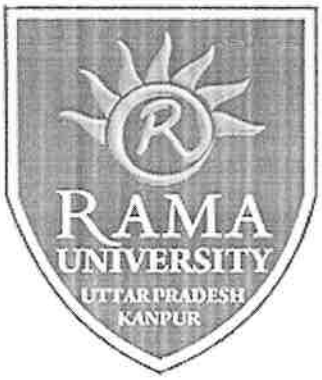
ORDINANCE
For
Master of Technology
In
Computer Science and Engineering
With Specialization in
Cloud Computing (CC)
Program Code:



Faculty of Engineering, Rama University

Preamble

The Master of Technology (M. Tech) in Computer Science and Engineering with specialization in Cloud Computing (CC) programme at Rama University is structured to impart advanced technical knowledge, research skills, and professional competence in the domain of computer science and its applications. This ordinance defines the academic framework, rules, and standards applicable M. Tech in Computer Science and Engineering with specialization in Cloud Computing (CC) programme, ensuring excellence in teaching, innovation, and research. The programme is aligned with the vision and mission of the University to foster quality education, promote technological advancement, and nurture holistic development of postgraduate students.

1. Program Name & Code

PROGRAM NAME: **MASTER OF TECHNOLOGY with specialization in Cloud Computing (CC) - Full Time**
PROGRAM CODE:

The Master of Technology (M. Tech) in Computer Science and Engineering with specialization in Cloud Computing (CC) is a Postgraduate (PG) programme offered at Rama University under the Faculty of Engineering and Technology. The programme is designed to provide in-depth technical knowledge, research orientation, and advanced skills in emerging domains of computer science and engineering.

2. Eligibility Criteria

A candidate must hold a B.Tech. degree in Computer Science, Information Technology, or a related engineering discipline with a minimum of 50% marks from a recognized University,
OR
a Master's degree (MCA/M.Sc.) in a relevant field with a minimum of 55% marks from a recognized University.

3. Admission Procedure

Admission to the programme shall be governed by the provisions of the Acts, Statutes, and Ordinances of Rama University, as in force and as may be amended from time to time. The admission shall be granted strictly on the basis of merit determined through the Entrance Test conducted by Rama University.

Provided further that, while granting admission to the programme, the reservation policy of the Government of Uttar Pradesh, as applicable to admissions in higher educational institutions and as notified from time to time, shall be duly implemented.

4. Duration of the Programme

The Master of Technology (M.Tech) in Computer Science and Engineering with specialization in Cloud Computing (CC) programme shall comprise regular study over a minimum period of four semesters spanning two academic years. The course of study shall be pursued through regular attendance in the prescribed number of lectures, tutorials, laboratory work, seminars, and project/dissertation components.

Ordinarily, the first semester shall commence from 1st August, and the third semester shall ordinarily be conducted from 1st July to 31st December; the remaining semesters shall be conducted from 1st January to 30th June. These periods shall include the time allocated for examinations and may be modified from time to time as notified by the Vice-Chancellor or other competent authorities.

The total duration of the Master of Technology (M.Tech) in Computer Science and Engineering with specialization in Cloud Computing (CC) programme shall be two years, each academic year comprising two semesters, with each semester normally consisting of at least 90 working days, or as otherwise prescribed by the UGC/AICTE from time to time.

5. Maximum Duration for Completion

The maximum permissible duration for the completion of the Master of Technology (MTech in Computer Science and Engineering with specialization in Cloud Computing (CC) programme shall be Four years, beyond which the candidate shall not be allowed to continue or be awarded the M.Tech degree.

6. Medium of Instruction

The medium of instruction, course delivery, examinations, assignments, and laboratory work shall be strictly in English. Students are encouraged to improve communication skills in English through remedial and language enhancement courses offered by the University.

7. Structure of the Programme

The Master of Technology (M.Tech) in Computer Science and Engineering with specialization in Cloud Computing (CC) programme is a two-year, four-semester postgraduate programme designed as per NEP-2020, UGC, and AICTE guidelines.

- **Core Courses:** Cover fundamental and advanced subjects in computer science and applications to build strong conceptual foundations.
- **Specialization Core (I and II):** Provide in-depth knowledge and skills in specific emerging domains.

- **Specialization Electives (I and II):** Offered in various areas such as Computer Science and Engineering, Artificial Intelligence, Cyber Security and Cloud Computing.
- **Professional Electives:** Enable students to gain advanced domain-specific expertise within the discipline.
- **Open Electives:** Promote interdisciplinary learning through courses offered by other faculties and departments.
- **Practical and Laboratory Courses:** Provide hands-on training aligned with theoretical subjects to enhance practical skills.
- **Dissertation Work:** Develop research aptitude, problem-solving ability, and application of knowledge to real-world challenges.
- **Professional Practice Internship:** Offer industry, startup setup and exposure, professional experience, and understanding of workplace practices.
- **Seminars, Workshops, and Pitch Deck:** Improve communication, presentation, teamwork, and professional competencies.

8. Marks/Credit Distribution

The Master of Technology (M.Tech) in Computer Science and Engineering with specialization in Cloud Computing (CC) programme spans four semesters, designed to provide a progressive balance of core theory, labs, electives, research, and project-based learning. The curriculum moves from advanced fundamentals and specialization courses in the first year to research, open electives, and dissertation/project work in the second year. This ensures a blend of academic depth, practical exposure, innovation, and industry orientation aligned with NEP-2020, UGC, and AICTE guidelines.

Semester	Course Type Included	Total Credits
I	Core Theory Courses + Core Labs + Specialization Core-I + Specialization Elective-I + Professional/Skill Course	20
II	Core Theory + Labs + Specialization Core-II + Specialization Elective-II + Open Elective-I	20
III	Seminar/Project (Pitch Deck) + Open Elective-II + Dissertation-I / Professional Practical Internship-I	18
IV	Dissertation-II / Professional Practical Internship-II	15
Total		73

9. Evaluation Procedure

The evaluation scheme is divided into Continuous Evaluation (CE) and End Term Examination (ETE).
Continuous Evaluation (CE) divided into
Continuous Assessment (CA) and Mid Term Examination (MTE)

Assessment Components, are structured as:
CA: 30 Marks,
MTE: 20 Marks,
and ETE: 50 Marks, Total 100 Marks.

Continuous Assessment (CA), the distribution will be:

i) Active participation of students in academic and co-curricular activities, including but not limited to seminars, Student Development Programme (SDP), workshops, and allied engagements, shall be in accordance with the stipulations contained in Circular No. RU/DA/2025/025 dated 25-08-2025. **– 10 Marks**

ii) Assignments/Quiz/Seminar/Term-Paper/Certificate/Class-Project **– 20 Marks**.

Mid Term Examination (MTE) **-20 Marks**
includes written theory papers, viva voce, and practical examinations conducted by internal examiners

End Term Examination (ETE) **– 50 Marks**
includes written theory papers, viva voce, and practical examinations conducted by internal and external examiners.

Dissertation-I / Professional Practical Internship-I (3rd Semester)

- **Marks Distribution**: CA – 100, MTE – 100, ETE – 300 (**Total = 500 Marks**)
- **Continuous Assessment (CA)**: Based on periodic progress reports, presentations, and performance during guidance sessions with the supervisor.
- **Mid-Term Evaluation (MTE)**: Conducted by an internal board to assess progress of the pre-thesis/project work.
- **End-Term Evaluation (ETE)**: Conducted by a **Board of Internal and External Examiners** appointed by the Dean, Faculty of Engineering & Technology.

Guidelines:

1. Each student shall undertake **pre-thesis work / internship** under the supervision of a guide/supervisor, appointed by the Dean.
2. A minimum of **four hard copies** of the Project Report along with **one soft copy (CD)** must be submitted at least **two weeks prior to the commencement of the Term-End Examination** of the 3rd Semester.
3. The evaluation shall be based on:
    - Quality of problem identification and objectives.
    - Methodology, technical depth, and use of tools/technologies.
    - Innovation, originality, and contribution to research/industry.
    - Quality of report writing, formatting, and referencing.
    - Seminar/viva-voce presentation before the examiners' board.

Dissertation-II / Professional Practical Internship-II (4th Semester)

- **Marks Distribution**: MTE – 200, ETE – 600 (**Total = 800 Marks**)
- **Mid-Term Evaluation (MTE)**: Progress review conducted by the supervisor(s) and internal faculty board.
- **End-Term Evaluation (ETE)**: Conducted by a **Board of Internal and External Examiners** appointed by the Dean, based on thesis submission, seminar, and viva-voce.

Guidelines:

1. The dissertation shall demonstrate **independent research ability**, analytical skills, and professional application.
2. Students are required to submit a **final thesis report** in prescribed format and defend their work in a **comprehensive viva-voce examination.**
3. Evaluation parameters include:
    - Originality and significance of research.
    - Technical depth, analysis, and results achieved.
    - Quality of documentation and adherence to academic integrity.
    - Presentation skills, clarity, and defense during viva-voce.

9.1 Appointment of Examiners

The Head of Department (HoD) shall normally appoint examiners for different courses, ensuring that at least two examiners other than the concerned course instructor are selected at random for theory courses in each semester.

For Laboratory/Project/Viva-Voce examinations, there shall be one internal examiner and one external examiner. A panel of external examiners shall be prepared and approved annually by the Board of Studies (BoS) to facilitate such appointments.

9.2 Moderation of Question Papers

A Moderation Committee constituted by the BoS shall review and, if necessary, revise or improve the question papers. The committee shall consist of:

1. The Dean
2. The Head of the Department
3. Three faculty members nominated by the Dean

9.3 Passing Criteria:

- Minimum 50% marks in aggregate (sessional + end-semester) in each theory subject, with at least 40% marks in the end-semester examination.
- Where no sessional marks are applicable, a minimum of 50% in the end-semester examination is required.
- Minimum 50% marks in project/practical subjects (including sessional marks, if applicable).
- To be promoted, a candidate must secure at least 50% aggregate marks in an academic year (both semesters combined), subject to other conditions prescribed in the University Bye-laws.

9.4 Transcripts:

Transcripts shall be issued by the University for each semester and a consolidated transcript for the entire programme, showing performance in terms of percentage.

9.5 Division and Promotion Rules

Award of Division (Final Year Result) as per below:

Percentage (%)	Division
Below 50%	Fail
50% – 59.99%	Second Division
60% – 74.99%	First Division
75% & above	First Division with Honors'

10. Rules for Backlogs / Supplementary Exams

A student failing in one or more courses shall be eligible to appear in supplementary examinations conducted by the University as per the notified schedule and prevailing rules. The number of permissible backlogs for promotion shall be governed by University promotion regulations. Students failing to clear such backlogs within the maximum duration of the program shall not be awarded the degree. Supplementary examinations may be attempted within the limit of attempts prescribed under University norms. Improvement examinations are permitted only for theory papers already passed, subject to approval of the Examination Cell and applicable University rules.

11. Special Academic Requirements

In addition to the prescribed regular coursework, every student of the M.Tech programme shall be required to complete all courses and activities as specified in the approved schema/syllabus. The programme also mandates participation in research-oriented, co-curricular, and professional development components designed to strengthen academic depth and industry readiness. Students shall be required to undertake a Seminar/Project (Pitch Deck on Innovation/Research Problem) in the third semester. They must also participate in at least two industrial/research lab visits during the programme to gain practical exposure.

During the third semester, students shall engage in Dissertation-I / Professional Practical Internship-I under the guidance of an appointed supervisor.

In the fourth semester, students shall pursue a full-fledged Dissertation-II / Professional Practical Internship-II of six months, in collaboration with research laboratories, industries, or academic institutions. Students must present their work through seminar and viva voce examinations, which shall form an integral part of the evaluation framework.

This structure ensures that students gain a balanced blend of coursework, applied learning, research exposure, and professional development, in alignment with the vision of NEP-2020, UGC, and AICTE guidelines.

12. Other Provisions

12.1 Attendance: Students must maintain a minimum of 75% attendance in every course to be eligible for appearing in examinations. Condonation may be granted in exceptional cases, as per University rules.

12.2 Discipline: Students must adhere to the code of conduct, anti-ragging policies, academic integrity rules, and ethical guidelines laid down by the University.

12.3 Use of Technology: Students are encouraged to complete online certification courses (MOOCs/NPTEL/SWAYAM) to earn credits.

12.4 Plagiarism and Malpractice: Strict action will be taken against students found guilty of unfair practices in examinations, assignments, or project work.

12.5 Change of Program: The change of branch shall be governed strictly in accordance with the prevailing University norms and the provisions contained in the previously applicable ordinances.

12.6 Teaching: Teaching shall be conducted strictly in accordance with the prevailing University norms and in conformity with the provisions of the previously applicable ordinance."

12.7 Examination: Examinations shall be held strictly in accordance with the prevailing University norms and in conformity with the provisions of the previously applicable ordinance.

12.8 Evaluation Feedback: The process of evaluation and feedback shall be regulated in accordance with the established University norms and subject to the stipulations of the earlier ordinance.

12.9 Promotion: Promotion of students shall be determined in pursuance of the University norms and in accordance with the directives contained in the preceding ordinance.

12.10 Carryover: Carryover of courses shall be administered in alignment with the University norms and in consonance with the provisions laid down in the earlier ordinance.

12.11 Ex-Studentship and Re-Admission: Matters pertaining to ex-studentship and re-admission shall be governed in accordance with the University norms and subject to the provisions embodied in the prior ordinance.

13. Exit Options (NEP-2020)

In accordance with NEP-2020 guidelines, the programme provides multiple exit options:

- After 1 year (2 semesters): **PG Diploma in Advance Computer Engineering (CS)**
- After 2 years (4 semesters): **Degree in Master of Technology in Computer Science and Engineering with specialization in Cloud Computing (CC)**

Students opting for exit must fulfill credit requirements and apply formally to the University.

Conclusion

This Ordinance shall come into effect from the academic session 2025-26 and shall be applicable to all new admissions henceforth. The University reserves the right to amend, modify, or update the Ordinance as and when required, subject to approval by statutory bodies. Any interpretation of these regulations shall rest with the Academic Council of Rama University.

Master of Technology (MTech): Syllabus
Computer Science & Engineering

Rama University, Uttar Pradesh Kanpur

Faculty of Engineering and Technology

MTech (CSE/AI/CS/CC)

I SEM

S No	Course Code	Course Name	L	T	P	CREDITS	CA	MTE	ETE	TOTAL MARKS
1	PCS1001	Advanced Data Structures using Python	3	1	0	4	30	20	50	100
2	PCS1002	Advanced Operating System	3	1	0	4	30	20	50	100
3	PCS1101-1103/PCS1003	Specialization Core- I/Soft Computing	3	0	0	3	30	20	50	100
4	PCSS201-219/PCSP301-320	Specialization Elective - I/Professional Elective-I	3	0	0	3	30	20	50	100
5	PCS1004	Ethics, Patents, Copyrights, and IPR	2	0	0	2	30	20	50	100
6	PCS1051	Advanced Data Structures using Python Lab	0	0	4	2	30	20	50	100
7	PCS1151-1153/PCS1053	Specialization Core- I Lab /Soft Computing Lab	0	0	4	2	30	20	50	100
		Total	**14**	**2**	**8**	**20**				**700**

II SEM

S No	Course Code	Course Name	L	T	P	CREDITS	CA	MTE	ETE	TOTAL MARKS
1	PCS2001	Computability, Complexity and Algorithms	3	1	0	4	30	20	50	100
2	PCS2002	Advanced Information Management Systems	3	0	0	3	30	20	50	100
3	PCS2101-2103/PCS2003	Specialization Core-II/Advanced Networks	3	0	0	3	30	20	50	100
4	PCSS201-219/PCSP301-320	Specialization Elective- II/Professional Elective-II	3	0	0	3	30	20	50	100
5	PCSO401-406	Open Elective-I	3	0	0	3	30	20	50	100
6	PCS2052	Advanced Information Management Systems Lab	0	0	4	2	30	20	50	100
7	PCS2151-PCS2153/PCS2053	Specialization Core-II Lab	0	0	4	2	30	20	50	100
		Total	**15**	**1**	**8**	**20**				**700**

III SEM

S No	Course Code	Course Name	L	T	P	CREDITS	CA	MTE	ETE	TOTAL MARKS
1	PCS3001	Seminar/Project: Pitch Deck	0	0	6	3	30	20	50	100
2	PCSO401-406	Open Elective-II	3	0	0	3	30	20	50	100
3	PCS3002	Dissertation-I/ Professional Practical Internship-I	0	0	24	12	100	100	300	500
		Total	**0**	**0**	**30**	**18**				**700**

IV SEM

S No	Course Code	Course Name	L	T	P	CREDITS	CA	MTE	ETE	TOTAL MARKS
1	PCS4001	Dissertation-II/Professional Practical Internship-II	0	0	30	15	-	200	600	800
		Total	**0**	**0**	**30**	**15**				**800**

Specialization Core I

S No	Course Code	Course Name	L	T	P	C	Specilization
1	PCS1101	Probability and Random Processes	3	0	0	3	AI Core I
2	PCS1102	High Performance Computing Principles and Practices	3	0	0	3	CC Core I
3	PCS1103	Modern Cryptography	3	0	0	3	Cyber Security Core I
4	PCS1151	Probability and Random Processes Lab	0	0	0	1	AI Core I
5	PCS1152	High Performance Computing Principles and Practices Lab	0	0	0	1	CC Core I
6	PCS1153	Modern Cryptography Lab	0	0	0	1	Cyber Security Core I

Specialization Core II

S No	Course Code	Course Name	L	T	P	C	Specilization
1	PCSS2101	Machine Learning	3	0	0	3	AI Core II
2	PCSS2102	Advanced Cloud Computing	3	0	0	3	CC Core II
3	PCSS2103	Cyber Security with Blockchain	3	0	0	3	Cyber Security Core II
4	PCSS2151	Machine Learning Lab	0	0	0	1	AI Core II
5	PCSS2152	Advanced Cloud Computing Lab	0	0	0	1	CC Core II
6	PCSS2153	Cyber Security with Blockchain Lab	0	0	0	1	Cyber Security Core II

Specialization Elective I

S No	Course Code	Course Name	L	T	P	C
1	PCSS201	Advanced Computer Vision and Video Analytics	3	0	0	3
2	PCSS202	Cognitive Modelling	3	0	0	3
3	PCSS203	AI in Healthcare	3	0	0	3
4	PCSS204	Image and Video Processing	3	0	0	3
5	PCSS205	Information Retrieval	3	0	0	3
6	PCSS206	Natural Language Processing	3	0	0	3
7	PCSS207	Social Network Analysis	3	0	0	3
8	PCSS208	Reinforcement Learning	3	0	0	3
9	PCSS209	Emerging Topics in Artificial Intelligence	3	0	0	3
10	PCSS210	Malware Analysis for Mobile Devices	3	0	0	3

Specialization Elective II						
1	PCSS211	Security and Privacy for Big Data Analytics	3	0	0	3
2	PCSS212	Device Level IoT Security	3	0	0	3
3	PCSS213	Vulnerability Analysis in Network Protocols	3	0	0	3
4	PCSS214	Penetration Testing, Auditing and Ethical Hacking	3	0	0	3
5	PCSS215	Forensics and Cyber Law	3	0	0	3
6	PCSS216	Web Security	3	0	0	3
7	PCSS217	Special Topics in Information Security	3	0	0	3
8	PCSS218	Cloud Security and Compliances	3	0	0	3
9	PCSS219	Emerging Topics in Cyber Security	3	0	0	3

Professional Electives I						
S No	Course Code	Course Name	L	T	P	C
1	PCSP301	User Centered Design	3	0	0	3
2	PCSP302	Secure Coding	3	0	0	3
3	PCSP303	Compiler Construction	3	0	0	3
4	PCSP304	Software Project Management	3	0	0	3
5	PCSP305	Distributed Computing	3	0	0	3
6	PCSP306	Agile Software Development	3	0	0	3
7	PCSP307	Virtual Reality: Interface, Application and Design	3	0	0	3
8	PCSP308	Engineering Optimization	3	0	0	3
9	PCSP309	Wireless Networks	3	0	0	3
10	PCSP310	Cloud Infrastructure and Services	3	0	0	3

Professional Electives I I						
S No	Course Code	Course Name	L	T	P	C
1	PCSP311	Mobile and Networked Embedded Systems	3	0	0	3
2	PCSP312	Programming using C++	3	0	0	3
3	PCSP313	Bioinformatics and Computational Genomics	3	0	0	3
4	PCSP314	Computational Geometry	3	0	0	3
5	PCSP315	Satellite Data Analysis	3	0	0	3
6	PCSP316	Special Topics in Computer Engineering	3	0	0	3
7	PCSP317	Cloud System Administration and Operations	3	0	0	3
8	PCSP318	Software Craftsmanship in DevOps	3	0	0	3
9	PCSP319	Modern and Contemporary Application in CS	3	0	0	3

10	PCSP320	Latest Advances in Engineering and Technology	3	0	0	3

Open Electives I

S.No	Course Code	Course Name	L	T	P	C
1	PCSO401	Business Analytics	3	0	0	3
2	PCSO402	Industrial Safety	3	0	0	3
3	PCSO403	Operations Research	3	0	0	3

Open Electives II

S.No	Course Code	Course Name	L	T	P	C
1	PCSO404	Cost Management of Engineering Projects	3	0	0	3
2	PCSO405	Composite Materials	3	0	0	3
3	PCSO406	Waste to Energy	3	0	0	3

Semester I

Name of Program	Master of Technology - Computer Science Engineering				
PCS1001/PCS1051	Advanced Data Structures using Python	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	1	4	6
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: Articulate the design, use, and associated algorithms of advanced data structures.
CO2: Examine various advanced searching and sorting techniques based on applicative solutions.
CO3: Demonstrate hands-on experience in implementing different advanced data structures.
CO4: Build optimized solutions for real-world programming problems using efficient data structures.

