SCHEME OF EXAMINATION

&

SYLLABI

for

Bachelor of Technology Programmes of Studies under the aegis of University School of Information, Communication & Technology offered at Affiliated Institutions of the University

(1st Year Common Scheme and Syllabus and 2nd Year onwards Scheme and Syllabus)

PART – III

(for Scheme of Examination and Syllabi for Bachelor of Technology (Computer Science and Applied Mathematics) offered at Affiliated Institutions of the University)

GURU GOBIND SINGH INDRAPRASTHA UNIVERSITY

University School of Information, Communication &Technology

Sector 16C, Dwarka, Delhi – 110 078 [INDIA]

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Approval History:

1. Scheme of Examination and Syllabi for Bachelor of Technology (Computer Science and Applied Mathematics) offered at Affiliated Institutions of the University from 2024-25 batch i.e. Part-III approved by Board of Studies of USICT held on dated 28.07.2025.
2. Scheme of Examination and Syllabi for Bachelor of Technology (Computer Science and Applied Mathematics) offered at Affiliated Institutions of the University from 2024-25 batch i.e. Part-III approved by Academic Council Sub-committee on dated 1.08.2025.

Important Notes:

1. This document contains the Scheme of Examination and Syllabi for **Bachelor of Technology (Computer Science and Applied Mathematics)** offered at Affiliated Institutions of the University.

2. This document is hereinafter refered to as **Part – III** of the earlier approved Scheme of Examination and Syllabi for Bachelor of Technology Programmes of Studies under the aegis of University School of Information, Communication & Technology offered at Affiliated Institutions of the University (approved by BoS on 24/08/2023 & AC subcommittee on 29/09/2023 and uploaded on website of the university at http://www.ipu.ac.in/Pubinfo2022/syllBTechAff130423.pdf dated: 18.10.2023; *hereinafter refered to as* **Part – I)**.

3. The 1st Year Scheme and Syllabi for **B.Tech (Computer Scienceand Applied Mathematics)** is also common as that of all other disciplines of B.Tech as described in Part – I (Page Nos. 9 – 12 and 14 - 51)

4. Bridge Courses for the **B.Tech (Computer Scienceand Applied Mathematics)** Lateral Entry students is also same as that of all other disciplines of B.Tech as described in Part – I (Page No. 13 and 301-304)

Provision for Smooth Implementation

This document describes the curriculum of the Bachelor of Technology Programmes that are (or allowed to be) offered at the affiliated institutions of Guru Gobind Indraprastha University, Delhi, under the aegis of the University School of Information, Communication and Technology. In the event of any difficulty of implementation, and / or interpretation of any clause of the document, the same may be brought to the notice of Dean of the University School of Information Communication and Technology. The decision of the Dean, University School of Information Communication and Technology shall be final and implemented to resolve the issue. The same shall be put up in the subsequent meeting of the Board of Studies of the University School of Information Communication and Technology for its approval. If the decision of the Board of Studies of the University School of Information Communication and Technology is at variance with the decision taken earlier by the Dean of the School, the decision of the Board shall be effective from the date of the approval by the Board of Studies. In the interim period (between the approval of the Dean, of the School and the Board of Studies approval), the decision already taken by the Dean of the school shall stand.

Note for implementation

The textbooks recommended by AICTE vide its public notification (Annexure 1 of the Part-I) and its amendments from time to time, may be utilized by the concerned teachers for teaching of subjects in any discipline (as relevant).

The Outcome Based Education Framework implementation was approved by the BoS. The framework as decided by the APC and of the school is shall be implemented w.e.f batch of Academic Session 2023-24.

The marking scheme for all non-NUES papers (theory/practical) to be as:

1. **Teachers Continuous Evaluation: 40 marks**
2. **Term end Theory Examinations: 60 marks**

w.e.f from the batch of A.S.: 2023-24 onwards (for lateral entry this provision shall be applicable from admissions through lateral entry from admissions in the academic session 2024-25). For earler batch (regular) admitted in the year 2021-22 and 2022-23 (and corresponding lateral entry admissions), the marking scheme for all non-NUES papers (theory/practical) to be as defined within this document, that is, NUES papers out of 100, Theory to have 25 marks for Teachers Continuous Evaluation and 75 marks for term end examinations while the corresponding bifurcation for practicals/projects/dissertation to be 40:60.

Programme Outcomes

1. **Engineering Knowledge** (**PO01**): Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. **Problem Analysis** (**PO02**): Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

3. **Design/Development of Solutions** (**PO03**): Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. **Conduct Investigations of Complex Problems** (**PO04**): Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions for complex problems:

    a. that cannot be solved by straightforward application of knowledge, theories and techniques applicable to the engineering discipline as against problems given at the end of chapters in a typical text book that can be solved using simple engineering theories and techniques;

    b. that may not have a unique solution. For example, a design problem can be solved in many ways and lead to multiple possible solutions;

    c. that require consideration of appropriate constraints / requirements not explicitly given in the problem statement such as cost, power requirement, durability, product life, etc.;

    d. which need to be defined (modelled) within appropriate mathematical framework; and

    e. that often require use of modern computational concepts and tools, for example, in the design of an antenna or a DSP filter.

5. **Modern Tool Usage** (**PO05**): Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

6. **The Engineer and Society** (**PO06**): Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and Sustainability** (**PO07**): Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics** (**PO08**): Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and Team Work** (**PO09**): Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. **Communication** (**PO10**): Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project Management and Finance** (**PO11**): Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Life-long Learning** (**PO12**): Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

Acronyms for Core Disciplines:

CSE : Computer Science and Engineering
IT : Information Technology
CST : Computer Science and Technology
ITE : Information Technology and Engineering
ECE : Electronics and Communications Engineering
EE : Electrical Engineering
EEE : Electrical and Electronics Engineering
ICE : Instrumentation and Control Engineering
ME : Mechanical Engineering
CE : Civil Engineering
CS : Computer Science

Acronyms for Emerging Area Disciplines:

MAE : Mechanical and Automation Engineering
CSE-AI : Computer Science and Engineering (Artificial Intelligence)
CSE-AIML : Computer Science and Engineering (Artificial Intelligence and Machine Learning)
CSE-DS : Computer Science and Engineering (Data Science)
CSE-IoT : Computer Science and Engineering (Internet of Things)
CSE-ICB : Computer Science and Engineering (Internet of Things and Cyber Security including Block Chain Technology)
CSE-Net : Computer Science and Engineering (Networks)
CSE-CS : Computer Science and Engineering (Cyber Security)
EE-VDT : Electronics Engineering (VLSI Design and Technology)
EC-ACT : Electronics and Communication (Advanced Communication Technology)
CSAM : Computer Science and Applied Mathematics

Acronyms for Course / Paper Groups and Codes:

BS : Basic Science
HS : Humanities, Social Science
MS : Management Studies
ES : Engineering Science
MC : Mandatory Courses
PC : Programme Core, that is course/paper offered in the discipline of the programme as a compulsory paper.
PCE : Programme Core Elective, that is elective course/paper offered in the discipline of the programme.
EAE/OAE: Emerging Area Elective / Open Area Elective offered in the institution
CIC : Computer Science / IT Core
CIE : Computer Science / IT Elective
ECC : Electronics Core
ECE : Electronics Elective
EEC : Electrical Core
EEE : Electrical Elective
ICC : Instrumentation Core
ICE : Instrumentation Elective
MEC : Mechanical Core
MEE : Mechanical Elective
CEC : Civil Core
CEE : Civil Elective
MAC : Automation Core
MAO : Automation Open Elective
AM : Applied Mathematics

Definitions:

Batch: The batch of the student shall mean the year of the first time enrolment of the students in the programme of study in the first semester. Lateral entry students admitted in the 3rd semester / 2nd year shall be designated as students admitted in the previous batch as they are admitted one year later. A student re-admitted in a programme of study in a lower / later batch shall be considered as the student of the original batch for the purpose calculation of duration of study (lateral entry o readmission due to academic break).

Programme of study shall mean Bachelor of Technology.

Major / Primary specialization / discipline shall mean the discipline in which the student is admitted / upgraded or transferred.

Minor specialization shall mean the specializations earned through the EAE or OAE route subject to fulfilment of requirements specified in the scheme of study for the concerned minor specialization.

Other Acronyms:

PCC	:	Programme Coordination Committee
APC	:	Academic Programme Committee comprising of all faculty of the department / institutions and as defined in the implementation rules and the Ordinance 11 of the University.
L	:	Number of Lecture hours per week
T/P	:	Number of Tutorial / Practical Hours per week
C	:	Number of credits assigned to a course / paper
COE	:	Controller of Examinations of the Examinations Division of the University.
SGPA/CGPA	:	Semester/Cumulative Grade Point Average.
NUES	:	Non University Examination System - No term end examination shall be held. The evaluation shall be conducted as per the scheme of examinations as described in the scheme of study.

FIRST YEAR

Common Scheme and Syllabus

for

All Bachelor of Technology Programmes of Study under the aegis of University School of Information, Communication & Technology offered at Affiliated Institutions of the University

In light of the eligibility condition specified in the **AICTE Process Handbook 2022-23** (Page Nos 89 and 90), the **Chemistry Papers BS-121 / BS-120 entitled "Basic Chemistry"** shall be offered to students admitted from Academic Session 2022-23 (in the 1st/ 2ndSemester) in lieu of **Chemistry Papers BS-103 / BS-104 entitled "Applied Chemistry".** This shall be offered only to students who have not studied Chemistry at 10+2 Level and are admitted to the following disciplines only:

1) Computer Science and Engineering (CSE)
2) Information Technology (IT)
3) Computer Science and Technology (CST)
4) Information Technology and Engineering (ITE)
5) Electronics and Communications Engineering (ECE)
6) Electrical Engineering (EE)
7) Electrical and Electronics Engineering (EEE)
8) Instrumentation and Control Engineering (ICE)
9) Computer Science (CS)
10) Computer Science and Engineering (Artificial Intelligence) (CSE-AI)
11) Computer Science and Engineering (Artificial Intelligence and Machine Learning) (CSE-AIML)
12) Computer Science and Engineering (Data Science) (CSE-DS)
13) Computer Science and Engineering (Internet of Things) (CSE-IoT)
14) Computer Science and Engineering (Internet of Things and Cyber Security including Block Chain Technology) (CSE-ICB)
15) Computer Science and Engineering (Networks) (CSE-Net)
16) Computer Science and Engineering (Cyber Security) (CSE-CS)
17) Electronics Engineering (VLSI Design and Technology) (EE-VDT)
18) Electronics and Communication (Advanced Communication Technology) (EC-ACT)
19) Computer Science and Applied Mathematics (CSAM)

Note: The corresponding practical paper (BS-155 / BS-156) shall be unchanged.(Addition from AY 2022-23)

First Semester					
Group	**Code**	**Paper**	**L**	**P**	**Credits**
Theory Papers					
ES BS	ES-101 BS-103/BS-121#	*Any one of the following: Programming in 'C' Applied Chemistry / Basic Chemistry#	3	-	3
BS	BS-105	Applied Physics – I	3	-	3
ES BS	ES-107 BS-109	*Any one of the following: Electrical Science Environmental Studies	3	-	3
BS	BS-111	Applied Mathematics – I	4	-	4
HS HS HS	HS-113 HS-115 HS-117	**Group 1 or Group 2 shall be offered: Group 1: Communications Skills OR Group 2: Indian Constitution*** Human Values and Ethics***	3 2 1	-	3 2 1
ES	ES-119	Manufacturing Process	4	-	4
Practical/Viva Voce					
BS	BS-151	Physics-I Lab	-	2	1
ES BS	ES-153 BS-155	Any of the following corresponding to the theory paper offered: Programming in 'C' Lab Applied Chemistry	-	2	1
ES	ES-157	Engineering Graphics-I	-	4	2
ES BS	ES-159 BS-161	Any of the following corresponding to the theory paper offered: Electrical Science Lab Environmental Studies Lab	-	2	1

Total	**20**	**10**	**25**

*For a particular batch of a programme of study one out of these two papers shall be taught in the first semester while the other shall be taught in the 2nd semester. Students who have to re-appear can only reappear in the odd semester if originally offered to the student in the 1st semester and similarly for the students who study the paper in the second semester. The institution shall decide which paper to offer in which semester.

**For a particular batch of a programme of study either the paper on "Communications Skills" (Group 1), or Group 2: papers ("Indian Constitution" and "Human values and ethics") shall be taught in the first semester while the other group shall be taught in the 2nd semester. Students who have to re-appear can only reappear in the odd semester if originally offered to the student in the 1st semester and similarly for the students who study the paper(s) in the second semester. The institution shall decide which paper group to offer in which semester.

***__NUES__: All examinations to be conducted by the concerned teacher as specified in the detailed syllabus of the paper.

#The students who have not studied Chemistry at 10+2 level shall be offered BS-121 in lieu of BS-103, as applicable in applicable disciplines. (Addition from the Academic Session 2022-23)

Group	Code	Paper	L	P	Credits
HS/MS	HS-352	NSS / NCC / Cultural Clubs / Technical Society / Technical Club*			2

***__NUES__:** Comprehensive evaluation of the students by the concerned coordinator of NCC / NSS / Cultural Clubs / Technical Society / Technical Clubs, out of 100 as per the evaluation schemes worked out by these activity societies, organizations; the co-ordinators shall be responsible for the evaluation of the same. These activities shall start from the 1st semester and the evaluation shall be conducted at the end of the 6th semester for students admitted in the first semester. Students admitted in the 2nd year (3rd semester) as lateral entry shall undergo training or participate in the activities for the period of 3rd semester to 6th semester only

Second Semester					
Group	**Paper Code**	**Paper**	**L**	**P**	**Credits**
Theory Papers					
ES BS	ES-102 BS-104/BS-120#	*Any one of the following: Programming in 'C' Applied Chemistry / Basic Chemistry#	3	-	3
BS	BS-106	Applied Physics – II	3	-	3
ES BS	ES-108 BS-110	*Any one of the following: Electrical Science Environmental Studies	3	-	3
BS	BS-112	Applied Mathematics – II	4	-	4
HS HS HS	HS-114 HS-116 HS-118	**Group 1 or Group 2 shall be offered: Group 1: Communications Skills OR Group 2: Indian Constitution*** Human Values and Ethics***	3 2 1	-	3 2 1
ES	ES-114	Engineering Mechanics	3	-	3
Practical/Viva Voce					
BS	BS-152	Physics-II Lab	-	2	1
ES BS	ES-154 BS-156	*Any of the following corresponding to the theory paper offered: Programming in 'C' Lab Applied Chemistry	-	2	1
ES	ES-158	Engineering Graphics-II	-	2	1
ES BS	ES-160 BS-162	*Any of the following corresponding to the theory paper offered: Electrical Science Lab Environmental Studies Lab	-	2	1
ES	ES-164	Workshop Practice		4	2
Total			**19**	**12**	**25**

*For a particular batch of a programme of study one out of these two papers shall be taught in the first semester while the other shall be taught in the 2nd semester. Students who have to re-appear can only reappear in the odd semester if originally offered to the student in the 1st semester and similarly for the students who study the paper in the second semester. The institution shall decide which paper to offer in which semester.

