Kerala University of Digital Sciences, Innovation and Technology

M.Tech Computer Science and Engineering
and
M.Sc Computer Science

Scheme and Syllabus
2023 Admission

August 2023

School of Computer Science and Engineering (SoCSE)

School of Computer Science and Engineering

The School of Computer Science and Engineering (SoCSE) of the Kerala University of Digital Sciences, Innovation and Technology (KUDSIT) was established in 2020 in the Technocity Campus, Trivandrum. The school offers the academic programs M.Tech Computer Science and Engineering, M.Sc Computer Science, and Ph.D.

Vision

To become a world-class centre of advanced learning, research and development, and societal outreach in the field of Computer Science and Engineering.

Mission

To provide an enriching scholastic environment that nurtures innovative and effective ways of knowledge creation, dissemination, and application to facilitate world-class education and cutting-edge research in Computer Science and Engineering, thereby contributing to society nationally and globally.

Objectives

SoCSE targets to focus its activities in the following dimensions:

- World-class research and academics with national and international collaborations.
- Nurturing a globally competent and socially responsible talent pool through academic programmes.
- Commercialization of research outcomes through consultancy, collaborative new business initiatives, and promotion of entrepreneurship.
- Creating an inclusive and collaborative environment fosters local, sustainable, and globally relevant knowledge and expertise.

Master of Technology (M.Tech) in Computer Science and Engineering (intake: 90)

M.Tech in Computer Science and Engineering will be offered with three specializations: Artificial Intelligence, Connected Systems and Intelligence, and Cyber Security Engineering. The students must choose one of the specializations in the second semester. The admission and eligibility requirements for all the three specializations are the same.

Three Specializations:

Artificial Intelligence

The annual growth rate of artificial intelligence (AI) is predicted to be 33.2% between 2020 and 2027. The market growth of AI is hampered due to a need for more experienced and trained professionals. This programme would transform and strengthen industries across the globe. It focuses on intelligence exhibited by the machines and is a hybrid intelligence, where AI systems and humans work together. The curriculum offers an opportunity to approach AI from a technical perspective that focuses on understanding, analyzing, and developing novel AI algorithms and social and human perspectives. Decision-making, problem-solving, perception, and understanding human communication (in any language and translation) for computers would be the key elements taught in this programme. This programme provides the foundation and advanced skills in the principles and technologies that underlie AI, including logic, knowledge representation, probabilistic models, and machine learning. Students can pursue topics in depth, with robotics, vision, and natural language processing courses available.

Connected Systems and Intelligence

The future era of the digitally connected world envisages being governed by intelligent connected devices aware of the context and the location and envisions cognitive decision making through smart data analytics. The synergy derived from the combination of artificial intelligence, big data analytics, the Internet of Things, and cloud and edge computing contributes significantly to realizing the automated interaction of real-world physical systems. In 2025, according to the International Data Corporation, 41.6 billion connected IoT devices would generate 79.4 zettabytes of data. Future systems will rely on data intelligence tools and approaches to identify hidden patterns, unknown correlations, and other relevant information from massive amounts of data.

Graduates from this master's programme are expected to develop novel solutions for intelligent and resilient networked systems and contribute to the design of stable digitally connected ecosystems involving distributed systems, computer vision, ubiquitous computing, machine learning, data science, and security services. They will be experts in the field, qualified for exciting careers in industry or doctoral studies.

Three key UN sustainable development goals addressed by this master programme are industry, innovation, and infrastructure (09), sustainable cities and communities (11), and responsible production and consumption (12). Both connected systems and data intelligence play a crucial role in enabling technologies to achieve the above mentioned objectives, such as

developing smart cities, safe and efficient transport systems, and efficient resource consumption and production.

Cyber Security Engineering

Cyber security remains one of the most growth-oriented career fields in the computer science domain. The Cyber Security Engineering degree programme focuses on the fundamentals of developing, engineering, and operating secure information systems. Graduates of this programme will be able to solve complex cyber security issues affecting various businesses worldwide and propose new solutions. Graduates will likely be employed in law enforcement, government, or other related agencies as cyber security specialists, in commercial IT Schools or security consultancies, or in different computing positions where cyber security is a significant issue. Opportunities also exist for further academic study toward a Ph.D and a research career.

M.Tech Programs Offered and Eligibility Requirements

Programme	Specialization	Duration	Minimum Eligibility for admission
Full-time Master of Technology (M.Tech) in Computer Science and Engineering	Artificial Intelligence	2 years (4 semesters)	● B.Tech/BE in CS/IT/ECE or related areas/MCA/M.Sc in CS/IT/Mathematics/ Statistics/Physics
	Cyber Security Engineering	2 years (4 semesters)	
	Connected Systems and Intelligence	2 years (4 semesters)	

Master of Science (M.Sc) in Computer Science (intake: 90)

M.Sc in Computer Science will be offered with two specializations: Cyber Security and Machine Intelligence. The students must choose one of the specializations while taking the admission. The admission and eligibility requirements for all the two specializations are the same.

Two Specializations:

Cyber Security

Cyber security, also known as computer security or IT security, applies to computers, computer networks, and the data stored and transmitted over them. The field is increasingly important due to the increasing reliance on computer systems. Governments, military, corporations, financial institutions, hospitals, and other businesses collect, process, and store confidential computer information and transmit that data across networks to other computers. The field of cyber security has increased in recent years. The subject embraces technologies such as

cryptography, machine learning, computer security, network security, ethical hacking forensics and fraud detection, and management of security and trade-offs while implementing information security.

With the growing volume and sophistication of cyber-attacks, ongoing attention is required to protect sensitive business and personal information and safeguard national security. By offering the M.Sc in Computer Science specializing in Cyber Security, we can harness students open to challenging job options in corporate and allied sectors, academics, R&D, government, etc.

Machine Intelligence

Master's programme in Machine Intelligence enables students to design, implement, and analyze intelligent systems. Intelligent decision-making and learning and intelligent web-based systems are areas of growing emphasis in the digital world. Machine learning algorithms can figure out how to perform important tasks by generalizing from examples. This is often feasible and cost-effective when manual programming is not. Machine learning (data mining, pattern recognition, and predictive analytics) is used widely in business, industry, science, and government, and there is a significant shortage of experts. This course provides the necessary foundation in Machine Intelligence and other core subjects for a graduate-level computer science education. Computers are learning to think, read, and write while picking up human sensory functions, with the ability to see and hear (arguably to touch, taste, and smell, though those have been of a lesser focus). Machine intelligence technologies cut across many problem types (from classification and clustering to natural language processing and computer vision) and methods (from support vector machines to deep belief networks). All of these technologies are reflected in this landscape.

M.Sc Programs Offered and Eligibility Requirements

Programme	Specialization	Duration	Minimum Eligibility for admission
Full-time Master of Science (M.Sc) in Computer Science	Cyber Security	2 years (4 semesters)	● B.Tech/BE in any branch. ● B.Sc with Mathematics as a core or complementary subject. ● BA Mathematics ● BCA
	Machine Intelligence	2 years (4 semesters)	

Program Structure

On average, each master's program is expected to have a maximum of 80 credits and a minimum of 70 credits.

One credit equates to 1 hour of contact classes (lectures or tutorials) per week or 2 hours of student workload (project, labs, or self-study). Given that there will be 15 teaching weeks, 1 hour of contact hour per week counting for 15 hours in a semester or, on average, 2 hours of self-learning hours or coursework activities counting for 30 hours of activities in a semester.

The normal duration to complete the master's program shall be 24 months, divided into four semesters. However, the student may be allowed to complete the program in 48 months. Zero year is permitted for medical reasons or for engaging in startups. To avail of zero years as part of the startups, the student must be a founder on the director board of a company registered as a startup. Any other reasons for availing of a zero year will be accessed on a case-to-case basis by the school committee for consideration of approval by the dean academic. The zero year does not count towards the total duration of the program.

The master programs of the university will have the following credit distribution:

Program courses (30 credits)		University courses (20 credits)		Final year Projects	Additional credits beyond mandatory course work and project		
Program Core (Mandatory)	Program electives (Mandatory)	University Core (Mandatory)	Open electives (Mandatory)	Capstone Project/ Thesis (Mandatory)	Activity credits (Mandatory)	Activity credits (Optional)	Additional courses (Optional)
15 credits	15 credits	5 credits	15 credits	15 credits	5 credits	5 credits	5 credits

Upto 15 credits can be through online/Swayam.

Group Projects must be incorporated within the allowed program elective/open program electives.

Every master’s program will have a university core that will have a single course called - **Digital Access for Community Empowerment** that covers four components:

A. Two credit modules are called Community Empowerment (CE). This is a five days outbound program where students get exposed to problems facing society and explore ways to use digital technologies to find solutions. At the end of the program, the students are expected to work and report their findings through a short dissertation.

B. One credit module is Digital Experience Laboratory (DEL), where hands-on lab projects expose them to various digital technologies. Each school may have its own curriculum for this course.

C. One credit module is Design Thinking and Innovation (DTI), where students will be exposed to applying innovative thinking in digital sciences.

D. One credit module on Personal Development and Scientific Communication (PDSC).

E. The students will complete this course through an interdisciplinary group project that covers all four modules. Each project group will have faculty mentors who will guide the students. The academic office will allocate the mentors. Every faculty will be responsible for at most ten students every year for mentorship. Each faculty will also have a teaching assistant, whom the faculty could select for the day-to-day administration of the mentoring program.

Every course needs to have a detailed course outline addressing the following components:

1. Objectives and expectations from the course
2. Why is this course essential and relevant to industry/research
3. Learning outcomes and mapping with program outcomes, assessments, and teaching methods
4. A detailed teaching and learning plan

The courses within the master's program can be classified into the following categories:

A. 100-level courses that are intended to fill gaps in Undergraduate level studies. This level, of course, is expected to cover, remember, and understand levels in Bloom's taxonomy.

B. 200-level courses that are intended to fill gaps in Undergraduate level studies. They usually are equivalent to advanced-level courses in undergraduate programs. This level, of course, is expected to cover, understand, and apply levels in Bloom's taxonomy.
C. 300-level courses that are intended to be Postgraduate level instruction-based courses. This level, of course, is expected to cover applying and analyzing levels in Bloom's taxonomy.
D. 400-level courses are intended to be Postgraduate level seminars or research-based courses. This level, of course, is expected to cover, analyze, and evaluate levels in Bloom's taxonomy.
E. 500-level courses that are intended to be research-based. This level, of course, is expected to cover, evaluate, and create levels in Bloom's taxonomy.

It is expected that master's programs with a three-year undergraduate degree as the minimum admission requirement will have the following limits on credits and distribution of courses within the program.

Course level	Credits
100 Level course	1-4 Credits
200 Level course	3-15 credits
300 Level courses	15-30 Credits
400 Level courses	6-15 Credits
500 Level courses	0-3 Credits

It is expected that master's programs with a four-year undergraduate degree as the minimum admission requirement will have the following limits on credits and distribution of courses within the program.

Course level	Credits
100 Level course	0-3 Credits
200 Level course	0-9 credits
300 Level courses	15-45 Credits
400 Level courses	15-30 Credits
500 Level courses	0-6 Credits

The common courses will be limited to the following levels:

Course type	Course level
University Core/Open Electives	100/200/300/400 Level
Mini-Project	300/400/500 Level
Final Project	400/500 Level

The minimum semester-wise distribution of credits expected in the master’s program are:

Minimum 70 credits Maximum 80 credits

Semester 1
5 credits for university core
15 credits for program core/program electives
Optional: 3 credits for projects/internship/inter-School courses/approved online courses/extra curricular credits/bridge courses

Semester 2
15 credits for program core/program electives/Open electives
Optional: 3 credits for projects/internship/inter-School courses/approved online courses/extra curricular credits/bridge courses

Semester 3
15 credits for program electives/Open electives
Optional: 3 credits for projects/internship/inter-School courses/approved online courses/extra curricular credits/bridge courses

Semester 4
15 credits for master thesis/Capstone project/internship
Optional: 3 credits for projects/internship/inter-School courses/approved online courses/extra curricular credits/bridge courses

Program Planning

The student will be responsible for complying with the program-level requirements. The semester-wise limits for the courses are:

Semester	University Core	School Core (maximum)	School/Open Elective courses	Capstone Project/thesis
Semester 1 (Range 15-18 credits)	3-5 credits (compulsory)	15 credits (compulsory)	0-15 credits	0 credits
Semester 2 (Range 15-18 credits)	0-5 credits (compulsory)	0-10 credits (compulsory)	15 Credits	0-3 credits
Semester 3 (Range 15-18 credits)	0-5 credits (compulsory)	0 credits (compulsory)	15 Credits	0-15 credits
Semester 4 (Range 15-18 credits)	0 credits	0 credits	0-9 Credits	15 Credits

Credit Requirements for the Master Program

Students must comply with the following credit limits for completing a master's program.

A. Complete a minimum of 70 Credits, with an upper limit of 80.
B. The students are allowed to take a maximum of 20 Credits in a semester.

C. The students are allowed to take a maximum of 12 Credits through audit courses. These credits do not count toward total credits for the program.
D. The students are allowed to obtain a maximum of 12 Credits through challenge exams. These credits count towards the total credits for the program.

Pass Criteria

A. There shall be no barrier between Year 1 and Year 2 of study.
B. The student shall obtain a minimum D grade in all core courses and a C in the project.
C. A minimum CGPA of 5 is required to award the master's degree.
D. All challenge examination courses and MOOC courses will not be counted for CGPA computation. However, passing such courses will enable them to be counted towards the total credits earned.
E. Project grade will be included in the CGPA calculations.

Grade Point Calculation

A. A letter grade system evaluates work items per the University's Policies and Procedures requirements.

B. The university follows a grade point system with a scale of 10 defined as:

Grade	Percentage of Marks	Grade Points	Remarks
S	95% and above	10	Outstanding
A+	90% to less than 95%	9	Excellent
A	80% to less than 90%	8	Very Good
B+	70% to less than 80%	7	Good
B	60% to less than 70%	6	Above Average
C	50% to less than 60%	5	Average
D	40% to less than 50%	4	Pass
E	30% to less than 40%	2	Low Pass
F	Below 30%	0	Fail

AB will be represented for Absent, and its GP is considered as 0.

" I " will represent incomplete.

- The minimum grade point required for passing a course is 4.
- The cumulative grade point averages (CGPA) are calculated by weighing grade points by the corresponding credit numbers. The thesis grade counts toward the GP by using the

same formula; that is, it is weighed by the credit number assigned to the thesis. The Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA) are calculated using the standard formula.

M.Tech in Computer Science and Engineering with Specialization in Cyber Security Engineering/Artificial Intelligence/Connected Systems and Intelligence (AY 2023-24 Onwards)

Semester 1				
Course Code	**Title of the Course**	**Credits**	**Credit Split Lecture/Lab/ Seminar/Project**	**Level**
M3000000	Digital Access for Community Empowerment I	3		300
M2000000	Mathematics for Computer Science	3	3-0-0-0	200
M3000002	AI and Machine Learning	4	3-1-0-0	300
	Open Elective	3 or 4		
M3000003	Advanced Data Structures and Algorithms	4	3-1-0-0	300
M1000000	Technical Communication	2	1-1-0-0	100
	Activity	1		
Total Credits		20		

Semester 2				
Course Code	**Title of the Course**	**Credits**	**Credit Split Lecture/Lab/ Seminar/Project**	**Level**
M3000001	Digital Access for Community Empowerment II	2		300
M3000004/ M3000005	Advanced Distributed Systems/Data and Intelligence	3	3-0-0-0	300
	Program Elective	9		300/400
	Open Elective	3		300/400
	Activity	2		
Total Credits		19		

Semester 3				
Course Code	**Title of the Course**	**Credits**	**Credit Split Lecture/Lab/ Seminar/Project**	**Level**
	Program Elective	6		300/400
	Open Elective	9		300/400

	Activity	2		
Total Credits		17		

Semester 4				
Course Code	**Title of the Course**	**Credits**	**Credit Split Lecture/Lab/ Seminar/Project**	**Level**
M4010002	Thesis	15	0-0-0-15	400
Total Credits		15		

Activity: Group project/internship/inter-School courses/approved online courses/extra curricular credits/bridge course/approved certifications.

Program Electives for Cyber Security Engineering (Minimum 15 Credits Required)				
Course Code	**Title of the Course**	**Credits**	**Credit Split Lecture/Lab/ Seminar/Project**	**Level**
M3000009	Introduction to Cyber Security	3	2-1-0-0	300
M3000010	Computer Networks and Security	3	2-1-0-0	300
M3000011	Cryptography	3	2-1-0-0	300
M3000012	Cyber Analytics	3	2-1-0-0	300
M3000013	Malware Analysis and Reverse Engineering	3	2-1-0-0	300
M3000014	Ethical Hacking and Penetration Testing	3	2-1-0-0	300
M3000015	Digital Forensics	3	2-1-0-0	300
M3000016	Database Security	3	2-1-0-0	300
M3000017	Artificial Intelligence for Cyber Security	3	2-1-0-0	300
M3000018	Hardware Security	3	2-1-0-0	300
M3000019	IoT Networks and Endpoint Security	3	2-1-0-0	300
M3000020	Mobile Application Security	3	2-1-0-0	300
M3000021	Systems Security and Risk Analysis	3	2-1-0-0	300
M3000022	Information Security Management System	3	2-1-0-0	300
	Approved SWAYAM Courses in Cyber Security	1-6		300
M4010000	Group Project in Cyber Security	3	0-0-0-3	400
M4010001	Research Project in Cyber Security	3	0-0-0-3	400

Program Electives for Artificial Intelligence (Minimum 15 Credits Required)				
Course	**Title of the Course**	**Credits**	**Credit Split**	**Level**

Code			Lecture/Lab/ Seminar/Project	
M3000023	Data Analytics	3	2-1-0-0	300
M3000024	Digital Image and Video Processing	3	2-1-0-0	300
M3000025	Deep Learning	3	2-1-0-0	300
M3000026	Reinforcement Learning	3	2-1-0-0	300
M3000027	Computer Vision	3	2-1-0-0	300
M3000028	Soft Computing	3	2-1-0-0	300
M3000029	Natural Language Processing	3	2-1-0-0	300
M3000030	Speech Processing	3	2-1-0-0	300
M3000031	Cognitive Computing	3	2-1-0-0	300
M3000032	Big Data Technologies	3	2-1-0-0	300
	Approved SWAYAM Courses in AI	1-6		300
M4010000	Group Project in AI	3	0-0-0-3	400
M4010001	Research Project in AI	3	0-0-0-3	400

Program Electives for Connected Systems and Intelligence (Minimum 15 Credits Required)				
Course Code	**Title of the Course**	**Credits**	**Credit Split Lecture/Lab/ Seminar/Project**	**Level**
M3000009	Introduction to Cyber Security	3	2-1-0-0	300
M3000010	Computer Networks and Security	3	2-1-0-0	300
M3000011	Cryptography	3	2-1-0-0	300
M3000017	Artificial Intelligence for Cyber Security	3	2-1-0-0	300
M3000018	Hardware Security	3	2-1-0-0	300
M3000019	IoT Networks and Endpoint Security	3	2-1-0-0	300
M3000021	Systems Security and Risk Analysis	3	2-1-0-0	300
M3000033	Software Defined Networking	3	2-1-0-0	300
M3000034	Social Network Analytics and Security	3	2-1-0-0	300
M3000035	Wireless Sensor Networks	3	2-1-0-0	300
M3000036	Connected Environments and Enabling Technologies	3	2-1-0-0	300
	Approved SWAYAM Courses in Connected Systems and Intelligence	1-6		300
M4010000	Group Project in Connected Systems and Intelligence	3	0-0-0-3	400
M4010001	Research Project in Connected Systems and Intelligence	3	0-0-0-3	400

M.Sc. in Computer Science with Specialization in Cyber Security/Machine Intelligence (AY 2023-24 Onwards)