Course Contents:

Module I **10 lecture hours**

Why Data Structures, First Python Program, Execution Cycle of Python Program, OOPs Concepts, Python Inheritance, Multiple inheritances, Friend Function, Run-time Polymorphism, Time Complexity: AsymptoticAnalysis, Big-Omega, Big-Theta, Big-Oh Notation, Handling Arrays, Insertion, Deletion, Traversal, Linear Search, Recursion, Binary Search, Tower of Hanoi, Sorting, Bubble Sort, Selection Sort, Insertion Sort, Merge Sort, Shell Sort, Counting Sort.

Module II **9 lecture hours**

Python Pointers, Structures and Unions, Linked List, Singly Linked List Implementation, Singly Linked ListTraversal, Searching, Insertion, Deletion, Polynomial Handling, Circular Linked List, Traversal, Insertion, Deletion, Stacks, Traversal, Insertion, Deletion, Infix to Postfix Conversion, Post-fix Expression Evaluation, Queues, Simple Queue Insertion, Deletion, Traversal, Circular Queue Insertion, Deletion, Traversal.

Module III **12 lecture hours**

Tree Data Structures, Height, Complete, Full, Perfect Trees, Binary Search Trees, Pre-Order, In-Order, Post-Order, BST Searching, BST Insertion, BST Deletion, Heaps, Min-Max Heaps, HeapSort, Hashing, Hash Functions, Hash Tables, Hashing Collision Resolution Strategies: Separate Chaining, Open Addressing, Double Hashing, Graphs, Different Types of Graphs, Graphs Representations, Incidence Matrix, AdjacencyMatrix, Graphs Traversals: BFS, DFS, Topological Sort. Priority Queues using Heaps; Implementation Problems on Hashing.

Module IV **11 lecture hours**

Height Balanced Trees: AVL Trees, Balanced Factor, Rotations, Insertion, Deletion, Red-Black Trees, Insertion, Deletion, B Trees, Insertion, Deletion, B+ Trees, Insertion, Deletion, Disjoint Sets, Path Compression, Union Finding Algorithm, van Emde Boas Tree.

Studio Work/Laboratory Experiments:

The lab component of this course is designed to introduce online-coding tools to the students and provide hands-on experience with the concepts taught in the lectures.

Text Books:

1. *Xin, Rachel, Tony Lee, and Elisabeth Feng. 2020. Data Structures and Advanced Algorithms. Lulu.com.*

2. *Vasudevan, Shriram K., Abhishek S. Nagarajan, and Karthick Nanmaran. 2021. Data Structures Using Python. New Delhi: Oxford University Press.*

Reference Books:

1. *Christoph Dürr, and Jill-Jênn Vie. 2021. Competitive Programming in Python 128 Algorithms to Develop Your Coding Skills. Cambridge Cambridge University Press.*

Name of Program	Master of Technology - Computer Science Engineering				
PCS1002	Advanced OperatingSystem	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	1	0	4
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: Get familiar with the basics of advanced operating systems, concurrency, and various deadlock models.
CO2: Comprehend the primitives of distributed operating systems with issues pertaining related to the deadlock detection.
CO3: Explore the diverse protocols available for the resource management and, fault recovery and tolerance in the distributed system.
CO4: Proverbial with the primitives and algorithms available for managing the database operating systems.

Course Contents:

Module I **12 lecture hours**

Introduction: Overview, Functions of an Operating System, Design Approaches, Types of Advanced Operating System - Synchronization Mechanisms, Concept of a Process, Concurrent Processes, The Critical Section Problem, Other Synchronization Problems, Language Mechanisms for Synchronization, Axiomatic Verification of Parallel Programs - Process Deadlocks - Preliminaries, Models of Deadlocks, Resources, System State, Necessary and Sufficient conditions for a Deadlock, Systems with Single-Unit Requests, Consumable Resources, Reusable Resources

Module II **12 lecture hours**

Distributed systems: network vs. distributed OS, robustness analysis, design issues; Remote procedure call (RPC), structure, parameter passing, handling partial failures, SunRPC and XDR; Distributed file systems, Servers: stateless and stateful, REST; Distributed shared memory, architecture, design principles, consistency model; Distributed Scheduling, Issues, Components, Algorithms. Security systems calls, authentication & authorization, reliability, availability & privacy, common attacks, crypto systems, Kerberos, access control lists; OS design: MAC, and iOS; Virtualization: Types, models; Cloud computing, architecture, service and deployment models, cloud challenges.

Module III **10 lecture hours**

Failure Recovery and Fault Tolerance: Basic Concepts-Classification of Failures, Basic Approaches to Recovery; Recovery in Concurrent System; Synchronous and Asynchronous Check pointing and Recovery; Check pointing in Distributed Database Systems; Fault Tolerance; Issues - Two-phase and No blocking Commit Protocols; Voting Protocols; Dynamic Voting Protocols

Module IV **08 lecture hours**

Multiprocessor and Database Operating Systems: Structures, Design Issues, Threads, Process Synchronization, Processor Scheduling, Memory Management, Reliability / Fault Tolerance; Database Operating Systems, Introduction, Concurrency Control, Distributed Database Systems, Concurrency Control Algorithms

Text Books:

1.*S Silberschatz, Abraham, Peter B Galvin, and Greg Gagne. 2018. Operating System Concepts. Hoboken, Nj: Wiley.*

2. *Stallings, Willam, Operating Systems Internals and Design Principles (9th ed.), Prentice Hall, 2021. ISBN 978-0134670959.*

Reference Books :

1. *Andrew S Tanenbaum and HerbertBos, Modern Operating Systems (1st ed.), Pearson, 2021. ISBN 9789332575776.*

2. Mukesh Singhal and N. G. Shivaratri, Advanced Concepts in Operating Systems (1st ed.), McGraw-Hill, 2000. ISBN NA.

3.Maurice J. Bach, esign of the Unix Operating Systems (1st ed.), Pearson, 2015. ISBN NA.

Name of Program	Master of Technology - Computer Science Engineering				
PCS1003/PCS1053	Soft Computing	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	4	5
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To comprehend the fuzzy logic and the concept of fuzzy set theory in soft computing.
CO2: To examine Neuro-Fuzzy and Genetic Algorithm expert system.
CO3: To implement applications on different soft computing techniques like Fuzzy, MultiObjective optimization and Genetic Algorithm (GA).

Course Contents:

Module I **12 lecture hours**

Soft Computing, Key characteristics and applications of soft computing, Soft vs. Hard computing, Fuzzy logic, Fuzzy set, Crisp vs. Fuzzy Set, Fuzzy Set Properties, Operations on Fuzzy set: Union, Intersection, Complement, Sum and Difference, Equality and Power, Cartesian Product, Fuzzy If- Then Rules – Fuzzy Reasoning, Fuzzy membership functions, Gaussian membership function, Sigmoid membership function, Triangular membership function, Trapezoidal membership function, Fuzzy proposition, Fuzzy interferences, Fuzzy relations- Max-Min Approach, Fuzzification – Defuzzification, Fuzzy Logic Controller, Neuro-Fuzzy modelling.

Module II **12 lecture hours**

Multi Objective Optimization, Multi-Objective Evolutionary Algorithm, Pareto based Approach, Non-Pareto based approaches, Genetic Algorithm (GA), GA working architecture, Genetic represent12ations, GA Encoding and Selection Techniques, Survival of the Fittest, Fitness Computations, GA Crossover Techniques, GA Mutation, Reproduction, Rank method, Rank space method, GA Case Studies: Optimisation of traveling salesman problem using Genetic Algorithm, Genetic algorithm-based Internet Search Techniques.

Module III **10 lecture hours**

Evolutionary Algorithm, Ant system, Ant Colony Optimization, Max-Min Ant System, Ant Miner, Snake-Ant Algorithm, Particle Swarm Optimization, Artificial Bee Colony, Cuckoo Search Algorithm, Working architecture, Co-evolution, Plasticity and life-time learning, Lamarckianlearning, "No free lunch" theorem, Hybrid fuzzy controller, Fuzzy Logic Controlled Genetic Algorithms.

Module IV **08 lecture hours**

Genetic Algorithms–Neural Networks, Neural Networks Fuzzy Logic, Extreme Learning Machine, Training SLFN using ELM, Extreme Learning Machine, Variants of ELM, Applicationsof ELM, Extended ELM.

Studio Work / Laboratory Experiments:

Fuzzy Logic, Multi Objective Optimization, GA, and hybrid fuzzy controller, implementation on MATLAB/PYTHON.

Text Books :

1.*Saroj Kaushik and SunitaTiwari, Soft Computing, on Fundamentals, Techniques andb Applications (1st ed.), McGraw-HillEducation, 2018. ISBN 978-9353160678.*

2.Sivanandam, S. N., and Deepa, S. N, Principles of soft computing (1st ed.), John Wiley&Sons, 2011. ISBN 978-8126527410.

Reference Books :

1.Buontemp F., Genetic Algorithmsand Machine Learning for on Programmers (1st ed.), Pragmatic Bookshelf, 2019. ISBN 978-1680506204.2. Gridin I., Learning Genetic Algorithms with Python (1st ed.), BPB Publications, 2021. ISBN 978-8194837756.

Name of Program	Master of Technology - Computer Science Engineering				
PCS1004	Ethics, Patents, Copyrights, and IPR	L	T	P	C
Owning School/Department	Computer Science and Engineering	1	0	0	1
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: Explain and Practice the professional ethics for engineers.
CO2: Examine and understand the patent law, and how patents are prosecuted and enforced.
CO3: Articulate the importance of intellectual property laws in modern engineering.

Course Contents:

Module I

Why Ethics, Patents, Copyrights, and IPR, Moral issues, Types of inquiry, Moral dilemmas, Moral autonomy, Theories about right action, Kohlberg's theory, Gilligan's theory, Models of Professional Roles, Self-interest, customs, and religion, uses of ethical theories, Patents, Patentable Subject Matter, Novelty, Non-Obviousness, Patenting Process, Infringement and Searching, Patent Applications, Claim Drafting, Patent Prosecution, Design Patents, Business Method Patents, Foreign Patent Protection, Computer-Related Inventions, Patent Enforcement, Technical Design-Around.

Module II (6 hours)

Copyrights Subject matter of Copyright, Rights of the owners of the copyright, Authorship, ownership, licensing, assignment of Copyright, Registration of Copyright & Authorities, Copyrights for Technology Protection, Intellectual Property Rights, IP Law Overview, Mask Works, Trade Secrets, Trademarks, Engineers as Expert Witnesses.

Text Books :

1. *H B Rockman, Intellectual Property Law for Engineers,Scientists, and Entrepreneurs(2nd ed.), Wiley-IEEE Press, 2020. ISBN 978-1119381976.*

Reference Books :

1. *William Stallings, Intellectual Assets for Engineers and Scientists:Creation and Management (1st ed.), CRC Press, 2018. ISBN 978-1498788472.*

Semester II

Name of Program	Master of Technology - Computer Science Engineering				
PCS2001	Computability, Complexity andAlgorithms	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	1	0	4
Pre-requisites/Exposure					

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: Examine and analyse the asymptotic performance of algorithms.
CO2: Explain various algorithmic techniques for solving problems.
CO3: Experiment to find and develop optimal solutions by applying different algorithmic strategiesfor polynomial and non-polynomial problems.

Course Contents:

Module I **10 lecture hours**

Introduction to algorithm, What is Time Complexity and Space Complexity, Order of Growth; Approximation; Asymptotic Notations : Big Oh, Theta, Omega, Amortized analysis, Analyzing control statement, Loop Invariant, Recurrence Relations Introduction, Back Substitution Method, Recursion Tree Method, Master's Theorem, Divide and Conquer Algorithm, Multiplying large Integers Problem, Median of two sorted arrays, Binary search, Quick Sort, Merge Sort, Max-Min problem, Strassen's Matrix Multiplication, Radix Sort, Bucket Sort.

Module II **14 lecture hours**

Greedy Algorithm: General Characteristics, Knapsack Problem, Huffman code, Activity selection problem, Minimum Spanning trees, Prim's algorithm, Kruskal's algorithm with Disjoint sets, Shortest paths: Dijkstra's Algorithm, Graphs Algorithms:- Applications of DFS- bi-connectivity, Topology Sort, Articulation point, Connected components, Max-Flow, Min-Cut, Ford-Fulkerson, Dynamic Programming:- Introduction, Principle of Optimality, Calculating Binomial Coefficient, 0-1 Knapsack, Matrix chain multiplication, Longest Common Subsequence, All Points Shortest path Floyd Warshall, Largest Divisible Subset.

Module III **10 lecture hours**

Backtracking and Branch and Bound: - State-Space Search Tree, eight queen's problem, Graph Coloring, Hamiltonian Cycle, Travelling Salesman Problem using Branch and Bound Approach, String Matching Algorithms, Naive string-matching algorithm, Suffix arrays, Suffix trees, tries, Rabin-Karp, Knuth-Morris-Pratt, Boyer-Moore algorithm

Module IV **8 lecture hours**

Introduction to NP-Completeness: - P and NP, NP-Complete and NP-Hard, Approximation algorithms, Travelling Salesman problem, Randomized Algorithms: Randomized Quick Sort, Computational Geometry: Convex hull, Online Algorithms: K Server Problem

Text Books :

1. *Cormen, Al. 2003. Introduction to Algorithms. Cambridge, Mass.: Mit Press.*

2. Horowitz, Ellis, Sartaj Sahni, and Sanguthevar Rajasekaran. 2008. Computer Algorithms/C++.

Reference Books :

1. Narasimha Karumanchi. 2019. Algorithm Design Techniques: Recursion, Backtracking, Greedy, Divide and Conquer, and Dynamic Programming. Madinaguda: Careermonk.

Name of Program	Master of Technology - Computer Science Engineering				
PCS2002/PCS2052	Advanced InformationManagement Systems	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	4	5
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: Articulate the competent understanding of database systems design and ER Modelling
CO2: Build database systems and understand new developments and trends in databases
CO3: Construct databases and make use of efficient SQL queries to retrieve and manipulate data as required

Course Contents:

Module I **10 lecture hours**

Purpose of IMS, Real-life applications of Data-Intensive systems, Typical system challenges, Data independence, Database system architecture levels, Role of several databases, ER diagram: Entity-set, Attributes, Relationships, Cardinality ratio, EER diagram: Specialization, Generalization, Constraints of EER, Aggregation, ER to Relational model, Relational model, Structure of relational databases, Constraints of relational model, Relational algebra: Basic and derived operator, Tuple relational calculus

Module II **10 lecture hours**

Functional dependency – definition, trivial and non-trivial FD, Armstrong's axioms, closure of FD set, Closure of attributes, Irreducible set of FDS, Normalization, 1NF, 2NF, 3NF, BCNF, Decomposition using FD, Dependency preservation, Multivalued Dependency, 4NF, join dependency, 5NF, Query optimization, Measures of query cost: selection operation, sorting, join, Evaluation of expressions, Transformation of relational expressions, Estimating statistics of expression results.

Module III **10 lecture hours**

Properties of transactions, Serializability of transactions, testing for serializability, System recovery, Two-Phase Commit protocol, Recovery and Atomicity, Log-based recovery, concurrent executions of transactions, Locking mechanism, Solution to concurrency related problems, Deadlocks, Two-phase locking protocol, Isolation, Intent locking, Discretionary Access Control, Mandatory Access Control, Authentication, Authorization, and access control, DAC, MAC, and RBAC models

Module IV **12 lecture hours**

Pipelining, Streaming algorithms framework, Turnstile model, Cash register models, Sliding window model, Data warehouse, Operational data store, Star schema, Snowflake schema, Data cube concept, OLAP, Cube and Roll-up, NoSQL database systems framework, Column stores, RDF stores, HBase, Big Data, Hadoop MapReduce architecture, Distributed Database Systems framework (DDS), Need forData Privacy, Privacy law, Anonymity models, Privacy in Cloud and Big Data

Studio Work / Laboratory Experiments:

Entity-Relationship model: Design process, constraints, Keys, Design issues, E-R diagrams, weak entity sets, extended E-R features – generalization, specialization, aggregation, reduction to E-R database schema. Basics of SQL, DDL, DML, DCL, structure – creation, alteration, defining constraints – Primary key, foreign key, unique, not null, check, IN operator Functions - aggregate functions, Built-infunctions –numeric, date, string functions, set operations, subqueries, 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.PL/SQL Concepts: - Cursors, Stored Procedures, Stored Function, Database Triggers, No SQL queries using Mongo DB and Firebase.