**For a particular batch of a programme of study either the paper on "Communications Skills" (Group 1), or Group 2: papers ("Indian Constitution" and "Human values and ethics") shall be taught in the first semester while the other group shall be taught in the 2nd semester. Students who have to re-appear can only reappear in the odd semester if originally offered to the student in the 1st semester and similarly for the students who study the paper(s) in the second semester. The institution shall decide which paper group to offer in which semester.

***__NUES__:** All examinations to be conducted by the concerned teacher as specified in the detailed syllabus of the paper.

#The students who have not studied Chemistry at 10+2 level shall be offered BS-120 in lieu of BS-104, as applicable in applicable disciplines. (Addition from the Academic Session 2022-23)

BRIDGE COURSES FOR THE B.TECH LATERAL ENTRY STUDENTS

All the Lateral Entry students of B.Tech., who are directly admitted in the 2nd Year / 3rd Semester of the Progarmme of Study, have to pass the following bridge courses.

Paper Code	Paper Name	L/P
BC-181	Bridge Course in Mathematics	3
BC-183	Bridge Course in Programming in C	3

Implementation Rules for Bridge Courses:

1. The institutions are required to conduct the classes for the above bridge courses in the 3rd Semester along with the classes of the other courses.
2. These papers have to be qualified by the students.
3. For these papers examination shall be conducted by the concerned subject teacher as NUES, the same shall be transferred to Examination Division of the University.
4. The degree to be awarded to the student only subject to the acquiring qualifying grade/marks in the bridge courses and the minimum credits in the regular courses of the scheme of study as prescribed.
5. These Courses shall be qualifying in nature; they shall not be included for calculation of CGPA. The qualifying marks shall be 40 marks in each paper.
6. A separate marksheet will be issued by the Examination Division of the University for the Bridge Course.

Bachelor of Technology in Computer Science and Applied Mathematics (CSAM)

2nd Year Onward Scheme and implementation guideline

Third Semester					
Group	**Paper Code**	**Paper**	**L**	**P**	**Credits**
Theory Papers					
ES	ES-201	Computational Methods	4		4
HS/MS	HS-203	Indian Knowledge System*	2		2
PC	CIC-205	Discrete Mathematics	4		4
PC	ECC-207	Digital Logic and Computer Design	4		4
PC	CIC-209	Data Structures	4		4
PC	AM-221	Linear Algebra and Calculus	4		4
Practical / Viva Voce					
ES	ES-251	Computational Methods Lab		2	1
PC	ECC-253	Digital Logic and Computer Design Lab		2	1
PC	CIC-255	Data Structures Lab		2	1
PC	AM-267	Linear Algebra and Calculus Lab		2	1
Total			**22**	**8**	**26**

***NUES:**All examinations to be conducted by the concerned teacher as specified in the detailed syllabus of the paper.

Fourth Semester					
Group	**Paper Code**	**Paper**	**L**	**P**	**Credits**
Theory Papers					
BS	BS-202	Probability, Statistics and Linear Programming	4		4
HS/MS	HS-204	Technical Writing*	2		2
PC	CIC-206	Theory of Computation	4		4
PC	CIC-212	Programming in Java	4		4
PC	CIC-214	Operating Systems	4		4
PC	AM-220	Differential Equations	4		4
Practical / Viva Voce					
BS	BS-252	Probability, Statistics and Linear Programming Lab		2	1
PC	CIC-258	Programming in Java Lab		2	1
PC	CIC-260	Operating Systems Lab		2	1
PC	AM-266	Differential Equations Lab		2	1
Total			**22**	**8**	**26**

***NUES:**All examinations to be conducted by the concerned teacher as specified in the detailed syllabus of the paper.

Fifth Semester					
Group	**Paper Code**	**Paper**	**L**	**P**	**Credits**
Theory Papers					
HS/MS	HS-301	Economics for Engineers	2		2
PC	CIC-315	Database Management Systems	4		4
PC	CIC-307	Computer Networks	4		4
PC	CIC-311	Design and Analysis of Algorithm	4		4
PC	AM-317	Number Theory	3		3
PC	AM-319	Mathematical Modelling and Graph Theory	3		3
Practical / Viva Voce					
PC	CIC-367	Database Management Systems		2	1
PC	CIC-355	Computer Networks Lab		2	1
PC	CIC-359	Design and Analysis of Algorithm Lab		2	1
PC	AM-369	Number Theory Lab		2	1
PC	AM-371	Mathematical Modelling and Graph Theory Lab		2	1
PC / Internship	ES-361	Summer Training Report - 1 *			1
Total			**20**	**10**	**26**

***NUES:**Comprehensive evaluation of the Summer Training Report – 1 (after 4th Semester) shall be done by the committee of teachers, constituted by the Academic Programme Committee, out of 100. The training shall be of 4 to 6 weeks duration. The training can be under the mentorship of a teacher of the institute.

Sixth Semester					
Group	**Paper Code**	**Paper**	**L**	**P**	**Credits**
Theory Papers					
HS/MS	MS-302	Principles of Management for Engineers	3		3
HS/MS	HS-304	Introduction to Universal Human Values*	1		1
PC	DA-304T	Statistics, Statistical Modelling & Data Analytics	3		3
PC	AI-316T	Artificial Intelligence and Machine Learning	3		3
PC	CS-310T	Information Theory and Coding	3		3
PC	AM-320	Operations Research	3		3
OAE		Open Area Elective Paper (OAE – 1)			4
Practical / Viva Voce					
PC	DA-304P	Statistics, Statistical Modelling & Data Analytics Lab		2	1
PC	AI-316P	Artificial Intelligence and Machine Learning Lab		2	1
PC	CS-310P	Information Theory and Coding Lab		2	1
PC	AM-360	Operations Research Lab		2	1
HS/MS	HS-352	NSS / NCC / Cultural Clubs / Technical Society / Technical Club*			2
Total					**26**

***NUES:**All examinations to be conducted by the concerned teacher as specified in the detailed syllabus of the paper.

****NUES:** Comprehensive evaluation of the students by the concerned coordinator of NCC / NSS / Cultural Clubs / Technical Society / Technical Clubs, out of 100 as per the evaluation schemes worked out by these activity societies, organizations; the faculty co-ordinators shall be responsible for the evaluation of the same. These activities shall start from the 1st semester and the evaluation shall be conducted at the end of the 6th semester for students admitted in the first semester. Students admitted in the 2nd year (3rd semester) as lateral entry shall be evaluated on the basis their performance, by the faculty co-ordinator for the period of 3rd semester to 6th semester only.

Seventh Semester					
Group	**Paper Code**	**Paper**	**L**	**P**	**Credits**
Theory Papers					
HS/MS	MS-401	Principles of Entrepreneurship Mindset	2		2
PC	DS-427T	Data Science using R	3		3
PC	SC-401T	Soft Computing	3		3
PC	CIC-403	Software Engineering	3		3
PC	CS-427T	Network Security and Cryptography	3		3
OAE		Open Area Elective Paper (OAE – 2)			4
Practical / Viva Voce					
PC	DS-427P	Data Science using R Lab		2	1
PC	SC-401P	Soft Computing Lab		2	1
PC	CIC-455	Software Engineering Lab		2	1
PC	CS-427P	Network Security and Cryptography Lab		2	1
PC / Project	ES-451	Minor Project**			3
PC / Internship	ES-453	Summer Training (after 6th semester) Report *			1
Total					**26**

***NUES:**Comprehensive evaluation of the Summer Training Report – 2 (after 6th Semester) shall be done by the committee of teachers, constituted by the Academic Programme Committee, out of 100. The training shall be of 4 to 6 weeks duration. The training can be under the mentorship of a teacher of the institute.

****The student shall be allocated a supervisor / guide for project work at the end 6th semester by the department / institution, the project shall continue into the 8th semester. In the 7th semester evaluation, the criteria for evaluation shall be conceptualization of the project work, the background study / literature survey and identification of objectives and methodology to be followed for project. 40 marks evaluation for the Teachers' Continuous Evaluation / Internal Assessment shall be done by concerned supervisor while the term end examination of 60 marks shall be conducted by the supervisor concerned and the external examiner deputed by the Examinations Division. In the absence of the supervisor, the Director of the Institution / Head of the Department can assign the responsibility of the supervisor (for purpose of examinations) to any faculty of the Institution / Department.

Eight Semester					
Group	**Paper Code**	**Paper**	**L**	**P**	**Credits**
Practical / Viva Voce%					
PC / Project	ES-452	Major Project – Dissertation and Viva Voce#			18
	ES-454	Project Progress Evaluation*			2
PC / Internship	ES-456	Internship Report and Viva Voce#			18
	ES-458	Internship Progress Evaluation*			2
Total			**0**	**0**	**20**

***NUES: Comprehensive evaluation by the committee of teachers, constituted by the Academic Programme Committee, out of 100.**

%By default every student shall do the project work (ES-452 and ES-454). A student shall either be allowed to do a project work (ES-452 and ES-454) or an internship (ES-456 and ES-458). The student must apply for approval to do internship before the commencement of the 8th semester to the institute, and only after approval of Principal / Director of the institute through Training and Placement Officer of the institute, shall proceed for internship.

#Students may be allowed to do internship in this semester in lieu of Major project. The students allowed to proceed for internship shall be required to maintain a log-book of activities performed during internship. The same has to be countersigned by the mentor at the organization where internship is completed.
ES-452: Evaluation shall be conducted of 40 marks (Teachers' continuous evaluation / internal assessment) by the supervisor. And, 60 marks by a bench of the supervisor and the external examiner deputed by Examination Division (COE), for a total of 100 marks.

ES-454 / ES-458: Comprehensive evaluation by the committee of teachers, constituted by the Academic Programme Committee, out of 100.

ES-456: Evaluation shall be conducted of 40 marks (Teachers' continuous evaluation / internal assessment) by the Training and Placement Officer of the department / institute on the basis of the report submitted by the student. And, 60 marks by a bench of the Training and Placement Officer of the department / institute and the external examiner deputed by Examination Division (COE), for a total of 100 marks.

In the absence of the supervisor or the Training and Placement Officer (as the case may be), the Director of the institute / Head of the Department can assign the responsibility of the supervisor or the Training and Placement Officer (for purpose of examinations) to any faculty of the department.

Note on Elective Papers: The elective papers shall be allowed to be taken / studied by the students, by the APC of the department / institute, keeping in view that two papers studied by the student should not have a substantial overlap. All papers studied by the student should be substantially distinct in content.

Note on Continuous Evaluation of All Papers (Theory and Lab/Practical): Papers shall have 40 Marks continuous evaluation by the teacher and 60 Marks term-end examinations. Both these component marks shall be reflected on the marksheet of the student.

**** The mid-term test shall be coordinated by the Programme Coordination Committee.***

If a student could not appear for a mid-term test due to situation beyond the control by the student, a supplementary test may be arranged towards the end of the semester, in a similar manner to the mid-term test for such students. The students must apply for this provision to the department / institution. On examination of the reason for non-appearing in the mid-term test by the Head of the Department / Institute, and with reason for allowing to appear in the supplementary test to recorded by the Head of the Department / Institute, the student may be allowed.

The attendance sheets, the question papers and the award sheets for the continuous evaluation to be retained by the concerned department / institute for at least 6 months after the declaration of the result by the Examination Division of the University.

Open Area Electives

Semester	Paper Code	OAE – 1 (Choose Any One)	L	P	Credits
6	FSD-320T	Web Development using MEAN Stack	3		3
	FSD-320P	Web Development using MEAN Stack Lab		2	1
6	FSD-322T	Web Development using MERN Stack	3		3
	FSD-322P	Web Development using MERN Stack Lab		2	1
6	CIE-332T	Programming in Python	3		3
	CIE-332P	Programming in Python Lab		2	1
6	OSD-334T	Android App Development	3		3
	OSD-334P	Android App Development Lab		2	1
6	IPCV-334T	Digital Image Processing	3		3
	IPCV-334P	Digital Image Processing Lab		2	1
6	OUHV-338	Understanding Human Being, Nature and Existence Comprehensively	4		4
6	OUHV-340	Vision for Humane Society	4		4
6	SE-350T	Software Measurements, Metrics and Modelling	3		3
	SE-350P	Software Measurements, Metrics and Modelling Lab		2	1
6	SE-352T	Service Oriented Architecture	3		3
	SE-352P	Service Oriented Architecture Lab		2	1
6	SE-354T	Software Project Management	3		3
	SE-354P	Software Project Management Lab		2	1
6	AM-382T	Computational Geometry and Topology	3		3
	AM-382P	Computational Geometry and Topology Lab		2	1
6	AM-384T	Real Analysis	3		3
	AM-384P	Real Analysis Lab		2	1
6	AM-386	Mathematical Biology	4		4
6	CIE-334	Quantum Computing	4		4
6		MOOCs (Swayam / NPTEL)			4
Semester	**Paper Code**	**OAE – 2 (Choose Any One)**	**L**	**P**	**Credits**
7	ML-463T	Supervised and Deep Learning	3		3
	ML-463P	Supervised and Deep Learning Lab		2	1
7	ML-411T	Pattern Recognition and Computer Vision	3		3
	ML-411P	Pattern Recognition and Computer Vision Lab		2	1
7	DS-429T	Big Data Analytics	3		3
	DS-429P	Big Data Analytics Lab		2	1
7	CIC-481T	Compiler Design	3		3
	CIC-481P	Compiler Design Lab		2	1
7	AM-483	Mathematical Finance	4		4
7	AM-485T	Quantum Cryptography	3		3
	AM-485P	Quantum Cryptography Lab		2	1
7	FSD-435T	PHP Programming and MySQL	3		3
	FSD-435P	PHP Programming and MySQL Lab		2	1
7	OECE-417T	Microprocessors and Interfacing	3		3
	OECE-417P	Microprocessors and Interfacing Lab		2	1
7	OSD-453T	Advanced Java Programming	3		3
	OSD-453P	Advanced Java Programming Lab		2	1
7	OUHV-463	Holistic Human Health	4		4
7	SC-479T	Global Optimization Methods	3		3
	SC-479P	Global Optimization Methods Lab		2	1
7	SE-487T	Software Verification, Validation and Testing	3		3
	SE-487P	Software Verification, Validation and Testing Lab		2	1
7		MOOCs (Swayam / NPTEL)			4

Note:

1. Each OAE slot is of 4 credits, if in a particular slot, the paper has no practical component, then it is of 4 credits (a pure theory paper), otherwise for purpose of examination and conduct of classes, the course is split in two papers, namely a theory paper of 3 credits and a practical paper of 1 credit. The student has to study for 4 credits per slot of OAE group. This is reflected by suffixing the paper code by T (for Theory component) and P (for Practical component), if required

2. The Open Area Electives described / enumerated are the one offered by engineering departments. If other departments, offering minor specialization or elective papers as open area electives to engineering students (approved by the university Academic Council) are possible at the concerned institution, the same may also be offered to the engineering students studying in the major disciplines under the aegis of the University School of Information, Communication and Technology. The APC of the department / intuition shall allow the choice of such electives, provided they follow the credit framework of the programme of study for open area electives.