Semester 1				
Course Code	**Title of the Course**	**Credits**	**Credit Split Lecture/Lab/ Seminar/Project**	**Level**
M3000000	Digital Access for Community Empowerment I	3		300
M2000000	Mathematics for Computer Science	3	3-0-0-0	200
M3000007/ M3000002	Python Programming /AI and Machine Learning	4	3-1-0-0	300
M3000006/ M3000003	Data Structures and Algorithms / Advanced Data Structures and Algorithms	4	3-1-0-0	300
M3000008	Database Systems	3	3-0-0-0	300
M1000000	Technical Communication	2	1-1-0-0	100
	Activity	1		
M0000000	Preparatory Mathematics	0		
Total Credits		20		

Semester 2				
Course Code	**Title of the Course**	**Credits**	**Credit Split Lecture/Lab/ Seminar/Project**	**Level**
M3000001	Digital Access for Community Empowerment II	2		300
	Program Elective	6		300/400
	Open Elective	9		300/400
	Activity	2		
Total Credits		19		

Semester 3				
Course Code	**Title of the Course**	**Credits**	**Credit Split Lecture/Lab/ Seminar/Project**	**Level**
	Program Elective	9		300/400
	Open Elective	6		300/400
	Activity	2		
Total Credits		17		

Semester 4				
Course Code	**Title of the Course**	**Credits**	**Credit Split Lecture/Lab/ Seminar/Project**	**Level**
M4022002/ M4021002	Project/Thesis	15	0-0-0-15	400
Total Credits		15		

Activity: Group project/internship/inter-School courses/approved online courses/extra curricular credits/bridge course/approved certifications

Program Electives for Cyber Security (Minimum 15 Credits Required)				
Course Code	**Title of the Course**	**Credits**	**Credit Split Lecture/Lab/ Seminar/Project**	**Level**
M3000009	Introduction to Cyber Security	3	2-1-0-0	300
M3000010	Computer Networks and Security	3	2-1-0-0	300
M3000011	Cryptography	3	2-1-0-0	300
M3000012	Cyber Analytics	3	2-1-0-0	300
M3000013	Malware Analysis and Reverse Engineering	3	2-1-0-0	300
M3000014	Ethical Hacking and Penetration Testing	3	2-1-0-0	300
M3000015	Digital Forensics	3	2-1-0-0	300
M3000016	Database Security	3	2-1-0-0	300
M3000017	Artificial Intelligence for Cyber Security	3	2-1-0-0	300
M3000018	Hardware Security	3	2-1-0-0	300
M3000020	Mobile Application Security	3	2-1-0-0	300
M3000022	Information Security Management System	3	2-1-0-0	300
	Approved SWAYAM Courses in Cyber Security	1-6		300
M4022000	Group Project	3		400
M4022001	Research Project	3		400

Program Electives for Machine Intelligence (Minimum 15 Credits Required)				
Course Code	**Title of the Course**	**Credits**	**Credit Split Lecture/Lab/ Seminar/Project**	**Level**
M3000023	Data Analytics	3	2-1-0-0	300
M3000024	Digital Image and Video Processing	3	2-1-0-0	300
M3000025	Deep Learning	3	2-1-0-0	300
M3000026	Reinforcement Learning	3	2-1-0-0	300
M3000027	Computer Vision	3	2-1-0-0	300

M3000028	Soft Computing	3	2-1-0-0	300
M3000029	Natural Language Processing	3	2-1-0-0	300
M3000030	Speech Processing	3	2-1-0-0	300
M3000031	Cognitive Computing	3	2-1-0-0	300
M3000032	Big Data Technologies	3	2-1-0-0	300
	Approved SWAYAM Courses in AI	1-6		300
M4021000	Group Project	3		400
M4021001	Research Project	3		400

Open Electives offered by SoCSE				
Course Code	**Title of the Course**	**Credits**	**Credit Split Lecture/Lab/ Seminar/Project**	**Level**
M1000000	Technical Communication	2	1-1-0-0	100
M3000002	AI and Machine Learning	3	2-1-0-0	300
M3000007	Python Programming	4	3-1-0-0	300
M3000009	Introduction to Cyber Security	3	2-1-0-0	300
M3000032	Big Data Technologies	3	2-1-0-0	300
M3000037	Operating Systems	3	2-1-0-0	300
M3000038	Blockchain Technology	3	2-1-0-0	300
M3000039	Augmented and Virtual Reality	3	2-1-0-0	300
M3000040	Optimization Techniques	3	2-1-0-0	300
M3000041	Computer Architecture	3	2-1-0-0	300
M3000042	Quantum Computing	3	2-1-0-0	300
M3000043	Web Technology	3	2-1-0-0	300
M3000044	OOPS and JAVA	3	2-1-0-0	300
M3000045	Object Oriented Software Engineering	3	2-1-0-0	300
M3000046	Cloud and Edge Computing	3	2-1-0-0	300
M4000000	Topics in Cyber Security Engineering	9	0-0-0-9	400
M4000000	Topics in AI	9	0-0-0-9	400
M4000000	Topics in Connected System and Intelligence	9	0-0-0-9	400

Theory Courses

PREPARATORY MATHEMATICS

Course Code	Course Name	Credit	Year of Introduction
M0000000	Preparatory Mathematics	0	2023

Prerequisites: Nil

Course Objectives:

1. To equip students with the necessary mathematics background for the postgraduate level Mathematics and Computer Science courses.
2. To serve as a refresher course for Mathematics.
3. To help the students develop the ability to solve problems using the learned concepts.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Gain enough mathematical maturity to do the postgraduate level computer science courses**.**

CO2: Analyze and evaluate critically the appropriate mathematical techniques required for solving various problems.

CO3: Apply mathematical techniques to solve various problems.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge.

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature.

PLO 3 Apply for a scholarship to conduct independent and innovative research.

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences.

PLO 5 Practice ethical standards of professional conduct and research.

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	3	3	0		
CO2	3	3	3	2		
CO3	3	3	3	2		

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Basic Properties of the integers, divisibility and primality, LCM, GCD, real numbers, properties of real numbers, Complex numbers, algebra of complex numbers

2	Sets, Set Operations, Functions, Sequences and Summations, Counting, Permutation, Combination.
3	Statistical population and sample, Measures of central tendency, Measures of dispersion, Skewness, Kurtosis.
4	Functions, limits, continuity, derivatives, Product, quotient, and chain rules.

Text Books:

1. Discrete Mathematics and its Applications, Kenneth Rosen, McGraw Hill Education; 7th edition
2. Calculus and Analytic Geometry, G B Thomas, R L Finney, Pearson Education India
3. Statistics, Freedman , Purves, Pisani, Viva Books; Fourth edition
4. Thomas Koshy, Elementary number theory with Applications, Elsevier.

DIGITAL ACCESS FOR COMMUNITY EMPOWERMENT I

Course Code	Course Name	Credit	Year of Introduction
M3000000	**Digital Access for Community Empowerment I**	**3**	**2023**

Prerequisites: Nil

Course Objectives:

1. Orient students to identify real-life problems beyond the classrooms through community engagement.
2. Exposing the students to human problems for which digital solutions are thought through to the ideational level and beyond.
3. Familiarize students with the interface between society and technological/digital solutions.
4. Enabling them to understand social innovation and define digital solutions.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Develop the ability to identify societal problems that can be transformed into digital solutions by fostering effective teamwork and communication skills.

CO2: Enhance creative thinking and problem-solving by employing brainstorming, ideation, and lateral thinking techniques within a multidisciplinary group.

CO3: Cultivate self-awareness and empathy, essential for collaboratively identifying and addressing community issues within a supportive learning environment.

Program Learning Outcomes:

PLO 1 Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and specialization to the solution of complex engineering problems

PLO 2 Problem analysis: Identify, formulate, research literature, and analyze engineering problems to arrive at substantiated conclusions using the first principles of mathematics, natural, and engineering sciences.

PLO 3 Design/development of solutions: Design solutions for complex engineering problems

and design system components processes to meet the specifications with consideration for public health and safety and cultural, societal, and environmental considerations.

PLO 4 Conduct investigations of complex problems: Use research-based knowledge, including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PLO 5 Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling for complex engineering activities with an understanding of the limitations.

PLO 6 The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PLO 7 Environment and sustainability: Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.

PLO 8 Ethics: Apply ethical principles and commit to professional ethics, responsibilities, and norms of the engineering practice.

PLO 9 Individual and team work: Function effectively as an individual, member, or leader in teams and multidisciplinary settings.

PLO 10 Communication: Communicate effectively with the engineering community and with society at large. Be able to comprehend and write effective reports and documentation. Make effective presentations, and give and receive clear instructions.

PLO 11 Project management and finance: Demonstrate knowledge and understanding of engineering and management principles and apply these to one's work as a member and leader in a team. Manage projects in multidisciplinary environments.

PLO 12 Life-long learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of course outcomes with program learning outcomes:

	PLO 1	**PLO 2**	**PLO 3**	**PLO 4**	**PLO 5**	**PLO 6**	**PLO 7**	**PLO 8**	**PLO 9**	**PLO 10**	**PLO 11**	**PLO 12**
CO1	2	3	1	3	2	3	3	3	3	3	2	3
CO2	2	3	2	3	2	2	3	2	3	2	3	3
CO3	1	2	1	3	3	1	3	1	2	1	2	3

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	**Content**

Design Thinking and Innovation- 1 Credit	Icebreaker Activity to Build Group Cohesion, Overview of Design Thinking and Its Relevance to Community Problem-Solving, Understanding the Importance of Empathy in Identifying Community Problems, Empathy Building Exercises, Techniques for Problem Framing and Defining Community Issues, Brainstorming and Ideation Methods Creating an Affinity Diagram or Problem Prioritization Exercise, Rapid Prototyping - Turning Ideas into Actionable Concepts, Preparing and Polishing Pitch Presentations
Community Empowerment/ Visits- 2 Credit	Classroom Interaction: community, society, sustainability, technology, development and discourse on development, various top down and bottom up approaches, democracy, political and administrative processes and divisions in India with focus on Kerala's context. Methods of approaching a community, Participatory Rural Appraisal, Rapid Rural Appraisal and other methods to identify issues in brief. Instructions on analysis of data and report writing. Ethical engagement with the community for development I: 5-day outbound program to various identified communities where students get exposed to societal problems and explore ways to use digital technologies to find solutions.

DIGITAL ACCESS FOR COMMUNITY EMPOWERMENT II

Course Code	Course Name	Credit	Year of Introduction
M3000001	**Digital Access for Community Empowerment II**	**2**	**2023**

Prerequisites: Successful completion of DACE - I

Course Objectives:

1. To provide digital solutions to communities based on the problem identified in DACE I.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Explore various innovation strategies and tools to develop and implement sustainable solutions to social problems.

CO2: Develop skills in assessing and measuring the impact of innovative solutions for social problems.

CO3: Demonstrate various phases of project management and explore diverse business models and revenue-generating strategies.

CO4: Engage with various stakeholders such as governments, corporations, NGOs, and communities to create effective alliances for social change.

CO5: Cultivate an entrepreneurial mindset and a strong sense of purpose in addressing social problems.

Program Learning Outcomes:

PLO 1 Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and specialization to the solution of complex engineering problems

PLO 2 Problem analysis: Identify, formulate, research literature, and analyze engineering problems to arrive at substantiated conclusions using the first principles of mathematics,

natural, and engineering sciences.

PLO 3 Design/development of solutions: Design solutions for complex engineering problems and design system components processes to meet the specifications with consideration for public health and safety and cultural, societal, and environmental considerations.

PLO 4 Conduct investigations of complex problems: Use research-based knowledge, including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PLO 5 Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling for complex engineering activities with an understanding of the limitations.

PLO 6 The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PLO 7 Environment and sustainability: Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.

PLO 8 Ethics: Apply ethical principles and commit to professional ethics, responsibilities, and norms of the engineering practice.

PLO 9 Individual and team work: Function effectively as an individual, member, or leader in teams and multidisciplinary settings.

PLO 10 Communication: Communicate effectively with the engineering community and with society at large. Be able to comprehend and write effective reports and documentation. Make effective presentations, and give and receive clear instructions.

PLO 11 Project management and finance: Demonstrate knowledge and understanding of engineering and management principles and apply these to one's work as a member and leader in a team. Manage projects in multidisciplinary environments.

PLO 12 Life-long learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of course outcomes with program learning outcomes:

	PLO 1	**PLO 2**	**PLO 3**	**PLO 4**	**PLO 5**	**PLO 6**	**PLO 7**	**PLO 8**	**PLO 9**	**PLO 10**	**PLO 11**	**PLO 12**
CO1	3	3	3	3	2	3	3	2	3	1	2	3
CO2	2	3	3	2	1	3	3	2	3	2	1	2
CO3	3	1	1	2	2	3	3	3	3	3	3	2
CO$	2	1	1	2	1	2	3	3	3	3	3	2
CO5	3	3	3	3	3	3	3	3	3	3	3	3

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
Digital Transformations of Societal Problems/ Social Innovation - 1 Credit	DACE I Recap: Refreshing the problems identified in DACE I, Revisiting Design Thinking and Innovation, Understand the problem in a deeper context, segments, gaps, and beneficiaries, Ethical considerations. Project Planning: Action Plan - Defining project objectives, deliverables, and success criteria, feasibility study - operational, legal, economic, technical, social, Budgeting, Cost table, Social marketing, SWOT analysis, Identifying (already done in DACE - I) project stakeholders and their roles, Introduction to project management tools, working with project scheduling (e.g., Gantt charts, Kanban boards) Technology: Selecting appropriate digital tools/platforms/services, Ensuring accessibility inclusivity, and ethical considerations, Developing prototypes, testing, implementation and feedback collection Implementation: Deploying solution in the community identified, Monitoring and evaluating performance, Engaging community and stakeholders, addressing challenges and feedback, social impact and ethical implications analysis. Social entrepreneurship, Sustainability and scaling in social ventures,Business models and funding strategies
Personal Development and Scientific Communication (PDSC)- 1 Credit	Dissertation/Report, Presentations to peers and mentors, Demonstration of working prototypes or digital solutions, Reflection on the development process and lessons learned, Implementation and Monitoring Reports, Marketing the product.

TECHNICAL COMMUNICATION

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M1000000	**Technical Communication**	**1-1-0-0**	**2023**

Prerequisites: Basic English, Grammar rules.

Course Objectives:

1. Get the fundamental knowledge of technical communication
2. Write technical documents in proper format and structure
3. Communicate effectively in a professional context, using appropriate rhetorical approaches
4. Adapt content and rhetorical strategies according to the audience and purpose of each document
5. Create and deliver technical briefings tailored to specific audiences, purposes, and media.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Understand the nature, objective, and importance of Technical Communication.

C02: Do the technical write-ups.

CO3: Boost their confidence in public speaking

C04: Do presentations in front of a diverse audience.

CO5: Become efficient communicators by learning the voice-dynamics.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences;

PLO 5 Practice ethical standards of professional conduct and research;

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3		1	2	1	3
CO2		2	1	3	1	3
CO3				3		3
CO4				2	3	2
CO5				2	2	2

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	**Fundamentals of Technical Communication:** Features of technical communication, The distinction between General and Technical Communication, Language as a tool of Communication, Dynamics of Communication: Definition and process, Kinesics, Proxemics, Paralinguistic features, Importance of Interpersonal and Intercultural Communication in today's organization, The flow of Communication: Downward; upward, Lateral or Horizontal, Barriers to Communication, Code and Content, Stimulus and Response, Encoding process, Decoding process, Professional Personality Attributes
2	**Forms of Technical Writing** Synopsis writing, Technical Report, Thesis/ Project writing, Technical research Paper writing, Seminar and Conference paper writing, Expert Technical Lecture, 7 Cs of effective business writing: concreteness, completeness, clarity, conciseness, courtesy, correctness, consideration, C.V./Resume writing, Technical Proposal, Email writing, Agenda of meeting, Minutes of meeting

3	**Voice Dynamics and Oral Communication** Pronunciation Etiquette; Syllables; Vowel sounds; Consonant sounds; Tone: Rising tone; Falling Tone; Flow in Speaking, Speaking with a purpose, Speech and personality, Professional Personality Attributes: Empathy; Considerateness; Leadership; Competence. Public speaking, Overcoming Stage Fear: Confident speaking; Audience Analysis and retention of audience interest, Presentation strategies, Interview skills, Negotiation skills Critical and Creative thinking in communication.
4	**Technical Presentation: Case Studies Using Learnt Strategies and Techniques** Presentation Skills for Technical Paper/Project Reports/ Professional Reports based on proper Stress and Intonation Mechanics, Comprehension Skills based on Reading and Listening Practicals on a model AudioVisual Usage, Role Play, Group Discussion, Extempore, Mock Interview, Conducting meetings and minutes of meeting.

Text Books:

1. M. Raman and S. Sharma, *Technical Communication – Principles and Practices*, Oxford Univ. Press, 2007.
2. R.C. Sharma and K. Mohan, *Business Correspondence and Report Writing*, Tata McGraw Hill and Co. Ltd., 2001.
3. L. U. B. Pandey, Practical Communication: Process and Practice, A.I.T.B.S. Publications India Ltd.,2014.
4. T. A. Sherman *et al*., *Modern Technical Writing*, Apprentice Hall, 2015.
5. S.D. Sharma, *A Text Book of Scientific and Technical Writing*, Vikas Publication, 2008.
6. M. Murphy, *Skills for Effective Business Communication*, Harvard University, 2014.
7. P. Mehra, *Business Communication for Managers*, Pearson Publication, 2011.

MATHEMATICS FOR COMPUTER SCIENCE

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M2000000	**Mathematics for Computer Science**	**3-0-0-0**	**2023**

Prerequisites: Nil

Course Objectives:

1. To provide students with a good understanding of the concepts of mathematics described in the syllabus.
2. To help the students develop the ability to solve problems using the learned concepts.
3. To connect the concepts to other domains, such as machine learning and pattern recognition, within and without mathematics.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Understand the mathematical foundations of the theory, problem, and state-of-the-art solutions.

CO2: Analyze and evaluate critically the building and integration of mathematical

foundations.
CO3: Design and demonstrate mathematical foundations through team research projects and project report presentations.

Program Learning Outcomes:
PLO 1 Develop strong fundamental disciplinary knowledge.
PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature.
PLO 3 Apply for a scholarship to conduct independent and innovative research.
PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences.
PLO 5 Practice ethical standards of professional conduct and research.
PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	2	3	2		
CO2	3	3	3	2		
CO3	2	3	3	2		

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Introduction to Probability Theory - sample space - events - Algebra of sets- Notion and Axioms of probability-Equally likely events - Conditional probability- independent events. Bayes' theorem.
2	Axiomatic definition of Probability - Probability spaces- Random variables- PMF and PDF - Discrete and Continuous distributions. Joint, probability mass function, Marginal distribution function, Joint density function. Popular distributions- binomial, Bernoulli, Poisson, exponential, Gaussian.
3	Fundamental concepts in statistics- Measures of location and variability- Population, sample, parameters. Sampling and Testing of Hypothesis: Introduction to testing of hypothesis - Tests of significance for large samples – t, F and Chi-square tests; ANOVA - one-way and two-way classifications. Correlation and Regression.
4	Scalar, Vectors, Vector addition and scalar multiplication, i, j, k notation, inner product, lines and hyperplanes, Vector spaces, Bases, Dimension, Linear transformations - The matrix representation – Change of basis – Rank and Nullity – Row and Column space of a matrix -System of linear equations. Inner product spaces – Cauchy Schwarz inequality- Gram Schmidt Orthogonalization – Normed linear spaces.

