>
<tr><td colspan="2">Infinity in Greek Mathematics – Chapter 4</td></tr>
<tr><td>4</td><td>Section 4.1, 4.2-Fear of Infinity, Eudoxus’ Theory of Proportions</td></tr>
<tr><td>5</td><td>Section – 4.3, 4.4-The Method of Exhaustion, Area of a Parabolic Segment</td></tr>
<tr><td colspan="2">Sets & Logic – Chapter 24</td></tr>
<tr><td>6</td><td>Sections 24.1, 24.2, 24.4- Sets, Ordinals, Axiom of Choice & Large Cardinals</td></tr>
<tr><td>7</td><td>Section 24.3- Measure</td></tr>
<tr><td>8</td><td>Section 24.5-The Diagonal Argument</td></tr>
<tr><td colspan="2">Biographical Notes: Pythagoras, Euclid, Diophantus, Archimedes</td></tr>
<tr><td rowspan="6">II</td><td colspan="2">Calculus – Chapter 9</td><td rowspan="6">9</td><td rowspan="6">Min 10</td></tr>
<tr><td>9</td><td>Section 9.1, 9.2-What is Calculus, Early Results on Areas & Volumes</td></tr>
<tr><td>10</td><td>Section 9.3-Maxima, Minima & Tangents</td></tr>
<tr><td>11</td><td>Section 9.4-The Arithemetica Infinitorum of Wallis</td></tr>
<tr><td>12</td><td>Section 9.5-Newton’s Calculus of Series</td></tr>
<tr><td>13</td><td>Section 9.6-The Calculus of Leibnitz</td></tr>
</table>

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

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

References:

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

Mapping of COs with PSOs and POs :

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

Correlation Levels:

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

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Determine the Satisfiability of a Propositional Formula Set.	Ap	C	Internal Exam/Assignment / Seminar/ Viva / End Sem Exam
CO2	Analyse Theorems of Propositional Logic	Ap	C	Internal Exam/Assignment / Seminar/ Viva / End Sem Exam
CO5	Remember Proofs of Major Theorems of Logic	An	M	Internal Exam/Assignment / Seminar/ Viva / End Sem Exam

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

Detailed Syllabus:

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

IV	**Resolution for Predicate Logic: Section 2.5**			

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

References:

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

Mapping of COs with PSOs and POs :

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

Correlation Levels:

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

Assessment Rubrics:

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

Mapping of COs to Assessment Rubrics:

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

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

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Demonstrate Proficiency in Basic and Intermediate R Programming	Ap	P	Internal Exam/ Seminar/Assignment / End Sem Exam
CO2	Create and Interpret Various Types of Graphs Using R	C	C	Internal Exam/ Seminar/Assignment / End Sem Exam
CO3	Apply Advanced Mathematical and Statistical Functions in R	Ap	P	Internal Exam/ Seminar/Assignment / End Sem Exam

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

Detailed Syllabus:

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

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

Mapping of COs with PSOs and POs :

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

Correlation Levels:

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

Assessment Rubrics:

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

Mapping of COs to Assessment Rubrics:

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

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

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Uncover the underlying fundamental principles of the traditional mathematics practised in medieval Kerala.	U	C	Seminar Presentation/ Group Tutorials
CO2	Appreciate the role of thought process and working rules in mathematics.	U	C	Seminar Presentation/ Group Tutorials
CO3	Appreciate the usage of infinite series in mathematical analysis.	U	C	Seminar Presentation/ Group Tutorials

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

Detailed Syllabus:

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

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

References:

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

Mapping of COs with PSOs and POs :

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

Correlation Levels:

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

Assessment Rubrics:

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

Mapping of COs to Assessment Rubrics:

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