Implementation Rules:

1. ***The examinations, attendance criteria to appear in examinations, promotion and award of the degree shall be governed by the Ordinance 11 of the University.*** The term "major discipline" / "primary discipline" in this document refers to the discipline in which student is admitted / studies from 3rd semester onwards. However credits of courses / paper for OAE / EAE groups shall not be considered for the purpose of promotion from one year of study to the subsequent year of study.

2. ***Minimum duration*** of the Bachelor of Technology programme shall be 4 years (N=4 years) (8 semesters) for the students admitted in the 1st year and 1st semester of the degree programme. Lateral entry students shall be admitted in the 2nd year and 3rd semester of the degree programme (effectively in the batch admitted in the first year in the previous academic session and shall be deemed to have been exempted from the courses / papers of the first year of the degree programme. No exemption certificate shall be issued in any case.

   A specific lateral entry students' minimum duration shall be the same as the minimum duration for the batch in which he/she is admitted as a lateral entry student in the 2nd year.

3. ***Maximum duration of the Bachelor of Technology programme shall be 6 years (N+2 years).*** After completion of N+2 years of study, if the student has appeared in the papers of all the semesters upto 8th semester, then a maximum extension of 1 year may be given to the student for completing the requirements of the degree if and only if the number of credits already earned by the student is atleast 150 (for lateral entry students it shall be at least 102 credits) from the (non-honours components). Otherwise, the admission of the student shall stand cancelled. After the period of allowed study, the admission of the student shall be cancelled.

   A specific lateral entry students' maximum duration shall be the same as the minimum duration for the batch in which he/she is admitted as a lateral entry student in the 2nd year.

4. ***The degree shall be awarded only after the fulfilment of all requirements of the Scheme and Syllabus of Examinations and the applicable Ordinance.***

5. (a) The students shall undergo the following group of Courses / Papers as enumerated in the scheme (***For the students admitted in the First Year / First Semester).***

Group	Semester (Credits)							Total Credits	Mandatory Credits
	I & II	III	IV	V	VI	VII	VIII		
BS	24		5					**29**	**14**
HS/MS	6	2	2	2	6	2		**20**	**10**
ES	20	5						**25**	**15**
PC		19	19	24	16	20	20	**118**	**104**
OAE					4	4		**8**	**4**
Total	**50**	**26**	**26**	**26**	**26**	**26**	**20**	**200**	**147**

TABLE 1: Distribution of Credits (Project / Internship credits are 25 out the 118 credits for Programme Core (PC) credits, while extra-curricular activities credits are 2 out of 20 credits for Humanities / Management / Social Science Group (HS/MS)) . This table is for students admitted in the First Year / First Semester of the Degree Programme.

(b) The students admitted as Lateral Entry shall undergo the following group of Courses / Papers as enumerated in the scheme***.***

Group	Semester (Credits)						Total Credits	Mandatory Credits
	III	IV	V	VI	VII	VIII		
BS		5					**5**	**0**
HS/MS	2	2	2	6	2		**14**	**7**
ES	5						**5**	**0**
PC	19	19	24	16	20	20	**118**	**104**
OAE				4	4		**8**	**4**
Total	**26**	**26**	**26**	**26**	**26**	**20**	**150**	**115**

TABLE 2: Distribution of Credits (Project / Internship credits are 25 out the 118 credits for Programme Core (PC) credits, while extra-curricular activities credits are 2 out of 14 credits for Humanities / Management / Social Science Group (HS/MS)) This table is for students admitted as Lateral Entry Students in the Second Year / Third Semester of the Degree Programme.

6. Mandatory Credits specify the number of credits from each subject group to be mandatorily acquired by the student for the award of the degree,for students admitted as students in the 1st year and 1st semester of the degree programme. While for students admitted as lateral entry in the 2nd year and 3rd semester the Mandatory Credits value is 115, and specify the number of credits from each subject group to be mandatorily acquired by the student for the award of the degree (Table 2). See clause 11 and 12 also**.**

7. Some of the papers are droppable in the sense that the student may qualify for the award of the degree even when the student has not cleared / passed some of the papers of these group. However, the student has to earn the minimum credits for the programme of study as specified. **See clause 11 and 12 also**.

8. The students may take 2 subjects from OAE group. The open electives of the OAE group of courses may also be taken through SWAYAM / NPTEL MOOCs platform. The student desirous of doing a MOOC based course among the OAE group must seek approval of the APC of the institute for the same before the commencement of the semester. The APC shall allow the MOOC based OAE option to the student if and only if the MOOC subject / course being considered for the student is being offered in line with the Academic Calendar applicable. The student shall submit the successful completion certificate with marks to the institution for onwards transfer to the Examination Division. The Examinations Division shall take these marks on record for incorporation in the result of the appropriate semester. These marks / grades of these courses shall be used for calculation of the SGPA/CGPA of the student concerned by the examination division of the University. The degree to the student on fulfilment of other requirements for such cases shall be through **clause 12.a. or 12.b.**

   These MOOC courses taken by the students, if allowed by the APC of the institute shall be of 4 credits or more collectively to be against or for one paper slot in the scheme, through MOOCs, though the marks shall be shown individually. That is in one paper slot in the scheme wherever a MOOC course is allowed, the student may register for more than one paper to aggregate 4 credits or more. **If the credits of these MOOC Courses, allowed to a student is more than 4, then the maximum credit for the programme shall be amended accordingly for the particular student.** Also, in a particular semester, a student may take more than one MOOC course with the approval of the APC to meet the credit requirements of OAE for the semester. The cost of taking the MOOC course is to be borne by the concerned student. The results of the MOOC courses shall be declared separately by the Examination Division from the result for the papers conducted by the examination division of the University.

   No minor specialization shall be offered / awarded.

9. To earn an Honours degree, the student may enrol for 20 credits or more through SWAYAM / NPTEL MOOCs platform. This point has to be read together with other points specially point 13 and 14. The

acquisition of the credits should be completed before the 15th of the July of the Admission Year plus 4 years. That is, if a student is admitted in the year X, then these credits must be acquired through MOOCs by 15th July of the year (X+4), no extra duration or time shall be allocated, this means, the student must submit the result of such papers on or before 15th July of the Admission Year plus 4 years.

Honours in the degree shall be awarded if and only if at least 20 credits are acquired through MOOCs. To obtain Honours in the programme, the student must apply to the institution about the same before the commencement of the 5th semester. The specific courses through MOOCs shall be registered by the student only after approval by the Academic Programme Committee (APC) of the Institute. The APC shall approve the course if it is not already studied by the student or the student shall not study it in future and adds value to the major area of specialization (which is the degree). The papers for which the student desires to appear for Honours through MOOCs, all papers results shall be submitted by the student to the Institute for onwards transfer to Examination Division of the University, to be taken on record of the University. The results of these papers shall be a part of the records of the examinations of the students. The records shall be submitted by the student to the Institute, then transferred to the Examination Division, shall be notified by the Examination Division of the University, and a separate marksheet shall be issued by the Examination Division. The cost of taking the MOOC course is to be borne by the concerned student. Such courses shall be reflected as additional courses / papers for the student.

If a student acquires less than 20 credits through MOOCs, following the mechanism specified, then also the results of these papers shall be taken on record as specified above, though no Honours degree shall be awarded.

The papers through MOOCs for Honours degree shall not be a part of the set of the papers over which the SGPA / CGPA of the student shall be calculated.

The papers through MOOCs for Honours degree shall be additional papers studied by the students and are to be taken into account only for award of Honours in the degree programme, if 20 credits are earned through MOOCs as approved by APC, by a student. **See Clause 13 also.**

10. Maximum Credits is at least 200 (Table 1) for students admitted in the 1st year and 1st semester, these are the credits for which the student shall have to study for the non-Honours component of the curriculum. And, for lateral entry students admitted in the 2nd year and 3rd semester of the degree programme, the maximum credit required to be studied is at least 150 (Table 2). **See clause 8 also**.

    The student has to appear in the examinations for these credits in all components of evaluation as specified in the scheme of studies.

11. Minimum Credits required to be earned is atleast 180 (out of the 200 non Honours papers credits, see clause 10 also) for students admitted in the 1st year and 1st semester. And, for lateral entry students admitted in the 2nd year and 3rd semester of the degree programme, the minimum credit required to be earned Is at least 135 (out of the 150 non Honours papers credits, see clause 10 also). See clause 6 also.

12. The following degree route can be taken by a student **(also refer point 13)**:

    a. The students shall be awarded the degree without any minor specialization under the following conditions:

        i. The student has earned the mandatory credits as defined in **Table 1** or **Table 2** (as applicable) and **clause 6**.

        ii. In addition, the total credits (including the above specified credits) earned by the student is atleast as specified in **clause 11**.

    The degree nomenclature of the degree shall be as: "***Bachelor of Technology in Computer Science and Applied Mathematics";*** if criteria / **point 9** is not satisfied for Honours. Otherwise, if criteria / **point 9**is met, then the degrees shall be an Honours degree and the nomenclature shall be as: "***Bachelor of Technology in Computer Science and Applied Mathematics (Honours)***", if in addition to **point 12.b.i and 12.b.ii**, the student fulfils the criteria for Honours as specified at **point 9**.

    b. If the student does not fulfil any of the above criterions (**point 12.a, or 12.b**), if the student earns at least the minimum credits specified in clause 11 (disregarding the mandatory credits clause of **Table 1**

or Table 2 (as applicable) and **Clause 6**), then the student shall be award the degree as "***Bachelor of Technology in Computer Science and Applied Mathematics".*** Such students shall not be eligible for the award of an Honours degree. Though, if credits are accumulated through MOOCs as per **clause 9**, the same shall be reflected in the marksheets of the students.

13. ***The Honours degree shall only be awarded if the CGPA of the student is above or equal to 7.5 in addition to fulfilment of criteria / point 10 and 13 above and the degree is awarded after the immediate completion of the 4th year of the batch from the year of admission.*** No Honours shall be conferred if the degree requirements are not completed in the minimum duration.
14. ***Pass marks in every paper shall be 40.***
15. ***Grading System shall be as per Ordinance 11 of the University.***
16. The institution shall offer atleast two elective groups out of the open area for students of each major discipline. The institute shall decide the group(s) and/or individual papers to be offered as electives based on the availability of infrastructure and faculty. From the groups / papers offered by the institute, an elective paper / group shall be taught if and only if the number of students in a paper is at-least 20 or at-least 1/3 of the students of a major discipline for which the paper / group is to be offered. The APC of the department / institute may define a maximum number of students allowed to register for a paper as an open area elective.
17. Teachers of the other department(s), as and when deputed by their department, for teaching the students enrolled in programmes offered by the department offering the programme shall be a part of the Academic Programme Committee of the discipline. Such teachers, for all academic matters, including teaching, teachers' continuous evaluation, term end examinations etc. shall be governed by the decisions of the APC of department offering the programme of study. Similarly, the guest faculty, the visiting faculty and the Contract / Ad Hoc faculty as and when deputed to teach students of a particular department shall form a part of APC of the department.
18. The Paper IDs will be generated / issued / assigned by the Examination Division of the University.
19. **The medium of instructions shall be English.**

Syllabus of 2nd Year Onward Papers

The syllabus of the following papers / subjects is described in the subsequent pages:

S.No.	Semester	Paper Code	Paper Name
1.	3	AM-221	Linear Algebra and Calculus
2.	3	AM-267	Linear Algebra and Calculus Lab
3.	4	CIC-214	Operating Systems
4.	4	AM-220	Differential Equations
5.	4	CIC-260	Operating Systems Lab
6.	4	AM-266	Differential Equations Lab
7.	5	CIC-315	Database Management Systems
8.	5	AM-317	Number Theory
9.	5	AM-319	Mathematical Modelling and Graph Theory
10.	5	CIC-367	Database Management Systems Lab
11.	5	AM-369	Number Theory Lab
12.	5	AM-371	Mathematical Modelling and Graph Theory Lab
13.	6	AM-320	Operations Research
14.	6	AM-360	Operations Research Lab
15.	6	AM-382T	Computational Geometry and Topology
16.	6	AM-382P	Computational Geometry and Topology Lab
17.	6	AM-384T	Real Analysis
18.	6	AM-384P	Real Analysis Lab
19.	6	AM-386	Mathematical Biology
20.	7	CIC-403	Software Engineering
21.	7	CIC-455	Software Engineering Lab
22.	7	CIC-481T	Compiler Design
23.	7	CIC-481P	Compiler Design Lab
24.	7	AM-483	Mathematical Finance
25.	7	AM-485T	Quantum Cryptography
26.	7	AM-485P	Quantum Cryptography Lab

However, the syllabus of rest of the papers / subjects shall be refered from **Part – I** using the Paper Code of the respestive paper / subject.

Linear Algebra and Calculus	L	P	C
	4		4

Discipline(s) / EAE / OAE	Semester	Group	Sub-group	Paper Code
CSAM	3	PC	PC	AM-221

Marking Scheme:

1. Teachers Continuous Evaluation: 40 marks
2. Term end Theory Examinations: 60 marks

Instructions for paper setter:

1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 20 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 10.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Course Objectives :

1.	To develop a foundational understanding of vector algebra and vector spaces, including linear independence, basis, and dimension.
2.	To introduce linear transformations, their matrix representation, and applications such as computer graphics and geometric transformations.
3.	To strengthen conceptual knowledge of limits and continuity, including uniform continuity and rigorous limit proofs using the sequential approach.
4.	To enable analytical skills in real-valued function differentiability, with a focus on important theorems and their practical applications.

Course Outcomes (CO)

CO 1	Understand and apply concepts of vector operations, vector spaces, linear dependence, and basis for solving engineering problems.
CO 2	Analyze and construct linear transformations and use their matrix forms to solve real-world problems including transformations in computer graphics.
CO 3	Demonstrate a thorough understanding of limits and continuity using formal definitions, and apply them in theoretical and applied contexts.
CO 4	Apply the principles of differential calculus including theorems like Rolle's and Mean Value Theorem to analyze and solve problems involving real-valued functions.