Text Books:

1. H.P. Hsu, *Theory and Problems of Probability, Random Variables, and Random Processes*, McGraw-Hill, 2014.
2. S. M. Ross, *Introduction to Probability Models (11th edition)*, Academic Press, 2014.
3. S. Lipschutz, *Schaum's Outline of Theory and Problems of Linear Algebra*, McGraw-Hill, New York, 1968.
4. G. Strang, *Linear Algebra and its Applications*, Cengage India Private Limited, 4th edition, 2005.
5. C. D. Meyer, *Matrix Analysis and Applied Linear Algebra*, Siam, June 2000.
6. P. J. Olver, C. Shakiban, *Applied Linear Algebra*, Prentice Hall, 2006.
7. E. J. Dudewicz and S. N. Mishra, *Modern Mathematical Statistics*, International Edition, Wiley, 1988.
8. R. V. Hogg, J. W. McKean and Allen T. Craig, *Introduction to Mathematical Statistics (7th Edition)*, Pearson Education, Asia, 2014.

References:

1. W. Feller, *An Introduction to Probability Theory and its Applications*, John Wiley and Sons, 2008.
2. D. S. Bernstein, *Matrix Mathematics: Theory, Facts, and Formulas with Application to Linear Systems Theory*, Princeton University Press, 2005.

AI AND MACHINE LEARNING

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000002	**AI and Machine Learning**	**3-1-0-0**	**2023**

Prerequisites: Nil

Course Objectives:

1. To impart algorithmic skills for designing AI and machine learning techniques and solutions.
2. To equip the students to identify and analyse problems solvable with AI/machine learning algorithms/techniques.
3. To impart solution design capability with AI/machine learning techniques.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Algorithm design/analysis capability in AI/Machine Learning

CO2: Problem identification and analysis skills on application domains requiring AI/machine learning techniques

CO3: Solution design capability with AI/machine learning techniques

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge.

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature.

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences;

PLO 5 Practice ethical standards of professional conduct and research;
PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	2	3	2		2
CO2	2	3	3	2		2
CO3	2	3	3	2		2

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Artificial Intelligence - Turing Test, Rule/Logic based AI and Machine Learning Based AI, Importance of search in AI - uninformed and informed search, local search - gradient descent, modelling the brain - Perceptron, Back Propagation Algorithm, Narrow and General AI.
2	Machine Learning Paradigms: Supervised, Unsupervised and reinforcement Learning. Generalization performance, Bias-Variance trade offs, Feature Engineering - relevance, feature extraction - PCA. Supervised Learning: - Classification - Bayesian, Decision Tree and Random Forests, Ensemble Methods - Boosting and Bootstrap Aggregation, Regression - linear, logistic.
3	Unsupervised Learning: Density Estimation - Maximum Likelihood and Parzen Windows, Clustering - Partition Based, Subspace Clustering, Incremental Clustering, Spectral Clustering. Sequence Modelling - Hidden Markov Models.
4	Statistical Learning theory - Empirical Risk Minimization, and Structural Risk Minimisation: VC Dimension. Kernel Machines - Support Vector Machines, Support Vector Clustering, Support Vector Regression, Scalable Kernel Machines, Deep Kernel Machines - Deep Kernels and Multi Kernel Learning

Lab Exercises:

Module 1:

Experiments on Google AI Experiments platform, Implementation of Perceptron

Module 2:

PrerequisitesImplementation of PCA, Nave Bayes Classifier, Logistic Regression

Module 3:

Implementation of ML Estimation, K-Means and HMM

Module 4:

Experiments with SVM Libraries - SVM and Deep SVM

Text Books:

1. S. Russell and P. Norvig, *Artificial Intelligence: A Modern Approach*, 4th Edition, Pearson, 2020.
2. S. ShalevShwartz, S. Ben-David, *Understanding Machine Learning: From Theory to*

Algorithms, Cambridge University Press, 2014.
3. I. Goodfellow, *Deep Learning*, The MIT Press, 2016.

References:

1. S. Haykin, *Neural Networks and Learning Machines*, 3rd Edition, Pearson, 2009.
2. G. Bonaccorso, *Mastering Machine Learning Algorithms*, Ingram short title, 2018.

ADVANCED DATA STRUCTURES AND ALGORITHMS

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000003	Advanced Data Structures and Algorithms	3-1-0-0	2023

Prerequisites: Students should possess the fundamental programming skills in Computer Programming Languages such as Python.

Course Objective(s):

1. Understand fundamental data structures and algorithms and the tradeoffs between various implementations of these abstractions.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Understand advanced data structures and their applications conceptually.

CO2: Implement various application algorithms and develop an insight into NP-completeness, randomization, approximation, and parameterized complexity.

CO3: Design, prove the correctness, and analyse new algorithms.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge.

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature.

PLO 3 Apply for a scholarship to conduct independent and innovative research.

PLO 4 Show communication skills in various formats (oral, written).

PLO 5 Practice ethical standards of professional conduct and research.

PLO 6 Acquire professional skills such as collaborative skills and write articles for scholarly journals.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3					
CO2	3	2		1		
CO3	3	2		1		

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Various Algorithm Design Strategies. Revising Asymptotic Complexity Analysis, Sorting, Searching and Divide and Conquer Algorithm strategy.
2	Balanced Binary Search Trees (AVL trees). Amortized Complexity and Splay Trees. Basic Graph Algorithms (BFS, DFS and applications), Strongly Connected

	Components.
3	Single-Source Shortest Paths and Minimum Spanning Trees: implementation through heaps, Greedy Algorithm design. All Pairs Shortest Paths and other Dynamic Programming examples.
4	Overview of P, NP Problems, NP-Completeness and a brief introduction to Randomization, Approximation and Parameterized Complexity.

Lab Exercises:

Implementation of linked list, stack, queue. Solving programs using recursion, Problems based on Single-Source Shortest Paths and Minimum Spanning Trees. Implementing sorting and searching algorithms, Implementation of hashing. Other interesting problems (from online platforms) where data structures need to be used in an intelligent way.

Other interesting problems (from online platforms like https://leetcode.com/) where data structures need to be used in an intelligent way.

Text Books:

1. T.H. Cormen *et al.*, *Introduction to algorithms*, MIT Press, 2009.
2. B. N. Miller and D. L. Ranum, *Problem Solving with Algorithms and Data Structures Using Python*, Franklin, Beedle and Associates, 2011.

References:

1. Y. Langsam *et al.*, *Data Structures using C*, Pearson Education Asia, 2004.
2. A. Drozdek, *Data Structures and Algorithms in Java* (Second Edition), Published by Brooks/Cole, 2002.
3. J. Kleinberg and E. Tardos, *Algorithm Design*, ISBN 0-321-29535-8, Pearson Education, 2006.
4. S. Dasgupta *et al.*, *Algorithms*, New York: McGraw-Hill Higher Education, 2008.

ADVANCED DISTRIBUTED SYSTEMS

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000004	**Advanced Distributed Systems**	**3-0-0-0**	**2023**

Prerequisites: Prior Knowledge of operating systems, computer networks, distributed systems, DBMS, Graph Theory.

Course Objectives:

1. To understand the basic principles of distributed systems, core problems, and solutions.
2. To introduce communication technologies used in distributed platforms, viz., computer networks and other inter-process communications.
3. To explore real-life examples of distributed systems and how core problems related to distributed systems are solved in those example domains.
4. To give hands-on experience in working with and implementing distributed systems.

Course Outcomes: After completion of this course, the students will be able to:

C01: Understand the fundamental problems of distributed systems and different solution algorithms.

C02: Apply the knowledge of distributed systems while developing distributed software solutions.

C03: Implement and configure the various state-of-the-art distributed systems solutions.

C04: Complete a term project, including independent research, oral presentation, and programming on the latest advancement in Distributed Systems.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge.

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature.

PLO 3 Apply for a scholarship to conduct independent and innovative research.

PLO 4 Show communication skills in various formats (oral, written) .

PLO 5 Practice ethical standards of professional conduct and research.

PLO 6 Acquire professional skills such as collaborative skills and write articles for scholarly journals.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3			1		
CO2	3	3	3	1		
CO3	3	3	3	3	1	1
CO4	1	3	2	3	2	1

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Basics of Computer Networks: Concept of layering: OSI and TCP/IP Protocol Stacks, Basics of packet, circuit and virtual circuit switching.Data link layer: framing, error detection, Medium Access Control, Ethernet bridging.Routing protocols, Fragmentation and IP addressing, IPv4, CIDR notation, Basics of IP support protocols (ARP, DHCP, ICMP), Network Address Translation (NAT).Transport layer: flow control and congestion control,UDP, TCP, sockets, Application layer protocols: DNS, SMTP, HTTP, FTP, Email, Introduction to Wireless Network.
2	Distributed Systems Fundamentals I: Introduction: Distributed computing Issues and Solutions, Examples of distributed systems. Architecture: Types of distributed Architecture Concepts: Process-Threads, Client-Server, Remote Procedure Call (RPC), Remote Method Invocation, Virtualization, Inter-Process Communication.
3	Distributed Systems Fundamentals II: Synchronization: Clock Synchronization, Mutual Exclusion, Leader Election.Consistency and Replication.Fault Tolerance. Security: secure

	channels, access control.
4	Distributed Systems' Examples: *Cloud:* Introduction to Cloud Computing, Cloud Computing Platforms, Parallel Programming in the Cloud, Distributed Storage Systems, Virtualization(Multicore Operating Systems). *Distributed Database Management Systems*: Introduction, Architecture, Design, Query Processing, Concurrency Control, Reliability Protocols. Distributed File Systems, Peer-to-Peer Computing (Bit Torrent), Distributed Network (TOR), Distributed Version/Source Control System (Git)

Lab Exercises:

Module 1:

Client-Server implementation (preferably using cloud-based virtual machines)

Module 2:

Message Queue implementation to communicate among multiple processes

Module 3:

Semaphore-based Mutual Exclusion Implementation

Module 4:

TOR implementation, Git Implementation, Distributed Data Processing with Apache Hadoop/Spark

Books and other resources:

1. A. S. Tanenbaum and M. V. Steen, *Distributed Systems*, *Principles and Paradigms*, 2nd Edition, 2016, Createspace Independent Pub.
2. S. Ghosh, *Distributed Systems*, *An Algorithmic Approach*, 2nd Edition, 2020, Chapman and Hall/CRC.
3. H. Attiya and J. Welch, *Distributed Computing: Fundamentals*, *Simulations*, *and Advanced Topics*, 2nd Edition, 2006, Wiley.
4. G. F. Coulouris *et al.*, *Distributed Systems. Concepts and Design*, 5th Edition, 2011, Pearson.
5. A. D. Kshemkalyani and M. Singhal, *Distributed Computing*, 1st Edition, 2011, Cambridge University Press.
6. W. Stevens, B. Fenner, and A. M. Rudoff, *Unix Network Programming*, *Volume 1: The Sockets Networking API*, 3rd Edition, 2015, Pearson Education India.
7. W. Stevens, *UNIX Network Programming*, *Volume 2: Interprocess Communications*, 2nd Edition, 2015, Pearson Education India.
8. A. S. Tanenbaum, *Computer Networks*, 5thEdition, 2013, Pearson Education India.
9. B. A. Forouzan, *Data communication and Networking*,5th Edition,2012, Mc GrawHill, India.
10. J. F. Kurose, K. W. Ross, *Computer Networking: A top down approach*, 6th Edition, 2017, Pearson Education.
11. Recent Publications from top-Tier Conferences and Journals.

DATA AND INTELLIGENCE

Course Code	Course Name	Credit Split	Year of

		Lecture/Lab/Seminar/Project	Introduction
M3000005	**Data and Intelligence**	**3-0-0-0**	**2023**

Prerequisites: Nil

Course Objectives:

1. To impart skills needed to identify and understand data problems
2. To equip with analytical thinking on problems solvable with data intelligence
3. To impart solution design capability with data intelligence

Course Outcomes: After completion of this course, the students will be able to:

CO1: Understand and develop techniques in data intelligence

CO2: Problem identification and analysis skills on data intelligence problems

CO3: Solution design capability with data intelligence

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge.

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature.

PLO 3 Apply for a scholarship to conduct independent and innovative research.

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences;

PLO 5 Practice ethical standards of professional conduct and research;

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	2	3	2		2
CO2	2	3	3	2		2
CO3	2	3	3	2		2

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Data Intelligence and Decision Making, Collaborative Intelligence - Humans and AI. Data Architecture, Data Profiling and Storage, Data Quality and Integration, ETL process
2	Data Analytics Thinking, Exploratory Analysis, Multidimensional Analysis, OLAP, Data Visualization, Data Modelling, Overfitting and Underfitting
3	Decision Analytic Thinking - Applications of Clustering, Classification and Association Mining. Big Data Environments and Knowledge Extraction. Enterprise Data Management - Collibra case study.

4	Responsible Data Intelligence - Digital Personal Data Protection Bill 2023, Intelligence in CRM - Telenor case study, Healthcare Intelligence - Videa Health Case study, Retail Intelligence - Vispera case study, Manufacturing Intelligence - Dow Chemicals case study.

Lab/Assignment:

A case study presentation and discussion (by a group of three)

Text Books:

1. F. Provost and T. Fawcett, *Data Science for Business*, Shroff Publishers and Distributors Pvt. Ltd, 2014.
2. D. T. Larose and C. D. Larose, *Data Mining and Predictive Analytics*, John Wiley and Sons, 2016.
3. HBR Case Studies

References:

1. T. Erl *et al*., *Big Data Fundamentals: Concepts*, *Drivers and Techniques*, Pearson Education India, 2016.
2. S. Stephens-Davidowitz, *Everybody Lies: Big Data*, *New Data*, *and What the Internet Can Tell Us About Who We Really Are*, HarperLuxe, 2017.

DATA STRUCTURES AND ALGORITHMS

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000006	**Data Structures and Algorithms**	**3-1-0-0**	**2023**

Prerequisites: Nil

Course Objectives:

1. To impart the basic concepts of data structures and algorithms
2. To understand concepts about searching and sorting techniques
3. To understand basic concepts about stacks, queues, lists, trees, and graphs
4. To enable writing algorithms and doing a step-by-step approach to solving problems with the help of fundamental data structures.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Analyze a given algorithm and express its time and space complexities in asymptotic notations. Summarize the operations and applications of abstract and concrete data structures. Explain various techniques for searching sorting. Show data representation and manipulation using linear data structures like list, stack, and queue.

CO2: Show data representation and manipulation using nonlinear data structures like trees and graphs.

CO3: Apply the algorithmic techniques to Divide and Conquer algorithms, Greedy algorithms, and Dynamic Programming.

CO4: Understanding the limits of principles of Algorithms, P vs NP.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences;

PLO 5 Practice ethical standards of professional conduct and research;

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	1	1	2	1	1
CO2	3	1	1	2	1	1
CO3	3	1	1	2	1	1
CO4	3	1	1	2	1	1

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Introduction to ADT and Algorithms, Complexity analysis of algorithms, asymptotic notations. Notion of best, worst and average case complexity. Searching algorithms, Sorting techniques. Implementation Lists and Linked List. Introduction to stack, basic operations, applications of stack. Introduction to queues, Circular queues, Priority Queues. Complexity analysis of LL, stack and queue. Introduction to non-linear data structures, Binary tree, traversal in a tree, binary search tree, notion of height balanced trees.
2	Introduction to Graph, graph traversal techniques, and applications.
3	Overview of algorithm design techniques. Solving problems using Recursion, writing recurrence relation for a given problem and solution using substitution technique. Divide and Conquer and Recurrences - Mergesort, Integer and Matrix multiplication, finding median. Greedy Algorithms - Scheduling, Single Source Shortest Paths, Minimum Spanning Trees. Dynamic Programming - Tabulation vs Memoization, Subset sum problem, Matrix chain multiplication, all pairs shortest paths.

4	Time and Space complexity, PTIME, NP, P-space etc., Polynomial Time reducibility etc, NP-completeness and Beyond.

Lab Exercises:

Module 1:

Plotting complexity values to show the asymptotic behaviour. Implementation of sorting and searching algorithms, linear data structures.

Module 2:

Implementation of non-linear data structures.

Module 3:

Implementation of problems like Divide and Conquer and Greedy algorithms, Dynamic Programming techniques.

Other interesting problems (from online platforms like https://leetcode.com/) where data structures need to be used in an intelligent way.

Text Books:

1. T. H. Cormen *et al.*, *Introduction to algorithms*, MIT Press, 2009.
2. B. N. Miller and D. L. Ranum, *Problem Solving with Algorithms and Data Structures Using Python*, Franklin, Beedle and Associates, 2011.

References:

1. Y. Langsam *et al.*, *Data Structures using C*, Pearson Education Asia, 2004.
2. A. Drozdek, *Data Structures and Algorithms in Java*, Second Edition, Brooks/Cole, 2002.
3. J. Kleinberg and E. Tardos, *Algorithm Design*, Pearson Education, 2006.
4. S. Dasgupta *et al.*, *Algorithms*, McGraw-Hill Higher Education, 2008.

PYTHON PROGRAMMING

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000007	**Python Programming**	**3-1-0-0**	**2023**

Prerequisites: Nil

Course Objectives:

1. To help students learn problem-solving techniques.
2. To help students understand the fundamental concepts of programming using the Python programming language and introduce the basic concepts of Object-Oriented programming in Python.
3. To introduce students to database concepts and simple data science tools.

4. To help students build practical skills for solving problems computationally.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Explain the basic concepts of computational problem solving, procedural and object-oriented programming paradigms, and database programming.

CO2: Use algorithms and flowcharts to lay out the procedure to solve a problem**.**

CO3: Explain the basics of Python, such as variables, data types, control structures, functions, and files, and apply Python knowledge to solve computational problems.

CO4: Explain coding and analyzing data with Python using tools like Pandas, NumPy, and Matplotlib and understand the basics of cybersecurity data analytics.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences;

PLO 5 Practice ethical standards of professional conduct and research;

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3					
CO2	3					1
CO3	3					
CO4	3			2		1

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Computational Problem Solving. Algorithms and Flowcharts, Introduction to Computer Programming. Programming Paradigms and Programming Languages. Introduction to Object Oriented Programming. Introduction to Database Programming and Scripting. Software Development Process. Programming Code of Ethics. Introduction to Python. Real-world Applications of Python. Features of Python Programming Language. Implementations of Python. Python Career Opportunities.
2	Python Data Types, Variables, Basic Input-Output Operations, Basic

	Operators. Boolean Values, Conditional Execution, Loops, Lists and List Processing, Logical and Bitwise Operations. Functions, Tuples, Dictionaries, and Data Processing. Modules, Packages, String and List Methods, and Exceptions.
3	The Object-Oriented Approach: Classes, Methods, Objects, and Exception Handling. A brief introduction to OO Design. File Handling in Python. Introduction to Data Science. Tools for Data Science (GitHub, Jupyter Notebooks). Database Concepts and SQL. SQL using Python.
4	Data Handling using NumPy and Pandas. Data Visualization in Python. Simple projects. Case studies.

Lab Exercises:

Module 1:

1. Problems on number systems and data encoding.
2. Writing simple algorithms and flowcharts.
3. Writing advanced algorithms and flowcharts, installing and running Python.
4. Writing simple programs (e.g. Drake equation) to familiarize with variables, keywords, operators, expressions, data types and operator precedence. The print() function, type conversion, formatting numbers and strings.

Module 2:

5. Conditional statements, writing simple scripts, using comments for program readability.
6. Loops, nested loops, break and continue statements (e.g. Prime number, Fibonacci series, Factorial, Armstrong number, Palindrome)
7. Built-in data structures and their applications - Lists, Tuples, Sets and Dictionaries, Range function, Functions such as zip() and enumerate().
8. More coding exercises using lists (e.g. Merging sorted lists), tuples, sets, dictionaries.

Module 3:

9. Defining and calling functions: Passing arguments and returning values (e.g. Pascal's triangle.), scope, local functions, Lambda functions, function redefinition, standard library modules.
10. File and exception handling.
11. Coding exercises to practice Object Oriented Programming.

Module 4:

12. Data Handling using NumPy and Pandas.
13. Python and SQL
14. Data Visualization in Python

Text Books:

1. C. Dierbach, *Introduction to Computer Science Using Python: A Computational Problem-Solving Focus*, Wiley, 2017.
2. A, N. Kamthane and A. A. Kamthane, *Programming and Problem Solving with Python*, McGraw-Hill Education, 2018.
3. S. F. Lott, *Object Oriented Python*, Packt Publishing, 2014.
4. W. McKinney, *Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython*, O'Reilly Media, 2012.