Text Books:

1. *Ramez Elmasri, Sham Navathe, Fundamentalsof Database Systems (7th ed.), Pearson, 2016. ISBN 9780133970779.*

2. *Abraham Silberschatz, Henry F. Korth, S. Sudarshan, Database System Concepts (7th ed.), McGraw-Hill, 2019.ISBN 9780078022159.*

Reference Books :

1. *Mukesh Negi, Fundamentals of Database Management System (1st ed.), BPB, 2019. ISBN 9789388176626.*

Name of Program	Master of Technology - Computer Science Engineering				
PCS2003/PCS2053	Advanced Networks	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	4	5
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: Examine the functionality of the different layers within the network architecture
CO2: Illustrate TCP/IP model suite protocols.
CO3: Design the networks for organization and select the appropriate networking architecture and technologies, subnetting and routing mechanism.

Course Contents:

Module I **12 lecture hours**

Why Computer Networks: Applications of Networks, Connecting Devices, Local Area Networks: LAN topologies: Bus topology, Ring topology, Star topologies, Mesh topology, Hybrid topology, TCP/IP Protocol suite, Physical Layer: Services, Line coding scheme, Modulation, Multiplexing, Switching methods, Ethernet, Bluetooth, Wi-Fi, Wi-Fi Direct, WPA/WPA2/WPA3, Data Link layer: Services, Framing, Switches

Module II **10 lecture hours**

Reliable Data Delivery: Error detection, Error Correction, Flow control: Stop and wait, Go Back- N, Flow control: S-R Protocol, Error control (Retransmission techniques, timers), Medium Accesssub-layer - Channel Allocations, LAN protocols /ALOHA protocols, CSMA, CSMA/CD, NetworkLayer Protocols: Services (IP, ICMP), IP addressing, subnetting, Super netting (CIDR), IPV4, IPV6.

Module III **12 lecture hours**

Routing and Forwarding, Static and dynamic routing, Unicast and Multicast Routing, Distance- Vector Routing, Link-State Routing, Shortest path computation-Dijkstra's algorithm, Addressmapping-ARP, RARP, BOOTP, DHCP, Transport Layer: Services, UDP and TCP segment formats, connection establishment and termination, Expert Lecture from Industry, Congestion control, Congestion control: Open Loop and closed-loop, Quality of service, Flow characteristics, Techniques to improve QoS.

Module IV **08 lecture hours**

Software-defined networks, network function virtualization, content distribution in peer-to-peer and overlay networks, QoS, Future network architectures. Cloud Systems: Services, Datacenter, 4G and5G Networks, Body area sensor Networks, Satellite networks, SWARM networks.

Studio Work / Laboratory Experiments:

Study of different types of networks cables and practically implement the cross-wired cable and straight through cable using clamping tool. Configure a network topology, connect differentnetworks, static routing and dynamic routing, virtual LAN, RIP and OSPF using packet tracer. Also,Wireshark will be used for network troubleshooting, analysis, software, and communications protocol development.

Text Books :

1. *B. A. Forouzan, Data communication and Networking (5th ed.), McGraw Hill, 2021. ISBN 10: 1260597822.*
2. *Andrew S. Tanenbaum and David J. Wetherall, Computer Networks (6th ed.), Pearson, 2021. ISBN 9780137523214.*

3. *Trollope, Data Communication & Networking (1st ed.).*

Reference Books :

1. *A Trollope. 2020. Data Communication & Networking. NC(v) Level 4. Pietermaritzburg: Shuter & Shooter Publishers.*

Semester III

Semester IV

Specialization Core I and II

Name of Program	Master of Technology - Computer Science Engineering				
PCS1101	Probability and Random Processes	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	2	4
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To explain the probability and random processes.
CO2: To formulate the problems and tackle with probability and random processes.
CO3: To implement the applications of probabilities for a real-world scenario.

Course Contents:

Module I **10 lecture hours**

Events, sample spaces, and probability, Limitation of classical and relative-frequency-based definitions, Independent events, Conditional probability, Sets and fields, Sample space and events, Axiomatic definition of probability, Joint probability, Conditional probability, Independence probability, Total probability, Stationarity: strict-sense stationary (SSS), wide-sense stationary (WSS) processes, Ergodicity and its importance, Bayes theorem, Combinatorics: Probability on finite sample spaces.

Module II **12 lecture hours**

Random variables, Discrete and continuous random variables, Probability mass functions, Moment generating functions – Binomial, Poisson, Geometric, Uniform distribution, Exponential, and Gamma distributions, Normal distributions: definitions, applications, Joint distributions – Marginal and conditional distributions, Covariance: definition, type, applications, Correlation regression, Linear regression, Transformation of random variables, Classification – Stationary process.

Module III **10 lecture hours**

Markov process, Poisson process, Random telegraph process, Bernoulli and Binomial random variables, Geometric random variables, Negative Binomial random variables, Random process realizations, Random process sample paths, Discrete time processes, Continuous time processes, Probabilistic structure of a random process.

Module IV **10 lecture hours**

Mean functions, Autocorrelation functions, Autocovariance functions, Poisson random variables, Hypergeometric random variables, Discrete uniform random variables and counting, Independent continuous random variables, Normal distribution and CLT, Approximate models of continuous uniform distribution, Probability in Spam filtering, Random processes in gambling app design, Probability and random processes in market prediction and risk prediction.

Studio Work / Laboratory Experiments:

Students will learn a practical exposure to implement different probability concepts. The students will design and develop applications of probability for insurance, stock market prediction, gamblingetc. During the lab works, students will be able to utilize programming and scientific tools for relevant probabilistic app design.

Text Books :

1. *Peebles. P. Z, Probability, RandomVariables and Random Signal Principles (4th ed.), Tata Mc GrawHill, 2017. ISBN 978-0070474284.*

Reference Books:

1.*Ibe. O. C, Fundamentals of Applied Probability and RandomProcesses on(2nd ed.), Elsevier, 2014. ISBN 978-0128008522*

Name of Program	Master of Technology - Computer Science Engineering				
PCS1102	High Performance Computing Principlesand Practices	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	2	4
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: Compare and Analyze data parallel and task parallel algorithms and their serial versions for searching and sorting tasks on matrix, tree, and graph data structures.
CO2: Explain distributed memory, message passing modelling and mapping of parallel programs to physical processors.
CO3: Implement serial and parallel algorithms for different applications using HPC libraries.

Course Contents:

Module I **6 lecture hours**

Why High-Performance Computing, Applications of High Performance Computing, Parallel programming Software platforms, Cloud computing, Grid computing and Cluster computing,Multi-core CPUs, Graphical Processing Units, SISD, SIMD, MISD, MIMD, Communication architecture, Shared memory, Cache memory, Virtual memory, Data parallelism, Task parallelism, Bit-level parallelism, Instruction-level parallelism, Concurrency, Decomposition, Mapping.

Module II **13 lecture hours**

PRAM, NUMA, Multithreading vs Multiprocessing, Shared memory model, OpenMP, Distributed memory model, Message passing interface, Computational graph, Multithreaded DAG model, Brent's theorem, Work optimality, Weak scaling, Dependencies in code, Data races, Race conditions, Sync and Spawn, Parallel for loops, Parallel merge sort, Parallel bubble sort, Parallel shear sort, Parallel quick sort, Comparator networks, Bitonic sequences, Bitonic splits, Bitonic merge, Bitonic sort.

Module III **11 lecture hours**

Parallel prefix scan, Prefix scan Application, Parallel list ranking, Parallel tree processing, Parallel independent sets, Parallel tree traversal, Parallel tree level finder, Parallel Euler tour, Parallel BFS, Distributed memory and Message passing networks, Broadcast, Reduction, Parallel Prefix Sum, Scatter, Gather, Network topologies for parallel computing, Network optimization.

Module IV **12 lecture hours**

Distributed BFS, Graphs and adjacency matrix, Matrix based BFS, CUDA programming, Parallel matrix operations, Sparse vs Dense matrices, BLAS, LAPAC, Cluster Computing, Job Scheduling,Load Balancing, Resource Allocation, Code optimization, Memory management for Parallel computing, Distributed memory sorting, Graph Partitioning, Parallel graph operations, Advanced research topics and tools in HPC, SLURM, LSF, InfiniBand, libraries for Cloud HPC, OpenACC, Docker, containers and Kubernetes, Shell, Power Shell

Studio Work / Laboratory Experiments:

Implementing the concepts of parallel programming using OpenMP and MPI in C.

Text Books :

1.*Robey and Yuliana Zamora, Parallel and HighPerformance Computing (1st ed.), Manning, 2021. ISBN9781638350385, 1638350388.*

2.Thomas Sterling and Maciej Brodowicz, , Matthew Anderson, High Performance Computing:Modern

Systems and Practices (1st ed.), Elsevier Science, 2017. ISBN : 9780124202153, 0124202152 .

Reference Books :

1.*Georg Hager and Gerhard Wellein, Introduction to High Performance Computing for Scientistsand Engineers (1st ed.), CRC Press, 2010. ISBN 9781439811931,1439811938.*

Name of Program	Master of Technology - Computer Science Engineering				
PCS1103	Modern Cryptography	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	2	4
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To comprehend and implement various cryptographic algorithms to protect the confidential data.
CO2: To identify network vulnerabilities and apply various security mechanisms to protectnetworks from security attacks.
CO3: To make use of security tools to locate and fix security leaks in a computer network/software.

Course Contents:

Module I **14 lecture hours**

Modular arithmetic, Modular Polynomial Arithmetic, Divisibility and greatest common divisors, Euclidean Theorem, Random Number Generator, Pseudorandom Number Generator, Prime numbers, unique factorization, finite fields, Powers and primitive roots in finite fields, Fermat's theorem, Euler's theorem, Symmetric ciphers (Difference between symmetric and asymmetric), Monoalphabetic ciphers (Caesar cipher, Affine cipher, Additive cipher).

Module II **14 lecture hours**

Polyalphabetic cipher (Playfair cipher, Vigenere cipher) hash functions, authentication and key establishment, Message Authentication Codes (MACs), digital signatures, PKI. Block Ciphers (Feistel Ciphers), Numerical of Feistel Ciphers, Data Encryption standards 8-bit, Discrete Logarithms, Logarithms for Modular Arithmetic.

Module III **14 lecture hours**

Data encryption standards 64 bits, Advanced encryption standards, Diffie Hellman Key Exchange Algorithm. Euclid Algorithm, Extended Euclid Algorithm, RSA Algorithm. Message Authentication and Hash Functions. Information Theory, Elliptic curves, Elliptic curves over finitefields, The elliptic curve discrete logarithm problem, Elliptic curve cryptography, Lenstra's ellipticcurve factorization algorithm, Hash Algorithm-SHA, MD5. Digital Signature Algorithm and Authentication, Authentication Applications KDC, RSA digital signatures, El Gamal digital signatures, GGH lattice-based digital signatures.

Studio Work / Laboratory Experiments:

Insert malicious shell code into a program file and check its malicious or benign status, create Client Server program to send data across systems as two variants clear text data and encrypted data with different set of encryption algorithms, demonstrate Buffer Overflow and showcase EIP and other register status, perform ARP poisoning, SQL Injection and demonstrate itscountermeasure methods, implement stateful firewall using IP Tables, showcase different set of security protocol implementation of Wireless LAN.

Text Books :

1.*William Stallings, NetworkSecurity Essentials (4^{th} ed.), Prentice Hall, 2018. ISBN 978- 9352866601.*

Reference Books :

1.*W. Stallings, Cryptography andNetwork Security (7^{th} ed.), Prentice Hall, 2017. ISBN 978-9332585225.*

Name of Program	Master of Technology - Computer Science Engineering				
PCSS2101	Machine Learning	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	2	4
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To articulate key features and methods of Statistical Machine Learning (SML).
CO2: To formulate and design the given application as a statistical machine learning problem.
CO3: To implement and evaluate common statistical machine learning techniques.

Course Contents:

Module I **07 lecture hours**

Statistical Theory, Supervised Learning, Unsupervised Learning, Data and Types, Feature variable, Machine Learning, Statistics terms, Supervised learning, Concentration inequalities,Generalization bounds, Plugin classifiers, Least-squares methods, Bias vs Variance, Theory of generalization, Understand Underfitting, Overfitting, Parametric methods, Maximum likelihood, Bayes algorithm, Minimax algorithm, Expectation-Maximization, Advantages and Disadvantages,Applications of EM Algorithm, Use case of EM Algorithm.

Module II **10 lecture hours**

Bayesian versus Non-Bayesian approaches, Density estimation, Gaussian Distributions, Gaussian Mixture Models, Gaussian Discriminant Analysis, Independent Component Analysis, Convexity and Optimization: Convexity, Conjugate functions, Nonparametric classifications methods, Unconstrained optimization, Constrained optimization, Nonparametric methods, KKT conditions, Lagrangian minimization, Primal feasibility, Dual feasibility, Complementary slackness.

Module III **13 lecture hours**

Basis pursuit, Polynomial Expansion, Feature maps, The "kernel trick", Vapnik-Chervonenkis (VC) dimension, VC generalization bounds, Sparsity: High dimensional data, The role of sparsity, Sparsistency, Consistency, Persistency, Sparsity in nonparametric regression, Sparsity in graphical models, Greedy algorithms, Sparse linear regression, Compressed sensing, Nonparametric Methods: Nonparametric regression, Density estimation, Factor Analysis, Matrix Factorization, Thebootstrap, Subsampling, Nonparametric Bayes.

Module IV **12 lecture hours**

Probability Distributions for modelling, Markov Networks, Hidden Markov Model, Advanced Theory: Concentration of measure, Covering numbers, Learning theory, Exact learning (Dana Angluin), Probably approximately correct learning (PAC learning), VC theory (Vladimir Vapnik and Alexey Chervonenkis), Risk minimization and its approaches, Bundle Methods, Graph Analytics, Graph-based machine learning algorithms, Simulation methods, Variational methods, Tsybakov noise conditions, Surrogate loss functions, Minimax rates for classification, Minimax rates for regression, Manifold methods, Spectral methods.

Studio Work / Laboratory Experiments:

Students will gain practical experience with the implementation of different statistical methods by using different statistical machine learning tools. Eventually, the lab works formulate the problem as a statistical machine learning problem followed by its implementation.

Text Books :

1.*Masashi Sugiyama, Introduction toKaufmann, 2017. ISBN 978- 0128021217. Statistical Machine Learning (1st ed.), Morgan*

2. *T. M. Mitchell, Machine Learning (1st ed.), McGraw Hill, 2017. ISBN 978-1259096952.*

Reference Books :

1.*Richard Golden, Statistical Machine Learning A Unified Framework unknown, 2020. ISBN*

Name of Program	Master of Technology - Computer Science Engineering				
PCSS2102	Advanced CloudComputing	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	2	4
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To articulate cloud computing principle and its business need.
CO2: To identify the design principles of virtualization techniques in cloud resource management.
CO3: To design and development of cloud architectural solution with its detailed monitoring.

Course Contents:

Module 1 **11 lecture hours**

Cloud Computing, Adoption of cloud-based IT resources, Service Models: Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), Software-as-a-Service (SaaS), Deployment models: Public Cloud, Private Cloud, Hybrid Cloud, Community Cloud, Cloud Computing Characteristics, Challenges of cloud computing, Virtualization concept, Types of virtualizations, Demo of virtualization, Virtualization Merits, Role of virtualization in cloud computing, Virtualization Demerits, VM Placement, VM Migration, VM Migration Demo, VM clustering, Design Issues in VM Clustering, Need of Dockers and Containers, Docker Eco-System, Hypervisor vs Docker.

Module II **12 lecture hours**

Microservices, Service-Oriented Architecture, REST API, IP Addressing, Subnetting, Super netting, Designing of Virtual Private Cloud, Demo of VPC, VPC Peering, VPC Case Study, Cloud Storage, Serverless Computing, Cloud API Gateway, Cloud Databases, Resource Provisioning, Time shared and space shared, Efficient VM Consolidation on cloud server, Task/DAG Scheduling Algorithms, Min-Min, Max-Min, MET, B-level Demo, T-level Demo, Task-VM Mapping, Auto Scaling, Load Balancing.

Module III **10 lecture hours**

Case Study: Cloud Market analysis, Security and Compliances, Shared security model in IAAS/PAAS/SAAS, Shared technology issues, Data loss or leakage, Account or service hijacking, Implementation of cloud security, Security Groups, Network Access Control Lists, Cloud databases, Parallel Query Execution with NoSQL Database, Big Data, Handling Big Data on Cloud Platform, Map-Reduce framework for large clusters using Hadoop, Design of data applications based on Map Reduce in Apache Hadoop.

Module IV **9 lecture hours**

Comparative study/analysis of public clouds, Edge Computing, Fog Computing, Data Offloading, Cloud-Based DevOps Tools, Task Partitioning, Data Partitioning, Data Synchronization, Distributed File System, Data center, Ongoing Research Topics.

Studio Work / Laboratory Experiments:

Practical experience on global cloud infrastructure by performing experiments on Amazon Web Services (AWS), Google Cloud Platform (GCP) and Microsoft Azure platform. The essential services and their hands-on is compulsory on Core IaaS, PaaS and SaaS.

Text Books :

1. *Lizhe Wang, Rajiv Ranjan, Jinjun Chenand BoualemBenatallah, Cloud Computing (1st ed.), CRC Press, 2017. ISBN 978-1351833097.*

2. *Judith S. Hurwitz and Daniel Kirsch, Cloud Computing For Dummies (1st ed.), Hoboken: John Wiley &Sons, 2020. ISBN 978-1119546658.*

Reference Books :

1.*Prerna Sharma, Moolchand Sharma and Mohamed Elhoseny,Applications of Cloud computing (1st ed.), missing, 2020. ISBN 9780367904128*

Name of Program	Master of Technology - Computer Science Engineering				
PCSS2103	Cyber Security with Blockchain	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	2	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To articulate the cyberthreat landscape and Security Challenges.
CO2: To build Blockchain-based apps for authentication and for storing DNS entries.
CO3: To implement various decentralized applications using blockchain to provide various security services.

Course Contents:

Module I **10 lecture hours**

Cyber Security, Internet Governance – Challenges, Constraints, Threats, Cyber Warfare, Cyber Crime, Terrorism, Espionage, Need for a Cyber Security Policy, Nodal Authority requirement, Requirement of an International Convention on Cyberspace, CIA model, Cyber Security vulnerabilities, Cyber Security attacks.

Module II **12 lecture hours**

Security services, Blockchain on the CIA Security Triad, Authentication mechanisms, Two-Factor Authentication with Blockchain, PKI Infrastructure, Deploying PKI-Based Identity withBlockchain, IPNS, Blockchain-Based DNS Security Platform, Deploying Blockchain-Based DDoSProtection, EIP Block for DDoS attacks, Security related issues in smart contracts development, Smart contract testing.

Module III **10 lecture hours**

Exception handling, debugging of applications, Formal verification, smart contracts security Oyente, why3 for smart contracts, Solgraph based formal verification, implications of blockchain technology for digital privacy, implication for Security, Membership and Access control in Fabric,authentication in fabric network.

Module IV **10 lecture hours**

Privacy in Fabric, Channel encryption, Blockchain Security (Fabric SideDB), Security of a ledger, anonymity, pseudonymity, blockchain Implementation Challenges, privacy law applicability, startups in blockchain based cyber security applications.