Course Outcomes (CO) to Programme Outcomes (PO) mapping (scale 1: low, 2: Medium, 3: High)

	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO 1	3	2	1	1	-	-	-	-	-	-	-	-
CO 2	3	3	2	2	-	-	-	-	-	-	-	-
CO 3	3	2	1	1	-	-	-	-	-	-	-	-
CO 4	3	3	2	2	-	-	-	-	-	-	-	-

UNIT-I

Fundamental operations with vectors in Euclidean space, Linear combinations of vectors, Dot product and their properties, Cauchy-Schwarz inequality, Triangle inequality.

Vector spaces, Subspaces, Algebra of subspaces, Linear combination of vectors, Linear span, Linear independence, Bases and dimension, Dimension of subspaces.

UNIT-II

Linear transformations, Null space, Range, Rank and nullity of a linear transformation, Matrix representation of a linear transformation, Algebra of linear transformations, Invertibility and isomorphisms; Application: Computer Graphics-Fundamental movements in a plane, homogenous coordinates, composition of movements.

UNIT-III

Limits of functions (sequential approach), Algebra of limits, Squeeze theorem, One-sided limits, Infinite limits and limits at infinity; Continuous functions and its properties on closed and bounded intervals; Uniform continuity.

UNIT - IV

Differentiability of a real-valued function, Algebra of differentiable functions, Chain rule, Relative extrema, Interior extremum theorem, Rolle's theorem, Mean-value theorem and its applications, Intermediate value theorem for derivatives.

Textbook(s):

1. Andrilli, S., & Hecker, D., "Elementary Linear Algebra", 5th ed., Elsevier India, 2016.
2. Friedberg, Stephen H., Insel, Arnold J., & Spence, Lawrence E., "Linear Algebra", 4th ed., Prentice-Hall of India Pvt. Ltd. New Delhi, 2003.
3. Anton, Howard, Bivens, Irl, & Davis, Stephen (2013). "Calculus", 10th ed., John Wiley & Sons Singapore Pvt. Ltd. Reprint (2016) by Wiley India Pvt. Ltd. Delhi.

References:

1. Lay, David C., Lay, Steven R., & McDonald, Judi J., "Linear Algebra and its Applications",5th ed., Pearson Education, 2016.
2. Kolman, Bernard, & Hill, David R., "Introductory Linear Algebra with Applications", 7th ed., Pearson Education, Delhi, First Indian Reprint 2003.
3. Bartle, Robert G., &Sherbert, Donald R. (2011). "Introduction to Real Analysis", 4th ed.. John Wiley & Sons. Wiley India Edition 2015.
4. Prasad, Gorakh, "Differential Calculus", 19th ed., PothishalaPvt. Ltd.,2016.

Linear Algebra and Calculus Lab	L	P	C
		2	1

Discipline(s) / EAE / OAE	Semester	Group	Sub-group	Paper Code
CSAM	3	PC	PC	AM-267

Marking Scheme:
1. Teachers Continuous Evaluation: 40 marks
2. Term end Theory Examinations: 60 marks

Instructions:
1. The course objectives and course outcomes are identical to that of (Linear Algebra and Calculus) as this is the practical component of the corresponding theory paper.
2. The practical list shall be notified by the teacher in the first week of the class commencement under intimation to the office of the Head of Department / Institution in which the paper is being offered from the list of practicals below. Atleast 10 experiments must be performed by the students, they may be asked to do more. Atleast 5 experiments must be from the given list.

1 Vector Operations and Dot Product: To implement basic operations on vectors (addition, scalar multiplication, dot product) and verify Cauchy-Schwarz and Triangle inequalities.

2 Linear Dependence and Span: To determine linear dependence/independence of vectors and visualize linear span in 2D/3D space.

3 Basis and Dimension of Subspaces: To find the basis and dimension of a given subspace of $\mathbb{R}^n$ using row-reduction or Gram-Schmidt process.

4 Matrix Representation of a Linear Transformation: To represent a linear transformation using a matrix and visualize its effect (rotation, reflection, scaling) on vectors or geometric shapes.

5 Null Space, Range, Rank, and Nullity: To compute null space, range, rank, and nullity of a linear transformation using matrix operations.

6 Computer Graphics Application – 2D Transformations: To simulate basic transformations in computer graphics (translation, rotation, scaling) using homogeneous coordinates.

7 Limit Evaluation and Graphical Verification: To compute limits (algebraically and numerically) and verify the behavior graphically, including one-sided and infinite limits.

8 Continuity and Uniform Continuity: To verify continuity of piecewise functions and test for uniform continuity over closed intervals using graphical and numerical techniques.

9 Differentiability and Mean Value Theorem: To verify differentiability and implement Mean Value Theorem or Rolle's Theorem for selected real-valued functions.

10 Extrema of Functions using Derivatives: To compute first and second derivatives of real-valued functions and identify relative extrema using first and second derivative tests.

Tools Suggested:

- Python Libraries: NumPy, SymPy, Matplotlib
- MATLAB / Octave: For matrix operations and graphical plotting
- GeoGebra (optional): For visualizing linear transformations and calculus concepts

Operating Systems	**L**	**P**	**C**
	4		**4**

Discipline(s) / EAE / OAE	Semester	Group	Sub-group	Paper Code
CS/CSAM	4	PC	PC	CIC-214
CSE/IT/CST/ITE	5	PC	PC	CIC-305
OAE	7	CSE-OAE	CSE-OAE-4	OCSE-409

Marking Scheme:

1. Teachers Continuous Evaluation: 40 marks
2. Term end Theory Examinations: 60 marks

Instructions for paper setter:

1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 20 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 10.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Course Objectives :

1.	To understand the basics of OS and their functions. To learn the scheduling policies of various operating systems.
2.	Learn memory management methods.
3.	To understand the characterisation of deadlock, system deadlock, preventing deadlock, avoiding deadlock and related concepts.
4.	To understand the meaning of a file, structure of the directories, file structure system and implementation, free-space management

Course Outcomes (CO)

CO 1	Understand the role of operating system in a computing device, and Ability to understand paging and segmentation methods of memory binding and their pros & cons.
CO 2	Understand scheduling of process over a processor.Ability to use concepts of semaphore and its usage in process synchronization.
CO 3	Ability to synchronize programs and make the system deadlock free.
CO 4	Ability to understand file system like file access methods, directory structures, file space allocation in disk and free space management in disk. Ability to understand disk scheduling and disk recovery procedures.

Course Outcomes (CO) to Programme Outcomes (PO) mapping (scale 1: low, 2: Medium, 3: High)

	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO 1	3	3	2	-	3	-	-	-	-	-	-	-
CO 2	3	3	-	-	2	-	-	-	-	-	-	-
CO 3	3	2	3	-	2	-	-	-	-	-	-	-
CO 4	3	3	-	-	2	-	-	-	-	-	-	-

UNIT-I

Introduction: What is an Operating System, Simple Batch Systems, Multiprogrammed Batches systems, Time Sharing Systems, Personal-computer systems, Parallel systems, Distributed Systems, Real-Time Systems, OS – A

Resource Manager.
Processes: Introduction, Process states, process management, Interrupts, Interprocess Communication Threads: Introduction, Thread states, Thread Operation, Threading Models. Processor Scheduling: Scheduling levels, preemptive vs no preemptive scheduling, priorities, scheduling objective, scheduling criteria, scheduling algorithms, demand scheduling, real time scheduling.

UNIT-II

Process Synchronization: Mutual exclusion, software solution to Mutual exclusion problem, hardware solution to Mutual exclusion problem, semaphores, Critical section problems. Case study on Dining philosopher problem, Barber shop problem etc.
Memory Organization & Management: Memory Organization, Memory Hierarchy, Memory Management Strategies, Contiguous versus non- Contiguous memory allocation, Partition Management Techniques, Logical versus Physical Address space, swapping, Paging, Segmentation, Segmentation with Paging Virtual Memory: Demand Paging, Page Replacement, Page-replacement Algorithms, Performance of Demand Paging, Thrashing, Demand Segmentation, and Overlay Concepts.

UNIT-III

Deadlocks: examples of deadlock, resource concepts, necessary conditions for deadlock, deadlock solution, deadlock prevention, deadlock avoidance with Bankers algorithms, deadlock detection, deadlock recovery.
Device Management: Disk Scheduling Strategies, Rotational Optimization, System Consideration, Caching and Buffering.

UNIT - IV

File System: Introduction, File Organization, Logical File System, Physical File System, File Allocation strategy, Free Space Management, File Access Control, Data Access Techniques, Data Integrity Protection, Case study on file system viz FAT32, NTFS, Ext2/Ext3 etc.

Textbook(s):
1. Deitel & Dietel, “Operating System”, Pearson, 3 rd Ed., 2011
2. Silbersachatz and Galvin, “Operating System Concepts”, Pearson, 5th Ed., 2001
3. Madnick & Donovan, “Operating System”, TMH,1st Ed., 2001

References:
1. Tannenbaum, “Operating Systems”, PHI, 4th Edition, 2000
2. Godbole, “Operating Systems”, Tata McGraw Hill, 3rd edition, 2014
3. Chauhan, “Principles of Operating Systems”, Oxford Uni. Press, 2014
4. Dhamdhere, “Operating Systems”, Tata McGraw Hill, 3rd edition, 2012
5. Loomis, “Data Management & File Structure”, PHI, 2nd Ed.

Differential Equations	L	P	C
	4		4

Discipline(s) / EAE / OAE	Semester	Group	Sub-group	Paper Code
CSAM	4	PC	PC	AM-220

Marking Scheme:

1. Teachers Continuous Evaluation: 40 marks
2. Term end Theory Examinations: 60 marks

Instructions for paper setter:

1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 20 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 10.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Course Objectives :

1.	To introduce advanced concepts in ordinary differential equations (ODEs), focusing on solution behavior, uniqueness, and dependence on initial conditions.
2.	To analyze linear and nonlinear systems using stability criteria, phase-plane techniques, and explore dynamical behaviors via Lyapunov's methods and Poincaré-Bendixson theory.
3.	To develop analytical skills for solving first-order partial differential equations and understanding Hamilton-Jacobi equations and classification of second-order PDEs.
4.	To explore classical PDEs such as Laplace, heat, and wave equations and their solutions through separation of variables and uniqueness theorems.

Course Outcomes (CO)

CO 1	Solve linear and nonlinear ODE systems and analyze existence and uniqueness of solutions using Peano's, Picard's theorems and Grownwall's inequality.
CO 2	Apply matrix methods and Lyapunov techniques for stability analysis of dynamical systems and interpret results using phase-plane analysis.
CO 3	Formulate and solve first-order PDEs including Hamilton-Jacobi equations and classify second-order PDEs for physical phenomena.
CO 4	Solve Laplace, diffusion, and wave equations using appropriate analytical methods and analyze uniqueness using Holmgren's theorem.

Course Outcomes (CO) to Programme Outcomes (PO) mapping (scale 1: low, 2: Medium, 3: High)

	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO 1	3	2	1	2	-	-	-	-	-	-	-	-
CO 2	3	3	2	3	-	-	-	-	-	-	-	-
CO 3	3	2	1	2	-	-	-	-	-	-	-	-
CO 4	3	2	1	2	-	-	-	-	-	-	-	-

UNIT-I

Ordinary differential equations II: Linear and Non-linear autonomous systems, linear independence, solution techniques. Existence and Uniqueness Theorems: Peano's and Picard's theorems, Grownwall's inequality, Dependence on initial conditions and associated flows.

UNIT-II

Linear system: The fundamental matrix, stability of equilibrium points, Phase- plane analysis, Sturm-Liouvile theory, Nonlinear system, and their stability: Lyapunov's method, Non-linear Perturbation of linear systems, Periodic solutions, and Poincare- Bendixson theorem.

UNIT-III

First order partial differential equation and Hamilton-Jacobi equations; Cauchy problem and classification of second order equations.

UNIT - IV

Holmgren's uniqueness theorem; Laplace equation; Diffusion equation; Wave equation; Some methods of solutions, Variable separable method.

Textbook(s):

1. Hartman, "Ordinary Differential Equations", P. Birkhaeuser, 1982.
2. R.K Jain and S.R.K. Iyengar, "Advanced Engineering Mathematics", Narosa, 5th Ed., 2017
3. Garabedian, P. R., "Partial Differential Equations", John Wiley and Sons, 1964.
4. Prasad. P. and Ravindran, R., "Partial Differential Equations", Wiley Eastern, 1985.

References:

1. Coddington, E. A. and Levinson, N., "Theory of Ordinary Differential Equations", Tata McGraw-Hill, 1972.
2. Perko, L., "Differential Equations and Dynamical Systems", Springer-Verlag, 1991.
3. Renardy, M. and Rogers, R. C., "An Introduction to Partial Differential Equations", Springer-Verlag, 1992.
4. Fritz John, "Partial Differential Equations", Springer (International Students Edition), 1971.

Operating Systems Lab	L	P	C
		2	1

Discipline(s) / EAE / OAE	Semester	Group	Sub-group	Paper Code
CS/CSAM	4	PC	PC	CIC-260
CSE/IT/CST/ITE	5	PC	PC	CIC-353

Marking Scheme:

1. Teachers Continuous Evaluation: 40 marks
2. Term end Theory Examinations: 60 marks

Instructions:

1. The course objectives and course outcomes are identical to that of (Operating Systems) as this is the practical component of the corresponding theory paper.
2. The practical list shall be notified by the teacher in the first week of the class commencement under intimation to the office of the Head of Department / Institution in which the paper is being offered from the list of practicals below. Atleast 10 experiments must be performed by the students, they may be asked to do more. Atleast 5 experiments must be from the given list.

1. Write a program to implement CPU scheduling for first come first serve.
2. Write a program to implement CPU scheduling for shortest job first.
3. Write a program to perform priority scheduling.
4. Write a program to implement CPU scheduling for Round Robin.
5. Wite a program for page replacement policy using a) LRU b) FIFO c) Optimal.
6. Write a program to implement first fit, best fit and worst fit algorithm for memory management.
7. Write a program to implement reader/writer problem using semaphore.
8. Write a program to implement Producer-Consumer problem using semaphores.
9. Write a program to implement Banker's algorithm for deadlock avoidance.
10. Write C programs to implement the various File Organization Techniques

Differential Equations Lab	L	P	C
		2	1

Discipline(s) / EAE / OAE	Semester	Group	Sub-group	Paper Code
CSAM	4	PC	PC	AM-266

Marking Scheme:
1. Teachers Continuous Evaluation: 40 marks
2. Term end Theory Examinations: 60 marks

Instructions:
1. The course objectives and course outcomes are identical to that of (Differential Equations) as this is the practical component of the corresponding theory paper.
2. The practical list shall be notified by the teacher in the first week of the class commencement under intimation to the office of the Head of Department / Institution in which the paper is being offered from the list of practicals below. Atleast 10 experiments must be performed by the students, they may be asked to do more. Atleast 5 experiments must be from the given list.