References:

1. R. Thareja, Python Programming using Problem Solving Approach, Oxford Higher Education, 2017.
2. B. N. Miller and D. L. Ranum, *Problem Solving with Algorithms and Data Structures Using Python*, Franklin, Beedle and Associates, 2011.
3. D. D. Riley and K. A. Hunt, *Computational Thinking for the Modern Problem Solver*, CRC Press, 2014.
4. J. VanderPlas, *Python Data Science Handbook*, Github.
5. F. Nelli, *Python Data Analytics: With Pandas, NumPy, and Matplotlib*, Second Edition, Kindle Edition.

DATABASE SYSTEMS

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000008	**Database Systems**	**3-0-0-0**	**2023**

Prerequisites: Nil

Course Objectives:

1. To provide students with a good understanding of fundamental principles of Database Management Systems (DBMS) with a particular focus on relational databases.
2. To help the students develop the ability to manage the data efficiently by identifying suitable structures to maintain organizations' data assets and develop systems that utilize database technologies.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Understand the fundamental nature and characteristics of database systems.

CO2: Model real-world scenarios given as informal descriptions, using Entity Relationship diagrams.

CO3: Model and design solutions for efficiently representing and querying data using a relational model.

CO4: Discuss and compare the aspects of Concurrency Control and Recovery in Database

Systems.

CO5: Explain various types of NoSQL databases.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge.

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature.

PLO 3 Apply for a scholarship to conduct independent and innovative research.

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences.

PLO 5 Practice ethical standards of professional conduct and research.

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	2	2	2		
CO2	3	2	2	2		
CO3	3	2	2	2		
CO4	3	2	2	2		
CO5	3	2	2	2		

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Introduction to Database Management Systems: Basic Concepts, History of DBMS, Comparison with File-based systems, DBMS Facilities, DBMS Users, DBMS Three Schema Architecture, Abstraction and Data Independence, DBMS Components, Data Modeling: E-R Modeling, Relational Model: Concepts, Tables, Keys, Data Integrity and Constraints, Database Normalization: Purpose, 1NF, Functional Dependency (FD), 2NF, 3NF, BCNF, Multi-valued Dependency (MVD), 4NF, Join Dependency (JD), 5NF.
2	Introduction to Relational Algebra, Introduction to SQL: SQL Features, SQL Operators, SQL data types, SQL Parsing and Execution, Types of SQL Commands – DDL, DML, TCL, Querying Data from the database – Basic Queries, Correlated Sub-queries, Joins, Nested Queries, Aggregation and grouping, Built-in Functions, Views, Functions, Stored Procedures and Triggers.
3	Introduction to Transaction Processing: ACID Properties of Transactions, Concepts of Concurrency Control and Recovery, Transaction States, System

	Log, Concurrency Control Techniques – Binary Locks, Shared/Exclusive Locks, Two Phase Locking. Recovery using System Log. Distributed Databases: Architectures, Data Fragmentation, Replication and Allocation, Query Processing in Distributed Databases, Commit Protocols, Concurrency control, Deadlock Handling and Recovery in Distributed Database Management Systems.
4	Overview, and History of NoSQL. The Emergence of NoSQL, SQL vs. NoSQL, ACID vs. BASE, CAP Theorem, Types of NoSQL Databases: Key-Value Store, Document Store, Column Family Store and Graph Database. Examples: MongoDB, Cassandra, and Neo4j. Replication and Sharding.

Text Books and References:

1. R. Elmasri and S.B. Navathe, *Fundamentals of Database Systems*, Pearson, 2000.
2. A. Silberschatz et al, *Database System Concepts*, 4th Edition, Mc Graw Hill, 2002.
3. S. Ceri and G. Pelagatti, *Distributed Databases: Principles and Systems*, Universities Press, 2000.
4. A. Meier and M. Kaufmann, *SQL and NoSQL Databases: Models*, *Languages*, *Consistency Options and Architectures for Big Data Management*, Springer,2019.
5. P. J. Sadalage and M. Fowler, *NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence*, *Addison Wesley Professional 2012 and* Kindle Edition
6. S. Acharya, *Demystifying NoSQL*, Wiley India (P) Ltd, 2020.

INTRODUCTION TO CYBER SECURITY

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000009	**Introduction to Cyber Security**	**2-1-0-0**	**2023**

Prerequisites: Nil

Course Objectives:

1. To introduce the fundamental aspects of cyber security.
2. To introduce the basic security problems related to data, internet, cloud, and IoT networks.
3. To introduce the basics of various security mechanisms.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Understand the foundational concepts of data security, including threats, security elements, potential losses, and methods to implement adequate security measures.

CO2: Develop the ability to recognize and address online security risks, including safe web browsing, secure communication, social media safety, and email security.

CO3: Acquire the skills to safeguard mobile devices, comprehend cloud security threats, privacy issues, network connections, and effectively secure home networks.

CO4: Gain basic knowledge in cryptographic methods, data backup strategies, disaster recovery planning, and securing Internet of Things (IoT) devices for a comprehensive approach to data protection.

CO5: Gain proficiency in safeguarding digital information through an in-depth exploration of data security concepts and applications.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge.

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature.

PLO 3 Apply for a scholarship to conduct independent and innovative research.

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences;

PLO 5 Practice ethical standards of professional conduct and research;

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	2	3	2		1
CO2	3	3	3	2	2	1
CO3	2	3	3	2	2	3
CO4		2	2	1	2	
CO5		1	2		1	3

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	**Introduction to Data Security** Foundations of Data Security: Introduction to Data Security and its Importance, Data as Digital Building Blocks, Common Threats to Data and Potential Losses Essential Security Elements: Confidentiality, Authenticity, Integrity, Availability, Non-repudiation Implementing Data Security: Strategies for Security Implementation Securing Operating Systems: Importance of OS Security, Guidelines for Windows and Linux OS Security, Introduction to Kali Linux OS Understanding Malware and Antivirus: Introduction to Malicious Software (Malware), Types of Malware and Symptoms of Infection, Antivirus Software: Functionality and Selection. Data Privacy: Concepts, Evolution of Data Privacy Laws in India, Key aspects of Digital Personal Data Protection Act 2023, Challenges and Opportunities in Implementing Data Privacy in India.
2	**Internet Security and Online Safety** Web Browser and Online Safety: Securing Web Browsers (e.g., Chrome, Mozilla),

	Browser Features: Benefits and Risks, Identifying Secure Websites Communication and Social Networking: Instant Messaging: Security Concerns, Child Online Safety: Key Considerations, Security on Social Networking Platforms, Risks of Social Networking and Geotagging Safe Social Media Usage: Safety Measures for Facebook and Twitter Email Security: Email Security Threats: Attachment, Phishing, Hoaxes, Addressing Nigerian Scams and Spam, Guidelines for Securing Email Communication
3	**Mobile Security and Cloud Protection** Mobile Device Security: Mobile OS Security, Common Mobile Threats, Mobile Security Guidelines Mobile Phone and Bluetooth Security: Security Checklists for Devices and Bluetooth Cloud Security: Cloud Threats and Privacy Issues, Selecting a Cloud Service Provider Securing Network Connections: Networking Basics, Wireless Network Setup, Wireless Security Measures, Home Network Safety: Threats to Home Networks and Countermeasures, Network Safety Checklist,
4	**Encryption, Data Backup, and IoT Security** Cryptography Essentials: Encryption and Decryption, Symmetric and Asymmetric Cryptography, Hashing Techniques, Digital Signature and Digital Certificates Data Backup and Recovery: Causes of Data Loss, Importance of Data Backup, Types of Backup and Online Benefits, Disaster Recovery Strategies Securing IoT Devices: IoT Security Considerations and Challenges

Text Books:

1. C. J. Brooks and C. Grow, *Cybersecurity Essentials*, 2nd Edition, Pearson, 2020.
2. W. Stallings, *Network Security Essentials: Applications and Standards*, Sixth Edition, Pearson, 2021.
3. I. Chlamtac *et al.*, *Mobile Computing and Wireless Communications: Applications, Networks, Platforms, Architectures, and Security*, Second Edition, Pearson, 2017.
4. W. Stallings, *Cryptography and Network Security: Principles and Practice*, 7th Edition, Pearson, 2020.

References:

1. A. Conklin *et al.*, *Principles of Computer Security*, 5th Edition, McGraw-Hill Education, 2018.
2. M. H. Au and R. Choo, *Mobile Security and Privacy: Advances, Challenges and Future Research Directions*, CRC Press, 2016.
3. M. E. Whitman and H. J. Mattord, *Principles of Information Security*, 6th Edition, Cengage Learning, 2020.

COMPUTER NETWORKS AND SECURITY

Course Code	Course Name	Credit Split	Year of

		Lecture/Lab/Seminar/Project	Introduction
M3000010	**Computer Networks and Security**	**2-1-0-0**	**2023**

Prerequisites: Nil

Course Objectives:

1. To introduce the fundamental aspects of computer networks .
2. To enable the students to understand various cyber attacks targeted on computer networks
3. To enable the students to develop various security mechanisms for computer networks
4. To enable the students to simulate various network attacks

Course Outcomes: After completion of this course, the students will be able to:

CO1: Summarize principles of Networks
CO2: Describe the layered protocol model.
CO3: Discriminate between various protocols
CO4: Appraise security threats and resolve them effectively.
CO5: Analyse the challenges in different network architectures

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge
PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature
PLO 3 Apply for a scholarship to conduct independent and innovative research
PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences;
PLO 5 Practice ethical standards of professional conduct and research;
PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	2	3	2		
CO2	3	3	3	2		
CO3	2	3	3	2		

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Network Basics: The Network Edge, The Network Core, Access Networks, Delay, Loss and Throughput, Protocol Layers and Their Service Models, Application Layer: RPC, P2P, HTTP, FTP, DNS, DHCP, Electronic Mail, WLAN, Socket, Programming with TCP and UDP

2	Transport Layer: Services, TCP, UDP, Network Layer: Functions, design issues, Internet Protocol (IP), IPV4 and IPv6, Routers, Routing algorithms, Congestion Control Algorithms
3	Data Link Layer: Design issues, framing methods, Error Detection and Correction, PPP, Sliding Window Protocols, Multiple Access Protocols, Address Resolution, Protocol (ARP), Ethernet, Link Layer Switches, Spanning Tree Protocol, VLAN
4	Security Attacks, Security Services, Security Mechanisms, Key Management and Distribution, User Authentication Protocols, SSL, TLS, Wireless Network Sec urity, Electronic Mail Security, Vulnerability Analysis, Attacks in sensor and IoT networks, Endpoint Security, familiarization of Network simulators - NS2/NS3 or Cooja/Contiki and simulation of attacks and analyze network perfor mance.

Text Books:

1. J. Kurose and K. Ross, Computer Networking: A Top-Down Approach, 7th Edition, Pearson, 2016.
2. A. S. Tanenbaum, Computer Networks, 5th Edition, Pearson, 2013.
3. W. Stallings, Cryptography and Network Security Principles and Practice, Prentice Hall, 1998.
4. V. Tsiatsis *et al*., *Internet of Things: Technologies and Applications for a New Age of Intelligence*, Elsevier Academic press, 2018.
5. Z. Mahmood, *Connected Vehicles in the Internet of Things: Concepts, Technologies and Frameworks for IoV*, Springer, 2020.
6. I. F. Akyildiz and M. Can Vuran, Wireless Sensor Networks. Wiley, 2010.

References:

1. L. L. Peterson and B. S. Davie, *Computer Networks, A systems approach*, Morgan Kaufmann, 2011.
2. S. Keshav, *An Engineering Approach to Computer Networking*, Pearson Education, 2000.
3. S. S. Shinde, *Computer Network*, New Age International, 2009.
4. P. Raj and A. C. Raman, *The Internet of Things: Enabling Technologies, Platforms, and Use Cases*, 1st Edition, Auerbach Publications, 2017.
5. A. McEwen, *Designing the Internet of Things*, Wiley, 2013.

CRYPTOGRAPHY

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000011	**Cryptography**	**2-1-0-0**	**2023**
Prerequisites: A basic understanding of algebra, linear algebra, modular arithmetic, probability			
Course Objectives:			

1. Learn modern cryptographic algorithms, their implementations in contemporary computing platforms, and security analysis.
2. Analyze countermeasures to thwart implementation-level attacks on cryptographic operations in hardware and software
3. Identify appropriate cryptographic techniques for real-world applications

Course Outcomes: After completion of this course, the students will be able to:

CO1: Understand the foundations of modern cryptography and its limitations.

CO2: Analyze and evaluate critically various cryptographic schemes and protocols.

CO3: Apply appropriate cryptographic techniques to solve real-world problems in information security.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences;

PLO 5 Practice ethical standards of professional conduct and research;

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	3	2	2	1	2
CO2	3	3	3	2	1	2
CO3	3	3	3	2	3	3

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Basic Properties of the integers, Divisibility and primality, Congruence, Residue classes, Euler's phi function, Fermat's little theorem, Classical cryptosystems
2	Block Ciphers, DES, Triple-DES, AES, Block Cipher Modes, Stream Ciphers, RC4
3	Public-Key Cryptography, Diffie Hellman Key Exchange, RSA, Rabin, ElGamal, ECC, Lattice Cryptography
4	Hash Functions, SHA-1, SHA3, MAC, HMAC, Digital Signatures, RSA, El Gamal, DSA, ECDSA

Text Books:

1. W. Stallings, *Cryptography and Network Security: Principles and Practice*, Pearson, 1998
2. N. Koblitz, *A Course in Number Theory and Cryptography*, Springer Verlag (low price edition), 2nd Edition, 1994

3. J-P. Aumasson, *Serious Cryptography: A Practical Introduction to Modern Encryption*, No Starch Press, 2017
4. D. R. Stinson, *Cryptography: Theory and Practice*, Chapman and Hall/CRC, Standard Edition, 2018

References:

1. R. Anderson, *Security Engineering: A Guide to Building Dependable Distributed Systems*, Wiley, 2020
2. T. R. Shemanske, *A Beginner's Guide, Modern Cryptography and Elliptic Curves*, American Mathematical Society, 2017

CYBER ANALYTICS

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000012	**Cyber Analytics**	**2-1-0-0**	**2023**

Prerequisites: Nil

Course Objectives:

1. To introduce various supervised, unsupervised, and reinforcement machine learning algorithms.
2. To enable the students to apply ML techniques to analyze cyber data .
3. To enable the students to perform cyber threat detection, risk estimation, vulnerability detection, and cyber attack detection.
4. To make the students design ML-based cyber security solutions.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Demonstrate a comprehensive understanding of the concepts and importance of cybersecurity analytics in modern cyber defense.

CO2: Apply various data collection and preprocessing techniques to extract valuable insights from cybersecurity data.

CO3: Utilize data analysis techniques and machine learning algorithms for effective threat detection and categorization.

CO4: Employ artificial intelligence approaches, including deep learning, natural language processing, and generative models, for analyzing complex cybersecurity challenges.

CO5: Utilize a comprehensive data engineering and machine learning tool/platform to explore advanced techniques in cybersecurity analytics, including deep learning and GPT.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences;

PLO 5 Practice ethical standards of professional conduct and research;

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	2	3	2		
CO2	3	3	3	2	2	2
CO3	2	3	3	2	1	1
CO4	2	2	2	1	2	3
CO5	1	2	3	1	2	3

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	**Cyber Threat Intelligence and Data Collection** Understanding Cyber Threat Intelligence and its Significance, Effective Data Collection for Cybersecurity Insights, Data Preprocessing Techniques for Enhanced Analysis, Exploratory Data Analysis for Identifying Threat Indicators, Leveraging Machine Learning in Cybersecurity: Concepts and Techniques Use Case: Network Intrusion Detection using Machine Learning
2	**Advanced Threat Detection and Profiling** Advanced Techniques for Threat Detection and Categorization, Clustering and Classification Methods for Effective Analysis, Feature Engineering and Selection for Improved Detection, Profiling User and Entity Behavior for Insider Threat Detection, Real-time Intrusion Detection Systems (IDS) and Intrusion Prevention Systems (IPS) Use Case: Identifying Suspicious Insider Activities using Behavioral Analysis
3	**Machine Learning and AI for Threat Analysis** Harnessing Deep Learning for Intrusion Detection, Leveraging Natural Language Processing for Threat Analysis, Synthetic Data Generation using Generative Adversarial Networks (GANs), Explainable AI Models for Transparent Cybersecurity Analysis, Utilizing Machine Learning in Security Information and Event Management (SIEM) Use Case: Detecting Zero-Day Attacks with Deep Learning Techniques
4	**Incident Response and Cyber Big Data Analytics** Effective Incident Response Strategies: Analytics-driven Incident Handling, Incorporating Analytics into Incident Response Workflow, Monitoring Key Performance Indicators (KPIs) for Cyber Defense Use Cases: ● Detecting and Responding to Advanced Threats with Analytics ● Analyzing Insider Threats and Unauthorized Data Exfiltration Cyber Big Data Analytics: Role of Cyber Big Data in Identifying Emerging Threat Patterns, Scalable Storage and Processing Solutions for Large-scale Security Data Use Case: Predictive Analysis of Cyber Threats using Big Data Techniques

Text Books:

1. T. Thomas *et al*., *Machine Learning Approaches in Cybersecurity Analytics*, Springer 2020.
2. K. Harbott, *Cybersecurity Analytics: The Evolution of Threat and Risk Management*, Wiley, 2015.
3. M. Panella, R. Setola, and Elisa Bertino, *Cybersecurity Analytics and Decision Support in Smart Grids*, Springer, 2021.
4. R. Chandel and P. Sharma, *Cybersecurity Analytics: A Hands-On Approach*, Apress, 2020.
5. I. Santos, C. Laorden, and X. Ugarte-Pedrero, *Data Science for Cyber-Security*, Springer, 2018.
6. O. Savas and Y. Karaca, *Big Data Analytics for Cybersecurity*, CRC Press, 2018.

References:

1. H. Xiong, S. Shekhar, and W. B. Croft, *Applied Data Analytics: Principles and Applications*, CRC Press, 2018.
2. S. Chen, J. Yan, and D-Z. Du, *Big Data Analytics for Cyber-Physical Systems: Machine Learning for the Internet of Things*, CRC Press, 2019.
3. E. D. Knapp and R. Samani, *Applied Cyber Security and the Smart Grid: Implementing Security Controls into the Modern Power Infrastructure*, Syngress, 2013.

MALWARE ANALYSIS AND REVERSE ENGINEERING

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000013	**Malware Analysis and Reverse Engineering**	**2-1-0-0**	**2023**

Prerequisites: Nil

Course Objectives:

1. To provide students with a knowledge of various malware types and families.
2. To help the students apply tools and techniques to detect malware.
3. To provide the students with an understanding of the need for protecting computer systems against malware attacks.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Understand the fundamentals of malware analysis, including various types of malware and their families across different operating systems.

CO2: Acquire proficiency in static analysis and reverse engineering techniques for detecting and analyzing obfuscated and packed malware.

CO3: Demonstrate dynamic analysis skills to investigate malware behavior and evasion techniques.

CO4: Explore advanced topics such as IoT malware analysis and using machine learning and deep learning for automated malware detection.