Studio Work / Laboratory Experiments:

Cyber-Security with Blockchain is to make companies, products, systems, and services as resilientas possible to cyber-attacks, by looking at security from the outset and throughout their entire life cycle. This lab enables students to get practical knowledge on cryptographic primitives, design, andanalysis of authentication protocols. Further, this lab mainly focusses on Transaction and communication security, preventing DDOS attacks, preventing data manipulation, and protection from compromised nodes.

Text Books :

1.R. Gupta, *Hands-on cybersecuritywith blockchain* (1st ed.), Packt Publishing, 2018. ISBN 978-788990189.

Reference Books :

1.Yassine Maleh, MamounAlazab,Mohammad Shojafar, Imed Romdhani, *Blockchain for Cybersecurity and Privacy:* Press, 2020. ISBN 9781000060164.

Specialization Elective I and II

Name of Program	Master of Technology - Computer Science Engineering				
PCSS201	Advanced ComputerVision and Video Analytics	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To articulate the key features of Computer Vision to analyze and interpret the visible world around us.
CO2: To build the applications of Deep Learning in Computer vision and video processing.
CO3: Implement the state-of-the-art computer vision and video analytics concepts to different applications.

Course Contents:

Module I **12 lecture hours**

Introduction to Computer Vision, The Four Rs of Computer Vision, Challenges in Computer Vision, Low-level vs High-level processing, Two View Geometry, Binocular Stereopsis: Camera and Epipolar Geometry, Planar Scenes and Homography, Depth estimation and multi-camera views, Robust Correspondence Estimation, 3-D reconstruction, Auto-calibration, DLT and RANSAC, Structure from Motion, Hough Transform, Fourier Transform, Interest Point Detection, Edge Detection, Local Binary Pattern, Convolution and Filtering, Gaussian derivative filters, Gabor Filters, DWT, Pyramids, Visual Matching: Bag-of-words, Pyramid Matching, Part based recognition models, Recognition: Detectors and Descriptors, Optical Flow & Tracking.

Module II **10 lecture hours**

Shape from Texture, Color, motion and edges, Face Detection, Feature Tracking & Motion Layers, SIFT & Single Object Recognition, Dense Neural Networks, Backpropagation, Convolutional Neural Networks (CNNs), AlexNet, VGG16, Image Quality Enhancement, Image Restoration, Super resolution, Residual Learning, Visual Saliency detection.

Module III **12 lecture hours**

Evolution of CNN Architectures: AlexNet, MobileNet, InceptionNets, ResNets, DenseNets, 3D CNN for images and videos, Unsupervised image segmentation, Watershed, Level set, Active Contour, GraphCut, Supervised image segmentation, Agglomerative clustering, Segmentation as pixel classification, UNets, FCN, Deep Generative Models, GANs, VAEs, PixelRNNs, NADE, Normalizing Flows, Zero-shot, One-shot, Few-shot Learning, Self-supervised Learning, Reinforcement Learning in Vision, Video Analytics, Spatial Domain Processing, Frequency Domain Processing, Background Modelling, Crowd Analysis, Video Surveillance, Traffic Monitoring, Intelligent Transport System.

Module IV **08 lecture hours**

Optical Character Recognition, Online Character Recognition, Visual Anomaly Detection, Anomalous action recognition, Post Estimation, Action Recognition, Graph CNN, Shape Recognition, Shape Retrieval, Content based Image retrieval, Visual Instance Recognition, Emotion Recognition from videos, Video Generation.

Studio Work / Laboratory Experiments:

In the lab work, the students will Implement the state-of-the-art computer vision and video analytics concepts to different applications.

Text Books :

1. *Rajalingappaa Shanmugamani, DeepLearning for Computer Vision (1st ed.), Packt Publishing,*

2018. ISBN 9781788295628

2. *2. J. Nedumaan, Prof Thomas Binford, J. Lepika, J. Tisa, J. Ruby and P. S. Jagadeesh Kumar, Modern Deep Learning and advanced Computer Vision (1st ed.), missing, 2019. ISBN 9781708798641 .*

Reference Books :

1. *Krishnendu Kar, Mastering Computer Visionwith TensorFlow (1st ed.), missing, 2020. ISBN 9781838826939.*

Name of Program	Master of Technology - Computer Science Engineering				
PCSS202	Cognitive Modelling	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:
CO1: To articulate the thought, learning, and mental organization.
CO2: To examine the extraction of brain signals into digital form and develop critical skills to evaluate and assess problems including psychology, philosophy, neuroscience, and computermodelling.
CO3: To implement the models that reflects human cognition and apply to different real-life scenarios.

Course Contents:

Module1 **10 lecture hours**
Why Cognitive Science, Structure and processes of human cognition, Computational simulation or modelling, Theory and Research in Human Cognition, Object Perception, Object Recognition, Attentional Processes, Concept formation, Visual perception, Acquisition and processing of natural language, Human reasoning and problem-solving

Module II **10 lecture hours**
Memory Introduction, Long Term Memory encoding, Retrieval from Long Term Memory, Memoryof general knowledge, Semantic memory basics, Models of semantic memory, Human language skills, Midlevel Vision and Attention, Motion, disparity, depth, and orientation representation, Convolution, Mechanisms underlying attention, Attention at the cognitive/algorithm level

Module III **10 lecture hours**
Brain Signals and Feature extraction, Types of Brain signals, case study, Feature extraction methodsand their analysis, Models of Understanding Cognition or Mind: Neuroscientific Model, Psychological Model, Representational Model, Computational Model, Isomorphic Model, Multiplerealizable Model, MultipleDraft Model, Subpersonal Model

Module IV **12 lecture hours**
Thought process and Problem Solving, Applications of cognitive computing in the field of psychology, Applications of cognitive computing in linguistics, Decision Making models, Commercial Applications of Cognitive science/computing, Advanced Topics in Cognitive computing, Applications of cognitive computing in philosophy, Applications of cognitive computing in computer modelling, Machine Learning models for cognitive computing, Neural Networks for cognitive computing

Studio Work / Laboratory Experiments:

Implement Long Term Memory encoding approach. Implement Models of semantic memory. Implement Brain Signals and Feature extraction. Implement Neuroscientific Model. Psychological Model. Implement Representational Model. Multiple realizable Model. Implement Isomorphic Model. MultipleDraft Model. Implement Decision Making models. Implement Machine Learning algorithms for cognitive computing. Implement Data Mining algorithms for cognitive computing. Implement Neural Networks algorithms for cognitive computing.

Text Books :

1. *José Luis Bermúdez, CognitiveScience: An Introduction to theScience of the Mind (3rd ed.), Cambridge UniversityPress, 2020. ISBN 978-1108440349.*

Reference Books : 1.*Rob High and Tanmay Bakshi, Cognitive Computing with IBM Watson: Build Smart Applications Using Artificial Intelligence as aService (1st ed.), missing, 2019. ISBN missing*

Name of Program	Master of Technology - Computer Science Engineering				
PCSS203	AI in Healthcare	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To articulate the factors involved in decision support that can improve business performance across the provider/payer ecosystem.
CO2: To build methods and techniques in order to appropriately apply to pain points using case studies.
CO3: To make use of opportunities to leverage decision support in adapting to trends in the industry.

Course Contents:

Module I **08 lecture hours**

History of AI in Medicine, AI for Decision Support, Capabilities and limitations of AI in Healthcare, Automated healthcare system: challenges and opportunities, Biostatistics, Research ethics in AI, Common healthcare data types, Medical data: quality vs quantity, Clinical Data, Clinical decision support systems, Electronic Health Records (EHR).

Module II **10 lecture hours**

Time series and non-time series data, Data Sourcing, Data Enrichment, Handling missing values, Advantages and challenges in observational data, Geographic and demographic variation in medical Data, Classification, regression, clustering for healthcare, Evaluation measures for healthcare applications, Bias and Error in medical data, Analysis of data from IOT body sensors, Automated diagnosis processes, Treatment protocol development.

Module III **12 lecture hours**

Predictive modeling, Disease prediction, Early detection, Cancer detection using tabular data, Risk estimation in medical insurance, Medical Imaging, MRI, CT scan, X-Ray, 3D CNN, Biomedical signals, Large scale medical image retrieval, Handling hyper-dimensional medical images, Electronic phenotyping, Rule based phenotyping, Probabilistic phenotyping, DNA phenotyping, Multimodal data analysis, Regression analysis for Patient Monitoring and Preventive Screening.

Module IV **12 lecture hours**

Clinical text, Medical Word Corpus, Text representation, BERT for medical data, PubMed BERT, Question answering systems, Finding similar patients through clustering, Medicine or treatment recommender systems, Q&A systems for Telemedicine, Personalized medicine recommendation system, Drug development analysis, Drug discovery, Modeling drug-drug interactions, Pandemic spread prediction, Infection pattern identification, Computer Vision systems for physiotherapy, Pose estimation, Gait Analysis.

Text Books :

1. *Adam Bohr and KavehcMemarzadeh, Artificial Intelligence in Healthcare (1st ed.), Elsevier Science, 2020. ISBN 978- 0128184387*

Reference Books :

1. *Arjun Panesar, Machine Learning andAI for Healthcare: Big Data for Improved Health Outcomes (1st ed.), Apress, 2019. ISBN 978- 1484237984.*

Name of Program	Master of Technology - Computer Science Engineering				
PCSS204	Image and VideoProcessing	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To articulate images using Histograms and spatial and image representation using textures.
CO2: To examine motion using optic flow, morphological operations, and compress images using lossless and lossy compression techniques.
CO3: To implement different low-level and high-level image and video processing techniques to a wide variety of applications.

Course Contents:

Module I **10 lecture hours**

Applications of Digital Image Processing, Elements of Digital image processing systems, Sampling and quantization, Neighbours of a pixel, adjacency, connectivity, Regions and Boundaries, Distance measures, Gray scale to Binary image using thresholding, Image Enhancement in the Spatial domain, Gray level transforms, Histogram Processing, Histogram Equalization, Enhancement using Spatial filters, Concept of convolution, Smoothing, Mean, median and Gaussian filters, Edge detection using Prewitt, Sobel, Laplace Filters, Laplace of Gaussian Filter

Module II **10 lecture hours**

Canny Edge Detector, Harris Corner Detector, Color models, RGB, HSV, YCbCr models Pseudocolor Image Processing, Color Transforms, Color to grayscale conversion, Handling Binary Images, Line detection using Hough transform, Polar form, Circle Detection, Morphological Operations, Dilation, Erosion, Opening, Closing, Boundary detection, Hole filling, connected components, Hit and Miss transform, Shape representation using moments, Texture analysis, Texture from the histogram, Texture from GLCM matrices, Motion Detection, Concept of Optical Flow, Optical flow equation, Lucas Kanade method.

Module III **10 lecture hours**

Image Enhancement in the Frequency domain, 1-D and 2-D Fourier Transform and their Inverse, Low pass and Hi pass Filtering, Ideal and Butterworth and Gaussian Filters, Homomorphic Filtering, Image Compression Fundamentals, Lossless Compression Models, Run-length Encoding, Huffman Coding, Lossy Compression, Discrete Cosine Transform, Quantization, Zigzag coding, Color image compression, Text recognition, Feature detection, Integral Image Formation.

Module IV **12 lecture hours**

Face Detection – Viola-Jones method, Face Recognition, Principal Component Analysis (PCA), Concept of Eigenface, Feature detection for Machine learning applications, SIFT and HOG parameters, Video Processing, Video formation, Video sampling, Motion estimation, Motion-compensated (MC) filtering, Frame-rate conversion, Video Coding, Video Compression, Frame-based compression (MPEG), Salient object detection, Human action recognition from videos, Depth cameras – Kinect camera data capture, RGBD data.

Text Books :

1.*Richard Szeliski, Computer Vision:Algorithms and Applications on (2nd ed.), missing, 2022. ISBN 978- 3030343712 .*

2.*Manas Kamal Bhuyan, ComputerVision and Image Processing Fundamentals and Applications (1st ed.), missing, 2021. ISBN9781351248383.*

Reference Books :

1. *Ling Guan, Multimedia Image and VideoProcessing (1st ed.), missing, 2019. ISBN 9781439830878.*

Name of Program	Master of Technology - Computer Science Engineering				
PCSS205	Information Retrieval	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To explain the comprehend types of text analysis, Information retrieval, IR system architecture, query processing models and probabilistic models.
CO2: To build information retrieval systems by performing indexing, compression, information categorization sentiment analysis, network management, search engine optimization, records compliance and risk management.
CO3: Implement different information retrieval approaches for applications in text domain.

Course Contents:

Module I **14 lecture hours**

Text analysis and types, Information retrieval, Text processing, Indexes and query matching, Semi-structured text data, Tokenization, Stemming, Lemmatization, Language modelling, Examples of open source IR Systems, Query processing models, Probabilistic models, Binary independence model, Robertson/Spark Jones weighting formula, Two-Poisson model, Relevance feedback, Term selection, Pseudo relevance feedback, Language models, Unigram, Bigram language models, Generating queries from documents, Language models and smoothing, Ranking with language models, Retrieval evaluation measures Normalized Discounted Cumulative Gain (NDCG), Kullback-Leibler divergence, Divergence from randomness, Passage retrieval and ranking, Management of Information Retrieval Systems, Knowledge management, Information management, Digital asset management, Networkmanagement.

Module II **14 lecture hours**

Search engine optimization, Records compliance and risk management, Version control, Data and data quality, Information system failure, Web retrieval and mining, Semantic web, XML informationretrieval, Recommender systems and expert locators, Knowledge management systems, Decision support systems, Geographic information system (GIS), Indexing, Inverted indices, Index components and Index life cycle, Interleaving Dictionary and Postings lists, Index construction, Query processing for ranked retrieval, Compression, General-purpose data compression, Symbol-wise data compression, Compressing posting lists, Compressing the dictionary.

Module III **14 lecture hours**

Information categorization and filtering, Classification, Probabilistic classifiers, Linear classifiers, Similarity-based classifiers, Multi category ranking and classification, Learning to rank, Text Clustering, Partitioning methods, Clustering versus classification, Reduced dimensionality/spectral methods, Lexicons, Corpora, Sentiment Analysis, Document-level, Sentence-level and Aspect-based sentiment analysis, Web crawling, Near duplicate pages, Distributed word representations, Link Analysis, PageRank algorithm, Search engine bias, Personalized searching, Question Answering, Crosslingual retrieval, Adversarial Information Retrieval

Text Books :

1.Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze, Introduction toInformation Retrieval (1st ed.), missing, 2019. ISBN 9781107666392.

2. Bhaskar Mitra and Nick Craswell, An Introduction to Neural Information Retrieval (1st ed.), missing, 2019. ISBN 9781680835327.

Reference Books :

1.*Muhammad Sarfraz, Critical Approaches to Information Retrieval Research missing, 2019. ISBN 9781799810232.*

Name of Program	Master of Technology - Computer Science Engineering				
PCSS206	Natural LanguageProcessing	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To articulate natural language processing and importance of word representation.
CO2: To build deep learning model for solving natural language problems such as language modelling, machine translation, POS tagging, Seq2Seq generation.
CO3: To implement state-of-the-art Machine Learning and Deep Learning solutions to NLP problems in Global & Indian context.

Course Contents:

Module I **10 lecture hours**

Natural Language Processing: Need, applications, industry demand, Challenges in NLP: Ambiguity in language, Contextual words and phrases and homonyms, Coreference, Domain-specific language, Low-resource languages, Segmentation, Stemming, Lemmatization, Spelling correction, Synsets, Hypernyms, Tokenization, N-grams, Stops Words, WordNet, WordNet Similarity, Language Corpus, N- gram Language Models, Hidden Markov Models.

Module II **10 lecture hours**

iNLTK (Natural Language Toolkit for Indic Languages), Text normalization, script normalization, Parallel Corpus, Handling Code-mix text, Cross Lingual Information Retrieval, Word representation, Sentence representation, Word embedding, Vector space model, Term Frequency, TF-IDF Representation, Distributional representation, Word2vec: CBOW(20), Word embedding for regional language, Word2Vec, GloVe, Document to Vector.

Module III **10 lecture hours**

Neural Networks for text, Recurrent Neural Networks, Vanishing Gradients, Exploding gradient, LSTM (Long sort term memory), GRU (Gated recurrent Unit), Seq2Seq Modelling, Bidirectional Model, Contextual Representations, Transformers, BERT, Multilingual Embedding, Transfer Learning in Word Embeddings, MUSE, POS tagging, Named Entity Recognition, Sentiment Analysis, Text Clustering

Module IV **12 lecture hours**

Topic Modeling, Latent Semantic Analysis, Statistical Machine Translation, Neural Machine Translation, Self-Attention for Generative Models, Natural Language Generation, Attention, Question Answering Bot, 1D-CNN for NLP, Sub-word Models, OpenAI's GPT, Google's ALBERT, ULMFiT, Facebook's RoBERTa, Text Summarization, Extractive, Abstractive Text summarization, Transformer models for Text Summarization

Text Books :

1.*Delip Rao and Brian McMahan,, NaturalLanguage Processing with PyTorch: Build Intelligent LanguageApplications Using Deep Learning (1st ed.), O'ReillyMedia, 2019. ISBN 978-1491978238.*

Reference Books :

1.*Jacob Eisenstein, Introduction to NaturalLanguage Processing (1st ed.), missing, 2019. ISBN 9780262042843.*
2.*Sowmya Vajjala, Bodhisattwa Majumder, Anuj Gupta and Harshit Surana, Practical Natural Language Processing (1st ed.), missing, 2020. ISBN 978149205402X.*

Name of Program	Master of Technology - Computer Science Engineering				
PCSS207	Social NetworkAnalysis	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To understand human behavior in social networks and related communities.
CO2: To build and apply networking models for understanding social interactions.
CO3: To implement network media graph virtualization and network relationships.

Course Contents:

Module I **12 lecture hours**

Social network analysis purposes, Phenomenology of social media, Social network monitoring tools, Entity resolution, Types of social networks, Networks Representation, Adjacency Matrix, Weighted and Directed Networks, Hypergraphs, Bipartite Networks, Graph Laplacian, Random Walks, One mode and two mode networks, Heterogeneous Information Networks, Closeness centrality, Betweenness centrality, Eigenvector centrality, Clustering coefficient, Density of graphs, Isomorphic graphs, Reachability, Cliques, Graph coloring problem, Valued graphs, Multigraphs.

Module II **10 lecture hours**

Large Scale Structure of Networks, Small World Effect, Degree Distributions, Power Law, Scale Free Networks, Assortative Mixing, Time series analysis in graph, Temporal graph algorithms, Parallel dynamic graph algorithm, Matching theory, Bipartite matching, Konig's theorem, Hall's Matching Theorem, Network flow, Max flow min cut theorem, Menger's theorem, Ford Fulkersonmethod.

Module III **10 lecture hours**

Ties, Structural holes, Structural balance, Equivalence, Motifs, Random Graphs, Giant Component, Small Components, Configuration Model, Excess Degree Distribution, Vertex Copying network models, Erdős-Rényi model, Barabási–Albert model, Exponential Random Graphs, Percolation.