1 Solution of linear/non-linear ODEs using numerical methods (e.g., Euler, RK4): Understand and simulate ODE behavior computationally

2 Verification of Picard's method and uniqueness of solution: Apply iterative methods to demonstrate convergence

3 Analyze solutions of linear systems using fundamental matrix: Understand system dynamics using matrix exponentials

4 Phase-plane analysis for 2D systems: Plot and interpret trajectories and equilibrium stability

5 Stability analysis using Lyapunov's method: Construct Lyapunov functions and test stability

6 Visualization of nonlinear perturbation effects on linear systems: Observe structural stability under perturbation

7 Solving first-order PDEs using method of characteristics: Apply analytical technique to derive solutions

8 Classification of second-order PDEs (elliptic, parabolic, hyperbolic): Categorize and interpret physical implications

9 Solution of Laplace/Heat/Wave equations using separation of variables: Apply and visualize classical PDE solutions

10 Validation of Holmgren's uniqueness theorem via counterexamples: Analyze role of initial/boundary conditions

Tools: MATLAB, Python (SymPy, SciPy, Matplotlib), Maple, or Octave

Database Management Systems	L	P	C
	4		4

Discipline(s) / EAE / OAE	Semester	Group	Sub-group	Paper Code
CSE/IT/CST/ITE	4	PC	PC	CIC-210
CS/CSAM	5	PC	PC	CIC-315

Marking Scheme:

1. Teachers Continuous Evaluation: 40 marks
2. Term end Theory Examinations: 60 marks

Instructions for paper setter:

1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 20 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 10.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Course Objectives :

1.	To introduce basic concepts, architecture and characteristics of database systems
2.	To introduce relational model concepts and PL/SQL programming
3.	To introduce relational database design and Normal forms based on functional dependencies
4.	To introduce concepts of object oriented & distributed databases

Course Outcomes (CO) :

CO 1	Ability to understand advantages of database systems
CO 2	Ability to use SQL as DDL, DCL and DML
CO 3	Ability to design database and manage transaction processing
CO 4	Understand object oriented & distributed databases systems and use them

Course Outcomes (CO) to Programme Outcomes (PO) mapping (scale 1: low, 2: Medium, 3: High)

	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO 1	3	3	2	2	2	-	-	-	3	2	2	3
CO 2	3	3	2	2	2	-	-	-	3	2	2	3
CO 3	3	3	2	3	3	-	-	-	3	2	2	3
CO 4	3	3	2	3	3	-	-	-	3	2	2	3

UNIT – I

Basic concepts: database & database users, characteristics of the database systems, concepts and architecture, date models, schemas & instances, DBMS architecture & data independence, database languages & interfaces, data modelling using the entity-relationship approach. Enhanced ER concepts - Specialization/Generalization, Aggregation, Mapping of ER model to Relational Model.

SQL – DDL, DCL & DML views and indexes in SQL. Basics of SQL, DDL, DML,DCL, structure – creation, alteration, defining constraints – Primary key, foreign key, unique, not null, check, IN operator.

UNIT - II:

Relational model concepts, relational model constraints, relational algebra, relational calculus.

SQL – Functions - aggregate functions, Built-in functions – numeric, date, string functions, set operations, sub-queries, correlated sub-queries, Use of group by, having, order by, join and its types, Exist, Any, All , view and its types. Transaction control commands – Commit, Rollback, Save point.

UNIT - III

Relational data base design: functional dependencies & normalization for relational databases, normal forms based on functional dependencies, (1NF, 2NF, 3NF & BCNF), lossless join and dependency preserving decomposition, normal forms based on multivalued & join dependencies (4NF & 5NF) & domain key normal form

Properties of Transaction, Transaction states, Transaction Schedule, Serializability, Concurrency control techniques, locking techniques, time stamp ordering, Recoverable schedules, granularity of data items, Deadlock detection and Recovery, recovery techniques: recovery concepts, database backup and recovery from catastrophic failures.
Database Programming – control structures, exception handling, stored procedures, Triggers.

UNIT - IV

File Structures and Indexing: Secondary Storage Devices, Operations on Files, Heap Files, Sorted Files, Hashing, Single level indexes, Multi-level indexes, B and B+ tree indexes.
Concepts of Object Oriented Database Management systems & Distributed Database Management Systems

Textbooks:
1. R. Elmsari and S. B. Navathe, “Fundamentals of database systems”, Pearson Education, 7th Edition, 2018
2. V. M. Grippa and S. Kumichev, “Learning MySQL”, O’Reilly, 2021.
3. SQL/ PL/SQL, The programming language of Oracle, Ivan Bayross, 4th Edition BPB Publications

References:
1. A. Silberschatz, H. F. Korth and S. Sudershan, “Database System Concept”, McGraw Hill, 6th Edition,2013.
2. Date, C. J., “An introduction to database systems”, 8th Edition, Pearson Education, 2008.
3. P. Rob & C. Coronel, “Database Systems: Design Implementation & Management”, Thomson Learning, 6th Edition, 2004
4. Desai, B., “An introduction to database concepts”, Galgotia publications, 2010
5. H. Garcia-Molina, J. D. Ullman, J. Widom, “Database System: The Complete Book”, PH.
6. Joel Murach, Murach'sMysql””, 3rd Edition-Mike Murach and Associates, Incorporated, 2019.
7. Oracle and MySQL manuals.

Number Theory	**L**	**P**	**C**
	3		**3**

Discipline(s) / EAE / OAE	Semester	Group	Sub-group	Paper Code
CSAM	5	PC	PC	AM-317

Marking Scheme:
1. Teachers Continuous Evaluation: 40 marks
2. Term end Theory Examinations: 60 marks

Instructions for paper setter:
1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 20 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 10.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Course Objectives :

1.	To introduce the foundational concepts of divisibility, Euclidean algorithm, congruences, and classical theorems in number theory.
2.	To explore arithmetic functions, their properties, and classical number-theoretic functions such as Möbius and Euler's phi function.
3.	To investigate properties of prime numbers and deepen understanding through quadratic reciprocity and related theorems.
4.	To apply number theory in solving Diophantine equations and understand fundamental ideas in cryptography including RSA.

Course Outcomes (CO)

CO 1	Apply fundamental theorems on divisibility, congruences, and modular arithmetic to solve elementary number-theoretic problems.
CO 2	Analyze and compute arithmetic functions including Euler's phi and Möbius functions, and apply inversion formulas.
CO 3	Demonstrate understanding of prime number theorems, quadratic residues, and symbols through problem-solving.
CO 4	Solve linear and nonlinear Diophantine equations and implement basic cryptographic algorithms like RSA.

Course Outcomes (CO) to Programme Outcomes (PO) mapping (scale 1: low, 2: Medium, 3: High)

	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO 1	3	3	1	2	-	-	-	-	-	-	-	-
CO 2	3	2	1	2	-	-	-	-	-	-	-	-
CO 3	3	3	1	2	-	-	-	-	-	-	-	-
CO 4	3	3	2	3	-	1	-	-	-	-	-	-

UNIT-I

Divisibility and factorization: Division algorithm, greatest common divisor, Euclid's algorithm, linear equations and its theorem, fundamental theorem of arithmetic.
Congruences: Linear congruence theorem, solution of linear congruence, simultaneous linear congruences, Chinese Remainder theorem, Wilson's theorem, Fermat's theorem, Euler's theorem.

UNIT-II

Arithmetic functions: Arithmetic function, multiplicative functions Moebius function, Moebius inversion formula, Euler phi function, Euler's formula, number- of -divisors, sum -of -divisors functions, perfect numbers, characterization of even perfect numbers.

UNIT-III

Prime numbers and Quadratic reciprocity: Prime number, Euclid's theorem, infinitely many prime theorem, Fermat primes, Mersenne primes, Dirichlet's theorem on primes, estimates for pi(x), Legendre and Jacobi symbols, Euler's criterion, Gauss's lemma, law of quadratic reciprocity. Applications in hashing and pseudorandom number generation.

UNIT - IV

Diophantine approximations and Cryptology: Linear Diophantine equations, Pell's equation, Fermat's equation, Diophantine approximations, character cipher, public key encryption, some algorithm for encrypts and decrypt, RSA crypto system.

Textbook(s):

1. Joseph H. Silverman, "A friendly Introductory Number Theory", 3rd edition, Pearson, 2009.
2. K.H. Rosen, "Elementary Number Theory, and its Application", 5ht edition, McGraw Hill, 2005.

References:

1. G.A. Jones and J.M. Jones, "Elementary Number Theory", Springer, 1998.
2. I Niven, H. Zuckerman, and H. Montgomery, "An Introduction to the Number Theory", 5th ed, Wiley, 1991.
3. G.E. Andrews, "Number Theory", Dover Publications, 1994.

Mathematical Modelling and Graph Theory	L	P	C
	3		3

Discipline(s) / EAE / OAE	Semester	Group	Sub-group	Paper Code
CSAM	5	PC	PC	AM-319

Marking Scheme:

1. Teachers Continuous Evaluation: 40 marks
2. Term end Theory Examinations: 60 marks

Instructions for paper setter:

1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 20 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 10.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Course Objectives :

1.	To introduce students to the fundamentals of mathematical modeling using differential equations and real-world phenomena such as disease spread and diet systems.
2.	To analyze the stability and behavior of dynamical systems using phase plane analysis, with applications to ecological and mechanical systems.
3.	To explore graph theory fundamentals including paths, circuits, and algorithms for solving shortest path and optimization problems.
4.	To apply graph theory to real-life network problems such as the Chinese Postman, scheduling, and minimum spanning trees using algorithms like Kruskal's and Prim's.

Course Outcomes (CO)

CO 1	Develop and analyze mathematical models for real-world systems using differential equations (e.g., SIR, SEIR).
CO 2	Perform phase plane and stability analysis of nonlinear systems in ecological and mechanical contexts.
CO 3	Apply graph theory concepts to analyze graph structures, solve TSP and shortest path problems.
CO 4	Solve network optimization problems using advanced graph algorithms including spanning trees and scheduling tools.

Course Outcomes (CO) to Programme Outcomes (PO) mapping (scale 1: low, 2: Medium, 3: High)

	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO 1	3	3	2	2	2	-	-	-	-	-	-	-
CO 2	3	3	2	2	2	-	-	-	-	-	-	-
CO 3	3	3	2	2	2	-	-	-	-	-	-	-
CO 4	3	3	3	3	3	-	-	-	-	-	1	-

UNIT-I

Modeling concepts and examples, Scaling of variables, and approximations of functions; SIR and SEIR models for disease spread: Methodology, Standard and solvable SIR models, Basic reproduction number; Dieting model with analysis and approximate solutions.

UNIT-II

Stability and the phase plane, Almost linear systems; Ecological models: Predators and competitors, Critical

points, Oscillating populations, Survival of single species, Peaceful coexistence of two species, Interaction of logistic populations, Wildlife conservation preserve; Nonlinear mechanical systems: Hard and soft spring oscillations, Damped nonlinear vibrations.

UNIT-III

Graphs and their representation, Pseudographs, Subgraphs, Degree sequence, Isomorphism of graphs, Paths and circuits, connected graphs, Euler trails and circuits, Hamiltonian paths and cycles, Adjacency matrix, Weighted graphs, Travelling salesman problem, Dijkstra's algorithm.

UNIT - IV

The Chinese postman problem; Digraphs, Bellman-Ford algorithm, Tournaments, Directed network, Scheduling problem; Trees and their properties, Spanning trees, Kruskal's algorithm, Prim's algorithm, Acyclic digraphs and Bellman's algorithm, Floyd-Warshall algorithm for all-pairs shortest path.

Textbook(s):

1. Mickens, Ronald E., "Mathematical Modelling with Differential Equations", CRC Press, Taylor & Francis Group, 2022.
2. Edwards, C. Henry, Penney, David E., &Calvis, David T., "Differential Equations and Boundary Value Problems: Computing and Modeling", 6th ed., Pearson, 2023.
3. Goodaire, Edgar G., &Parmenter, Michael M., "Discrete Mathematics with Graph Theory", 3rd ed., Pearson Education Pvt. Ltd. Indian Reprint, 2011.

References:

1. Giordano, Frank R., Fox, William P., & Horton, Steven B., "A First Course in Mathematical Modeling", 5th ed., Brooks/Cole, Cengage Learning India Pvt. Ltd, 2014.
2. Barnes, Belinda &Fulford, Glenn R., "Mathematical Modeling with Case Studies, Using Maple and MATLAB", 3rd ed., CRC Press. Taylor & Francis Group, 2015.
3. Bondy, J. A. &Murty, U.S.R., "Graph Theory with Applications", Springer, 2008.
4. Chartrand, Gary, & Zhang, P., "A First Course in Graph Theory", Dover Publications, 2012.

Database Management Systems Lab	L	P	C
		2	1

Discipline(s) / EAE / OAE	Semester	Group	Sub-group	Paper Code
CSE/IT/CST/ITE	4	PC	PC	CIC-256
CS/CSAM	5	PC	PC	CIC-367

Marking Scheme:

1. Teachers Continuous Evaluation: 40 marks
2. Term end Theory Examinations: 60 marks

Instructions:

1. The course objectives and course outcomes are identical to that of (Database Management Systems) as this is the practical component of the corresponding theory paper.
2. The practical list shall be notified by the teacher in the first week of the class commencement under intimation to the office of the Head of Department / Institution in which the paper is being offered from the list of practicals below. Atleast 10 experiments must be performed by the students, they may be asked to do more. Atleast 5 experiments must be from the given list.

1. Experiments based on DDL commands – CREATE, ALTER, DROP and TRUNCATE.
2. Apply the integrity constraints like Primary Key, Foreign key, Check, NOT NULL, etc. to the tables.
3. Experiments based on basic DML commands – SELECT, INSERT, UPDATE and DELETE.
4. Write the queries for implementing Built-in functions, GROUP BY, HAVING and ORDER BY.
5. Write the queries to implement the joins.
6. Write the queries to implement the subqueries.
7. Write the queries to implement the set operations.
8. Write the queries to create the views and queries based on views.
9. Demonstrate the concept of Control Structures.
10. Demonstrate the concept of Exception Handling.
11. Demonstrate the concept of Functions and Procedures.
12. Demonstrate the concept of Triggers.

Number Theory Lab	L	P	C
		2	1

Discipline(s) / EAE / OAE	Semester	Group	Sub-group	Paper Code
CSAM	4	PC	PC	AM-369

Marking Scheme:
1. Teachers Continuous Evaluation: 40 marks
2. Term end Theory Examinations: 60 marks

Instructions:
1. The course objectives and course outcomes are identical to that of (Number Theory) as this is the practical component of the corresponding theory paper.
2. The practical list shall be notified by the teacher in the first week of the class commencement under intimation to the office of the Head of Department / Institution in which the paper is being offered from the list of practicals below. Atleast 10 experiments must be performed by the students, they may be asked to do more. Atleast 5 experiments must be from the given list.