CO5: Develop an awareness of adversarial evasion techniques in malware detection mechanisms.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences;

PLO 5 Practice ethical standards of professional conduct and research;

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	1	2	2			
CO2	1	3			3	
CO3	1	2	2			
CO4		3			1	
CO5	1		3	1		

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	**Introduction to Malware and Operating Systems** Understanding Android Malware: Source Code, Security Assessment Tools; Types and Families of Android Malware, Reverse Engineering Android Applications, Windows Operating System and Malware Types, Reverse Engineering Windows Applications, Security Assessment Tools for Windows, Types of Linux and IoT Malware and Families, Linux Operating System Overview, Reverse Engineering Linux OS and IoT Firmware, Security Assessment Tools for Linux and IoT.
2	**Static Analysis and Reverse Engineering** Static Analysis of Android Malware, Detection of Obfuscated and Packed Android Malware, Dalvik Opcode Analysis, Static Analysis Tools for Android Malware, Static Analysis of Windows Malware, Reverse Engineering Windows Malware, Detection of Obfuscated and Packed Windows Malware, Static Analysis Tools for Windows Malware, Static Analysis of Linux and IoT Malware, Reverse Engineering Linux and IoT Malware, Detection of Obfuscated and Packed Linux and IoT Malware, Static Analysis Tools for Linux and IoT Malware, IoT Implant Toolkit for Malware Implantation.

3	**Dynamic Analysis and Evading Malware** Dynamic Analysis of Android Malware, Investigating Android Malware Obfuscation, Dynamic Analysis Tools for Android Malware, Android Malware Evasion and Current Trends, Dynamic Analysis of Windows Malware, Process Monitoring for Dynamic Analysis of Windows Malware, Windows Registry Monitoring, Investigating Windows Malware Obfuscation, Dynamic Analysis Tools for Windows Malware, Dynamic Analysis of Linux and IoT Malware, Examining Memory Snapshots for Linux Malware, Investigating Security of Linux Kernel Against Malware Attacks, Detecting IoT Malware Using Network Traffic Analysis.
4	**Machine Learning and Deep Learning in Malware Detection** Machine Learning for Malware Detection: Static and Dynamic Features, Deep Learning for Automated Malware Analysis, Introduction to Adversarial Malware Evasion, Adversarial Evasion in Various OS Malware Detection Mechanisms.

Text Books:

1. A. Kleymenov and A. Thabet, *Mastering Malware Analysis: The complete malware analyst's guide to combating malicious software, APT, cybercrime, and IoTattacks*, Packt Publication, 2019.
2. K. A. Monappa, *Learning Malware Analysis: Explore the concepts, tools, and techniques to analyze and investigate Windows malware*, Packt Publication, 2018.
3. A. D. Joseph *et al.*, *Adversarial Machine Learning*, Cambridge University Press, 2019.
4. T. Thomas *et al.*, *Machine Learning Approaches in Cybersecurity Analytics*, Springer, 2020.
5. K. Dunham, *Android Malware and Analysis* (first edition), Auerbach Publications, 2014.
6. M. Sikorski and A. Honig, *Practical Malware Analysis: The Hands-On Guide to Dissecting Malicious Software*, 1st Edition, No Starch Press, 2012.

References:

1. M. H. Ligh et al., *The Art of Memory Forensics: Detecting Malware and Threats in Windows, Linux, and Mac Memory*, 1st Edition, Wiley, 2014.
2. C. Chio and D. Freeman, *Machine Learning and Security*, O Reilly, 2018.
3. X. Fu, *Malware Analysis Tutorials: A Reverse Engineering Approach*, Online.

ETHICAL HACKING AND PENETRATION TESTING

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000014	**Ethical Hacking and Penetration Testing**	**2-1-0-0**	**2023**

Prerequisites: Nil

Course Objectives:

1. To help the students apply tools and techniques to explore cyber security breaches.
2. To provide students with a knowledge of the need for protecting the cyber assets from an adversary.
3. To provide students with a knowledge of employing machine learning techniques for

vulnerability assessment.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Understand the fundamental principles and legal aspects of ethical hacking and penetration testing.

CO2: Identify various information security threats, vulnerabilities, and their assessment techniques.

CO3: Apply password cracking, social engineering, and authentication mechanisms to enhance security.

CO4: Analyze and counter network-level attacks, web application vulnerabilities, and insider threats.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences;

PLO 5 Practice ethical standards of professional conduct and research;

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3		3		3	
CO2	3	2			1	
CO3	3	3		3		1
CO4			2		2	2

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	**Ethical Hacking Fundamentals and Information Security Threats** Understanding Ethical Hacking: Principles, Importance, and Legal Aspects, Basics of Cybersecurity: Threats, Attacks, and Defense Mechanisms, Information Security Laws, Standards, and Regulatory Compliance, Footprinting and Reconnaissance: Gathering Information for Assessments, Network Scanning and Enumeration: Identifying Targets and Services, Vulnerability Assessment and Analysis: Identifying Weaknesses, Developing Comprehensive Vulnerability Assessment Reports

2	**Password Cracking and Social Engineering Techniques** Password Cracking Techniques: Brute Force Attack, Dictionary or Word List Attack and Rainbow Table Attack, Password Cracking Tools and Countermeasures; Strengthening Authentication: Multi-Factor Authentication (MFA), Social Engineering Concepts and Techniques, Countermeasures to Social Engineering and Identity Theft, Insider Threats and Countermeasures Hands-on Password Cracking and Social Engineering Simulations
3	**Network and Web Application Attacks** Network Level Attacks: DoS, DDoS, Session Hijacking, and Mitigation, Hacking Web Applications: Common Vulnerabilities and Attack Surfaces, OWASP Top 10: Understanding and Mitigating Web App Threats, Countermeasures to Web App Attacks: Security Best Practices, Network Intrusion Detection and Prevention Systems (IDS/IPS), Firewalls and Network Infra Devices: Concepts and Configurations, Practical Penetration Testing: Network and Web Application Targets
4	**Wireless, Mobile, and Cloud Security Assessment** Wireless Network Security: Threats, Attacks, and Mitigation, Hacking Wireless Networks: Techniques and Countermeasures, Mobile Device Security: Vulnerabilities and Exploits, Assessing Mobile Apps: Identifying Security Flaws, Cloud Computing Security: Risks, Benefits, and Best Practices, IoT and OT Security: Attacks and Countermeasures Hands-on Wireless Hacking, Mobile Exploitation, and Cloud Assessment

Text Books:

1. M. Walker, *Certified Ethical Hacker All-in-One Exam Guide*, 4th Edition, McGraw-Hill Education, 2020.
2. J. Erickson, *Hacking: The Art of Exploitation*, 2nd Edition, No Starch Press, 2021.
3. W. Stallings, *Network Security Essentials: Applications and Standards*, 7th Edition, Pearson, 2021.
4. P. L. Wylie, *The Pentester Blue Print*, Wiley Publication, 2021.

References:

1. P. Kim, *The Hacker Playbook 2: Practical Guide to Penetration Testing*, Createspace Independent Pub, 2015
2. M. T. Simpson, *Hands-On Ethical Hacking and Network Defense*, Second Edition, Cengage Learning, 2012.
3. M. Meucci and A. Muller, *Owasp testing guide v. 4.0*, Open Web Application Security Project, 2014.
4. D. Kennedy *et al.*, *Metasploit: The Penetration Tester's Guide*, 4th Edition, No Starch Press, 2018.

DIGITAL FORENSICS

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction

M3000015	Digital Forensics	2-1-0-0	2023

Prerequisites: Nil

Course Objectives:

1. Familiarize students with cyber crimes and cyber security
2. Understand various techniques of cyber attacks and defenses
3. Perform digital forensic investigations

Course Outcomes: After completion of this course, the students will be able to:

CO1 Understand the foundational concepts of digital forensics, including the investigation process and roles of forensic investigators.

CO2 Analyze different types of storage media and demonstrate proficiency in data acquisition and duplication.

CO3 Conduct a thorough analysis of operating systems, including memory forensics and file system examination.

CO4 Apply network forensics techniques to capture, analyze, and interpret network traffic.

CO5 Develop the skills to collaborate with legal professionals, prepare comprehensive reports, and adhere to ethical considerations in digital investigations.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences;

PLO 5 Practice ethical standards of professional conduct and research;

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	3	2			
CO2	3	3	3	1	3	
CO3	3	3	3		3	
CO4					3	3
CO5			2	3	3	3

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	**Foundations of Digital Forensics** Fundamentals of Computer Forensics, Digital Evidence and Forensic Readiness, Roles and Responsibilities of a Forensic Investigator, Digital Forensics Investigation Process, Importance of Digital Forensics, Investigative Phases: Pre-

	investigation, Investigation, Post-investigation; Chain of Custody and Digital Evidence Handling, Steps of a Digital Forensic Investigation: Identification, Collection, Analysis, Reporting; Technology and Law: Digital Evidence in the Courtroom, Legal and Ethical Considerations in Digital Investigations, Collaboration with Law Enforcement and Legal Professionals, Report Preparation and Effective Communication.
2	**Storage Media Analysis** Characteristics of Different Disk Drive Types, Logical Structure of Disk Drives, Booting Process of Windows, Linux, and Mac Operating Systems; File Systems of Windows, Linux, and Mac Operating Systems; File System Examination Techniques, Data Acquisition and Duplication Fundamentals, Data Acquisition Formats and Methodologies.
3	**Operating System Forensics** Volatile and Non-Volatile Information, Windows Memory forensic, Registry Analysis, Analysis of Cache, Cookie, and History Recorded in Web Browsers Windows Files and Metadata analysis. Hibernation File Analysis, Crash Dump Analysis, File System Analysis. Linux and Mac Forensics: Volatile and Non-Volatile Data in Linux, Analyze Filesystem Images Using Sleuth Kit, Memory Forensics, Mac Forensics.
4	**Network and Mobile Forensics** Fundamentals of Network Forensics, Understanding Protocols Using Wireshark, Packet Capturing with Wireshark, tshark, and tcpdump, Packet Filtering and Data Extraction from PCAP Files, Analysis of Network Logs: Apache, IIS, and System Logs, Event Correlation: Concepts and Types, Identifying Indicators of Compromise (IoCs) from Network Logs, Investigating Network Traffic and Identifying Network-Based Attacks, Intrusion Detection and Identification of Network-Based Attacks. Mobile Forensics: Data Extraction Techniques, Analysis of Mobile Data - Call Logs, Messages, emails, Images, Videos, and App Data; Mobile App and Social Media Forensic.

Text Books:

1. B. Nelson *et al*., *Guide to Computer Forensics and Investigations*, Sixth Edition, 2020.
2. J. Sammons, *The Basics of Digital Forensics: The Primer for Getting Started in Digital Forensics*, Elsevier, 2014.
3. A. M. Marshall, *Digital Forensics: Digital Evidence in Criminal Investigation*, John – Wiley and Sons, 2008.
4. N. Reddy, *Practical Cyber Forensics: An Incident-Based Approach to Forensic Investigations*, New York, Apress, 1st Edition, 2019.
5. L. E. Daniel and P. R. Johnson, *Digital Forensics for Legal Professionals: Understanding Digital Evidence from the Warrant to the Courtroom*, Syngress, 2012.

References:

1. T. J. Holt *et al*., *Cybercrime and Digital Forensics: An Introduction*, Routledge, 2nd

Edition, 2017.
2. S. Widup and J. Sammons, *Computer Forensics and Digital Investigation with EnCase Forensic*, Syngress, 2014.
3. M. H. Ligh *et al.*, *The Art of Memory Forensics: Detecting Malware and Threats in Windows, Linux, and Mac Memory*, Wiley, 2014.
4. EC-Council, *Computer Forensics: Investigating Network Intrusions and Cyber Crime*, EC Council Press Series: Computer Forensics, 2016.

DATABASE SECURITY

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000016	**Database Security**	**2-1-0-0**	**2023**

Prerequisites: Nil

Course Objectives:

1. To teach different types of databases.
2. To teach the security aspects of databases
3. To perform data auditing

Course Outcomes: After completion of this course, the students will be able to:

CO1: Discriminate between different Types of Databases
CO2: Develop and design Entity Relationship Models
CO3: Summarize concepts related to applications of SQL
CO4: Identify differential attributes of Structured Data, Unstructured Data and Semi-Structured Data
CO5: Apply principles of Database Security for efficient Data auditing.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge
PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature
PLO 3 Apply for a scholarship to conduct independent and innovative research
PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences;
PLO 5 Practice ethical standards of professional conduct and research;
PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	2	3	2		
CO2	3	3	3	2		
CO3	2	3	3	2		

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Different Types of Databases, Entity Relationship Models, Relational Models, Relational Algebra, Calculus, ACID Properties, Relational Databases, Concurrency Control, Process of Database Design, Dependencies and Normalization for Relational Databases, Object-oriented/Object-Relational Models, Threats to the Database, Principles of Database Security, Levels of Database Security, Database Security Issues.
2	Introduction to SQL, SQL Features, SQL Operators, SQL Datatypes, SQL Parsing, Types of SQL Commands, Advanced Study of Structured Query Language, Querying Data from the database, Correlated Sub-queries, Joins, Hierarchical Queries, Bind Variables, Cursors, Functions, Stored Procedures, MySQL, Basics of New SQL Databases, SQL Injection and Mitigation.
3	Structured Data, Unstructured Data, Semi-Structured Data, Limitations of Traditional RDBMSs, SQL and Structured Data, SQL and Semi-Structured Data, SQL and Unstructured Data, The Emergence of NoSQL, NoSQL Database features, Types of NoSQL Databases, Search Engine Databases, Basics of MongoDB and Neo4j, Data Auditing, Statistical Database Security, Semantic Integrity Control, Privilege Analysis, Virtual Private Database (VPD), DataRedaction, SensitiveDataProtection.
4	Authentication and Authorization in DBMS,PropertiesandBasicPrinciplesofAccess Control Mechanisms, Views for AccessControl, Classical Database Access Control: Discretionary Access Control, Role-Based Access Control and Mandatory Access Control; Access Control in OpenEnvironments such as Attribute Based Encryption and Identity Based Encryption, Access Control in SQL, Network Data Encryption, Strong Authentication, Private Data Aggregation, Search in Encrypted Data : Searchable Encryption Overview, Selected Schemes on Searchable Encryption.

Text Books:

1. A. Silberschatz *et al*., *Database System Concepts*, 6th Ed., Tata McGraw Hill, 2011.
2. A. Meier and M. Kaufmann, *SQL and NoSQL Databases: Models*, *Languages*, *Consistency Options and Architectures for Big Data Management*, Springer, 2019.
3. G. Harrison, *Next Generation Databases: NoSQL*, *NewSQL*, *and Big Data*, Apress, 2015.
4. R. Elmasri and S. B. Navathe, *Fundamentals of Database Systems*, 6th Ed., Pearson Education, 2011.
5. R. B. Vatan, *Implementing Database Security and Auditing*, Digital Press, 1st Edition, 2005.

References:

1. C. J. Date *et al*., An Introduction to Database Systems, 8th Ed, Pearson Education, 2006.
2. R. Elmasri and S. Navathe, *Fundamentals of Database Systems*, Pearson, 2000.
3. G. K. Gupta, *Database Management Systems*, Tata McGraw Hill, 2011.
4. J. Hellerstein and M. Stonebraker, *Readings in Database Systems (The Red Book)*, 4th Ed., MIT Press, 2005.
5. J. L. Harrington, *Object Oriented Database Design Clearly Explained*, Harcourt, 2000.
6. R. Ramakrishnan, *Database Management Systems*, 4th Ed, McGraw-Hill, 2015.

7. R. Ramakrishan and J. Gehrke, *Database Management Systems*, 3rd Ed. McGraw-Hill, 2002.
8. S. Ceri and G. Pelagatti, *Distributed Databases: Principles and Systems*, Universities Press, 2000.
9. V. Atluri and P. Samarati, Security of Data and Transaction Processing, Springer, 2000.

ARTIFICIAL INTELLIGENCE FOR CYBER SECURITY

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000017	**Artificial Intelligence for Cyber Security**	**2-1-0-0**	**2023**

Prerequisites: A basic understanding of algebra, linear algebra, modular arithmetic

Course Objectives:

1. To provide students with a good understanding of AI, ML, and deep learning for applying to various cyber security problems.
2. To help the students develop the ability to solve cyber security problems using the learned concepts.
3. To help the students to build autonomous cyber defense systems.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Understand and analyze various AI, ML, and deep learning algorithms.

CO2: Apply the AI, ML and deep learning concepts for solving various cyber security problems.

CO3: Develop autonomous cyber defense systems.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences;

PLO 5 Practice ethical standards of professional conduct and research;

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	2	2			
CO2	3	3	3	3	1	1
CO3	3	3	3	3	3	3

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Artificial Intelligence, Rule/Logic based AI and Machine Learning Based AI, Modeling the brain - Perceptron, Back Propagation Algorithm, Supervised, Unsupervised and reinforcement Learning, Bias-Variance tradeoffs, Feature Engineering - relevance, feature extraction - PCA.
2	Supervised Learning: - Classification - Bayesian, SVM, Decision Tree and Random Forests, Ensemble Method, Regression - linear, logistic. Applications: spam email detection, phishing page detection, malware detection, detection of APT, security risk analysis/estimation
3	Unsupervised Learning: Clustering - Partition Based, Subspace Clustering, Incremental Clustering, Spectral Clustering, Hidden Markov Models Applications: DoS and DDoS attack detection, anomaly detection, fraud detection, Network Traffic Analysis
4	Deep neural networks, Deep Feed Forward Networks, Convolutional Neural Networks, Recurrent Neural Network (RNN) and Long Short-Term Memory (LSTM), Generative Adversarial Networks, Auto encoders Applications: Malware detection, Network intrusion detection, Botnet detection and DGAs, CPS attack detection, Fraud detection, Encrypted traffic analysis

Text Books:

1. T. Thomas, A. P. Vijayaraghavan, Sabu Emmanuel, Machine Learning Approaches in Cybersecurity Analytics, Springer 2020.
2. T. Thomas, et. al, *Intelligent Mobile Malware Detection*, CRC Press, Taylor and Francis, 2023.
3. S. Russell and P. Norvig, *Artificial Intelligence: A Modern Approach (4th Edition)*, Pearson, 2020.
4. S. Shalev-Shwartz and S. Ben-David, *Understanding Machine Learning: From Theory to Algorithms*, Cambridge University Press, 2014.
5. C. Chio and D. Freeman, *Machine Learning and Security*, O Reilly, 2018.
6. M. Alazab and M. Tang, *Deep Learning Applications for Cyber Security (Eds.)*, Springer, 2019.
7. R. M. Verma and D. J. Marchette, *Cybersecurity Analytics*, Chapman and Hall/CRC, 2019.

References:

1. A. Kleymenov and A. Thabet, *Mastering Malware Analysis: The complete malware analyst's guide to combating malicious software, APT, cybercrime, and IoT attacks*, Packt Publishing, 2019.
2. K. A. Monappa, *Learning Malware Analysis: Explore the concepts, tools, and techniques to analyze and investigate Windows malware*, Packt Publication, 2018.
3. Y. Xin et. al, *Machine Learning and Deep Learning Methods for Cybersecurity*, IEEE Access, 2018.
4. B. Xi, *Adversarial machine learning for cybersecurity and computer vision: Current developments and challenges*, WIREs Computational Statistics, 2020.
5. M. Al-Rubaie, *Privacy Preserving Machine Learning: Threats and Solutions*, IEEE

Security and Privacy Magazine, 2019.
6. I. D. Aiyanyo, et al, *A Systematic Review of Defensive and Offensive Cybersecurity with Machine Learning*, Applied Scxiences, MDPI, 2020.
7. K. Shaukat, et al, *A Survey on Machine Learning Techniques for Cyber Security in the Last Decade*, IEEE Access, 2020.
8. A. D. Joseph, et. al, *Adversarial Machine Learning*, Cambridge University Press, 2019.

HARDWARE SECURITY

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000018	**Hardware Security**	**2-1-0-0**	**2023**

Prerequisites: Prior knowledge of computer networks, cryptography, sensor networks and basics of computer hardware.

Course Objectives:

1. Provide knowledge of state-of-the-art security methods and devices.
2. Familiarize the range of hardware-level attack techniques and countermeasures.
3. Make students aware of potential hardware vulnerabilities and provide them with the knowledge and skills to build trustworthy hardware.

Course Outcomes: After completion of this course, the students will be able to:

C01: Describe the vulnerabilities in the current digital system design flow and the physical attacks on these systems.