Module IV **10 lecture hours**

Communities in network, Community detection from network, Louvain Method, Overlapping communities, Non-overlapping communities, Information diffusion in social networks, Cascading Behavior in Networks, Link Prediction, Preferential Attachment, Geospatial social networks, Crowdsourcing, Rumours and Deception in social network, Fake News, Spamming, Identify theft.

Text Books :

1. *Gerardus Blokdyk, Social NetworkAnalysis A Complete Guide (3rd ed.), 5starcooks, 2020. ISBN 978-1867330097.*
2. *Lowell W. Beineke, Martin Charles Golumbic and Robin J. Wilson, Topics in Algorithmic GraphTheory (1st ed.),Cambridge University Press, 2021. ISBN 9781108492607 .*

Reference Books :

1.*Nilanjan Dey, Social Network Analytics: Computational ResearchMethods and Techniques (1st ed.), Academic Press, 2018. ISBN 978- 0128154588.*

Name of Program	Master of Technology - Computer Science Engineering				
PCSS208	Reinforcement Learning	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To articulate the key features of Reinforcement Learning (RL).
CO2: To examine the formulation, design, and implementation of the given application as RL problem.
CO3: To implement common RL algorithms and evaluate them using relevant metrics.

Course Contents:

Module I **10 lecture hours**

Reinforcement Learning (RL), RL vs ML, RL applications, Ethics in RL, Sequential Decision Making, Modelling the World, RL simulators, State, Action, Reward, Environment, Taxonomy of reinforcement learning agents, Fully vs partially observed environment, Markov Processes, Markovproperty, Markov chains, Markov Decision Processes (MDP), Markov Reward Process (MRP)

Module II **10 lecture hours**

Polices, Value Functions, Value based RL, Policy based RL, Bellman Equations, Exploration vs exploitation, Q Learning, Deep Q Networks (DQN), DDQN, Dueling DQN, Experience Replay, Bandit Algorithms, Online Learning, Optimality Proofs, Contextual Bandits, Dynamic Programming, Asynchronous Dynamic Programming

Module III **12 lecture hours**

Policy-based Reinforcement Learning, Policy Gradients, Policy Evaluation (Prediction), Policy Improvement, Policy Iteration, Value Iteration, REINFORCE algorithm, Stochastic policy search, Actor-critic methods (A2C, A3C), Hierarchical Reinforcement Learning, Generalized Policy Iteration, Hierarchical RL: MAXQ, Monte Carlo Policy Gradients, Generalized Advantage Estimation (GAE), Monte Carlo Prediction, Monte Carlo Estimation of Action Values, Monte CarloControl,

Module IV **10 lecture hours**

On-Policy Learning, Off-Policy Learning, Temporal Difference Prediction, Full RL, Reinforcement Learning in Continuous Spaces, State–action–reward–state–action (SARSA), Incremental Implementation, Policy optimization methods, Trust Region Policy Optimization(TRPO), Proximal Policy Optimization (PPO), Meta-learning, Multi-Agent Reinforcement Learning, Partially Observable Markov Decision Process

Text Books :

1. *Richard S. Sutton and Andrew G. Barto, Reinforcement Learning: AnIntroduction (2nd ed.), MIT Press, 2018. ISBN 978-0262039246.*

Reference Books :

1.*Mohit Sewak, Deep Reinforcementlearning: Frontiers of Artificial Intelligence (1st ed.), Springer, 2019. ISBN 978-9811382840.*

Name of Program	Master of Technology - Computer Science Engineering				
PCSS209	Emerging Topics in Artificial Intelligence	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

CO1: Develop an understanding of the current trends and challenges of emerging Artificial Intelligence (AI) technologies.
CO2: Identify and analyse potential applications of AI in the context of real-world problems.

Module 1 **lecture hours: 42**

The Emerging Topics in Artificial Intelligence course will provide an overview of the current state of Artificial Intelligence (AI) research. Students will learn about the major topics in AI such as machine learning, natural language processing, computer vision, robotics, and reinforcement learning. Additionally, students will be exposed to the latest applications of AI in various domains such as healthcare, finance, and autonomous vehicles. They will learn how to apply AI algorithms and explore the ethical implications of AI. Finally, students will get an introduction to the potential future of AI and the implications of these technologies on society.

Name of Program	Master of Technology - Computer Science Engineering				
PCSS210	Malware Analysis forMobile Devices	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To Possess the skills to carry out independent analysis of modern malware samples.
CO2: To understand and analyse the Mobile application threat landscape.
CO3: To Apply techniques to unpack, extract, decrypt, or bypass in future malware samples.

Course Contents:

Module I **10 lecture hours**
Mobile Operating- System and Threats, Mobile Development Tools, Risky Apps, Looking Closer at Mobile Apps. Malware Threats, Hoaxes, and Taxonomy- FakePlayer, DroidSMS, FakeInst, TapSnake, SMSReplicator, Geinimi, ADRD, Pjapps, AirPush, Boxer, GGSmart, Defender, DriveGenie, Torec.

Module II **10 lecture hours**
Open-Source Tools- Locating and Downloading Mobile Packages, Vulnerability Research for Mobile OS, Antivirus Scans, Static Analysis, Linux File Command, APK, Key tool Key and Certificate Management Utility, Sandbox Analysis, Emulation Analysis, Native Analysis, ReverseEngineering, Memory Analysis.

Module III **12 lecture hours**
Static Analysis, Collections and Marketplace, Marketplace Mirrors and Cache, Contagio Mobile, File Data, Cryptographic Hash Types and Queries, Metadata, Antivirus Scans and Aliases, Certificate Information, Permissions, Strings, Mobile Malware Evolution, Detecting malwarebehaviour, Mobile Malware Trends and Reversing Tactics.

Module IV **10 lecture hours**
Behavioural Analysis, AVD, Component & IPC security, Android app permissions, Network Architecture for Sniffing in a Physical Environment, Traffic analysis and manipulation, Application dynamic runtime analysis, identifying code level vulnerabilities.

Text Books :

1.M. Sikorski and A. Honig, *PracticalMalware Analysis*(1st ed.), Practical MalwareAnalysis, 2017. ISBN 978-1593272901

2. Abhijit Mohanta an Anoop Saldanha, *Malware Analysis and Detection Engineering a Comprehensive Approach to Detect and Analyze Modern Malware* (1st ed.), Packt Publishing, 2022. ISBN 9781484261927.

Reference Books :

1.Alexey Kleymenov, and Amr Thabet, Mastering Malware Analysis / (1st ed.), Packt Publishing, 2019. ISBN 9781789614872.

Name of Program	Master of Technology - Computer Science Engineering				
PCSS211	Security and Privacy for Big Data Analytics	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To articulate security threats in big data analytics.
CO2: To examine the system vulnerabilities, exploitation.
CO3: To implement defence mechanisms on big data analytics.

Course Contents:

Module I **10 lecture hours**

Introduction and Basic Concepts, privacy by design, security roadmap, Map Reduce Architecture, Detailed Design of Architecture, Hadoop, Spark, Hive etc. Generic Data Security, Data Theft, Data Manipulations, Privilege Escalations, Big Data Storage based Security Issues, Hardware Failure Impacts, Known Trivial Countermeasures, Failure of Trivial Methods on Big Data.

Module II **16 lecture hours**

Case Study of Stolen Data in Big Data Environment, Types of Threats, Distinguished Security Goals for Big Data, Implementing Security on Big Data: Methods and Aim of each Method, Administrative Measures of Big Data, Preventive Measures of Big Data Security using Encryption,Preventive Measures of Big Data Security using Access Control, Detective Measures of Security inBig Data, Auditing, Log Analysis, Data and Network Monitoring Methods and Tools, Best Practicefor Securing Big Data, Security Cost of Big Data, Data Anonymization, Data Pseudo Anonymization.

Module III **16 lecture hours**

Differential Privacy in Big Data, Methods for Differential Privacy and Impact of each Method, Homomorphic Encryption, Heteromorphic Encryption, Complexity Analysis of Encryption Techniques, Complexity Analysis of Privacy-based Methods. Malware and their Impact on Big Data, Secure Multiparty Communication in Distributed Environment, Data Protection Laws for BigData, General Data Protection Regulation, Important changes resulting from the GDPR, Personal Data, Personal data and Big Data applications.

Text Books :

1.*R. Joshi, Security, Privacy, andForensics Issues in Big Data Network Security Essentials (1st ed.), IGI Global, 2019. ISBN 978- 1522597421.*

Reference Books :

1. *T. Dumming, Sharing Big DataSafely: Managing Data Security (1st ed.), O'Reilly,2016. ISBN 978-9352133482.*

Name of Program	Master of Technology - Computer Science Engineering				
PCSS212	Device Level IoT Security	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:
CO1: To articulate the security issues in IoT.
CO2: To apply the cryptographic techniques in IoT.
CO3: To implement various types of access control mechanism for IoT devices in network environment.

Course Contents:

Module I **08 lecture hours**
Brief review of the Internet of Things IoT, IoT in business world, Benefits Applications of IoT, Security Issues with IoT, Basic Architecture of IoT, IoT Attack Surface, OWASP Top 10 for IoT. Concept of Vulnerability management, Quarantine and Prevention.

Module II **16 lecture hours**
Security Requirements in IoT Architecture - Security in Enabling Technologies - Security Concernsin IoT Applications. Security Architecture in the Internet of Things- Security Requirements in IoT - Insufficient Authentication/Authorization - Insecure Access Control - Threats to Access Control, Privacy, and Availability - Attacks Specific to IoT. Vulnerabilities - Secrecy and Secret-Key Capacity- Authentication/Authorization for Smart Devices - Transport Encryption - Attack Fault trees.

Module III **18 lecture hours**
Cryptographic primitives and its role in IoT, Encryption and Decryption, Hashes, Digital Signatures, Random number generation, Cipher suites, key management fundamentals cryptographic controls built into IoT messaging and communication protocols, IoT Node Authentication, Identity lifecycle, authentication credentials, IoT IAM infrastructure, Authorizationwith Publish / Subscribe schemes, access control. Concerns in data dissemination , Lightweight androbust schemes for Privacy protection, Trust and Trust models for IoT, self- organizing Things, Preventing unauthorized access, Cloud security for IoT, Cloud services and IoT, offerings related to IoT from cloud service providers, Cloud IoT security controls.

Text Books :

1.Vijayalakshmi Saravanan, *SecuringIoT and Big Data: Next GenerationIntelligence (Internet of Everything(IoE)* (1st ed.), CRC Press, 2020. ISBN 0367432889.

Reference Books :

1.S. Bhattacharjee, *Practical IndustrialInternet of Things Security* Publications, 2018. ISBN 978-178882687.

Name of Program	Master of Technology - Computer Science Engineering				
PCSS213	Vulnerability Analysisin Network Protocols	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To understand the vulnerabilities of network protocols.
CO2: To examine penetration testing on each network protocol for vulnerability detection.
CO3: To make use of tools for detecting vulnerabilities in OSI layers.

Course Contents:

Module I **08 lecture hours**

OSI model and TCP/IP suite, Layer wise security issues, Network Access Layer Vulnerabilities, Wiretaps, Reconnaissance, Hardware Breakage, Voltage Fluctuations, Natural Disaster, Misconfigurations and Malfunctioning of Network Interface Cards, Signal Disruption Attacks.

Module II **10 lecture hours**

Absence of VLANs, Network Layer Protocol Vulnerabilities, IPv4 Packet Structure and Vulnerabilities, IPv4 Header Based Modification Attack, IPv4 flooding Attack, Man in the Middle Attack by Manipulating IPv4 , IPv6 Security Issues IPSec and its Key Management, ICMP Packet Structure and Working, ICMP Header based Modification Attack, Ping of Death, Countermeasuresfor Each Attack in Network Layer Protocol, Attacks on Routers and Routing, RIP, OSPF, BGP, Countermeasures of Attacks.

Module III **10 lecture hours**

Transport Layer Protocol Vulnerabilities, TCP Packet Structure and its Working, TCP Header Based Modification Attacks, TCP Incomplete Connection Attack, TCP SYN Flooding Attack, TCP Reset Attack, TCP Session Hijacking Attack, Reverse Shell Attack, Detection and Countermeasuresof Each type of TCP Attack, UDP Packet Structure and its Working, UDP Header Based Modification Attack, UDP Generic Flooding Attack, Detection andCountermeasures of Each type of UDP Attack.

Module IV **14 lecture hours**

Application Layer Protocol Attacks, DHCP Packet Structure and Working, Classic DHCP Starvation Attack, Induced DHCP Starvation Attack, DHCP Spoofing Attacks, DHCP Flooding Attacks, Countermeasures for each attack on DHCP, DNS Packet Structure and Working, DNS Cache Poisoning for Phishing, Domain Hijacking DNS Flooding, Reflection and Amplification Attack, Random Subdomain Attack, NXDomain and Phantom Domain Attack, Countermeasures for each attack on DNS, HTTP Packet Structure and its Working, Method based Flooding Attacks,HTTP Half Connection Attack, HTTP fuzzers and misbehaved fields, Cache bypassing attacks, Countermeasures for each attack on HTTP, Wireless Access Point Firmware Vulnerabilities, SSIDBeaconing and Checking for Hidden and Fake Wireless Networks, Brute Force Attack, Evil twin Attack, WiMax vulnerability, Vulnerability of zigbee protocols.

Text Books :

1.C. Sanders, *Practical PacketAnalysis* (3rd ed.), No StarchPress, 2017. ISBN 978- 1593278020.

Reference Books :

1.F. Gebali, *Network Vulnerability Assessment: Identify security loopholes in your network's infrastructure* (1st ed.), Springer, 2018. ISBN 978-1788627252.

Name of Program	Master of Technology - Computer Science Engineering				
PCSS214	Penetration Testing, Auditing and Ethical Hacking	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To identify and analyze the stages an ethical hacker requires to compromise a target system.
CO2: To utilize tools and techniques to carry out a penetration testing.
CO3: To critically evaluate security techniques used to protect system and user data.

Course Contents:

Module I **14 lecture hours**

Penetration Testing Concepts, Plan a Pen Test Engagement, Rules of engagement, Communication escalation path, Resources and requirements, Budget, Impact analysis and remediation timelines, Disclaimers, Technical constraints, Support resources, Key legal concepts, Contracts, Environmental differences, Written authorization, Scope and Negotiate a Pen Test Engagement, Prepare for a Pen Test Engagement, Conducting Passive Reconnaissance, Information gathering, Perform Social Engineering Tests, Perform Physical Security Tests on Facilities.

Module II **16 lecture hours**

Active Reconnaissance, Scan Networks, Enumerate Targets, Analyzing Vulnerabilities, Exploiting Cross-Site Scripting, Cross-Site Request Forgery, Web Application Exploitation, File upload vulnerability , HTTPS Requests: Get & Post , Using Burp as a Proxy Server, Code Execution Vulnerabilities, Countermeasures, Penetrating Networks, Exploit Network-Based Vulnerabilities, Exploit Wireless and RF-Based Vulnerabilities, Evil twin, Karma attack, Downgrade attack, De-authentication attacks, Fragmentation attacks, Credential harvesting, WPS implementation weakness, Bluejacking, Bluesnarfing, RFID cloning, Jamming, Repeating, Local File Inclusion Vulnerabilities, Getting Shell from LFI Vulnerability, OSINT Tools, Maltego, Shodan, Google Dorks, The Harvester, Metagoofil, TinEye.

Module III **12 lecture hours**

Analyze Pen Test Data, Reporting Pen Test Results, Write and Handle Reports, Normalization of data, Written report of findings and remediation, Risk appetite, Storage time for report, Secure handling and disposition of reports, Conduct Post-Report-Delivery Activity, Post-engagement cleanup, Removing shells, Removing tester-created credentials, Removing tools, Client acceptance, Lessons learned, Follow-up actions/retest, Attestation of findings, Develop Recommendations for Mitigation Strategies, Solutions, Findings, Remediations.

Text Books :

1.Allen harper, *Gray Hat Hacking: TheEthical Hacker's Handbook* (6th ed.), McGraw-Hill Osborne Media, 2022. ISBN 1264268947.

Reference Books :

1.Connor Wallace, *Penetration Testing: Penetration Testing: A /onHands-On Guide For Beginner* (1st ed.), Independently Published, 2020. ISBN 979- 8614981143.

Name of Program	Master of Technology - Computer Science Engineering				
PCSS215	Forensics and CyberLaw	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:
CO1: To understand the Volatile Data Collection from Windows system.
CO2: To understand cyber activities which are considered as crime in India.
CO3: To apply forensic analysis in Computer Investigations.

Course Contents:

Module I **10 lecture hours**

Cyberspace and Criminal Behaviour, Traditional Problems Associated with Computer Crime, The Emergence of e-Cash: A New Problem for Law Enforcement. Hacking, Intellectual Property, Web-Based Criminal Activity, Theft of Information, Data Manipulation, Web Encroachment, Cyberterrorism, Dissemination of Contraband or Offensive Materials, Threatening and Harassing Communications, Money Laundering, Online Fraud, Identity Theft/Fraud, Victimology, Virtual or Internet-Facilitated Methods, Data Piracy and Counterfeit Goods, Volatile Data Collection from Windows system, Volatile Data Collection from Unix system.

Module II **10 lecture hours**

Computer Fraud and Abuse Act of 1986, National Information Infrastructure Protection Act of 1996 (NIIPA), Evolving Child Pornography Statutes, Identity Theft and Financial Privacy Statutes, Law Enforcement Operations and Tools in the United States, Computer-Related Crime of the Council of Europe, Council of Europe's (CoE) Cybercrime Conventions, Law to Child Pornography Statutes, Unlawful Internet Gambling Enforcement Act of 2006, Electronic Communications Privacy Act of 1986, Privacy Protection Act, Electronic Surveillance and Criminal Investigations, Communications Assistance for Law Enforcement Act, Other Questions Regarding Privacy: Peer-to-Peer or File sharing, Internet Service Provider Subscriber Records, Web sites, Cell phones.

Module III **12 lecture hours**

Traditional Problems in Computer Investigations, Forensic Duplication, Forensic Duplicates as Admissible Evidence, Forensic Duplication Tool Requirements, Creating a Forensic Duplicate/Qualified Forensic Duplicate of a Hard Drive, Phase after detection of an incident, Disk Structure and Data Storage, File Systems, Firmware Operating Instructions, Data Integrity, DevelopingComputer Forensic Science Capabilities, Traditional Problems Associated with Finding Digital Evidence, Pre-search Activities, On-scene Activities: Knock, Notice, and Document, Securing the Crime Scene, Determining the Need for Additional Assistance, Scene Processing, Locating Evidence, Seizure and Documentation of Evidence, Bagging and Tagging, Interviewing Witnesses, Collecting Network Based Evidence, Scene Departure and Transportation of Evidence to Lab, Forensic Analysis of File Systems, Hard Drives Evidence Handling, Challenges in evidence handling.

Module IV **10 lecture hours**

Email Tracing Internet Fraud, Data Analysis Techniques, Investigating Live Systems (Windows & UNIX), Email Tracing Internet Fraud, Data Analysis Techniques, Investigating Live Systems (Windows & UNIX), Issues related to Data Privacy, Criminal Liability, Electronic Contracts & Digital Signatures, Misappropriation of information, Civil Rights, Evidence. Legal Developments, Security in cyber laws case, Trademarks, Reverse Hijacking, Jurisdiction in Trademark Disputes, Copyright in the Digital Medium, Copyright and WIPO Treaties, Concept of Patent Right (30), Cryptography Laws, Ethical Issues – Cybercrime6.