1 Implementation of Euclidean algorithm and extended Euclidean algorithm: To compute GCDs and solve linear Diophantine equations

2 Solving linear congruences using brute-force and modular inverse: Understand modular arithmetic solutions

3 Program for Chinese Remainder Theorem: Solve simultaneous linear congruences efficiently

4 Computation of Euler's phi and Möbius functions: Understand multiplicative functions using algorithms

5 Use of Wilson's and Fermat's theorems in primality testing: Apply theoretical results in checking primes

6 Generate and test prime numbers (Sieve of Eratosthenes/Fermat test): Explore prime generation and distribution

7 Implementation of Legendre and Jacobi symbols: Understand quadratic residues computationally

8 RSA cryptographic system: Key generation, encryption, decryption: Apply number theory in secure communication

9 Solving Pell's and Fermat's equations using continued fractions: Explore techniques for classic Diophantine equations

10 Number-theoretic function visualizations (e.g., distribution of $\phi(n)$): Interpret behavior and growth patterns graphically

Tools: Python (with SymPy), SageMath, C++, or any math-oriented software like MATLAB.

Mathematical Modelling and Graph Theory Lab	L	P	C
		2	1

Discipline(s) / EAE / OAE	Semester	Group	Sub-group	Paper Code
CSAM	5	PC	PC	AM-371

Marking Scheme:
1. Teachers Continuous Evaluation: 40 marks
2. Term end Theory Examinations: 60 marks

Instructions:
1. The course objectives and course outcomes are identical to that of (Mathematical Modelling and Graph Theory) as this is the practical component of the corresponding theory paper.
2. The practical list shall be notified by the teacher in the first week of the class commencement under intimation to the office of the Head of Department / Institution in which the paper is being offered from the list of practicals below. Atleast 10 experiments must be performed by the students, they may be asked to do more. Atleast 5 experiments must be from the given list.

1 Simulate and plot SIR/SEIR models using Python/Matlab: Understand disease dynamics and compute R_0

2 Model and simulate dieting system using ODEs: Develop health-related predictive models.

3 Phase plane analysis and stability of predator-prey models: Analyze ecological interactions using simulations.

4 Simulate damped and nonlinear spring oscillations: Understand mechanical systems using modeling.

5 Represent graphs using adjacency and incidence matrices Practice graph representations computationally.

6 Implement Dijkstra's algorithm for shortest path: Solve path problems in weighted graphs.

7 Implement Traveling Salesman Problem with brute force/greedy methods: Analyze NP-hard combinatorial problems.

8 Simulate Chinese Postman Problem using networkx or equivalent: Solve real-world postal delivery routing problems.

9 Implement Kruskal's and Prim's algorithms for MST: Understand cost optimization in networks.

10 Use Bellman-Ford algorithm for graphs with negative weights: Compare shortest-path algorithms under varied conditions.

Tools: Python (networkx, matplotlib), MATLAB, SageMath, or R (igraph).

Operation Research	L	P	C
	3		3

Discipline(s) / EAE / OAE	Semester	Group	Sub-group	Paper Code
CSAM	6	PC	PC	AM-320

Marking Scheme:

1. Teachers Continuous Evaluation: 40 marks
2. Term end Theory Examinations: 60 marks

Instructions for paper setter:

1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 20 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 10.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Course Objectives :

1.	To introduce the evolution, scope, and modeling techniques of Operations Research and formulate real-world problems as Linear Programming Problems (LPPs).
2.	To provide solution strategies for LPPs using the Simplex method, Big M, Two-Phase, and Dual Simplex methods, including understanding of duality.
3.	To apply mathematical techniques to solve Transportation, Assignment, and Travelling Salesman Problems for optimal resource allocation.
4.	To analyze and manage projects using Network Analysis (CPM & PERT) and understand queuing theory models for service system optimization.

Course Outcomes (CO)

CO 1	Formulate and solve linear programming models for optimization problems using graphical and simplex methods.
CO 2	Analyze and solve LPPs using advanced simplex techniques including duality and degeneracy.
CO 3	Apply operations research methods like transportation, assignment, and TSP to decision-making and logistics problems.
CO 4	Use network analysis (CPM/PERT) and queuing models for efficient project management and service systems.

Course Outcomes (CO) to Programme Outcomes (PO) mapping (scale 1: low, 2: Medium, 3: High)

	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO 1	3	3	2	2	2	-	-	-	-	-	1	-
CO 2	3	3	2	2	2	-	-	-	-	-	1	-
CO 3	3	3	3	2	2	-	-	-	-	-	2	-
CO 4	3	3	3	2	2	-	-	-	-	-	3	-

UNIT-I

Introduction: Evolution of OR, Definitions of OR, Scope of OR, Applications of OR, Phases in OR study. Characteristics and limitations of OR, models used in OR, Linear Programming Problem (LPP), Generalized LPP-Formulation of problems as L.P.P. Solutions to LPP by graphical method (Two Variables).

UNIT-II

LPP: Simplex method, Canonical and Standard form of LP problem, slack, surplus and artificial variables, Solutions to LPP by Simplex method, Big-M Method and Two Phase Simplex Method, Degeneracy in LPP. Concept of Duality, writing Dual of given LPP. Solutions to L.P.P by Dual Simplex Method.

UNIT-III

Transportation Problem: Formulation of transportation problem, types, initial basic feasible solution using North-West Corner rule, Vogel's Approximation method. Optimality in Transportation problem by Modified Distribution (MODI) method. Unbalanced T.P. Maximization T.P. Degeneracy in transportation problems, application of transportation problem.
Assignment Problem- Formulation, Solutions to assignment problems by Hungarian method, Special cases in assignment problems, unbalanced, Maximization assignment problems. Travelling Salesman Problem (TSP). Difference between assignment and T.S.P, Finding best route by Little's method. Numerical Problems.

UNIT - IV

Network analysis: Introduction, Construction of networks, Fulkerson's rule for numbering the nodes, AON and AOA diagrams; Critical path method to find the expected completion time of a project, determination of floats in networks, PERT networks, determining the probability of completing a project, predicting the completion time of project; Cost analysis in networks. Crashing of networks- Problems.
Queuing Theory: Queuing systems and their characteristics, Pure-birth and Pure-death models (only equations), Kendall & Lee's notation of Queuing, empirical queuing models – Numerical on M/M/1 and M/M/C Queuing models.

Textbook(s):

1. Hillier and Lieberman, "Introduction to Operations Research", McGraw Hil, 8th Edition.
2. Hamdy A. Taha, "Operations Research, An Introduction", PHI, 7th Ed., 2006
3. Madnick & Donovan, "Operating System", TMH,1st Ed., 2001

References:

1. J K Sharma, "Operations Research, Theory and Applications", Operations Research, Theory and Applications, 6th Edition, 2016
2. Paneerselvan, "Operations Research", PHI
3. P K Gupta and D S Hira, "Operations Research", Chand and Company LTD. Publications, 2007

Operation Research Lab	L	P	C
		2	1

Discipline(s) / EAE / OAE	Semester	Group	Sub-group	Paper Code
CSAM	6	PC	PC	AM-360

Marking Scheme:
1. Teachers Continuous Evaluation: 40 marks
2. Term end Theory Examinations: 60 marks

Instructions:
1. The course objectives and course outcomes are identical to that of (Operation Research) as this is the practical component of the corresponding theory paper.
2. The practical list shall be notified by the teacher in the first week of the class commencement under intimation to the office of the Head of Department / Institution in which the paper is being offered from the list of practicals below. Atleast 10 experiments must be performed by the students, they may be asked to do more. Atleast 5 experiments must be from the given list.

1 Solve LPP using graphical method (2 variables): Understand feasible region, optimal solution.

2 Implement Simplex method manually and using software (e.g., Excel Solver): Learn iterative optimization for LPPs.

3 Apply Big-M and Two-Phase methods for constrained LPPs: Solve complex LPPs with artificial variables.

4 Convert and solve dual of a given LPP: Understand duality theory in optimization.

5 Solve transportation problem using VAM and MODI method: Optimize resource distribution.

6 Solve assignment problems using Hungarian method: Minimize cost or maximize profit in assignments.

7 Solve Travelling Salesman Problem using Little's method: Find optimal tour in routing problems.

8 Construct project networks and perform CPM analysis: Identify critical paths and project duration.

9 Solve PERT problems with time estimates and probability: Handle uncertainty in project timelines.

10 Implement M/M/1 and M/M/C queuing models: Analyze service efficiency and waiting times.

Tools: MS Excel Solver, Python (SciPy/OR-Tools), MATLAB, LINGO, TORA.

Computational Geometry and Topology	**L**	**P**	**C**
	3		**3**

Discipline(s) / EAE / OAE	Semester	Group	Sub-group	Paper Code
CSAM	6	CSAM-OAE	CSAM-OAE-1	AM-382T

Marking Scheme:
1. Teachers Continuous Evaluation: 40 marks
2. Term end Theory Examinations: 60 marks

Instructions for paper setter:
1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 20 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 10.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Course Objectives :

1.	To introduce the fundamental geometric structures like Voronoi diagrams, Delaunay triangulations, and lattice configurations in 2D and 3D spaces.
2.	To explore alpha complexes, spatial models, and area computations relevant to physical and biological systems.
3.	To build a foundational understanding of topology, simplicial complexes, and homology for studying shapes and connectivity.
4.	To analyze filtrations, persistent homology, and topological invariants using matrix algorithms and barcodes.

Course Outcomes (CO)

CO 1	Explain and apply geometric constructs like Voronoi diagrams, Delaunay triangulations, and lattice structures in computational geometry.
CO 2	Analyze alpha shapes and filtration processes in spatial data and construct area approximations using topological tools.
CO 3	Interpret topological spaces, manifolds, and compute homology groups using simplicial complexes.
CO 4	Implement filtration algorithms, compute persistent homology, and interpret barcodes and persistence diagrams for shape analysis.

Course Outcomes (CO) to Programme Outcomes (PO) mapping (scale 1: low, 2: Medium, 3: High)

	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO 1	3	3	2	2	2	-	-	-	-	-	-	1
CO 2	3	3	2	2	2	-	-	-	-	-	-	1
CO 3	3	2	2	3	2	-	-	-	-	-	-	2
CO 4	3	3	3	3	3	-	-	-	-	-	-	2

UNIT-I

Roots of Geometry and Topology: Platonic Solids, Euler Formula, Disk Packings, Sphere Packings, Space Filling. Voronoi and Delaunay Diagrams: Convex Polygons, Voronoi Diagrams, Delaunay Triangulations, Planar Graphs, Maximally Planar Graphs, Incremental Construction, Expectations.Weighted Diagrams: Apollonius Diagrams, Power Diagrams, Weighted Delaunay Triangulations, Geometric Primitives.Three Dimensions: Lattices, Cube Lattice, BCC Lattice, FCC Lattice, Quadratic Example.

UNIT-II

Alpha Complexes: Jarvis' Construction, The Alpha Shape, Union of Disks, Voronoi Decomposition, Filtration, Space-Filling Models of Proteins. Holes: Holes in the Plane, Filtration by Thickening, Pockets, Iterative Stochastic Construction, Hierarchical Pocket Structure, Tunnels.Area Formulas: Space-Filling Models, Principle of Inclusion-Exclusion, Independent Disks, Substitution, Full Subcomplexes.

UNIT-III

Topological Spaces: Topology and Topology Equivalence, Manifolds, Classification of Compact Surfaces, Simplicial Complexes, Triangulations. Homology Groups: Little Creatures, Chain Groups, Chain Complex, Cycles and Boundaries, Homology, Euler-Poincaré Formula, Some Computations. Complex Construction: Abstract Simplicial Complexes, Homotopy, Homotopy Equivalence, Nerves, C˘ech Complexes, Vietoris-Rips Complexes.

UNIT - IV

Filtrations: Alpha Complex Filtration, Incremental Algorithm, Topological Noise, Birth and Death, Barcodes, Persistence Diagrams. PL Functions: Piecewise Linear Interpolation, Sublevel Sets, Full Subcomplexes, PL 2-Manifolds, Alternating Sum, Bottleneck Distance, Stability. Matrix Reduction: Boundary Matrices, Reduction Algorithm, Translation to Barcode, Uniqueness of Pivots, Alternative Algorithm.

Textbook(s):

1. Mark de Berg et al., "Computational Geometry: Algorithms and Applications", Springer, 3 rd Ed., 2011
2. Herbert Edelsbrunner, "A Short Course in Computational Geometry and Topology", Springer, 2014

References:

1. Herbert Edelsbrunner and John L. Harer, "Computational Topology : An Introduction", Indian Edition, 2010
2. Preparata and Shamos, "Computational Geometry - an introduction", Springer-Verlag.
3. J. O' Rourke, "Computational Geometry in C", Cambridge University Press.

Computational Geometry and Topology Lab	L	P	C
		2	1

Discipline(s) / EAE / OAE	Semester	Group	Sub-group	Paper Code
CSAM	6	CSAM-OAE	CSAM-OAE-1	AM-382P

Marking Scheme:
1. Teachers Continuous Evaluation: 40 marks
2. Term end Theory Examinations: 60 marks

Instructions:
1. The course objectives and course outcomes are identical to that of (Computational Geometry and Topology) as this is the practical component of the corresponding theory paper.
2. The practical list shall be notified by the teacher in the first week of the class commencement under intimation to the office of the Head of Department / Institution in which the paper is being offered from the list of practicals below. Atleast 10 experiments must be performed by the students, they may be asked to do more. Atleast 5 experiments must be from the given list.

1 Implement 2D Voronoi diagram and Delaunay triangulation (using Python / CGAL): Understand geometric duals and spatial subdivisions.

2 Construct Apollonius and Power Diagrams for weighted points: Apply geometric weights in partitioning space.

3 Visualize 3D lattices (BCC, FCC) using OpenGL or 3D libraries: Explore spatial structures in solid geometry.

4 Build alpha shapes and compute filtration: Model and simplify geometric shapes.

5 Compute Euler characteristic for simple surfaces and complexes: Understand basic topological invariants.

6 Construct simplicial complexes and compute homology groups: Perform chain complex analysis.

7 Implement Čech and Vietoris-Rips complexes for point cloud data: Analyze data connectivity.

8 Develop filtration and compute persistence barcodes: Interpret topological features across scales.

9 Reduce boundary matrices and extract topological features: Understand matrix reduction for homology.

10 Apply bottleneck distance to compare shapes: Evaluate stability and similarity in data structures.

Tools: Python (GUDHI, scikit-tda), MATLAB, CGAL, JavaScript (Three.js for visualization)

Real Analysis	L	P	C
	3		3

Discipline(s) / EAE / OAE	Semester	Group	Sub-group	Paper Code
CSAM	6	CSAM-OAE	CSAM-OAE-1	AM-384T

Marking Scheme:

1. Teachers Continuous Evaluation: 40 marks
2. Term end Theory Examinations: 60 marks

Instructions for paper setter:

1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 20 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 10.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Course Objectives :

1.	To develop understanding of the real number system, including completeness, bounds, and countability.
2.	To analyze sequences, their convergence, monotonicity, and important theorems like Bolzano-Weierstrass and Cauchy criterion.
3.	To introduce metric spaces and study continuity, convergence, and topological properties.
4.	To explore integrability in metric spaces, Riemann integration, and foundational theorems of calculus.