C02: Demonstrate proficiencies in understanding hardware security issues.

C03: Apply the tools and skills to build secure and trusted hardware

C04: Discuss the recent trends in hardware security and apply their knowledge in research and development.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written)

PLO 5 Practice ethical standards of professional conduct and research

PLO 6 Acquire professional skills such as collaborative skills and write articles for scholarly journals.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	2	1		2		
CO2	2	1	1	1		
CO3	2	2	1	2	1	
C04		2	2	2	3	2

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:	
Module	**Content**
1	Hardware Security threats, Vulnerabilities, and Attacks. Challenges in Securing Hardware, Threats to Hardware. Hardware Security Vulnerability Assessment. Hardware-Assisted Computer Security: ARM TrustZone, Intel SGX. Hardware Root of Trust, Trusted Platform Module (TPMs), TPM Cryptographic Hardware, Hardware Accelerators, Cryptographic Coprocessors. Implementing Security in Reprogrammable Hardware. FPGA Basics, Applications and Uses, FPGA Based Security Solutions.
2	Modern IC Design and Manufacturing Practices and Their Implications: Hardware Intellectual Property (IP) Piracy and IC Piracy, Design Techniques to Prevent IP and IC Piracy, Physically Unclonable Functions (PUFs), PUF Implementations and using PUFs to prevent Hardware Piracy, Model Building Attacks on PUFs (Case Study: SVM Modeling of Arbiter PUFs, Genetic Programming based Modeling of Ring Oscillator PUF). JTAG Protection**.**
3	Side-channel Attacks (SCA) on Cryptographic Hardware: Current-measurement based Side-channel Attacks, power, electromagnetic SCA. Design Techniques to Prevent Side-channel Attacks, Improved Side-channel Attack Algorithms and Cache Attacks. Fault-tolerance of Cryptographic Hardware, Fault Attacks. Hardware Trojan based SCA.
4	Hardware Trojans: Hardware Trojan Nomenclature and Operating Modes, Countermeasures-Design and Manufacturing Techniques to Prevent/Detect Hardware Trojans, Logic Testing and Side-channel Analysis based Techniques for Trojan Detection. Case study: Hardware security issues and solutions in vehicles, hardware security of fog end-devices for the internet of things.

Books and other resources:

1. Recent Publications from top-Tier Conferences and Journals.
2. D. Mukhopadhyay and R. S. Chakraborty, *Hardware Security: Design, Threats, and Safeguards*, Chapman and Hall/CRC, 2014.
3. Y. Jin, *Introduction to hardware security*, Electronics, *4*(4), pp.763-784, 2015.
4. S. Sidhu *et al.*, *Hardware security in IoT devices with emphasis on hardware Trojans*, Journal of Sensor and Actuator Networks, 8(3):42, 2019.
5. I. Butun *et al.*, *Hardware Security of Fog End-Devices for the Internet of Things*, Sensors, 20(20):5729, 2020.
6. C. Labrado and H. Thapliyal, *Hardware security primitives for vehicles*, IEEE Consumer Electronics Magazine, 8(6):99-103, 2019.
7. P. Prinetto and G. Roascio, *Hardware Security, Vulnerabilities, and Attacks: A Comprehensive Taxonomy*, InITASEC, pp. 177-189, 2020.

IOT NETWORKS AND ENDPOINT SECURITY

Course Code	Course Name	Credit Split	Year of

		Lecture/Lab/Seminar/Project	Introduction
M3000019	**IoT Networks and Endpoint Security**	**2-1-0-0**	**2023**

Prerequisites: Prior knowledge of distributed systems, computer networks, cryptography, sensor networks and basics of connected systems.

Course Objectives:

1. To impart a comprehensive and in-depth understanding of network security, IoT Networks, endpoint security, and various security mechanisms.
2. To expose the students to frontier areas of IoT security while providing sufficient foundations for further study and research.

Course Outcomes: After completion of this course, the students will be able to:

C01: Understand network security threats, security services, and countermeasures.

C02: Understand vulnerability analysis and risk mitigation strategies and prepare a sample Vulnerability Assessment Report.

C03: Expose students to current literature in IoT networks and endpoint security and understand various security challenges and issues.

C04: Complete a term project, including independent research, oral presentation, and programming on the latest advancement in the related areas.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written)

PLO 5 Practice ethical standards of professional conduct and research

PLO 6 Acquire professional skills such as collaborative skills and write articles for scholarly journals.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	2	1	3		
CO2	3	2	2	2	2	
CO3	2	2	2	2	2	
C04	2	2	2	3	3	1

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Overview of TCP/IP, TCP/IP networks, Network Vulnerabilities, Zero-day vulnerabilities, Malwares, Threat and Risk Assessment, Network Vulnerability Assessment, Vulnerability Naming Schemes, Information Infrastructure Defense, Reverse Engineering and Code Obfuscation. Network Access Control. Firewalls. DMZ Network. Router Security. Enterprise Wireless Network Security Protocols. Security in 5G and 6G. Endpoint Devices, Security of Endpoint Devices, Endpoint Device Security Challenges. Case Studies: Cyber Attacks on Critical Infrastructure.

2	IoT Architecture, Resource Management, Interoperability in IoT, IoT Communication Protocols, Network and Transport Layer Challenges, IoT Threats and Security Challenges, Attacks on Different Layers and Categorization of IoT Attacks, IoT Gateway Security, IoT Routing Attacks, Secure Data Aggregation Mechanisms, *Security Analytics and Threat Prediction*. IoT Endpoint Devices, Threats to IoT Endpoints, General Attacks on IoT Endpoint Devices, IoT Endpoint Security Mechanisms, Security of AIOT Devices. Endpoint Security Best Practices. Case Studies.
3	Security Frameworks for IoT networks, Intrusion Detection and Prevention, Lightweight Cryptography, Key Management and Authentication, Privacy Enhancing and Anonymization Techniques, Trust and Identity Management, Access Control, IoT Simulators to simulate IoT Networks and Attacks on IoT networks, IoT Operating Systems and Security, IoT Forensics. IoT Security Standards.
4	Case Studies: Internet of Vehicles (IoV), Unmanned Aerial Vehicle (UAV) Networks, Industrial IoT Networks. Future Research Direction/Opportunity in the IoT Networks and Endpoint Security.

Books and other resources:

1. Recent Publications from top-Tier Conferences and Journals
2. C. H. Gebotys, *Security in Embedded Devices*, Springer, ISBN 978-1-4419-1529-0, 2010.
3. C. H. (John) Wu and J. David Irwin, *Introduction to Computer Networks and Cybersecurity*, CRC Press, 2013.
4. E. A. Lee and S. A. Seshia, *Introduction to Embedded Systems, A Cyber-Physical Systems Approach* (Second Edition), MIT Press, ISBN 978-0-262-53381-2, 2017.
5. F. Hu, *Security and Privacy in Internet of Things (IoTs): Models, Algorithms, and Implementations*, CRC Press, ISBN 9780367574925, 2020.
6. K. Namuduri *et al.*, *UAV Networks and Communications*, Cambridge University Press, 2017.
7. N. Gupta *et al.*, *Internet of Vehicles and its Applications in Autonomous Driving*, Springer, ISBN 978-3-030-46334-2, 2021.
8. R. Buyya and A. V. Dastjerdi, *Internet of Things Principles and Paradigms*, Elsevier, ISBN 978-0-12-805395-9, 2016.
9. R. Buyya and S. N. Srirama, *Fog and Edge Computing: Principles and Paradigms*, Wiley, ISBN: 978-1-119-52498-4, 2019.
10. W. Stallings, *Cryptography and Network Security: Principles and Practice*, Pearson education, 2013.
11. Z. Mahmood, *Connected Vehicles in the Internet of Things: Concepts, Technologies and Frameworks for the IoV*, Springer, ISBN 978-3-030-36166-2, 2020.

MOBILE APPLICATION SECURITY

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000020	**Mobile Application**	**2-1-0-0**	**2023**

	Security		

Prerequisites: Nil.

Course Objectives:

1. To impart a comprehensive and in-depth understanding of mobile application security, mobile OS security, and various security mechanisms.
2. To expose the students to frontier areas of mobile security while providing sufficient foundations for further study and research.

Course Outcomes: After completion of this course, the students will be able to:

C01: Understand the fundamental concepts of mobile application security, the importance of securing smartphone devices, and the various types of mobile applications.

C02: Grasp the architecture and components of Android OS, including activities, services, content providers, broadcast receivers, fragments, and intents.

C03: Analyze Android security models, app sandboxing, permissions, and data encryption techniques.

C04: Develop secure Android applications using best practices, including app signing, secure communication, and root protection mechanisms.

C05: Acquire hands-on skills in mobile application vulnerability identification, analysis, and mitigation techniques, including malware analysis, static and dynamic analysis, and runtime manipulation.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written)

PLO 5 Practice ethical standards of professional conduct and research

PLO 6 Acquire professional skills such as collaborative skills and write articles for scholarly journals.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	2	1	3		
CO2	3	2	2	2	2	
CO3	2	2	2	2	2	
C04	2	2	2	3	3	1
C05		1	2	3	2	2

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content

1	**Introduction to Mobile Application Security and Android Basics** Importance of Smartphone Security, Types and Categories of Mobile Applications, History of Android and its Evolution, Features and Architecture of Android OS, Components of Android: Activity, Service, Content Provider, Broadcast Receiver, Fragment, Intent, Resources.
2	**Android Security and Development Environment** Android Security Models: App Sandboxing, App Signing, App Permissions; Data Encryption and Secure Coding Practices, Securing Android Devices: Best Practices and Configuration, Certificate/SSL Pinning for Secure Communication, Android Software Development Kit (SDK) Tools, Android Emulator and Debugging with Android Debug Bridge (adb), Using Android Studio for Application Development.
3	**Mobile Application Vulnerabilities and Analysis** Common Mobile Vulnerabilities and Avoidance Techniques, Identifying Vulnerable Features in Android Applications, Decompiling Android Applications: Smali Files and Java Code Recovery, Risk Analysis and Classification of Android Applications, Tools for Mobile Malware Analysis, Android Malware Analysis Approaches: Static, Dynamic, Network, Hybrid Analysis; Bypassing Root Detection and Certificate/SSL Pinning, Application Patching and Runtime Manipulation using Frida and Objection, Introduction to OWASP Top 10 Mobile Security Risks.
4	**iOS and Windows Phone Security** iOS Security Model and Architecture, Introduction to Jailbreaking and its Implications, Xcode and iOS Application Development Environment, File System and Device Interaction in iOS, Decompiling iOS Applications and Reverse Engineering, Intercepting Network Traffic for Analysis, Security Model of Windows Phone OS, Comparative Analysis of Mobile Security across Platforms.

Text Books :

1. M. Swamynathan and J. Mannino, *Mobile Security and Privacy: A Hands-On Guide*, O'Reilly Media, 2019.
2. H. Dwivedi, *Mobile Application Security*, Packt Publishing, 2019.
3. Tim Speed *et al.*, *Mobile Security: How to Secure, Privatize, and Recover Your Devices*, Apress, 2019.
4. V. K. Velu, *Mobile Application Penetration Testing*, Packt Publishing, 2020.
5. N. Elenkov, *Android Security Internals: An In-Depth Guide to Android's Security Architecture*, 1st Edition, No Starch Press, 2014.
6. D. Thiel, *iOS Application Security: The Definitive Guide for Hackers and Developers*, 1st Edition, O'Reilly Media, 2016.
7. N. Bergman *et al.*, Hacking Exposed Mobile: Security Secrets and Solutions, 2nd Edition, McGraw-Hill Education, 2020.

References:

1. A. Hoog and K. Strzempka, *Android Forensics: Investigation, Analysis, and Mobile Security for Google Android*, 1st Edition, Elsevier Science and Technology, 2011.
2. C. Miller *et al.*, *iOS Hacker's Handbook*, 1st Edition, Wiley, 2012.

3. D. Chell *et al.*, *The Mobile Application Hacker's Handbook*, 1st Edition, Wiley, 2015.

SYSTEMS SECURITY AND RISK ANALYSIS

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000021	**Systems Security and Risk Analysis**	**2-1-0-0**	**2023**

Prerequisites: Prior Knowledge of operating systems, computer networks, web technology, DBMS, security fundamentals, mathematics.

Course Objectives:

1. To impart a comprehensive and in-depth understanding of systems security and risk analysis.
2. To enable the students to study an organization, model security, measure risk, and design security strategy.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Perform threat analysis of an IT organization.

CO2: Perform risk analysis of an IT organization.

CO3: Find comprehensive defense strategies for the organization.

CO4: Respond in case of security emergency scenarios.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written)

PLO 5 Practice ethical standards of professional conduct and research

PLO 6 Acquire professional skills such as collaborative skills and write articles for scholarly journals.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	3	2	2	1	1
CO2	2	3	3	2	2	1
CO3	3	3	3	3	2	2
C04	1	1	1	3	3	3

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Discussion of fundamental Network and Systems security issues: Various Attacks on - Network Protocols, Systems, Web Infrastructure
2	Phases of YACRAF Risk Analysis: Phase 0: Scope and delimitations

	Phase 1: Business Analysis Phase 2: System Definition and Decomposition
3	Phase 3: Threat Analysis Phase 4: Attack and Resilience Analysis Phase 5: Risk Assessment and Recommendations
4	Main Assignment: Think like a CISO!

Text Books:

1. M. Ekstedt, Z. Afzal, P. Mukherjee, et al, *Yet another cybersecurity risk assessment framework*, Int. J. Inf. Secur. (2023). https://doi.org/10.1007/s10207-023-00713-y
2. T. UcedaVelez and Marco M. Morana, *PASTA: Risk Centric Threat Modeling: Process for Attack Simulation and Threat Analysis*, ISBN: 978-0-470-50096-5, 2015.
3. J. Freund and J Jones, *Measuring and managing information risk: a FAIR approach*, Butterworth-Heinemann., 2014.
4. W. Du, *Computer Security: A Hands-on Approach*, CreateSpace Independent Publishing, ISBN-13: 978-1548367947, 2017.
5. Latest course materials (from DUK and KTH Sweden).

Reference:

1. A. Hoffman, *Web Application Security*, O'Reilly Media, 2020.
2. P. Ackerman, *Industrial Cybersecurity: Efficiently secure critical infrastructure systems*, Packt Publishing Limited, 2017.
3. W. Stallings, *Cryptography and Network Security Principles and Practice*, Prentice Hall, 2017.

INFORMATION SECURITY MANAGEMENT SYSTEM

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000022	**Information Security Management Systems**	**2-1-0-0**	**2023**

Prerequisites: Nil.

Course Objectives:

1. To impart an in-depth understanding of information security management systems.
2. To prepare students for managing all the aspects of security of any large organization.

Course Outcomes: After completion of this course, the students would be able to:

CO1: Manage the security of an organization.

CO2: Prepare a complete risk treatment plan.

CO3: Prepare security policies, procedures, guidelines.

CO4: Audit security and check compliance.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences;

PLO 5 Practice ethical standards of professional conduct and research;

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	3	3	3	1	2
CO2	3	3	3	2	2	2
CO3	1	3	3	3	3	3
CO4	2	1	1	2	1	3

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Introduction to Information Security: Fundamentals of Information Security and Risk Management, Introduction to ISMS, Introduction to Information Security Standards
2	Information Security Management Systems: Identification of Information Security Requirements, Application of Risk Assessment Techniques, Risk Treatment and Security Control Identification, Statement of Applicability. Practical: Assessing the risk for an IT organization, Preparation of the risk treatment plan.
3	Information Security Policies: Selection of Protective Measures, Preparation of Documented Information (ISMS Manual, Information Security Policies, Information Security Procedures, Information Security Guidelines, Forms and Records) Practical: Preparation of the security policy and guidelines for an IT organization.
4	Implementation Techniques and Measuring Effectiveness: Asset Management, Information Security Incident Management, Business Continuity Management, Measuring Effectiveness of ISMS, Internal Audit and Compliance Checking. Practical: Preparation of security audit report for an IT organization.

Text Books:

1. A. Calder and S. Watkins, ISO 27001:2013 - A Pocket Guide, IT Governance Publishing, 2017.
2. D. Alexander and A. Finch, Information Security Management Principles, BCS, The Chartered Institute for IT, 2020.
3. ISO, ISO/IEC 27001:2022 - Information Security Management System - Requirements, ISO, 2013.
4. W. Siler, Information Security Management Systems: A Novel Framework and Software as a Tool for Compliance with Information Security Standard, CRC Press, 2013.
5. A. Nair, G. M. R., Mastering Information Security Compliance Management, Packt Pub, 2023.
6. K. C. Laudon and J. P. Laudon, Management Information System, Pearson Education, 2022.
7. S. Nadkarni, Fundamentals of Information Security, BPB Publications, 2020.

Reference Books:

1. H. F. Tipton and M. Krause, Information Security Management Handbook, Auerbach Publications, 2019.
2. P. H. Gregory, CISM Certified Information Security Manager All-in-One Exam Guide, McGraw-Hill Education, 2018.
3. A. Kohnke and D. Shoemaker, The Complete Guide to Cybersecurity Risks and Controls, Apress, 2017.
4. D. Kosutic, ISO 27001 Risk Management in Plain English, Advisera, 2015.

DATA ANALYTICS

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000023	Data Analytics	2-1-0-0	2023

Prerequisites: Basic knowledge in Machine learning, statistics and Python

Course Objectives:

1. To provide students with a good understanding of the concepts of data analytics described in the syllabus.
2. To help the students develop the ability to solve problems using the learned concepts.
3. Connect the concepts to other domains, such as machine learning and pattern recognition, within and without data analytics.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Understand the data analytics techniques and state-of-the-art solutions.

CO2: Analyze and evaluate critically the building and integration of data analytics.

CO3: Design and demonstrate data analytics through team research projects and project report presentations.

Program Learning Outcomes:

PLO1 Develop strong fundamental disciplinary knowledge

PLO2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO3 Apply for a scholarship to conduct independent and innovative research

PLO4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences;

PLO5 Practice ethical standards of professional conduct and research;

PLO6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course out comes with program learning out comes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	3	2	2	1	2
CO2	3	3	3	2	1	2
CO3	2	1	1	2	3	3

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Introduction to Data science fundamentals, Nature of Data and its characteristics, Total information awareness, Bonferroni's Principle, Rhine's paradox, Recap of Statistical and Inferential Analysis, Data preprocessing, Data wrangling, Data exploration, Dealing with missing data – single and multiple data imputation, Entropy based techniques.
2	Sampling distributions; Point estimation - estimators, minimum variance unbiased estimation, maximum likelihood estimation, method of moments, consistency; Interval estimation; Testing of hypotheses - tests and critical regions, likelihood ratio tests; Linear regression.
3	Monte Carlo and MCMC simulations; Correcting inconsistent data – Deduplication, Entity resolution, Pairwise Matching; Fellegi-Sunter Model, Advanced processing- Regression, Correlation, Covariance analysis, Aggregation, Sampling
4	Dimensionality Reduction; Feature extraction and feature selection; Graph data analysis, Stream processing and online analytics, Dealing with infinite length, concept drift, concept/feature evolution, Visual analytics, Current trends and research.

Text Books:

1. Jure Leskovec, Anand Rajaraman and Jeffrey Ullman, Mining of Massive Datasets

Cambridge University Press, 2014.
2. Sinan Ozdemir, Principles of Data Science - Second Edition Packt Publishing, 2018.
3. Sam Lau, Joey Gonzalez, and Deb Nolan, Principles and Techniques of Data Science.
4. Jeffrey S. Saltz and Jeffrey M. Stanton, An Introduction to Data Science, Sage Publications, 2017.

References:

1. R. V. Hogg, J. W. McKean and A. Craig, Introduction to Mathematical Statistics, 6th Ed., Pearson Education India, 2006.
2. Davy Cielen, Arno D.B. Meysman, Mohamed Ali Introducing Data Science: Big Data, Machine Learning, and More, 2016.
3. Garrett Grolemund, Hadley Wickham, R for Data Science O'Reilly, 2017.
4. Nina Zumel and John Mount, Practical Data Science with R, 2014.