Text Books :

1. Marjie T Britz, *Computer Forensics and Cyber Crime: An Introduction* (4th ed.), Pearson Education India, 2022. ISBN 9780134847528.

2. Gerard Johansen, *Digital Forensics and Incident Response: Incident response techniques and proceduresto respond to modern cyber threats* (2nd ed.), Packt Publishing Limited, 2020. ISBN 978-1838649005.

Reference Books :

1.Niranjan Reddy, *Practical Cyber Forensics*(1st ed.), Apress, 2019. ISBN 9781484244605.

Name of Program	Master of Technology - Computer Science Engineering				
PCSS216	Web Security	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:
CO1: To possess the skills to carry out independent analysis of modern malware samples.
CO2: To understand and analyse the Mobile application threat landscape.
CO3: To apply techniques to unpack, extract, decrypt, or bypass in future malware samples.

Course Contents:

Module I **10 lecture hours**
Web Basics: HTML, CSS, JS, URLs, DOM, Frames, HTTP, Navigation, X-Domain communication, web security, Security elements, Implementation of safety assessment, understanding the dangers of an insecure communication channel, Network Attacks & HTTPS, HTTPS deployment, HTTPS impact on your application, Insights into the latest evolutions for HTTPS deployments, Limitations of HTTPS, Cookie Flaws and Server Misconfiguration.

Module II **10 lecture hours**
Security of Browser same origin policy, sandbox browser, malicious URL intercept, Rapid development of browser security, cross-site scripting attack, Advanced XSS attack, XSS defence, Cross-Site Request Forgery, Advanced CSRF defence, Clickjacking, HTML5 Securities, other security problems.

Module III **10 lecture hours**
Injection Attacks, SQL injection attacks, Database attacking techniques properly defending againstSQL injection and other injection, File Upload Vulnerability, designing secure file upload features, Authentication and session management, Attacks on User Interfaces, Access control, Encryption algorithms and random numbers, Web framework security, Application-layer Denial- of-Service Attacks, PHP security, TCP Reset Attack.

Module IV **12 lecture hours**
Security of Internet Business, Business logic security, How the account is stolen, Internet garbage phishing, User privacy protection ,Security development lifecycle, Security operations, Process of vulnerability patch, security monitoring, Practical ways to secure the authentication process,prevent authorization bypasses and harden session management mechanisms (10) security planning,business continuity planning, Handling incidents Risk Analysis, Dealing with disaster: privacy on the web, Privacy impacts of emerging technologies, Handling incidents, Risk Analysis,Dealing withdisaster: privacy on the web, Privacy impacts of emerging technologies, Browser Design & Flaws.

Text Books :

1.Andrew Hoffman, *Web ApplicationSecurity: Exploitation and Applications* (1st ed.), O'ReillyMedia, 2020. ISBN 978-1492053118

Reference Books :

1. Malcolm McDonald, *Web Security for Developers* (1st ed.), No Starch Press, 2020. ISBN 9781593279957.

Name of Program	Master of Technology - Computer Science Engineering				
PCSS217	Special Topics in Information Security	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To familiarize and learn about the latest trends and research in the field.
CO2: To equip themselves with the conceptual and practical experience of few latest methods, tools, technologies or algorithms in Information Security (IS).

Course Contents:

Module I **42 lecture hours**

This course covers the cutting-edge topics in Information Security and these modules will be chosenby the instructor based on the requirements and relevance at that point of time. These modules needto be relevant to the industry and start-ups will also include related case studies, usecases and implementations scenarios. Students will be working on lab work and projects to get real hands-on experience of these topics and modules.

Name of Program	Master of Technology - Computer Science Engineering				
PCSS218	Cloud Security andCompliances	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To learn and examine the security breaches of IaaS, PaaS and SaaS.
CO2: Apply various data encryption methods and security mechanisms to get the administrative control using IAM service.
CO3: Create a secure production environment using cloud security features and services.

Course Contents:

Module I **14 lecture hours**

Security Patterns for Cloud Computing – Network Security, Identity & Access Management & Trust, Secure On-Premises Internet Access, Secure External Cloud Connection, Cloud Denial-of- Service Protection, Cloud Traffic Hijacking Protection, Automatically Defined Perimeter, Cloud Authentication Gateway, Federated Cloud Authentication, Cloud Key Management, Trust Attestation Service, Collaborative Monitoring and Logging, Independent Cloud Auditing.

Module II **14 lecture hours**

End-to-end security, Shared responsibility in the cloud, Backup and restore, Detect and mitigate threats, Plan for ransomware, recovering from systemic identity compromise, Threat protection, Securing Workloads, Security technical capabilities, Physical security, Components and boundaries, Operations and Monitoring, Platform integrity and security, Secure Data Protection Law: National and International, Firmware security, Code integrity, Secure Boot, Secure Isolation of Physical & Logical Infrastructure, Compute, Network, Storage, Common attack vectors and threats, Secure Isolation Strategies, Multitenancy, Virtualization strategies.

Module III **14 lecture hours**

Data Protection for Cloud Infrastructure and Services. Understand the Cloud based Information Life Cycle, Data protection for Confidentiality and Integrity, Encryption, Data Redaction, Tokenization, Obfuscation, PKI and Key, Management, Assuring data deletion, Data retention, deletion and archiving procedures for tenant data, Data Protection Strategies.

Text Books :

1. Chen, Lei, Hassan Takabi, and Nhien-An Le-Khac, *Security, privacy, and digital forensics in the cloud* (1st ed.), John Wiley & Sons, 2019. ISBN 13: 9781119053286.

Reference Books :

1. Tevault, Donald A, *Mastering Linux Security and Hardening: Secure your Linux server and protect it from intruders, malware attacks, and other external threats* (1st ed.), Packt Publishing Ltd, 2018. ISBN 1788620305.

Name of Program	Master of Technology - Computer Science Engineering				
PCSS219	Emerging Topics in Cyber Security	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

On completion of this course, the students will be able to:

CO1. Develop an understanding of the emerging threats, technologies, and strategies for defending and protecting an organization's cyber security.

CO2. Analyse and evaluate the effectiveness of current cyber security protocols and systems and develop best practices for mitigating and preventing new threats.

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Module 1 **lecture hours: 42**

Cyber security is an ever-evolving field as new technologies and threats continue to emerge. In the past few years, there have been several emerging topics in cyber security that have become increasingly important, including cloud security, artificial intelligence, the Internet of Things (IoT), mobile security, blockchain technology, and quantum computing. Cloud security is the practice of protecting cloud-based systems, services, and data from malicious actors. Artificial intelligence is being used to detect and prevent cyber-attacks in real-time, as well as to automate manual security tasks. The Internet of Things (IoT) is a rapidly growing network of connected devices, all of which need to be secured. Mobile security is the practice of protecting mobile devices, including phones, tablets, and laptops, from threats. Blockchain technology is a distributed, secure ledger that is being used to store and share data and transactions, increasing security. Lastly, quantum computing is a new technology that has the potential to revolutionize computing power, with both positive and negative implications for cyber security. All of these technologies and topics must be addressed in order to ensure the security of systems, data, and users.

Professional Electives

Name of Program	Master of Technology - Computer Science Engineering				
PCSP301	User Centered Design	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: Articulate appropriateness of potential design methods such as contextual design, prototyping, ideation given a problem setting.
CO2: Examine the issues and challenges to achieving a user-cantered design process.
CO3: Implement design methods at a basic level of competence: interviews, personas, storyboarding, sketching, and evaluation.

Course Contents:

Module I **12 lecture hours**

User Centred Analysis (UCA), Mental models, knowing how the user works, Learnability, User model vs System Model, Which UCA steps to perform, Obstacles of user-centred analysis, Return on Investment (ROI), Justifying the right process, Creating a Design Strategy: Components of a design strategy, Site strategy drives design strategy, Where to get strategy information, Mining existing documentation, Working with brand objectives, Design techniques: Sketching, Scenarios,Storyboards, Design patterns.

Module II **14 lecture hours**

Profiles and Personas, Value of profiles and Personas, User profiles, Task profiles, Environment profiles, Data gathering methods, Choosing the right method, Elements of field interview, Developing interview questions, Good and bad interview technique, Conducting a user observation.Complementary Data Gathering Methods: Value of complementary methods, Focus groups, User group meetings, Usability roundtables, Complementary Data Gathering Methods, Facilitated workshops, JAD sessions, Using surveys and other indirect methods, Online surveys, Usingmultiple methods.

Module III **16 lecture hours**

Primary Noun Architecture, Describing primary nouns, Primary noun views, Primary noun details, Primary nouns to navigation, Information Architecture, Costs of poor organization, Basic organization schemes, Hybrid schemes, Shallow vs. deep structures, Labelling systems, InformationArchitecture, Affinity diagrams, Card sorting techniques, Card sorting tools, Getting sign-off on thecontract for design, Using concept sketches to drive out requirements, Setting usability criteria, Scenario and Task Analysis: The power of a scenario, Scenarios vs. use cases, Determining the levelof detail, Scenarios driven priorities. Scenario and Task Analysis: Identifying functions and tasks, Common errors and challenges in task analysis, Characterizing the new task design, Primary NounArchitecture: Value of primary nouns, Identifying primary nouns, Domain Analysis, Requirement analysis.

Text Books :

1.Krug Steve, *don't make me think Revisited: A common sense approachto web usability* (3rd ed.), Berkeley CA: New Riders Publishing, 2020. ISBN 978- 0321965516.

Reference Books :

1.Travis, D., and Hodgson, P., *Think Like a UX Researcher: How to Observe Users, InfluenceDesign, and Shape Business Strategy* (1st ed.), CRC Press, 2019. ISBN 978-1138365292.

Name of Program	Master of Technology - Computer Science Engineering				
PCSP302	Secure Coding	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To explain secure programming philosophy, design principles, and its methods.
CO2: To examine typical mistakes done during programming and the methods of their handling.
CO3: To implement the typical threats in programming and understand concepts of implementingthe secure codes.

Course Contents:

Module I **12 lecture hours**

Secure Programming, Robust vs. Secure Programming, Security Policies and Procedures, Checking Design and Implementation, Where to Look for Vulnerabilities, Classification of Security Flaws, Landwehr's Taxonomy, Fortify Taxonomy, Protection methods at different layers,PreDeCo matrixof software security. Input Validation in Programming, Improper Error and Exception Handling, Code Injection and Mitigation, Broken Authentication.

Module II **14 lecture hours**

Secure Programming Design Principles, Principle of Least Privilege, Fail-Safe Defaults, Principle of Economy of Mechanism, Principle of Complete Mediation, Separation of Privilege Principle, Principle of Open Design, Principle of Least Common Mechanism, Principle of Least Astonishment, Control Hijacking Attacks and Defences, Attacks Using Virtual Machines, Static and Dynamic Analysis, Language-based Security Models, Isolation Techniques.

Module III **16 lecture hours**

XML External Entity (XXE), Cross-Site Scripting (XSS), Insecure Deserialization, LFI (Local File Inclusion) and RFI (Remote File Inclusion) vulnerabilities, Unvalidated File Upload vulnerability, Buffer Overflow vulnerabilities, Client Side Security, JavaScript Security, Click Jacking, Ajax Security, HTML5 Security, Java Secure Socket Extension (JSSE), Common CodingErrors and Vulnerability, Automation and Testing for secure coding, Research Issues in Secure Coding.

Text Books :

1. Richardson T. and Thies C. N., *Secure Software Design, onesBartlett Learning* (1st ed.), Jones& Bartlett, 2012. ISBN 978- 1449626327.

Reference Books :

1.Zach Codings, *Computer Programming and Cyber Security for Beginners* (1st ed.), Independently published, 2019. ISBN 978-1671532908.

2.Seacord Robert C., *Secure Coding in C and C++* (2nd ed.), Pearson Education, 2013. ISBN 978-0321822130.

Name of Program	Master of Technology - Computer Science Engineering				
PCSP303	Compiler Construction	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To articulate major phases of compilation.
CO2: To examine various parameters passing scheme, explain memory management of a programming languages and perform code optimization.
CO3: To Implement lexical analyzers, parsers, and small compilers by using general purpose programming languages.

Course Contents:

Module I **16 lecture hours**

Compiler, Code Analysis, Interpreter, Single Pass, Two pass, Multi Pass compiler, Preprocessor, Macros, Phases of compiler, Symbol table manager, Operations on symbol table, Error handling, Bootstrapping and cross compiler, Lexical Analysis, Tokens, Regular expression, Generation of lexical analysis from DFA, Syntax Analysis, Parser, Context Free Grammar, Conversion Rule for Ambigous To Unambigous Grammar, Non-Deterministic & Deterministic Grammar, Left Recursive And Right Recursive Grammar, Parsing: Top down and Bottom up, Backtracking and their automatic generation, LL (1) Parser, LR Parser, LR (0) items, SLR (1), LALR (1), CanonicalParsing.

Module II **16 lecture hours**

Error Analysis, Error Classification, Error detection, Error Detection in LL and LR parsers, Error recovery, Panic mode error recovery, Static semantic, Intermediate code generation, static semantic analyses in declaration processing, name, and scope analysis, S-attribute, Semantic analysis throughS-attribute grammar, L-attribute, Type checking, Language features influencing run time memory management. Parameter passing mechanism, Division of memory into code, stack, heap and static, Activation record, Garbage collection, Code generation for expressions, issues in efficient code generation.

Module III **10 lecture hours**

Sethi Ullman algorithm, optimal code generation, Retargetable code generation, Code generation for control structures, Code Optimization, Local and global optimization, Control flow analysis, Data flow analysis, Global optimizations, Graph colouring in optimization, Live ranges of run timevalues.

Text Books :

1.*Sunitha, K. V. N., Compiler construction (1st ed.), Pearson Douglas Thain, Introduction to Compilers and Language Design (2nd ed.), Lulu.com, 2019. ISBN978-0359142835.*

Reference Books :

1. Introduction to Compiler Design: An Object-Oriented Approach Using Java (1st ed.), Softmoore Consulting, 2019 . ISBN 978-1734139105.

Name of Program	Master of Technology - Computer Science Engineering				
PCSP304	Software Project Management	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

On completion of this course, the students will be able to:
CO1: To articulate and determine the purpose and importance of basic processes involved in project management from the perspectives of planning, tracking and completion of project.
CO2: To exam in different organization structure and project structures.
CO3: To implement programs to manage project management, project schedule, expenses and resources with the applications of project management tools.

CO – PO /PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3				3						2			
CO2		2		2			1							
CO3	3	2		3		3			1				1	1

1=weakly related 2= moderately related 3=strongly related

Course Contents:

Module I **14 lecture hours**

Project Management: Characteristics of software projects, Objectives, Stakeholders, Feasibility Study, Cost-benefit Analysis, Planning, Project Execution, Project and Product Life Cycles, Role of project manager, Knowledge areas, Tools & Techniques, System view of project management, Agile software, Iterative steps for planning, Project Plan documentation methods, Software Requirement Specification, Measurement and Control, Reviews, feedback and reporting mechanisms, revisiting the plan, Scope Planning & Scope management plans, Function point calculation, Scope definitions & project scope statement, Project time management, Activities sequencing, Network diagrams, Activity recourse estimation, Activity duration estimation, Schedule development, Gantt Charts, Critical path method, Program evaluation & review technique (PERT) and CPM, Principles of cost management, Cost estimating, Type of cost estimate, Cost estimate tools & techniques, COCOMO.

Module II **14 lecture hours**

Putnam/SLIM model Estimating by Analogy, Cost budgeting, Cost control, Earned value management, Project portfolio management, Project Quality Planning, Quality Assurance, Quality control, Tool & techniques for quality control, Pareto Analysis, Six Sigma, CMM, ISO Standards, Juran Methodology, Project Hwnan resource planning, Project organisational charts, Responsibility assignment metrics, Acquiring project team, Resource assignment, resource loading, Resource levelling, Team structures, Project Communication Planning, Performance reporting, Managing stakeholders.

Module III **14 lecture hours**

Project Risk Management planning, Common sources of risk, Risk identification techniques, Qualitative risk analysis, Expert judgement, Decision trees, Expected monetary value, Simulation, sensitivity analysis, Risk response planning, Risk monitoring & control, Project Procurement

management plans, Contract statement of work. Planning contracts, Requesting seller responses, Selecting sellers, Administrating the contract, Closing the contract, Software Configuration Management, Retaining versions, Software Configuration elements (SCI's), Change Control and Management.

Text Books:

1. *Roger Pressman and Bruce Maxim, Software Engineering : A practitioners approach (9th ed.), TataMcGraw Hill, 2020. ISBN 978-1259872976.*

Reference Books:

1. *Manuj Aggarwal and Tetra Tutorials Team, The Art of Project Management for Software and IT Engineers (l8t ed.), Packt Publishing, 2018.ISBN 978-1789804768.*

Name of Program	Master of Technology - Computer Science Engineering				
PCSP305	Distributed Computing	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To articulate the models, architectures, and the concept of virtual clock and clock synchronization. (BTL-2)

CO2: To examine the algorithms for mutual exclusion, deadlock detections, and termination detection. (BTL-2)

CO3: To implementing the concepts of distributed computing on Google File System , Hadoop Distributed File System (HDFS), and sensor networks. (BTL-3)

Course Contents:

Module I **12 lecture hours**

Introduction, process communication, Message Passing, Leader Election, Leader election algorithm, Distributed Models, Causality and Logical Time, Size of Vector Clock, Matrix Clocks, Virtual Time and Physical Clock Synchronization, Global State and Snapshot Recording Algorithms, Distributed Mutual Exclusion and Non-Token based Approaches, Quorum Based Distributed Mutual Exclusion Approaches: Maekawa's Algorithm.

Module II **12 lecture hours**

Distributed Mutual Exclusion-Token based approaches, Consensus & Agreement, Checkpointing & Rollback Recovery, Deadlock Detection in Distributed Systems, Approaches, Algorithms for deadlock detection:Path-Pushing, Edge Chasing, Diffusion Compution, and Global state detection Distributed Shared Memory, Features and advantage, Distributed Minimum Spanning Tree.

Module III **08 lecture hours**

Termination Detection, Huang's algorithm, Message Ordering & Group Communication, Fault Tolerance and Self-Stabilization, Distributed Randomized Algorithms, Distributed Hash Tables andPeer to Peer Computing.

Module IV **10 lecture hours**

Case Studies: Google File System and HDFS, Distributed Execution using Map Reduce, Introduction to Spark, Introduction to Sensor Networks, Distributed Algorithms for Sensor Networks: Coverage and Connectivity, Topology Discovery, LEACH – Cluster based Low Power Algorithm , Authentication in Distributed Systems, Security in Distributed Systems and Block Chain.

Text Books :

1.Van Steen Maarten and TanenbaumAndrew S., *Distributed Systems* (3rd ed.), Amazon Digital Services, 2017. ISBN 978-1543057386.

Reference Books :

1.Notes on Theory of Distributed Systems on James Aspnes, (1st ed.), Yale University, 2021. ISBN .