Course Outcomes (CO)

CO 1	Demonstrate understanding of real numbers, completeness properties, and cardinality of sets.
CO 2	Analyze sequences for convergence using Cauchy criteria and related theorems.
CO 3	Examine the properties of metric spaces, continuity, and limits of functions.
CO 4	Apply the concept of measure, Riemann integrability, and fundamental calculus results.

Course Outcomes (CO) to Programme Outcomes (PO) mapping (scale 1: low, 2: Medium, 3: High)

	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO 1	3	2	1	1	-	-	-	-	-	-	-	2
CO 2	3	3	1	2	1	-	-	-	-	-	-	2
CO 3	3	3	2	2	2	-	-	-	-	-	-	2
CO 4	3	3	2	3	2	-	-	-	-	-	-	2

UNIT-I

Real number system $\mathbb{R}$, Peano's Postulate/Axiom, countable and uncountable sets, concepts of bounds, least upper bound & greatest lower bound, order and completeness properties of $\mathbb{R}$, Archimedean property of real numbers.

UNIT-II

Definition of real sequence, sub-sequence, bounded sequence, convergence of a sequence (Limit of a sequence), monotone sequences and their convergence, operations on convergent and divergent sequences, Bolzano-Weierstrass theorem for sequences, Cauchy sequence, Cauchy's general principle for convergence, Nested intervals.

UNIT-III

Definition and examples of Metric Spaces, limits of functions in a metric space, Pseudo metric space, Euclidean space, continuity of functions, open and closed spheres, open sets, closed sets, closure, inverse image of an open or a closed set, convergent sequences in metric space.

UNIT - IV

Cluster points, Convergent sequences in metric space, Cauchy sequence in a metric space, Neighbourhood.Concept of set of measure zero, Riemann sums, Riemann integral, criterion for integrability, properties of Riemann integral, fundamental theorem of calculus.

Textbook(s):

1. Richard R. Goldberg, Methods of Real Analysis, Oxford & IBH publishing Co., 2020
2. Bartle, R.G., and Sherbert, D.R., Introduction to real analysis (4th edition), John Wiley & Sons, Inc., New York., 2011

References:

1. Mathematical Analysis, Apostol, Narosa pub. House (2nd Edition)., 2002
2. Mathematical Analysis, S.C. Malik and Savita Arora (5th Edition) New Age International publishers., 2017
3. Principles of Mathematical Analysis, Walter Rudin, 3rd Edition, Mc Draw Hill, 2017

Real Analysis Lab	L	P	C
		2	1

Discipline(s) / EAE / OAE	Semester	Group	Sub-group	Paper Code
CSAM	6	CSAM-OAE	CSAM-OAE-1	AM-384P

Marking Scheme:
1. Teachers Continuous Evaluation: 40 marks
2. Term end Theory Examinations: 60 marks

Instructions:
1. The course objectives and course outcomes are identical to that of (Real Analysis) as this is the practical component of the corresponding theory paper.
2. The practical list shall be notified by the teacher in the first week of the class commencement under intimation to the office of the Head of Department / Institution in which the paper is being offered from the list of practicals below. Atleast 10 experiments must be performed by the students, they may be asked to do more. Atleast 5 experiments must be from the given list.

1. Visualize countable vs. uncountable sets using Python: Understand difference via examples (e.g., $\mathbb{Q}$ vs. $\mathbb{R}$).
2. Plot bounded and monotonic sequences: Explore convergence of sequences visually.
3. Implement Cauchy and Bolzano-Weierstrass tests on sequences: Determine convergence without limit formulas.
4. Construct metric spaces using examples in $\mathbb{R}^2$: Learn open/closed sets, closure, interior via plotting.
5. Check continuity of functions using ε-δ definition (using small intervals): Apply theoretical concepts computationally.
6. Visualize open/closed balls in Euclidean and Pseudo-metric spaces: Compare topological properties.
7. Implement nested interval theorem to approximate real numbers: Understand limits and decimal approximations.
8. Compute Riemann sums and approximate definite integrals: Practice integration as a limit of sums.
9. Explore measure-zero sets using dense sets like rationals in [0,1]: Reinforce abstract concepts visually.
10. Fundamental Theorem of Calculus – graphical interpretation using integration and differentiation: Bridge the connection between integral and derivative.

Tools: Python (NumPy, Matplotlib), SageMath, GeoGebra, MATLAB (optional)

Mathematical Biology	**L**	**P**	**C**
	4		**4**

Discipline(s) / EAE / OAE	Semester	Group	Sub-group	Paper Code
CSAM	6	CSAM-OAE	CSAM-OAE-1	AM-386

Marking Scheme:
1. Teachers Continuous Evaluation: 40 marks
2. Term end Theory Examinations: 60 marks

Instructions for paper setter:
1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 20 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 10.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Course Objectives :

1.	To introduce mathematical modeling techniques in biological systems, focusing on population dynamics, predator-prey models, and applications in ecology and epidemiology.
2.	To analyze biological systems using functional responses, stability theory, periodic solutions, and apply bifurcation tools to real-life models such as chemostats.
3.	To understand nonlinear phenomena like the Allee effect, harvesting models, and bifurcations using qualitative analysis and dimensional scaling.
4.	To explore stochastic and computational approaches in biology, with emphasis on bioinformatics, sequence analysis, and Monte Carlo simulations.

Course Outcomes (CO)

CO 1	Formulate and analyze differential equations for biological models such as growth and predator-prey systems.
CO 2	Apply nonlinear dynamics concepts like limit cycles and bifurcation theory to biological systems including chemostats.
CO 3	Analyze ecological phenomena like Allee effect and harvesting models using phase-plane methods and bifurcation theory.
CO 4	Implement computational and stochastic models to solve problems in genomics, molecular biology, and evolutionary studies.

Course Outcomes (CO) to Programme Outcomes (PO) mapping (scale 1: low, 2: Medium, 3: High)

	PO01	**PO02**	**PO03**	**PO04**	**PO05**	**PO06**	**PO07**	**PO08**	**PO09**	**PO10**	**PO11**	**PO12**
CO 1	3	3	2	2	1	-	-	-	-	-	-	2
CO 2	3	3	2	3	2	-	-	-	-	-	-	2
CO 3	3	3	2	2	1	-	-	-	-	-	-	2
CO 4	3	3	3	3	3	-	-	-	-	-	-	3

UNIT-I

Introduction to Mathematical Biology: Basics of mathematical modeling in biological systems, Growth models: Exponential and logistic growth, Population dynamics and predator-prey models (Lotka-Volterra equations), Stability analysis and equilibrium points and Applications in ecology and epidemiology.

UNIT-II

Different types of functional responses - Holling type- I, II, III growths. Improved predator-prey model introducing the logistic growth term for the prey and other predator-prey models, their steady stares and linear stability analysis. Periodic solutions and limit cycles: Statement of Poincare-Bendixson theorem, Bendixson's negative criterion, Dulaccriteion, Hopf bifurcation theorem (statementonly). Examples in the context of biological scenario.The chemostat: Bacterial growth in a chemostat. Michaelis-Menten kinetics. Formulation of model and steady states.

UNIT-III

Allee effect: Basic idea and discussion with the model dx/dt=rx(1-x/K)(x/Ko-1), stability analysis of steady states. Harvesting problems of a single natural population: Constant-yield harvesting constant-effort harvesting. Non-dimensionalisation and reparametrisation in a model: Necessity and application. Bifurcation: Saddle-node, transcritical and pitchfork bifurcation in one-dimensional case. lnsect outbreak model: The spruce budworm model - deduction, analysis of steady states, presence of saddle-node bifurcation.

UNIT - IV

Computational Biology and Stochastic Models: Introduction to bioinformatics and sequence analysis, Markov models in genetics and neural networks, Stochastic processes in molecular biology, Monte Carlo simulations for biological systems, Applications in evolutionary biology and genomics.

Textbook(s):

1. J. D. Murray, "Mathematical Biology", Springer, 1993
2. D.S. Jones, "Differential Equations and Mathematical Biology", CRC Press, 1st Edition, 2009
3. L.E. Keshet, "Mathematical Models in Biology", SIAM, 1988
4. Y.C. Fung, "Biomechanics", Springer-Verlag,2nd Ed., 1990

References:

1. F. Brauer, P.V.D. Driessche and J. Wu,"Mathematical Epidemiology", Springer, 2008
2. M. Kot, "Elements of Mathematical Ecology", Cambridge University Press, 2001
3. F Brauer and C. Castillo-Chavez, "Mathematical Models in Population Biology and Epidemiology", Springer, 2012.
4. S. H. Strogatz, "Nonlinear Dynamics and Chaos", Perseus Books, 1994.
5. N.F. Britton, "Essential Mathematical Biology", Springer, 2003.

Software Engineering	**L**	**P**	**C**
	3		**3**

Discipline(s) / EAE / OAE	Semester	Group	Sub-group	Paper Code
CSE/IT/CST/ITE/CS	5	PC	PC	CIC-309
CSAM	7	PC	PC	CIC-403

Marking Scheme:

1. Teachers Continuous Evaluation: 25 marks
2. Term end Theory Examinations: 75 marks

Instructions for paper setter:

1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 15 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 15.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Course Objectives :

1.	To introduce the basic concepts of the software development processes, Software requirements and specifications
2.	To impart knowledge of Software Project Planning and various Software design techniques for developing large software systems.
3.	To understand Software Metrics, Software Reliability, and Quality assurance using ISO 9001 and SEI-CMM.
4.	To impart the knowledge and use of software engineering processes and tools in analysis, design, implementation, software testing, documentation, and maintenance for software systems.

Course Outcomes (CO)

CO 1	Ability to have an understanding of SDLC Models, Techniques for Requirement Elicitation, and SRS Document.
CO 2	To be able to explain Software Project Planning and various methods for software design
CO 3	To Understand Software Metrics, Software Reliability, and Quality assurance
CO 4	Ability to have an understanding of Software testing, documentation and maintenance.

Course Outcomes (CO) to Programme Outcomes (PO) mapping (scale 1: low, 2: Medium, 3: High)

	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO 1	3	2	2	2	3	-	-	-	3	2	2	3
CO 2	3	2	2	2	3	-	-	-	3	2	2	3
CO 3	3	2	2	2	3	-	-	-	3	2	2	3
CO 4	3	2	2	2	3	-	-	-	3	2	2	3

UNIT-I

Introduction: Introduction to Software Engineering,Importance of software engineering as a discipline, Software applications, Software Crisis, Software Processes & Characteristics, Software life cycle models, Waterfall, Prototype, Evolutionary and Spiral Models.

Software Requirements Analysis & Specifications: Requirement engineering,Functional and non-functional requirements, User requirements, System requirements, requirement elicitation techniques like FAST, QFD & Use case approach, requirements analysis using DFD, Data dictionaries & ER Diagrams, Requirements documentation, Nature of SRS, Characteristics & organization of SRS, Requirement Management, IEEE Std. for SRS.

UNIT-II

Software Project Planning: Size Estimation like lines of Code & Function Count, Cost Estimation Models, COCOMO, Putnam resource allocation model, Validating Software Estimates, Risk Management.
Software Design: Cohesion & Coupling, Classification of Cohesiveness & Coupling, Function Oriented Design, Object Oriented Design, User Interface Design.

UNIT-III

Software Metrics: Software measurements: What & Why, Token Count, Halstead Software Science Measures, Data Structure Metrics, Information Flow Metrics.
Software Reliability: Importance, Hardware Reliability & Software Reliability, Failure and Faults, Reliability Models- Basic Model, Logarithmic Poisson Model, Software Quality Models, CMM & ISO 9001.

UNIT – IV

Software Testing: Testing process, Functional testing: Boundary value analysis, Equivalence class testing, Decision table testing, Cause effect graphing, Structural testing: Path testing, Data flow and mutation testing, unit testing, integration and system testing, Debugging, Testing Tools & Standards.
Software Maintenance: Management of Maintenance, Maintenance Process, Maintenance Models, Regression Testing, Reverse Engineering, Software Re-engineering, Configuration Management, Documentation.

Textbook(s):
1. K. K. Aggarwal and Yogesh Singh, “Software Engineering”, New Age International, 3rd Ed., 2005.
2. R. S. Pressman, “Software Engineering – A Practitioner's Approach”, McGraw Hill Int. , 5th Ed., 2001.
3. Pankaj Jalote, “An Integrated Approach to Software Engineering”, Narosa, 3rd Ed., 2005.

References:
1. Stephen R. Schach, “Classical & Object Oriented Software Engineering”, IRWIN, 1996.
2. James Peter, W. Pedrycz, “Software Engineering: An Engineering Approach”, John Wiley & Sons.
3. I. Sommerville, “Software Engineering”, Addison Wesley,8th Ed., 2009.
4. Frank Tsui and Orlando Karan, “Essentials of Software Engineering”, Joes and Bartlett, 2nd Ed., 2010.
5. Kassem A. Saleh, “Software Engineering”, Cengage Learning, 2009.
6. Rajib Mall, “Fundamrntal of Software Engineering”, PHI, 3rd Ed., 2009.
7. Carlo Ghizzi, Mehdi Jazayeri and Dino Mandrioli, “Fundamental of Software Engineering”, PHI, 2nd Ed., 2003.
8. Carol L. Hoover, Mel Rosso-Llopart and Gil Taran, “Evaluating Project Decision Case Studies in Software Engineering”, Pearson, 2010.

Software Engineering Lab	L	P	C
		2	1

Discipline(s) / EAE / OAE	Semester	Group	Sub-group	Paper Code
CSE/IT/CST/ITE/CS	5	PC	PC	CIC-357
CSAM	7	PC	PC	CIC-455

Marking Scheme:

1. Teachers Continuous Evaluation: 40 marks
2. Term end Theory Examinations: 60 marks

Instructions:

1. The course objectives and course outcomes are identical to that of (Software Engineering) as this is the practical component of the corresponding theory paper.
2. The practical list shall be notified by the teacher in the first week of the class commencement under intimation to the office of the Head of Department / Institution in which the paper is being offered from the list of practicals below. Atleast 10 experiments must be performed by the students, they may be asked to do more. Atleast 5 experiments must be from the given list.