DIGITAL IMAGE AND VIDEO PROCESSING

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000024	Digital Image and Video Processing	2-1-0-0	2023

Prerequisites: Nil

Course Objectives:

1. To provide students with a good understanding of the concepts of image and video processing tasks described in the syllabus.
2. To help the students develop the ability to solve problems using the learned concepts.
3. Connect the concepts to other domains, such as machine learning and pattern recognition, within and without image and video processing.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Understand the foundations of modern image/video signal processing theory, problems, and state-of-the-art solutions.

CO2: Analyze and evaluate critically the building and integration of image/video signal processing algorithms and systems.

CO3: Design and demonstrate a working image/video signal processing system through a team research project, project report, and presentation.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences;

PLO 5 Practice ethical standards of professional conduct and research;

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty

in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	2	3	2		
CO2	3	3	3	2		
CO3	2	3	3	2		

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Introduction to Image Processing Systems, Image Acquisition, Sampling and Quantization, Pixel Relationships, Color Fundamentals and Modules, File Formats, Image Enhancement and Restoration, Spatial Domain Gray Level Transformations, Histogram Processing, Spatial Filtering, Smoothing and Sharpening.
2	Frequency Domain: Filtering in Frequency Domain, DFT, FFT, DCT, Smoothing and Sharpening Filters, Homomorphic Filtering. Noise Models: Spatial and Frequency Properties of Noise, Important Noise Probability Density Functions, Periodic Noise, Estimation of Noise Parameters, Constrained and Unconstrained.
3	Restoration Models, Image Deblurring Algorithms. Morphological Image Processing: Erosion and Dilation, Opening and closing, Hit or miss transformation, basic morphological algorithms, gray scale morphology. Image Segmentation and Feature Analysis, Detection of Discontinuities, Edge Operators, Edge Linking and Boundary Detection, Thresholding, Region based Segmentation: Region Growing, Region Splitting and Merging. Representation and description: boundary and regional descriptors, Image Compression: classification of lossy and lossless image compression schemes.
4	Video Formation, Perception and Representation: Video Capture and Display, Analog Video Raster, Digital Video, Fourier Analysis of Video Signals and Frequency Response of the Human Visual System. Video Sampling: Basics of the Lattice Theory, Sampling of Video Signals Over Lattices, Filtering Operations in Cameras and Display Devices. Video Sampling Rate Conversion, Different Video Modeling.Video Object Tracking and segmentation. Object recognition, pattern and pattern classes, recognition based on decision- theoretic methods, structural methods, case studies –image analysis, image coding.

Text Books:

1. R. C. Gonzalez and R. E. Woods, *Digital Image Processing*, Prentice Hall, Upper Saddle River, N.J, 2008.
2. A. K. Jain, *Fundamentals of Digital Image Processing*, Prentice-Hall, Inc., USA, 1989.
3. J. W. Woods, *Multidimensional Signal, Image, and Video Processing and Coding* (Second Edition), Academic Press, Inc., USA, 2011.
4. Y. Wang *et al.*, *Video Processing and Communications*, Signal Proc. Series, Prentice Hall, 2002.

References:

1. W. K. Pratt, *Digital Image Processing: PIKS Scientific Inside*, Wiley-Interscience, USA, 2007.
2. S. E. Umbaugh, *Digital Image Processing and Analysis: Human and Computer Vision Applications with CVIPtools* (Second Edition), CRC Press, Inc., USA, 2010.
3. A. M. Tekalp, *Digital Video Processing* (Second Edition), Prentice Hall Press, USA, 2015.
4. A. C. Bovik, *Handbook of Image and Video Processing (Communications, Networking and Multimedia)*, Academic Press, Inc., USA, 2005.

DEEP LEARNING

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000025	**Deep Learning**	**2-1-0-0**	**2023**

Prerequisites: AI and Machine Learning

Course Objectives:

1. To provide students with a good understanding of the concepts of the deep learning described in the syllabus.
2. To help the students develop the ability to solve problems using the learned concepts.
3. To connect the concepts to other domains.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Understand the foundations of modern deep learning theory, problem, and state-of-the-art solutions.

CO2: Analyze and evaluate critically the building and integration of deep learning algorithms and systems.

CO3: Design and demonstrate a working deep learning system through a team research project and project report presentation.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences;

PLO 5 Practice ethical standards of professional conduct and research;

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	3	2	2	1	2

CO2	3	3	3	2	1	2
CO3	2	1	1	2	3	3

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Deep FeedForward Networks, Regularization for Deep Learning
2	Optimization for Training Deep Models. Convolutional Neural Networks, Sequence Modeling - Recurrent and Recursive Nets
3	Practical Methodology, Autoencoders, Representation Learning
4	Deep Generative Models, Applications of Deep Learning

Text Books:

1. J. Patterson and A. Gibson, *Deep learning: A Practitioner's Approach*, O'Reilly, 2017.
2. I. Goodfellow, Y. Bengio and A. Courville, *Deep Learning*, MIT Press, 2016.
3. M. A. Nielsen, *Neural Networks and Deep Learning*, Determination Press, 2015.

References:

1. L. Deng and D. Yu, *Deep Learning: Methods and Applications*, now Publishers Inc, 2013.
2. D. Koller and N. Friedman, *Probabilistic Graphical Models*, MIT Press. 2009.

REINFORCEMENT LEARNING

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000026	**Reinforcement Learning**	**2-1-0-0**	**2023**

Prerequisites: Mathematics for Computer Science

Course Objectives:

1. To provide students with a good understanding of the concepts of the reinforcement learning described in the syllabus.
2. To help the students develop the ability to solve problems using the learned concepts.
3. To connect the concepts to other domains.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Understand the foundations of modern reinforcement learning theory, problem, and state-of-the-art solutions.

CO2: Analyze and evaluate critically the building and integration of reinforcement learning algorithms and systems.

CO3: Design and demonstrate a working deep learning system through a team research project and project report presentation.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge.

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature.

PLO 3 Apply for a scholarship to conduct independent and innovative research.

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences.

PLO 5 Practice ethical standards of professional conduct and research.

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	3	2	2	1	2
CO2	3	3	3	2	1	2
CO3	2	1	1	2	3	3

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Introduction to Reinforcement Learning, Markov Processes Markov Reward Processes (MRPs) Markov Decision Processes (MDPs), MDP Policies, Policy Evaluation, Policy Improvement, Policy Iteration, Value operators.
2	Model-free learning - Q-learning, SARSA, Scaling up: RL with function approximation, RL with function approximation.
3	Imitation learning in large spaces, Policy search, Exploration/Exploitation, Meta-Learning, Batch Reinforcement Learning, Bandit problems and online learning.
4	Solution methods: dynamic programming, Monte Carlo learning, Temporal difference learning, Eligibility traces, Value function approximation, Models and planning.

Text Books:

1. R. S. Sutton and A. G. Barto, *Reinforcement Learning: An Introduction*, MIT Press, 1998.
2. C. Szepesvari, *Algorithms for Reinforcement Learning*, Morgan and Claypool Publishers, 2010.

References:

1. K. P. Murphy, *Machine Learning: A Probabilistic Perspective*, The MIT Press, 2012.
2. M. L. Puterman, *Markov Decision Processes: Discrete Stochastic Dynamic Programming (1st. ed.)*, John Wiley and Sons, Inc., USA, 1994.

COMPUTER VISION

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000027	Computer Vision	2-1-0-0	2023

Prerequisites: Mathematics for Computer Science

Course Objectives:

1. To provide students with a good understanding of computer vision concepts described in the syllabus.
2. To help the students develop the ability to solve problems using the learned concepts.
3. Connect the concepts to other domains, such as machine learning and pattern recognition, within and without computer vision.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Understand the foundations of modern computer vision theory, problems, and state-of-the-art solutions.

CO2: Analyse and evaluate critically the building and integration of computer vision algorithms and systems.

CO3: Design and demonstrate a working computer vision system through a team research project, project report, and presentation.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences;

PLO 5 Practice ethical standards of professional conduct and research;

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	2	3	2		
CO2	3	3	3	2		
CO3	2	3	3	2		

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	The Four Rs of Computer Vision, Geometry of Image Formation and Sensing, Single/Two View Geometry, Camera Calibration, Vanishing Points, Planar Scenes and Homography, Interest Point Detection, Robust Correspondence Estimation
2	Feature Extraction: Edges - Canny, LoG, DoG; Line detectors (Hough Transform),

	Corners - Harris and Hessian Affine, Orientation Histogram, SIFT, SURF, HOG, GLOH, Scale-Space Analysis- Image Pyramids and Gaussian derivative filters, Gabor Filters and DWT.
3	Image Segmentation: Region Growing, Edge Based approaches to segmentation, Graph-Cut, Mean-Shift, MRFs, Texture Segmentation; Object detection
4	Motion Analysis: Background Subtraction and Modelling, Optical Flow, KLT, Spatio-Temporal Analysis, Dynamic Stereo; Motion parameter estimation.

Text Books:

1. R. Szeliski, *Computer Vision: Algorithms and Applications*, Springer-Verlag London Limited 2011.
2. D. A. Forsyth, J. Ponce, *Computer Vision: A Modern Approach*, Pearson Education, 2003.
3. R. Hartley and A. Zisserman, *Multiple View Geometry in Computer Vision*, Second Edition, Cambridge University Press, March 2004.

References:

1. S. J. D. Prince, *Computer Vision: Models*, *Learning*, *and Inference*, 1st Edition, Cambridge University Press, USA, 2012.
2. E. R. Davies, *Computer Vision: Principles*, *Algorithms*, *Applications*, *Learning*, 5th Edition, Academic Press, Inc., USA, 2017.

SOFT COMPUTING

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000028	**Soft Computing**	**2-1-0-0**	**2023**

Prerequisites: Nil

Course Objectives:

1. To impart algorithmic skills needed for designing soft computing techniques and solutions.
2. To equip the students to identify and analyze problems solvable with soft computing techniques.
3. To impart solution design capability with soft computing techniques.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Algorithm design/analysis capability in Soft Computing

CO2: Problem identification and analysis skills on application domains requiring soft computing techniques

CO3: Solution design capability with soft computing techniques

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in a variety of formats (oral, written) and to expert and non-expert audiences;

PLO 5 Practice ethical standards of professional conduct and research;

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and write articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**
CO1	3	2	3	1	1	2
CO2	3	2	3	1	1	2
CO3	3	3	3	2	1	2

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	**Content**
1	Difference between Soft and Hard computing, Overview of different components of soft computing techniques - Fuzzy Logic, Rough Logic, ANNs, Genetic Algorithms, Swarm Intelligence
2	Introduction to Fuzzy logic, Fuzzy membership functions, Operations on Fuzzy sets, Fuzzy relations, Fuzzy propositions, Fuzzy implications, Fuzzy inferences, Defuzzification, Fuzzy logic controller.
3	Genetic algorithms basic concepts, encoding, fitness function, Parent Selection - Roulette wheel, Rank, Tournament, Mutation and Crossover operators, Convergence of GA, Applications of GA, Case studies.
4	Swarm Intelligence - agent systems, social agents, Particle Swarm Optimisation - path planning applications, Ant Colony Optimisation - solving traveling salesman problem with ACO, introduction to Artificial Immune Systems

Text Books:

1. R. Rajasekaran *et al.*, *Neural Networks, Fuzzy Logic, and Genetic Algorithms: Synthesis and Applications*, Prentice Hall of India, 2011.
2. T. Ross, *Fuzzy Logic with Engineering Applications*, Tata McGraw Hill, 1997.
3. A. Slowik, *Swarm Intelligence Algorithms*, CRC press, 2020.

References:

1. D. E. Goldberg, *Genetic Algorithms in Search, Optimisation, and Machine Learning*, Addison-Wesley, 1989.
2. E. Bonabeau *et al.*, *Swarm Intelligence: From Natural to Artificial Systems*, Oxford University Press, 1999.
3. L. Polkowski and P. Verlag, *Rough Sets: Mathematical Foundations*, Heidelberg, 2002.

NATURAL LANGUAGE PROCESSING

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000029	**Natural Language Processing**	**2-1-0-0**	**2023**

Prerequisites: Prior knowledge of Python, Probability and Statistics and Machine Learning

Course Objectives:

1. To introduce the fundamental concepts of Natural Language Processing.
2. To impart the principles, concepts, and theory behind Language Modeling from an algorithmic point of view.
3. To get insights into the conceptual and application levels of Natural Language Processing.

Course Outcomes: After completion of this course, the students will be able to:

C01: Understand the fundamental theories and application levels of Natural Language Processing.

C02: Develop language models based on the practical knowledge acquired from the subject area.

C03: Understand the latest advancements and research opportunities within this domain.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written)

PLO 5 Practice ethical standards of professional conduct and research

PLO 6 Acquire professional skills such as collaborative skills and write articles for scholarly journals.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	1	1	2		

CO2	2	2	2	2	1	1
CO3	2	2	1	2	2	2

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	**Content**
1	Introduction to Natural Language Processing: Phases of Natural Language analysis – Syntax – Semantics and Pragmatics, Language Modeling: Defining language models - Corpus, Token, and Lexicon, Tokenization, Word Level Analysis: Regular Expressions- Finite-State Automata- Morphological Parsing, Syntactic Analysis: Parsing - Constituency Grammar - Dependency Grammar - Context Free Grammar, Semantic Analysis.
2	Parts-of-Speech (POS) Tagging, Named Entity Recognition, Probabilistic Language Modeling, n-gram models, Probabilistic Approaches for POS Tagging and Morphological analysis- Hidden Markov Model (HMM) - Viterbi algorithm and Conditional Random Fields(CRF), Maximum Entropy models, Word Sense Disambiguation(WSD), Information Retrieval, Sentiment Analysis, Topic Modeling- LDA
3	Machine Translation - Rule-Based Machine Translation (RBMT) – Hybrid Machine Translation -Statistical Machine Translation (SMT) -Neural Machine Translation (NMT), Machine learning of cross-lingual mappings, learning representations using cross-lingual supervision, Challenges in using NLP with multilingual resources.
4	NLP using Deep Learning: word embedding, Dependency Parsing, RNN and CNN applications in Language Models, Attention, Transformer Models in LLM, Multilingual Seq2seq Deep Neural Network, Encode-decoder Model.

Books and other resources:

1. Recent Publications from top-Tier Conferences and Journals.
2. E. M. Bender, Linguistic Fundamentals for Natural Language Processing: 100 Essentials from Morphology and Syntax, Morgan and Claypool Life Sciences, ISBN-13: 978-1627050111, 2013.
3. G. S. Ingersoll et al., Taming Text: How to Find, Organize, and Manipulate It, O'Reilly Media, ISBN-13: 978-1491981658, 2017.
4. H. Lane et al., Natural Language Processing in Action: Understanding, analyzing, and generating text with Python, Manning Publications, ISBN-13: 978-1617294631, 2019.
5. J. Eisenstein, Introduction to Natural Language Processing, The MIT Press, ISBN-13: 978-0262042840, 2019.
6. N. Indurkhya and F. J. Damerau, Handbook of Natural Language Processing (Second Edition), Taylor and Francis, ISBN-13: 978-1420085921, 2010.
7. P. Goyal et al., Deep Learning for Natural Language Processing- Creating Neural Networks with Python, Apress, ISBN-13: 978-1-4842-3684-0, 2018.
8. R. Mihalcea and D. Radev., Graph-based Natural Language Processing and Information

Retrieval, Cambridge University Press, doi:10.1017/CBO9780511976247, 2011.
9. S. Vajjala et al., Practical Natural Language Processing: A Comprehensive Guide to Building Real-World NLP Systems, O'Reilly Media, ISBN-13: 978-1492054054, 2020.
10. S. Bird et al., Natural Language Processing with Python – Analyzing Text with the Natural Language Toolkit, O'Reilly Media, ISBN: 978-0-596-51649-9, 2009.
11. T. Strzalkowski, Natural Language Information Retrieval, Springer, ISBN 978-90-481-5209-4, 1999.
12. Y. Goldberg and G. Hirst, Neural Network Methods for Natural Language Processing, Morgan and Claypool Life Sciences, ISBN-13: 978-1627052986, 2017.

SPEECH PROCESSING

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000030	**Speech Processing**	**2-1-0-0**	**2023**

Prerequisites: Mathematics for Computer Science

Course Objectives:

1. To give students a good understanding of speech processing tasks described in the syllabus.
2. To help the students develop the ability to solve problems using the learned concepts.
3. Connect the concepts to other domains, such as machine learning and pattern recognition, within and without speech.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Understand the foundations of modern speech processing theory, problems, and state-of-the-art solutions.

CO2: Analyze and evaluate critically the building and integration of speech signal processing algorithms and systems.

CO3: Design and demonstrate a working speech signal processing system through a team research project, project report, and presentation.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences;

PLO 5 Practice ethical standards of professional conduct and research;

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and write articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6

CO1	3	2	3	2		
CO2	3	3	3	2		
CO3	2	3	3	2		

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	The human vocal and auditory systems. Characteristics of speech signals: phonemes, prosody, IPA notation. Lossless tube model of speech production. Time and frequency domain representations of speech; window characteristics and time/frequency resolution tradeoffs. Properties of digital filters: mean log response, resonance gain and bandwidth relations, bandwidth expansion transformation, all-pass filter characteristics.
2	Autocorrelation and covariance linear prediction of speech; optimality criteria in time and frequency domains; alternate LPC parametrisation. Speech coding: PCM, ADPCM, CELP. Speech synthesis: language processing, prosody, diphone and formant synthesis; time domain pitch and speech modification.
3	Speech recognition: hidden Markov models and associated recognition and training algorithms. Language modelling. Large vocabulary recognition. Acoustic preprocessing for speech recognition.
4	Speech Processing: Spectral and non-spectral analysis techniques, Model- based coding techniques, Noise reduction and echo cancellation, Synthetic and coded speech quality assessment. Selection of recognition unit, Model-based recognition, Language modeling, Speaker Identification, Text analysis and text-to-speech synthesis.

Text Books:

1. L. Rabiner and R. Schafer, *Theory and Applications of Digital Speech Processing*, 1st Ed., Prentice Hall Press, USA, 2010.
2. B. Gold *et al.*, *Speech and Audio Signal Processing: Processing and Perception of Speech and Music*, 2nd Ed. Wiley-Interscience, USA, 2011.

References:

1. D. O'Shaughnessy, *Speech Communication: Human and Machine*, Addison-Wesley, 1987.
2. T. Ogunfunmi *et al.*, *Speech and Audio Processing for Coding*, *Enhancement and Recognition*, Springer Publishing Company, Incorporated, 2014.
3. J. Benesty *et al.*, *Springer Handbook of Speech Processing*, Springer, Berlin, 2008.

COGNITIVE COMPUTING

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000031	**Cognitive Computing**	**2-1-0-0**	**2023**

Prerequisites: 10th class biology and chemistry, basic background in simple differential equations and probability theory, interest in neuroscience and cognitive science.

Course Objectives:

1. To provide students with a basic understanding of the concepts of neuroscience, cognitive science, and cognitive computing described in the syllabus.
2. To help them understand how to connect the concepts of cognitive science and neuroscience to the computing domain.
3. To inform students of current research trends in cognitive computing and artificial emotional intelligence.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Understand the various cognitive and emotional processes in the brain/mind and how this knowledge can be applied in the computing domain.

CO2: Analyze and evaluate critically the building of cognitive and affective computing models and systems.