Name of Program	Master of Technology - Computer Science Engineering				
PCSP306	Agile SoftwareDevelopment	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To articulate existing problem with the team, development process, and wider organization.
CO2: To specify the most appropriate way to improve the results for a specific need using agile techniques.
CO3: To apply understanding of agile principles and specific practices.

Course Contents:

Module I **12 lecture hours**

Agile mindset, Agile manifesto, Predictive model, adaptive model, Agile principles, Organizational impact of adopting agile, Agile case study, Agile requirements, User stories and acceptance criteria,3 C's in user stories.

Module II **16 lecture hours**

Epics and tasks, Product backlog and refinement, Scrum framework, Roles in scrum, Phases in scrum, Sprints, Sprint backlog, Daily scrum, Scrum rules, Agile estimation and planning, Effectively using story points, Need of velocity and duration, Planning poker technique for PBI sizing, Fixed estimation based on velocity, Velocity range, Release planning, Fixed scope release, Fixed date release, Agile and DevOps.

Module III **14 lecture hours**

Sprint planning, Capacity determination, Sprint Execution, Flow management, Swarming in flow management, Task board and task table, Sprint charts, Sprint review, Pre-work, process, and activities, Sprint retrospective, Participants, pre-work, process, and activities, Sprint retrospective steps, Extreme Programming (XP) in agile, XP values, XP practices, XP process model, Scrum vs XP.

Text Books :

1.Craig Larman and Bas Vodde, *Large-Scale Scrum: More with LeSS* (1st ed.), Addison-Wesley Professional, 2016. ISBN 978- 0321985712.

Reference Books :

1. Alex Cambell, *Agile: All You Need toKnow about Agile Software Development. Team and ProjectManagement using Scrum* (1st ed.), Independently Published, 2020. ISBN 979-8672282909.

Name of Program	Master of Technology - Computer Science Engineering				
PCSP307	Virtual Reality: Interface, Applicationand Design	L	T	P	C
Owning School/Department	Computer Science and Engineering	2	0	2	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)
By the end of this course, students should have the following knowledge, skills and values:

CO1: To demonstrate an understanding of fundamental techniques, processes, technologies, and equipment used in immersive virtual reality.
CO2: To explore the materials and processes used in immersive virtual reality.
CO3: To show a basic awareness and understanding of historical and theoretical contexts relevantto immersive virtual reality and demonstrate an understanding of the importance of critical and self-reflective practice.

Course Contents:

Module I **16 lecture hours**
VR Goals and definitions, Historical perspective, Birds-eye view, Geometry of Virtual Worlds, Geometric modelling, transforming models, Matrix algebra and 2D rotations, 3D rotations and yaw, pitch, and roll, Axis-angle representations, Quaternions, Converting and multiplying rotations, Homogeneous transforms, the chain of viewing transforms, Eye transforms, Canonical viewtransform, Viewport transform. Hardware Technologies for 3D user Interfaces: Visual Displays Auditory Displays, Haptic Displays, Choosing Output Devices for 3D User Interfaces.3D user Interface Input hardware: Input device characteristics, Desktop input devices, Tracking Devices, 3D Mice, Special Purpose Input Devices, Direct Human Input, Home - BrewedInput Devices, Choosing Input Devices for 3D Interfaces.

Module II **10 lecture hours**
Light and Optics: Three interpretations of light, Refraction, Simple lenses, Dioptres, Imaging properties of lenses, Imaging properties of lenses, Lens aberrations, Optical system of eyes. VisualPhysiology: Photoreceptors, Enough resolution for VR, Light intensity, Eye movements, Eye movement issues for VR, Neuroscience of vision. Visual Perception: Depth perception, Motion perception, Frame rates and displays.

Module III **08 lecture hours**
Tracking Systems: Orientation tracking, Tilt drift correction, Yaw drift correction, Tracking with a camera, Perspective n-point problem, Filtering, Lighthouse approach. Visual Rendering: Visual Rendering-overview, Shading models, Rasterization, Pixel shading, VR-specific problems, Distortion shading, Post-rendering image warp.

Module IV **08 lecture hours**
Physics and physiology, Auditory perception, Auditory localization, Rendering, Spatialization and display, Combining other senses. Interfaces: Interfaces -overview, Locomotion, Manipulation, System control, Social interaction, Evaluation of VR Systems.

Text Books :
1.William R. Sherman and Alan Craig, *Understanding Virtual Reality,Interface, Application and Design* (2nd ed.), Morgan Kaufmann, 2018. ISBN 978- 0128183991.

2.Josh Gregory, *Minecraft Virtual Reality* (1st ed.), Cherry Lake Publishing, 2018. ISBN 978-1534133112.

Reference Books :

1.Tasgin Z, *Virtual and AugmentedReality* (1st ed.), Routledge, 2020. ISBN 978-1527548725.
2. Samuel Greengard, *Virtual Reality* (1st ed.), The MIT Press, 2019. ISBN 978-0262537520.

Name of Program	Master of Technology - Computer Science Engineering				
PCSP308	Engineering Optimization	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To articulate, Identify and develop operational research models from the verbal descriptionof the real system.
CO2: To examine the mathematical tools & software that are needed to solve optimizationproblems.
CO3: To analyze the results to resolve resource optimization.

Course Contents:

Module I **10 lecture hours**

Need of Optimization, Development of Optimization, Engineering Applications of Optimization, Design Vector, Design Constraints and Constraint Surface, Objective Function, Objective Function Surfaces, Stationary Points: Functions of Single and Two variables, Convexity and Concavity of Functions of One and Two Variables, Optimization of Functions of Single and Two Variables, Multiple Variables Subject to Equality Constraints, Lagrangian Function, Hessian Matrix Formulation, Eigen Values Kuhn-Tucker Conditions.

Module II **16 lecture hours**

Linear Programming (LP) Problem, Canonical Form of LP Problem, Assumptions in LP Models, Elementary Operations, Graphical Method for Two Variable Optimization Problem, Branch-and-Bound Method, Sequential Linear Discrete Programming, Generalized Penalty Function Method, Geometry and Formulation of LPP, Graphical Solution, Duality Theory, Duality in LP, Primal- dual Relations, Dual Simplex Method, Post Optimality Analysis, Karmarkar's Projective Scaling Method, Network Models, Shortest-Route Problem, Maximal Flow Model, CPM and PERT,Transportation Model, Nontraditional Transportation Models, Transportation Algorithm, Hungarian Method, Probability Theory, Random Variables and Probability Density Functions, Stochastic Linear Programming, Stochastic Nonlinear Programming, Objective Function and Constraints, Stochastic Geometric Programming, Heuristic Programming, Local Search Heuristics,Tabu Search Algorithm, Simulated Annealing Algorithm.

Module III **16 lecture hours**

Genetic Algorithms, Differential Evolution, Particle Swarm Optimization, Ant Colony Optimization, Crow Search Algorithm, Firefly Optimization Algorithm, Harmony Search Algorithm, Teaching-Learning-Based Optimization, Honey Bee Swarm Optimization Algorithm, Reduced Basis Technique, Design Variable Linking Technique, Incremental Response Approach, Basis Vector Approach, Derivatives of Static Displacements and Stresses, Multi-objective Optimization, Parallel Processing, Utility Function Method, Inverted Utility Function Method, Global Criterion Method, Bounded Objective Function Method, Lexicographic Method, Goal Programming Method, Goal Attainment Method, Game Theory Approach, Inventory Problem: A Supply Chain Perspective, Static Economic-Order-Quantity Models, Dynamic EOQ Models, StickyIssues in Inventory Modeling.

Text Books :

1.Singiresu S. Rao, *Engineering OptimizationTheory and Practice* (5th ed.), John Wiley &Sons, 2019. ISBN 978-1119454717.

Reference Books :

1. H.A. Taha, *Operations Research: An Introduction* (10th ed.), PearsonGlobal Edition, 2017. ISBN 978- 0134444017.

Name of Program	Master of Technology - Computer Science Engineering				
PCSP309	Wireless Networks	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To explain where the wireless technologies can be applicable and evolving wireless technologies and standards.
CO2: To articulate the architecture of various wireless technologies.
CO3: To experiment with various wireless technologies through hands-on projects.

Course Contents:

Module I **9 lecture hours**

Wireless technologies: Cellular systems, satellite systems, broadcast systems, wireless LANs. Propagation modes, Fading in the Mobile Environment, Characteristics of wireless transmission (signals, antennas, multiplexing, modulation, interference). Signal Encoding Criteria, Digital Data, Analog Signals, Analog Data, Analog Signals, Analog Data, Digital Signals. Frequency Hopping Spread Spectrum, Direct Sequence Spread Spectrum, Code Division Multiple Access, Generation of Spreading Sequences.

Module II **10 lecture hours**

Recent trends in Wireless Networking Technology, Layered architecture for Wireless communication, Wireless TCP, Physical and Logical Architecture. Radio and Infrared Communication. Satellite Communications, 802.11 WLAN Standards, 802.11 MAC Layer, 802.11 PHY Layer, 802.11 Enhancements, Other WLAN Standards like 802.11g, 802.11n and 802.11p. Wireless sensor network platforms, Communication architecture and protocols, Energy Management, Area Optimization, Time Synchronization, Duty Cycle Optimization, Sensor Data Acquisition, Processing and Handling.

Module III **9 lecture hours**

Wireless Personal Area Network Standards, Bluetooth (IEEE 802.15.1), Wireless USB, ZigBee (IEEE 802.15.4), Infrared Data Association (IrDA), Gigabit Wireless LANs, 5G Technology: Small Cells, Massive MIMO, mmWave, Intrusion Detection System for WSN, Anomaly and misuse detection, Evolution of cellular systems, 6G Technologies, Starlink wireless, 7G Technology: Intelligent Communication of the Inevitable.

Text Books :

1.*Beard C and Stallings W., WirelessCommunication Networks and Systems (1st ed.), Pearson, 2015. ISBN 978- 1292108728.*

2.Gordon Colbach, Wireless Networking: Introduction to Bluetooth and WiFi (1st ed.), IndependentlyPublished, 2017.ISBN 978-1973252115.

Reference Books :

1.*Saro Velrajan, AnIntroduction to5G Wireless Networks (1st ed.), Notion Press, 2020. ISBN 978-1649511164.*

2. R. Vannithamby and S. Talwar, Towards 5G: Applications, Requirements and CandidateTechnologies (1st ed.), John Willey & Sons, 2017. ISBN 978-1118979839.

Name of Program	Master of Technology - Computer Science Engineering				
PCSP310	Cloud Infrastructureand Services	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To articulate the building blocks of cloud infrastructure in the current industry scenario.
CO2: To design the cloud infrastructure using infrastructure as code.
CO3: To develop and deploy cloud services as per the cloud architectural use case.

Course Contents:

Module I **16 lecture hours**

Cloud Models, Cloud Migration, On-premises IT vs On-Cloud IT, Virtualization, Virtual Cluster Formation, Classic Data Centre (CDC), Virtualized Data Centre (VDC), Virtual Network devices, Compute Resource, Storage resource, Network clusters, Edge Location, Cloud infrastructure vs. cloud architecture, Defining Cloud Infrastructure, Design issues of cloud-based development and deployment, Software Development Life Cycle, Agile Methodology, DevOps Culture, CI/CD implementation of Infrastructure as a code, Cloud-Infrastructure cost estimation, Specifying the service level agreements, Publishing Cloud Resource Templates, Defining licensing models, Categories of Cloud Infrastructure, Datacentre Rack Management, Green Cloud computing, Ubiquitous clouds, Utility Computing, Cluster Computing, Grid Computing, Case Study of Edge Computing.

Module II **10 lecture hours**

Data Centre Management Tools Integration, Service and Resource Management, Infrastructure Security and compliances Case and Study, Designing Cloud Infrastructure template/code, Inter- cloud Resource Management & Demo, Interfaces for Users, Admins, and Developers, Service- oriented architecture (SOA), Services lifecycle management, Cloud APIs, Message-oriented Middleware, Workflow in SOA.

Module III **16 lecture hours**

Case Study: Cloud Infrastructure market analysis, Active Directory Concept, Demo of Active Directory, Microservices and its detailed programming model, Serverless Computing, Serverless Demo, Parallel and distributed programming paradigms, Coupling and Decoupling of Well-defined Architecture, Criteria for cloud service selection, Parameters affecting to performances of service implementation, Popular open sources DevOps tools, Case Study of DevOps Tools,Working with Container and Docker, Working with Kubernetes, Application Development and Deployment on Kubernetes, Continuous Integration and Continuous Development (CI-CD), Demo CI/CD pipeline, Everything is as a service: Case Studies.

Studio Work / Laboratory Experiments:

Studio work includes best practices of cloud infrastructure principles by integrating cloud servicesto make it scalable, reliable, and highly available. It also leverages CSP Managed Services to enablegreater flexibility and resiliency in an infrastructure. In addition, lab works cover well- architectedframework to optimized underlying cloud resources for any workload.

Text Books :

1.Judith S. Hurwitz and Daniel Kirsch, *Cloud Computing for Dummies* (1st ed.), Hoboken: JohnWiley & Sons, 2020. ISBN 978- 1119546658.

2.Chandra Rajasekharaiah, *Cloud-Based Microservices:Techniques, Challenges, and Solutions* (1st

ed.), Apress, 2020. ISBN 9781484265642.

Reference Books :

1.Silvano Gai, *Building a Future-ProofCloud Infrastructure* (1st ed.), Addison- Wesley, 2020. ISBN 9780136624154.

Name of Program	Master of Technology - Computer Science Engineering				
PCSP311	Mobile and NetworkedEmbedded Systems	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To articulate the concepts of mobile and networked embedded systems.
CO2: To explain the architecture of networked embedded systems.
CO3: To design and develop networking systems for automated applications for smart cities, building, parking.

Course Contents:

Module I **16 lecture hours**

Smart Environments, Paradigms for pervasive networking, Networked Embedded Systems, Wireless Embedded Networking, Applications, Network Topology, Real-time embedded systems,Components of networked embedded systems, Centralized and distributed embedded systems, Physical sensor, Passive sensor, Semi-passive, Active sensors, Soft sensors, Sensor nodes, Hardware architecture. Operating systems for sensor nodes, Mobile sensor network, Sensor networks with mobile nodes.

Module II **14 lecture hours**

Power management and mobile node discovery, Data transfer to mobile nodes, Routing to mobile nodes, Sensor networks with all mobile nodes, Participatory sensing, Vehicular Networked Embedded Systems, Embedded Networks for Car Domains, Intra -vehicular Network Embedded Systems, Event Triggered Systems, Time Triggered Systems, Inter-Vehicular Network Embedded Systems.

Module III **12 lecture hours**

Applications for smart cities (pollution monitoring), Applications for smart cities (smart lighting, context-aware applications), Smart mobility (parking area management), Smart mobility(intelligent transportation systems), Smart buildings (home/building automation, energy efficiency), Social sensing applications.

Text Books :

1.Chattopadhyay S., *EmbeddedSystem and Design* (2nd ed.), Prentice Hall IndiaLearning Private Limited, 2013. ISBN 978-8120347304.

Reference Books :

1. Lyla B. Das, *Embedded Systems: An Integrated Approach* (1st ed.), Pearson EducationIndia, 2012. ISBN 978-8131787663.

2. Peckol, *Embedded Systems* (2nd ed.), Wiley, 2019. ISBN 978-1119457503.

Name of Program	Master of Technology - Computer Science Engineering				
PCSP312	Programming usingC++	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To explain the fundamental programming concepts and methodologies to building C++ programs.

CO2: To implement various OOPs concepts including memory allocation/deallocation proceduresand Member functions.

Course Contents:

Module I **12 lecture hours**

Principles of Object-Oriented Programming, data types, Symbolic constants, Reference by variables, Operators, Operator precedence, Control structures, If-else, Nested If, Switch, break, continue, Functions, main function, Function prototyping, Call by reference, Return by reference, Inline function, Default arguments, Function overloading, Defining a class and member functions,Private member functions, Nesting of member functions.

Module II **16 lecture hours**

Arrays within a class, Arrays of objects, Memory allocation, Static data members, Static member functions, Friendly functions, Objects as function arguments, Returning Objects, Constructors, Default constructor, Parameterized constructor, Copy constructor, Multiple constructors, Constructors with default arguments, Dynamic constructor, Destructors, Rules for overloading, Operator overloading, Unary and binary operator overloading, Overloading using friends, Type conversion, Inheritance, Defining derived classes, Visibility modes, Single inheritance, Multilevel inheritance, Multiple inheritance, Hierarchical inheritance, Hybrid inheritance, Runtime Polymorphism.

Module III **14 lecture hours**

Virtual base classes, Abstract classes, File Handling, Throwing Mechanism, Caching Mechanism, Rethrowing an Exception, Constructors in derived classes, Nesting of classes, Exception Handling, Opening and closing a file, Detecting End-of-file, Sequential input and output operations, Generic Programming using template, Class template, Function template, Class member function template, Function overloading, Standard Template Library: Containers, Stack, List, Queue, Algorithms, Iterators.

Text Books :

1.*Bjarne Stroustrup, The C++Programming Language.(4th ed.), Addison-WesleyProfessional, 2013. ISBN 978-0321563842.*

2.E. Balagurusamy, Object Oriented Programming withC++ (1st ed.), Tata McGraw EducationHill, 2013. ISBN 978-1259029936.

Reference Books :

1.*D Ravichandran, Programming withC++ (3rd ed.), McGraw Hill Education, 2017. ISBN 9780070681897.*

Name of Program	Master of Technology - Computer Science Engineering				
PCSP313	Bioinformatics andComputational Genomics	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:
CO1: To articulate knowledge of Bioinformatics, Computational Biology, and Genomics.
CO2: Implement algorithms and programs related to sequence database, search and alignments, gene prediction and homology.

Course Contents:

Module I **14 lecture hours**

DNA, RNA, Proteins, Splicing, Gene structure, Medicine as a Data-Driven Science, Human Genome Project, Biomedical Data, Exact Sequence Searches: Z-algorithms, Knuth-Morris, Boyer-Moore, Rabin-Karp, Sequence Analysis: Pairwise Sequence Alignment, Homology, Sequence alignment with Dynamic Programming, Extensions of Pairwise Sequence Alignment, Phylogenetic Tree Reconstruction, Biological and Molecular Databases, BLAST Search Engine, Human Variation Databases and Genome Viewers.

Module II **14 lecture hours**

Markov chain, Hidden Markov Model, Viterbi Algorithm, Forward Backward algorithm, HMM for motif finding, Advanced alignment techniques: Linear space, Affine gaps, Banded linear time alignments, Time warping, Burrow Wheeler Index, Next Generation Sequencing, Comparative genomics, Micro arrays, Shotgun sequencing, BAC to BAC sequencing, Phylogeny, Fitch algorithm.

Module III **14 lecture hours**

Multiple sequence alignment, MSA algorithms, Progressive alignment, CLUSTALW, Expectation Maximization, Gibbs Sampling, Genetic Algorithm, Clustering with a Genetic Algorithm, System Biology: Network Analysis,Rational Drug Design, Biomarkers, Human Genomic Variations, Monogenic Diseases, Complex Diseases, Genetic Predisposition to Cancer, Cancer Immunotherapy.