1. Write down the problem statement for a suggested system of relevance.
2. Do requirement analysis and develop Software Requirement Specification Sheet (SRS) for suggested system.
3. To perform the function oriented diagram: Data Flow Diagram (DFD) and Structured chart.
4. Draw the entity relationship diagram for the suggested system.
5. To perform the user's view analysis for the suggested system: Use case diagram.
6. To draw the structural view diagram for the system: Class diagram, object diagram.
7. To draw the behavioral view diagram: State-chart diagram, Activity diagram
8. To perform the behavioral view diagram for the suggested system: Sequence diagram, Collaboration diagram
9. To perform the implementation view diagram: Component diagram for the system.
10. To perform the environmental view diagram: Deployment diagram for the system.
11. To perform various testing using the testing tool unit testing, integration testing for a sample code of the suggested system.
12. Perform Estimation of effort using FP Estimation for chosen system.
13. To prepare time Line Chart / Gantt Chart / PERT Chart for selected software project.

Compiler Design	L	P	C
	3		3

Discipline(s) / EAE / OAE	Semester	Group	Sub-group	Paper Code
CSE/IT/CST/ITE/CS	5	PC	PC	CIC-303
CSAM	7	CSAM-OAE	CSAM-OAE-2	CIC-481T

Marking Scheme:

1. Teachers Continuous Evaluation: 25 marks
2. Term end Theory Examinations: 75 marks

Instructions for paper setter:

1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 15 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 15.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Course Objectives :

1.	introduce the major concept areas of language translation and compiler design.
2.	To enrich the knowledge in various phases of compiler ant its use, code optimization techniques, machine code generation, and use of symbol table.
3.	To extend the knowledge of parser by parsing LL parser and LR parser.
4.	To provide practical programming skills necessary for constructing a compiler.

Course Outcomes (CO)

CO 1	Able to apply the knowledge of LEX tool & YACC tool to develop a scanner & parser.
CO 2	Able to design & implement a software system for backend of the compiler.
CO 3	Able to design syntax tree and intermediate code generator.
CO 4	To understand the concept of symbol table and to use various code optimization techniques

Course Outcomes (CO) to Programme Outcomes (PO) mapping (scale 1: low, 2: Medium, 3: High)

	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO 1	3	2	-	2	3	2	-	-	-	-	-	3
CO 2	3	2	-	2	3	2	-	-	-	-	-	3
CO 3	3	2	-	2	3	2	-	-	-	-	-	3
CO 4	3	2	-	2	3	2	-	-	-	-	-	3

UNIT-I

Compilers and translators, need of translators, structure of compiler: its different phases, compiler construction tools, Lexical analysis: Role of lexical analyzer, Input Buffering, A simple approach to the design of Lexical Analyzers, Specification and recognition of tokens, Finite automata, From regular expressions to automata, and vice versa, minimizing number of states of DFA, A language for specifying Lexical Analyzers, Design and implementation of lexical analyzer.

UNIT-II

The role of the parser, Context free grammars, Writing a grammar: Lexical versus Syntactic analysis, Eliminating ambiguity, Elimination of left recursion, Left factoring, Top Down Parsing: Recursive- Decent parsing, Non-recursive Predictive parsing, LL(1) grammars, Bottom Up Parsing: Shift Reduce Parsing, Operator precedence parsing, LR Parsing: SLR, LALR and Canonical LR parser, Parser Generators.

UNIT-III

Syntax Directed Translation: Syntax directed definitions, Evaluation orders for SDD's, construction of syntax trees, syntax directed translation schemes, implementation of syntax directed translation,
Intermediate Code Generation: Kinds of intermediate code: Postfix notation, Parse trees and syntax trees, Three-address code, quadruples and triples, Semantic Analysis: Types and Declarations, Translation of Expressions, Type checking.

UNIT - IV

Symbol Table: Symbol tables, its contents, Data Structure for Symbol Table: lists, trees, linked lists, hash tables, Error Detection and Recovery: Errors, lexical phase errors, syntactic phase errors, semantic errors, Error seen by each phase.
Code Optimization: The principal sources of optimizations, Loop optimization, Basic blocks and Flow Graphs, DAG representation of basic blocks, Code Generation: Issues in the design of code generation, A simple target machine mode, A Simple Code Generator, Peep-hole optimization, Register allocation and assignment.

Textbook(s):

1. Alfred V. Aho, Monica S. Lam, Ravi Sethi and Jeffrey D. Ullman, "Compilers Principle, Techniques, and Tool", Pearson.
2. Alfred V. Aho, Ravi Sethi and Jeffrey D. Ullman, "Compilers Principle, Techniques, and Tool", Addison Wesley.

References:

1. Trembley and Sorenson, "Theory and Practice of Compiler Writing", McGraw Hill.
2. Jhon R. Levine, Tony Mason and Doug Brown, —Lex &Yacc, O'Reilly.
3. M. Joseph, "Elements compiler Design", University Science Press.

Compiler Design Lab	L	P	C
		2	1

Discipline(s) / EAE / OAE	Semester	Group	Sub-group	Paper Code
CSE/IT/CST/ITE/CS	5	PC	PC	CIC-351
CSAM	7	CSAM-OAE	CSAM-OAE-2	CIC-481P

Marking Scheme:

1. Teachers Continuous Evaluation: 40 marks
2. Term end Theory Examinations: 60 marks

Instructions:

1. The course objectives and course outcomes are identical to that of (Compiler Design) as this is the practical component of the corresponding theory paper.
2. The practical list shall be notified by the teacher in the first week of the class commencement under intimation to the office of the Head of Department / Institution in which the paper is being offered from the list of practicals below. Atleast 10 experiments must be performed by the students, they may be asked to do more. Atleast 5 experiments must be from the given list.

1. Practice of LEX/YACC of compiler writing.
2. Write a program to check whether a string belong to the grammar or not.
3. Write a program to check whether a string include Keyword or not.
4. Write a program to remove left Recursion from a Grammar.
5. Write a program to perform Left Factoring on a Grammar.
6. Write a program to show all the operations of a stack.
7. Write a program to find out the leading of the non-terminals in a grammar.
8. Write a program to Implement Shift Reduce parsing for a String.
9. Write a program to find out the FIRST of the Non-terminals in a grammar.
10. Write a program to check whether a grammar is operator precedent.

Mathematical Finance	**L**	**P**	**C**
	4		**4**

Discipline(s) / EAE / OAE	**Semester**	**Group**	**Sub-group**	**Paper Code**
CSAM	7	CSAM-OAE	CSAM-OAE-2	AM-483

Marking Scheme:

1. Teachers Continuous Evaluation: 40 marks
2. Term end Theory Examinations: 60 marks

Instructions for paper setter:

1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 20 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 10.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Course Objectives :

1.	To introduce basic concepts of financial markets, arbitrage, and options, and demonstrate risk management using derivative instruments.
2.	To develop an understanding of binomial pricing models and derive the Black-Scholes formula for option pricing.
3.	To introduce stochastic processes and calculus including Brownian motion and Itô calculus and apply them in option pricing models.
4.	To explore portfolio optimization through the Markowitz model and CAPM, and understand modern risk measures.

Course Outcomes (CO)

CO 1	Understand financial derivatives, no-arbitrage principle, and use options for risk mitigation in financial markets.
CO 2	Apply single and multi-period binomial models and derive the Black-Scholes option pricing formula.
CO 3	Utilize stochastic calculus and Itô's lemma to solve stochastic differential equations in finance.
CO 4	Apply mean-variance analysis and CAPM for optimal portfolio construction and evaluate modern risk measures.

Course Outcomes (CO) to Programme Outcomes (PO) mapping (scale 1: low, 2: Medium, 3: High)

	PO01	**PO02**	**PO03**	**PO04**	**PO05**	**PO06**	**PO07**	**PO08**	**PO09**	**PO10**	**PO11**	**PO12**
CO 1	3	3	2	2	2	-	-	-	-	-	2	1
CO 2	3	3	2	2	3	-	-	-	-	-	2	2
CO 3	3	3	2	3	3	-	-	-	-	-	2	2
CO 4	3	3	3	2	2	-	-	-	-	-	2	2

UNIT-I

Introduction: Some basic definitions and terminology: Basic Notions and Assumptions, No-Arbitrage Principle, One-Step Binomial Model, Risk and Return, Forward Contracts, Call and Put Options, Managing Risk with Options.

UNIT-II

Basic Theory of Option Pricing: Single and Multi-Period Binomial Pricing Models, Cox Ross-Rubinstein (CRR)

Model, Black-Scholes Formula for Option Pricing as a Limit of CRR Model.

UNIT-III

Introduction to Brownian and Geometric Brownian Motion, Theory of Martingales. Stochastic Calculus, Stochastic Differential Equations, Ito's Formula to Solve SDE's.FeymannKac Theorem. Applications of Stochastic Calculus in Option Pricing. Black-Scholes Partial Differential Equation and Black-Scholes Formula.

UNIT - IV

Mean-Variance Portfolio Theory: Markowitz Model of Portfolio Optimization and Capital Asset Pricing Model (CAPM). Limitations of Markowitz Model and New Measures of Risk.

Textbook(s):

1. M. Capińsky and T. Zastawniak, "Mathematics for Finance: An Introduction to Financial Engineering", Springer, 2004
2. D. G. Luenberger, "Investment Science", Oxford University Press, 1999
3. Madnick & Donovan, "Operating System", TMH,1st Ed., 2001

References:

1. Thomas Mikosch, "Elementary Stochastic Calculus with Finance in view", World Scientific, 2006
2. S. E. Shreve, "Stochastic Calculus for Finance, Vol. I & Vol. II", Springer, 2004

Quantum Cryptography	L	P	C
	3		3

Discipline(s) / EAE / OAE	Semester	Group	Sub-group	Paper Code
CSAM	7	CSAM-OAE	CSAM-OAE-2	AM-485T

Marking Scheme:

1. Teachers Continuous Evaluation: 40 marks
2. Term end Theory Examinations: 60 marks

Instructions for paper setter:

1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 20 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 10.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Course Objectives :

1.	To understand the foundational principles of quantum mechanics including state representation, measurement, and operators.
2.	To explore quantum computation concepts, quantum algorithms, and their application in computational tasks.
3.	To integrate classical cryptography fundamentals with quantum computing frameworks and assess the security implications.
4.	To introduce post-quantum cryptographic schemes, including lattice-based cryptography, quantum key distribution, and encryption techniques.

Course Outcomes (CO)

CO 1	Describe quantum mechanical postulates, state vectors, density matrices, and measurement theory.
CO 2	Apply quantum gates and algorithms (e.g., Shor's, Grover's) to solve computational problems.
CO 3	Analyze and implement classical cryptographic primitives and their transformation under quantum frameworks.
CO 4	Evaluate and apply quantum and post-quantum encryption schemes like QKD, LWE, and Fully Homomorphic Encryption.

Course Outcomes (CO) to Programme Outcomes (PO) mapping (scale 1: low, 2: Medium, 3: High)

	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO 1	3	2	1	2	1	-	-	-	-	-	1	2
CO 2	3	3	2	2	3	-	-	-	-	-	2	2
CO 3	3	3	2	3	2	-	-	-	-	-	3	2
CO 4	3	3	3	3	3	-	-	-	-	-	3	3

UNIT-I

Review of Quantum Mechanics: Basic postulates, Superposition principle, Stern-Gerlach Experiment, Pauli Matrices, Measurement in quantum mechanical system, Density operators.

UNIT-II

Quantum Computation: The idea of qubit gates, Quantum algorithms, Quantum Fourier transform and applications, Shor algorithm, Computational Complexity, Quantum Search, Physical realization of Quantum

Computers Bell States.

UNIT-III

Introduction to Cryptography, Principles of Cryptographic design, Building Cryptography: Factoring, RSA, DLog. Build OWF, OWP, TDP, CDH, DDH. Key Exchange and SKE. PKE: Ind-cpa security. ElGamal Encryption. Random Oracle Model. RSA Encryption in ROM. Finishing RSA Encryption. Boolean Fourier Analysis. Grover's Algorithm. Quantum Fourier Transform over Z_N, Simon's Algorithm over Z_N, Shor's Algorithm, Hidden Subgroup Problem.

UNIT - IV

Introduction to Lattices, Public Key Encryption from LWE, Fully Homomorphic Encryption, Quantum Key Distribution, Quantum One time Pad and Encryption, Quantum PKE, Quantum FHE.

Textbook(s):

1. Chuang and M.Nielsen, “Quantum Computation and Quantum Information”, Cambridge University Press, 2012
2. Jonathan Katz, “Introduction to Modern Cryptography: Principles and Protocols”, Chapman & Hall/CRC, 1st Ed., 2007

References:

1. J.J.Sakurai, “Modern Quantum Mechanics”, Addision-Wesley, 1994
2. Ryan O’Donnell, “Quantum Computation”, CMU Notes, 2015

Quantum Cryptography Lab	L	P	C
		2	1

Discipline(s) / EAE / OAE	Semester	Group	Sub-group	Paper Code
CSAM	7	CSAM-OAE	CSAM-OAE-2	AM-485P

Marking Scheme:
1. Teachers Continuous Evaluation: 40 marks
2. Term end Theory Examinations: 60 marks

Instructions:
1. The course objectives and course outcomes are identical to that of (Quantum Cryptography) as this is the practical component of the corresponding theory paper.
2. The practical list shall be notified by the teacher in the first week of the class commencement under intimation to the office of the Head of Department / Institution in which the paper is being offered from the list of practicals below. Atleast 10 experiments must be performed by the students, they may be asked to do more. Atleast 5 experiments must be from the given list.

1 Simulate Stern-Gerlach experiment using Qiskit or MATLAB: Understand superposition and measurement in quantum mechanics

2 Visualize Qubit states and Pauli matrices on Bloch Sphere: Gain hands-on with state manipulation

3 Implement single-qubit gates and multi-qubit circuits: Explore quantum gate behavior

4 Simulate Shor's Algorithm to factor integers (e.g., 15): Understand quantum speedup over classical methods

5 Implement Grover's Search for unsorted data: Demonstrate quantum searching

6 Simulate Quantum Fourier Transform on basic input: Learn foundational algorithm for periodicity

7 RSA encryption/decryption and attack simulation: Understand classical cryptography vulnerabilities

8 Implement ElGamal encryption and compare with quantum-safe models: Classical to post-quantum cryptography transition

9 Simulate Quantum Key Distribution (BB84 Protocol): Explore secure key generation and eavesdropping detection

10 Implement basic Fully Homomorphic Encryption from LWE: Understand encrypted computation concepts

Tools: IBM Qiskit, Microsoft Q#, Python (NumPy, SymPy), SageMath, MATLAB, CrypTool