Text Books :

1.*Altuna Akalin,Vedran Franke,BoraUyar and Jonathan Ronen, Computational Genomicswith R (1st ed.), CRC Press, 2020. ISBN 978- 1498781855.*

2.Baxevanis A. D., Wishart D. S., Bader G. D., Bioinformatics (4th ed.), Wiley, 2020. ISBN 978-1119335580.

Reference Books :

1. *Dev Bukhsh Singh and Rajesh KumarPathak, Bioinformatics,Methods and Applications (1st ed.), eBook, 2021. ISBN 978-0323900058.*

Name of Program	Master of Technology - Computer Science Engineering				
PCSP314	Computational Geometry	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To articulate the representation of geometric primitives and evaluation of geometricpredicates.
CO2: To implement Motion Planning and approximation methods, related problems, andalgorithms.

Course Contents:

Module I **16 lecture hours**

Convex Hulls: Naïve Algorithm, Graham's scan, Quick Hull, Chan's algorithm, Polygon Triangulation and partitioning, Triangulations of point sets, Triangulating a monotone polygon, Ear-cutting algorithm, Art gallery problems, Gift Wrapping algorithm, Polyhedra, Fractional cascading, Priority search trees, Plane-sweep intersection, Line segment intersection, Representation and intersection of planar subdivisions, Trapezoidalization, Voronoi Diagrams, Post Office problem, Divide and conquer algorithm, History graphs, Fortune's algorithm, Connection toConvex Hulls.

Module II **16 lecture hours**

Delaunay refinement, Mesh refinement algorithm, Roadmaps, Linear Programming, Half-plane intersection, Arrangements, Duality, Point/line duality, Kirkpatrick's method, Point Location,Convex polygons, Intersection of convex polygons, Extreme point of convex polygon, Search and Intersection, One-dimensional range searching,KD-trees, Range trees, Higher dimensional range trees, Convex Partitioning, Zone theory.

Module III **10 lecture hours**

Motion planning: Shortest paths, Visibility graphs, Approximation Method : Dudley's theorem, Well separated partitioning, Epsilon-Nets, VC Dimension, Geometric set cover, Clustering point sets using Quadtree, Quadtrees epsilon, Construction of epsilon.

Text Books :

1.*M. de Berg, M. van Kreveld, M.Overmars and O.Schwarzkopf, ComputationalGeometry: Algorithms and Applications (CGAA) (3rd ed.), Springer, 2008. ISBN 978- 3642096815.*

Reference Books :

1. *Boissonnat, Jean-Daniel, Chazal,Frédéric, Yvinec and Mariette, Geometric andTopological Inference (1st ed.), Cambridge UniversityPress, 2018. ISBN 978- 1108410892.*

Name of Program	Master of Technology - Computer Science Engineering				
PCSP315	Satellite Data Analysis	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)
By the end of this course, students should have the following knowledge, skills and values:

CO1: To explain the mechanisms of GIS and spatial data towards the preparation of thematic maps.
CO2: To examine and interpret various land features over satellite images.
CO3: To design and implement techniques for land feature recognition and image mosaicking.

Course Contents:

Module I **10 lecture hours**
GIS Data Representation, Geospatial data for GIS applications, Digital representation of geospatialdata, Mapping, Paper based maps vs digital maps, Map scale, Cartography, Electromagneticspectrum, Pre-processing of Satellite Images, Georeferencing, Image enhancement, Ground Control Points collection, Satellite Image Interpretation, Raster Based GIS, Raster representation of data grid size and resolution, Data capture/preparation, Raster to vector conversion, Vector based GIS, Vector representation of data, Spatial data Collection, Sampling, Scaling.

Module II **10 lecture hours**
Type of Spatial Data, Geospatial Analysis, Mobile Geospatial Computing, Spatial Database Management, Standard Data Formats, Modelling Features, Spatial Data Analysis and Modelling, Proximity Analysis, Overlay Analysis, Buffer Analysis Network Analysis, Interaction mechanismsof EM radiation with ground, Spectral response curves, Multi-spectral scanning, Salient characteristics of Satellites.

Module III **12 lecture hours**
Different types of resolutions in Remote Sensing, Image interpretation of different geological landforms, rock types and structures, Remote Sensing integration with GIS and GPS, SAR Technique and its applications, Hyperspectral Remote Sensing, Integrated RS and GIS, Limitationsof Remote Sensing Techniques, 3-dimensional viewing of land features, Spatial maps and Geoservers, Image mosaicking, Keypoint Detection, Projective Layouts, Image interpretation.

Module IV **10 lecture hours**
Onboard data handling in LandSat 8 and 9, Handling reflective bands, Handling thermal infrared bands, Liner adaptive contrasting, Non-linear adaptive contrasting (25), Hubble telescope images, Data Calibration and Pipeline reduction, Chandra X-ray Observatory, Processing False Color Images, 3-Color Composite Image Reduction, Google Earth Engine for large scale and multi- temporal data analysis (25) Limitations and future of satellite Image analysis.

Text Books :
1. *Chang, K. T., Introduction to geographic information systems on (9th ed.), McGraw-Hill Higher Education, 2019. ISBN 978-1260136371.*

2. D. Jude Hemanth, Artificial Intelligence Techniques For Satellite Image Analysis (1st ed.), Springer, 2020. ISBN 9783030241803.

Reference Books :
1.T*imothy Prat, Satellite Communications (3rd ed.), Wiley, 2021. ISBN 9354243037*

2. Qihao Weng and Yuhong He, High Spatial Resolution Remote Sensing (1st ed.), CRCPress, 2018. ISBN 9780429892993.

Name of Program	Master of Technology - Computer Science Engineering				
PCSP316	Special Topics in Computer Engineering	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To familiarize and learn about the latest trends and research in the field.
CO2: To equip themselves with the conceptual and practical experience of few latest methods, tools, technologies or algorithms in Computer Engineering.

Course Contents:

Module I **42 lecture hours**

This course covers the cutting-edge topics in Computer Engineering, and these modules will be chosen by the instructor based on the requirements and relevance at that point of time. These modules need to be relevant to the industry and start-ups will also include related case studies, use cases and implementations scenarios. Students will be working on lab work and projects to get realhands-on experience of these topics and modules.

Name of Program	Master of Technology - Computer Science Engineering				
PCSP317	Cloud System Administration & Operations	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

On completion of this course, the students will be able to:

CO1: To get fundamentals of support and maintain cloud workloads as per the cloud architecture.
CO2: To perform operations by using the cloud management console, CLI and SDK.
CO3: To implement architectural requirements with monitoring, logging, and troubleshooting.

Course Contents:

Module I: **16 lecture hours**

Need of cloud administration and operations, Roles and responsibilities of cloud Admin, Inter-cloud Resource Management, Resource Deployment and Provisioning, Identifying the steps to provision cloud resources, Identify, and remediate deployment issues, Storage and Data Management Connectivity services of public/private cloud Automation and Optimization, Manage and assess resource utilization, Employ cost optimization strategies, Automate manual or repeatable process, Minimize management overhead, Monitoring and Reporting, Maintain metrics and alarms utilizing, Recognize and differentiate performance metrics, Availability metrics, Manage security policies on cloud, Access controls when using cloud, Shared responsibility model.

Module II: **12 lecture hours**

Data Centre Management Tools Integration, Service and Resource Management, implement scalability and elasticity, highly available and resilient environments on cloud, automate snapshots, Data Lifecycle Manager, Data Retention policy, Restore databases versioning, Lifecycle rules, Disaster recovery procedures, Cost optimization strategies, Networking and Content Delivery, Performance optimization strategies.

Module III: **14 lectures hours**

OS boot process (Win/Linux) and Troubleshooting: Memory management, Memory pages, Buffer and Caches, System date/time management, Network time protocol, Network Logs Auditing, Managing Users and groups, File permissions, Assessment/Buffer Lecture, managing software, Managing system services, Background processes, Windows start-up tasks Integrated Internet-aware network troubleshooting, Network tools to report the problem, Network address translation, troubleshooting in common VPC, Troubleshooting in On-premises to VPC, System performance – DISK, System performance – Memory, System performance – Network System Login issues, System booting issues System logs, Network connectivity issues

Text Books :

1. *S., Digby, G., Fitch, C., Friedberg, S., Qualheim, S., Rhoads, J and Sundrud, B, AWS Certified SysOps Administrator Official Study Guide: Associate Exam (1 ed.), John Wiley & Sons, 2017. ISBN 9781119377429.*
2. *Chandra Rajasekharaiah, Cloud-Based Microservices: Techniques, Challenges, and Solutions (1 ed.), Apress, 2020. ISBN 9781484265642.*

Reference Books :

1. *Jackson, K. L., & Goessling, Architecting Cloud Computing Solutions: Build cloud strategies that align technology and economics while effectively managing risk (1 ed.), Packt Publishing Ltd, 2017. ISBN 9781788472425.*

Name of Program	Master of Technology - Computer Science Engineering				
PCSP317	Software Craftmanship in DevOps	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

On completion of this course, the students will be able to:

CO1 : To articulate the concept of Software Craftsmanship
CO2 : To examine the concept of software documentation, structure, testing and validation.
CO3 : To implement the rules and principles of software craftsmanship.

Course Contents:

Module I: **12 lecture hours**

Software Craftsmanship, Four Dimensions of Quality, Software Ethics, Clean code, Craftsmanship Vs Engineering, Frameworks and Tools, Design, Structure, Formatting, and Documentation of Code, Types of Designs/Models, Design Structure Matrix (DSM), Product-Service System using DSM.

Module II: **14 lecture hours**

Process Documentation, Product Documentation, Different Phases of Design, Requirement of Documentation, Advantages of Documentation, Technical and Non-Technical Challenges in Code Documentation, Content Authoring, Formatting, Styling, Issue Tracking, Testing, Publishing, Documentation: Testing, Debugging, Refactoring Improving Structure.

Module III: **08 lectures hours**

Testing and Validation, Different Types of Testing, Properties of Testing, Customizable, Extendable, Link Validity, Component Checking, Semantic, and Syntax Parsing.

Module IV: **08 lectures hours**

Frameworks, Tools, and the Programming Process, DevOps Frame Definition, Agile Framework, Scaled Agile Framework, Adoption Framework, Industry Practices.

Text Books :

1. *Fowler Martin, Refactoring: Improving the Design of Existing Code (2nd ed.), Addison- Wesley, 2019. ISBN 978-0134757599.*

2. *Martin Series Robert C., Software Craftsman, The: Professionalism, Pragmatism, Pride 1st Edition (1st ed.), Addison Wesley, 2020. ISBN 978-0134052502.*

Name of Program	Master of Technology - Computer Science Engineering				
PCSP319	Modern and Contemporary Application in CS	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course-Outcomes (COs):

On completion of this course, the students will be able to:

CO1. Develop the skills to identify and apply modern and contemporary technologies to solve real-world computer science problems.

CO2. Become familiar with programming languages and software tools related to Neche technologies, Analyse the advantages and disadvantages of various technologies and how they impact the world

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Course Contents:

Module I **lecture hours: 42**

This course will provide an overview of modern and contemporary applications of computer science. We will cover topics such as artificial intelligence, machine learning, robotics, data science, cloud computing, and more. We will explore the various technologies and techniques used in each area, as well as their real-world applications. We will also look at the ethical implications of certain applications and the importance of responsible use of computer science technology. The course will also feature programming projects and assignments to give students a practical understanding of the concepts discussed. Learning outcomes include an understanding of the fundamentals of computer science, knowledge of the various applications of computer science, and an ability to apply these concepts to real-world problems.

Name of Program	Master of Technology - Computer Science Engineering				
PCSP320	Latest advances in Engineering and Technology	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course-Outcomes (COs):

On completion of this course, the students will be able to:

CO1. Gain an understanding of the latest engineering and technology advances, their implications, and applications.

CO2. Develop the skills necessary to analyze and apply the latest engineering and technology advances to solve engineering and technology-related problems.

Course Contents:

Module I **lecture hours: 42**

This course will cover the latest advances in engineering and technology, including topics such as artificial intelligence, machine learning, robotics, control systems, Internet of Things, big data, cloud computing, and more. Students will learn about the newest technologies, their applications, and their implications for engineering and technology. They will also explore case studies and gain a better understanding of how current technologies are being used in the industry today. Students will develop their knowledge of the fundamentals of engineering and technology and learn how to apply them to solve real-world problems. Additionally, students will develop their ability to think critically and strategically about the current state of engineering and technology.

Open Electives

Name of Program	Master of Technology - Computer Science Engineering				
PCSO401	Business Analytics	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To introduce students to data-driven decision-making in business contexts.
CO2: To develop skills in using analytical tools and techniques for business problem-solving.
CO3: To understand the role of analytics in optimizing business processes.

Course Contents:

Module I **08 lecture hours**
Definition, scope, and applications of business analytics, Types: Descriptive, predictive, and prescriptive analytics, Role of analytics in decision-making.

Module II **08 lecture hours**
Data collection, cleaning, and preprocessing, Data visualization techniques (charts, dashboards), Tools: Excel, Tableau, Power BI (introduction).

Module III **08 lecture hours**
Probability distributions, hypothesis testing, regression analysis, Time-series analysis and forecasting.

Module IV **08 lecture hours**
Machine learning basics: Classification, clustering, decision trees, Applications in customer segmentation and demand forecasting.

Module V **10 lecture hours**
Analytics in marketing, finance, and operations, Hands-on projects using real-world datasets.

Text Books/Reference Books :

1. Evans, J. R. (2016). *Business Analytics*. Pearson.
2. Albright, S. C., & Winston, W. L. (2017). *Business Analytics: Data Analysis & Decision Making*. Cengage Learning.

Name of Program	Master of Technology - Computer Science Engineering				
PCSO402	Industrial Safety	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To introduce optimization techniques for decision-making.
CO2: To develop skills in mathematical modeling and problem-solving.
CO3: To apply operations research tools in engineering and management.

Course Contents:

Module I **08 lecture hours**
Importance of safety in industries, Types of hazards: Mechanical, chemical, electrical, fire, Safety management systems.

Module II **08 lecture hours**
Hazard identification and risk analysis, Techniques: HAZOP, FMEA, Fault Tree Analysis.

Module III **08 lecture hours**
OSHA, ISO 45001, and local safety laws, Personal protective equipment (PPE) and its applications.

Module IV **08 lecture hours**
Fire prevention, detection, and firefighting systems, Electrical safety: Lockout/Tagout, grounding.

Module V **10 lecture hours**
Industrial accident case studies, Conducting safety audits and preparing reports.

Text Books :

1. Goetsch, D. L. (2019). *Occupational Safety and Health for Technologists, Engineers, and Managers*. Pearson.
2. Reese, C. D. (2016). *Industrial Safety and Health Management*. CRC Press.

Name of Program	Master of Technology - Computer Science Engineering				
PCSO403	Operations Research	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	Basic mathematics and linear algebra.				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To introduce optimization techniques for decision-making.
CO2: To develop skills in mathematical modeling and problem-solving.
CO3: To apply operations research tools in engineering and management.

Course Contents:

Module I **08 lecture hours**
Definition, scope, and applications, Phases of OR: Problem formulation, modeling, solution.

Module II **10 lecture hours**
Formulation, graphical method, simplex method, Duality and sensitivity analysis.

Module III **08 lecture hours**
Transportation models, Vogel's approximation method, Assignment models, Hungarian method.

Module IV **08 lecture hours**
Transportation models, Vogel's approximation method, Assignment models, Hungarian method.

Module V **08 lecture hours**
Transportation models, Vogel's approximation method, Assignment models, Hungarian method.

Text Books/ Reference Books :

1. Taha, H. A. (2017). Operations Research: An Introduction. Pearson.
2. Hillier, F. S., & Lieberman, G. J. (2021). Introduction to Operations Research. McGraw-Hill.

Name of Program	Master of Technology - Computer Science Engineering				
PCSO404	Cost Management of Engineering Projects	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	Basic knowledge of project management				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To understand cost estimation and budgeting in engineering projects.
CO2: To learn techniques for cost control and financial analysis.
CO3: To apply cost management principles to optimize project outcomes.

Course Contents:

Module I **08 lecture hours**
Importance of cost management in projects, Cost components: Direct, indirect, fixed, variable.

Module II **08 lecture hours**
Analogous, parametric, and bottom-up estimation, Cost estimation tools and software.

Module III **08 lecture hours**
Developing project budgets, Earned Value Management (EVM), variance analysis.

Module IV **08 lecture hours**
Break-even analysis, NPV, IRR, Risk analysis in cost management.

Module V **10 lecture hours**
Cost management in construction, IT, and manufacturing projects, Group project: Preparing a cost management plan.

Text Books :

1. Kerzner, H. (2017). *Project Management: A Systems Approach to Planning, Scheduling, and Controlling*. Wiley.
2. Burke, R. (2013). *Project Management: Planning and Control Techniques*. Wiley.

Name of Program	Master of Technology - Computer Science Engineering				
PCSO405	Composite Materials	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	-				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To understand the properties and applications of composite materials.
CO2: To learn manufacturing and testing methods for composites.
CO3: To explore the design of composite structures.

Course Contents:

Module I **08 lecture hours**
Definition, types (polymer, metal, ceramic matrix composites), Advantages and limitations of composites.

Module II **08 lecture hours**
Fibers (glass, carbon, aramid), matrices, and interfaces, Mechanical and thermal properties.

Module III **08 lecture hours**
Lay-up, filament winding, pultrusion, resin transfer molding; Quality control in manufacturing.

Module IV **08 lecture hours**
Lay-up, filament winding, pultrusion, resin transfer molding, Quality control in manufacturing.

Module V **10 lecture hours**
Lay-up, filament winding, pultrusion, resin transfer molding, Quality control in manufacturing.

Text Books/ Reference Books:

1. Mallick, P. K. (2007). *Fiber-Reinforced Composites: Materials, Manufacturing, and Design*. CRC Press.
2. Chawla, K. K. (2012). *Composite Materials: Science and Engineering*. Springer.

Name of Program	Master of Technology - Computer Science Engineering				
PCSO406	Waste to Energy	L	T	P	C
Owning School/Department	Computer Science and Engineering	3	0	0	3
Pre-requisites/Exposure	Basic knowledge of environmental science or energy systems.				

Course Outcomes (COs)

By the end of this course, students should have the following knowledge, skills and values:

CO1: To understand technologies for converting waste to energy.
CO2: To explore sustainable waste management practices.
CO3: To evaluate the environmental and economic impacts of waste-to-energy systems.

Course Contents:

Module I **08 lecture hours**
Types of waste: Municipal, industrial, agricultural, Overview of waste-to-energy technologies.

Module II **08 lecture hours**
Incineration, gasification, pyrolysis, Energy recovery from thermal processes.

Module III **08 lecture hours**
Anaerobic digestion, fermentation, Biogas and bioethanol production.

Module IV **08 lecture hours**
Emissions control, ash management, Cost-benefit analysis of WTE systems.

Module V **10 lecture hours**
WTE plants: Design and operation, Innovations in waste-to-energy technologies.

Text Books/ Reference Books:

1. Rogoff, M. J., & Screve, F. (2019). *Waste-to-Energy: Technologies and Project Implementation*. Academic Press.
2. Klinghoffer, N. B., & Castaldi, M. J. (2013). *Waste to Energy Conversion Technology*. Woodhead Publishing.