CO3: Think about research ideas in cognitive science and computing and pursue them.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences

PLO 5 Practice ethical standards of professional conduct and research;

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	1		1		1
CO2	3	2	1	1	1	1
CO3	2	2	2		1	1

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Basic neuroscience: Neurons, Dendrites and Axons, Synapses, Synaptic and Action Potentials, Action Potential generation and propagation, Brain organization, anatomy and functions, Synaptic integration and plasticity, the Concept of a Basic Circuit, Abstractions of Cortical Basic Circuits, Neocortical Brain Organization. Neuron models - McCulloch-Pitts, Integrate-and-Fire, Hodgkin-Huxley.
2	Cognitive psychology of decision making, neural basis, Scientific theories and measures of Consciousness, Cognitive models of memory, Mental Imagery,

	Understanding a problem, a cybernetic view of cognition consciousness and free will. Hierarchical temporal memories, Brain Simulations, Eye Tracking and other modalities for data acquisition. Scope of Realization of Cognition in Artificial Intelligence.
3	Brain Computer Interface: Types – Synchronous and Asynchronous, Invasive-Partially Invasive - Non-Invasive BCI, Structure of BCI System, BCI Monitoring Hardware-EEG, EEG Pre-processing Techniques, Analysis -time, spatial and frequency domains, fMRI, neuro imaging tools, Brain Response useful for Building BCIs, BCI applications. Emotions and Machines; Theories, models and neural basis of emotions, computational models for synthetic emotion simulation and dynamics, application of artificial emotional intelligence in healthcare, video surveillance.
4	Introduction to Brain networks, graph models for complex systems, graph theory and brain, connectivity at microscale. Clinical applications of brain network analysis, network visualization, case studies. Demonstration and tools for computing different connectivity measures and their visualizations.

References:

1. E. Kandel *et al*., *Principles of Neural Science*, McGraw-Hill Professional, 2012.
2. E. Bruce Goldstein, *Cognitive Psychology: Connecting Mind, Research, and Everyday Experience*, Cengage Learning Inc, 4th edition, 2014
3. R. P. N. Rao, *Brain Computer Interfacing: An Introduction*, Publisher: Cambridge, 2013.
4. N. Panigrahi and S. P. Mohanty, *Brain Computer Interface EEG Signal Processing*, CRC Press, 2022
5. A. Ortony, G. L. Clore, and A Collins, *The Cognitive Structure of Emotions*, Cambridge University Press, 2011
6. J. Friedenberg and G. Silverman, *Cognitive Science: An Introduction to the Study of Mind*, Sage Publications, 2021.
7. Connectomics: A New Approach to Understanding Brain Function by Olaf Sporns
8. M. Gazzaniga, *Cognitive neuroscience: the biology of the mind*, W W Norton and Co Inc, 2018.

BIG DATA TECHNOLOGIES

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000032	**Big Data Technologies**	**2-1-0-0**	**2023**

Prerequisites: Nil

Course Objectives:

1. To introduce various technologies related to big data analysis.
2. To enable the students to design big data analysis systems using machine learning.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Understand the concept of bigdata

CO2: Analyze and process bigdata using Apache Spark

CO3: Perform mining in data stream

CO4: Design bigdata analysis system using machine learning with spark

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences;

PLO 5 Practice ethical standards of professional conduct and research;

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	3	2	1	2	1
CO2	3	2	1	1	1	1
CO3	3	3	1	1	1	2
CO4	3	3	2	1	2	1

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Introduction to Big Data Technology, Hadoop, HDFS and MapReduce, Hadoop Environment -PIG, Hive, Messaging systems, Distributed SQL Query Engines, No SQL Database.
2	Introduction to Apache Spark, Spark Cluster ASpark Core, High level architecture, Spark Context, RDD, Lazy Operation, Caching methods, Spark SQL
3	Machine learning with spark, Spark Machine Learning libraries, Spark ML and Applications, Graph Processing with Spark
4	Mining data stream, Examples of data stream applications, Sampling in data streams, filtering streams, counting distinct elements in stream, Querying on Windows.

Text Books:

1. Chris Eaton,Dirk deroos et al, Understanding Big Data, McGraw Hill, 2017.
2. Subhashini Chellappan Seema Acharya, Big Data and Analytics, 2ed, Wiley, 2019.
3. Nathan Marz and James Warren, Big Data: Principles and Best Practices of Scalable Real-Time Data Systems, Manning Publishers, 2015.

References:

1. Jeffrey Aven, Data Analytics with Spark Using Python, Addison Weley Data and Analytics series, 2018.
2. Mohammed Guller, Big Data Analytics with Spark, APress, 2015.

SOFTWARE DEFINED NETWORKING

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000033	Software Defined Networking	2-1-0-0	2023

Prerequisites: Basic knowledge in computer networks, operating systems, distributed systems, machine learning and Python Programming.

Course Objectives:

1. To instill a thorough understanding of SDN fundamentals, technologies, and applications by introducing and investigating cutting-edge topics, technologies, applications, and implementations.
2. To expose students to cutting-edge research in SDN and NFS while providing a sufficient foundation for further study and research.

Course Outcomes: After completion of this course, the students will be able to:

C01: Analyze the evolution of SDNs, express the various components of SDN and their uses, explain the use of SDN in the current networking scenario, and develop various applications.

C02: Describe Network Functions Virtualization and investigate emerging SDN models and security aspects of SDN and NFV.

C03: Complete paper reviews, oral presentations, and a final course project.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written)

PLO 5 Practice ethical standards of professional conduct and research

PLO 6 Acquire professional skills such as collaborative skills and write articles for scholarly journals.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	1		1		
CO2	2	2	1	2		
CO3	1	2	1	2	1	1

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Networking Basics - Switching, Addressing, Routing, The history of SDN, SDN Architecture, Data, Control, and Management Planes, Distributed Control Planes, Centralized Control Planes, Hardware Lookup, Forwarding Rules, Dynamic Forwarding Tables, Autonomous Switches and Routers, Network Automation and Virtualization, SDN Network Updates, SDN Scalability, SDN Applications.

2	OpenFlow: Switch-Controller Interaction, Flow Table, Packet Matching, Actions and Packet Forwarding, Extensions and Limitations, Mininet: A simulation environment for SDN; White-box Switching, Open Sourcing SDN, Open Networking Foundation, OpenDaylight, ONOS, OpenStack, OpenSwitch; Programming Languages, Verification Techniques, Debugging Tools for SDN, Virtual appliances on SDN, Virtualization and SDN.
3	Emerging SDN Models: Protocol Models: NETCONF, BGP, MPLS; Controller Models; Application Models: Proactive, Declarative, External; SDN in Datacenters: Multitenancy, Failure Recovery; SDN in Internet eXchange Points (IXPs); SDN-Powered Mobile Edge Computing, IoT–SDN. Network Function Virtualization (NFV): Introduction to Network Functions, SDN vs. NFV, NFV Reference Architecture, OPNFV, Inline Network Functions, Service Creation and Chaining, NFV Orchestration, Network Slicing, Developing Virtual Network Functions, Deploying Virtualized Network Functions.
4	Security Threats and Vulnerabilities Introduced by NFV and SDN, Threat Detection and Mitigation through SDN and NFV;, Authentication, Authorization, and Access Control (AAA), Anomaly Detection and Prevention Mechanisms, Intrusion Detection and Prevention Systems, Security of applying SDN to Wireless and Mobile Networks, Security of applying NFV and SDN to IoT and Cloud/Edge Computing, Security of SDN API, Security Architecture for SDN, Security of SDN Data Plane, Control Plane and Application Plane, Security of Routing in SDN, Security of Network Slicing, Security as a Service for SDN, Machine and Deep Learning for SDN Security, Secure SDN with Blockchain.

Books and other resources:

1. Recent Publications from top-Tier Conferences and Journals.
2. P. Goransson and C. Black, *Software Defined Networks: A Comprehensive Approach*, Morgan Kaufmann Publications, 2017.
3. N. Thomas and K. Gray, *SDN - Software Defined Networks*, O'Reilly, 2013.
4. K. Gray and T. D. Nadeau, *Network Function Virtualization. Morgan Kaufmann*, ISBN: 978-0-12-802119-4, 2016.
5. S. Zhu *et al.*, *Guide to Security in SDN and NFV: Challenges, Opportunities, and Applications*, ISBN-13: 978-3319646527, Springer, 2017.
6. D. Huang et al., *Software-Defined Networking and Security from Theory to Practice*, ISBN 9780367780647, CRC Press, 2021.
7. J. Gooley *et al.*, *Cisco Software-Defined Wide Area Networks: Designing, Deploying and Securing Your Next Generation WAN with Cisco SD-WAN*, ISBN-13: 978-0-13-653317-7, Cisco Press, 2020.

SOCIAL NETWORK ANALYTICS AND SECURITY

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000034	**Social Network Analytics**	**2-1-0-0**	**2023**

	and Security		

Prerequisites: Prior knowledge of Computer Networks, Natural Language Processing, DBMS, Graph Theory and Machine Learning

Course Objectives:

1. To impart a comprehensive and in-depth understanding of social networks, research challenges, and social media analytics to M. Tech students by researching and providing insights into cutting-edge topics, technologies, applications, and implementations.
2. To expose the students to the frontier areas of social networks and provide sufficient foundations for further study and research.

Course Outcomes: After completion of this course, the students will be able to:

C01: Summarize social network concepts and security issues and apply basic principles behind network analysis algorithms to develop practical skills in network analysis

C02: Summarize human cognition and social networks and analyse the techniques used for behaviour analysis in social networks

C03: Apply mechanisms on how big data technologies, machine and deep learning algorithms are employed in social networks

C04: Understand how social technologies impact society and vice versa and examine the ethical and legal implications of leveraging social media data

C05: Complete a term project, including independent research, oral presentation, and programming on the latest advancement in the related areas.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written)

PLO 5 Practice ethical standards of professional conduct and research

PLO 6 Acquire professional skills such as collaborative skills and write articles for scholarly journals.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	1	1	1		
CO2	2	2	2	2	2	1
CO3	2	2	1	2		
C04	1	2	2	2	2	2
C05	2	2	2	2	2	2

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Online Social Networks- Introduction, Types of networks, Properties of nodes and networks, Social Network Analysis: Graph Structure of Social Networks, Centrality

	Measures- Degree, Closeness, Betweenness, Eigenvector centrality, Idea of small worlds, Networks and Groups- Identifying actors, Activating and mobilizing ties, understanding how people form communities. System Architectures of OSN- Client Server, P2P.
2	Privacy and Security in Social Networks: Security Threats- Malware attacks, Sybil attacks, Phishing in OSN, Fake Profiles, Social Engineering Attacks, Information Leakage, Dark Web and Social Media. Social Network Analysis and its applications – Influence Maximization-How Information is being created and distributed, Information diffusion among people in a network, How Online Social Networks are formed and evolve over time, Visualizing complex relationships, Identifying powerful and influential participants, Community Detection, Link Prediction. Big Data Analytics and Deep Learning for Social Network Security.
3	Data extraction from Online Social Media, APIs, Modeling and Visualizing Social Network graphs - Tools- Gephi, Graphviz, and NodeXL. Dataset Collection for Social Media Analytics – Visualizing data using Ne04j. Challenges in collecting social media data. esearch in Social Networks: Design of novel algorithms for analyzing social networks, Improving the performance of information sharing in social networks. Rumor Detection, Semantic Analysis, Online Sentiment Analysis- opinion mining, feature based sentiment analysis, Trust, credibility, and reputations in social systems. Emerging Areas in OSN: Decentralized Social Networks- When Blockchain meets social networks, Mobile Social Networks, Social Internet of Things (SIoT), Internet of Behavior (IoB) and Social Networks, Cognitive and AI in Social Network Security.
4	Human Cognition and Social Networks: Human Social Networks and ego networks, Analysis of ego networks in online social networks, Applying structural knowledge to Online Social Networking services. User Behavior Analysis in Social Networks: Psychology of social media users, Personality theories and User Behavior Prediction – Five Factor Theory- TPB-MBTI, Relationships between Personality and Interactions in social networks, Cognitive Psychology and Social Network Usage.

Books and other resources:

1. Recent Publications from top-Tier Conferences and Journals.
2. Social Media Security - *Leveraging Social Networking While Mitigating Risk-1st Edition*, eBook ISBN: 9781597499873, Michael Cross, 2013.
3. P. Kazienko *et al.*, *Applications of Social Media and Social Network Analysis*, eBook ISBN: 978-3-319-19003-7, Springer, 2015.
4. S. Wasserman and K. Faust, *Social network analysis: methods and applications*, Cambridge; New York: Cambridge University Press, 1994.
5. P. Federico *et al.*, *Sentiment Analysis in Social Networks*, 1st Edition - eBook ISBN: 9780128044384, Elsevier, 2016.
6. V. Arnaboldi et al., *Online Social Networks: Human Cognitive Constraints in Facebook and Twitter Personal Graphs*, Elsevier - 1st

Edition. eBook ISBN: 9780128030424.
7. D. Hansen *et al.*, *Analyzing Social Media Networks with NodeXL: Insights from a Connected World*, Morgan Kaufmann, 2010.
8. R. Missaoui *et al.*, *Social Network Analysis - Community Detection and Evolution*, Springer, 2014.
9. R. Missaoui *et al.*, T*rends in Social Network Analysis - Information Propagation, User BehaviorModeling, Forecasting, and Vulnerability Assessment*, Springer, 2017.

WIRELESS SENSOR NETWORKS

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000035	**Wireless Sensor Networks**	**2-1-0-0**	**2023**

Prerequisites: Prior knowledge of operating systems, computer networks, distributed systems, DBMS, Graph Theory.

Course Objectives:

1. To understand the fundamentals of wireless sensor networks and their application to real-world scenarios.
2. To investigate the protocols at various layers and their differences with traditional protocols.
3. To understand the issues about sensor networks and the challenges involved in managing a sensor network.
4. To introduce students to cutting-edge areas of wireless sensor networks while providing foundations for further study and research.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Understand the basis of sensor networks, sensor node hardware and software, architecture and placement strategies of sensors, analyze routing and congestion algorithms.

CO2: Explore and implement solutions to real- world problems using sensor networks.

CO3: Expose students to current literature in wireless sensor networks and related areas.

CO4: Complete a term project, including independent research, oral presentation, and programming on the latest advancement in Wireless Sensor Networks.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written)

PLO 5 Practice ethical standards of professional conduct and research

PLO 6 Acquire professional skills such as collaborative skills and write articles for scholarly journals.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	2	1	1		
CO2	3	2	2	2		
CO3	2	2	2	2		
C04	2	2	2	3	2	1

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Introduction to Wireless Sensor Networks: Motivations, Application domains of sensor networks, Design Challenges. Operational and Computational Models, Performance metrics, Network Architecture: Traditional Layered Stack, Cross-Layer Designs, Sensor Network Architecture. Single-Node Architecture. Sensor node hardware: mica2, micaZ, telosB, cricket, Imote2, tmote, btnode; Sensor Node Software (Operating System): tiny0S, MANTIS, Contiki, and Ret0S. Introduction to Simulation tools- TOSSIM, OPNET, NS2, NS3, Description of the NS-3 core module and simulation examples and projects.
2	Middleware for WSN, Protocol Stack in WSN, Medium Access Control in WSN, MAC Protocols, Node Discovery Protocols, Network Clustering, Introduction to Markov Chain: Discrete time Markov Chain definition, Properties, Classification and Analysis; MAC Protocol Analysis; Programming in WSNs, Programming Tools: C, nesC. Challenges and Limitations of Programming WSNs.
3	Robust Route Setup, Routing Protocols for WSN, Coping with energy constraints, Clustering in WSNs, QoS Management, Topology Management. Network Bootstrapping: Sensor deployment mechanisms, Issues of Coverage. Localization Schemes. Fault Tolerance. Mobile WSN, Synchronization, Congestion and Flow Control; Sensor Data Storage, Retrieval, Processing. Sensor Fusion and Aggregation: Sensor Fusion Paradigms, Probabilistic, Dempster-Shafer Based, Centralized and Distributed Kalman filter, Q-digest. Compressive Sensing and Data Gathering in WSN.
4	Underwater Acoustic Sensor Networks: Issues and Challenges, Simulation Tools, Application Areas. Body Area Sensor Networks. IoT-Enabled Sensor Networks. Sensor Cloud. Sensor Networks and Edge Computing. Security, Trust and Privacy. Key Management. Real Life Deployment of WSN and Underwater Sensor Networks.

Books and other resources:

1. Recent Publications from top-Tier Conferences and Journals.

2. A. Prayati, *Problem Solving for Wireless Sensor Networks*, ISBN:9781848002036, Springer London, 2008.
3. A. Kurniawan, *Practical Contiki-NG: Programming for Wireless Sensor Networks*, APress, ISBN:9781484234082, 2018.
4. A. Forster, *Introduction to Wireless Sensor Networks*, Wiley, ISBN:9781119079958, 2016,
5. A. Hac, *Wireless Sensor Network Designs*, ISBN-13: 978-0470867365, John Wiley and Sons, December 2003.
6. E. H. Callaway *et al*., *Wireless Sensor Networks: Architectures and Protocols*, ISBN 9780849318238, CRC Press, August 2003.
7. H. Karl and Andreas Willig, *Protocols and Architectures for Wireless Sensor Networks*, ISBN-13: 978-0470519233, Wiley-Interscience, 2007.
8. H. M. A. Fahmy, *Wireless Sensor Networks: Concepts*, *Applications*, *Experimentation and Analysis*, ISBN: 9789811004124, Springer Singapore, 2021.
9. I. M. M. El Emary and S. Ramakrishnan, *Wireless Sensor Networks: From Theory to Applications*, ISBN 9781138198821, CRC Press, 2016.
10. J. Zheng and A. Jamalipour, *Wireless Sensor Networks: A Networking Perspective*, ISBN: 0470167637, Wiley-IEEE Press, 2009.
11. K. Sohraby and T. Znati, *Wireless Sensor Networks: Technology*, *Protocols*, *and Applications*, ISBN 978-0-471-74300-2, John Wiley and Sons, 2007.
12. M. Conti, *Secure Wireless Sensor Networks: Threats and Solutions*, ISBN:9781493934607, Springer New York, 2015.
13. M. Matin, *Wireless Sensor Networks - Technology and Protocols*, ISBN 978-953-51-0676-0, InTech, 2012.
14. S. Yang, *Wireless Sensor Networks: Principles*, *Design and Applications*, ISBN:9781447155058, Springer London, 2013.
15. W. Dargie and Christian Poellabauer, *Fundamentals of Wireless Sensor Networks: Theory and Practice*, ISBN: 978-0-470-99765-9, Wiley, 2010.

CONNECTED ENVIRONMENTS AND ENABLING TECHNOLOGIES

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000036	**Connected Environments and Enabling Technologies**	**2-1-0-0**	**2023**

Prerequisites: Prior knowledge of Computer Networks, Distributed Computing, DBMS, Programming in Python

Course Objectives:

1. To learn the current state of the art in the IoT domain and learn details regarding several necessary principles required for future connected systems.
2. To expose the students to the different application areas of IoT along with providing sufficient foundations for further study and research.
3. To improve the critical reading, presentation, and research skills.

Course Outcomes: After completion of this course, the students will be able to:

C01: Understand the various building blocks of IoT and its characteristics and application areas.

CO2: Explore the relationship between IoT, cloud computing, and big data and apply basic principles to develop practical skills in IoT and related fields.

C03: Complete written paper reviews, an oral paper presentation, and a final course project.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written)

PLO 5 Practice ethical standards of professional conduct and research

PLO 6 Acquire professional skills such as collaborative skills and write articles for scholarly journals.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	1		1		
CO2	2	2	1	2		1
CO3	2	2	1	2		1

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Demystifying the IoT Paradigm, IoT Network Architecture and Design, IoT Sensors and Devices, IoT Edge Gateways, IoT Access Technologies, IP as the IoT Network Layer, IoT Standards and Protocols, Machine to Machine Communications, RFID, 5G, Software-defined Networking (SDN), Network Functions Virtualization (NFV), Semantic Technologies, Discovery Services, Industrial IoT, Internet of Medical Things, Semantic Web of Things and Cognitive IoT
2	Microcontrollers, Single Board Computers (SBCs) and boards based on Arduino and Raspberry PI, Data Transmission and Service Access Protocols such as MQTT, COAP, etc., IoT Graphical user interface: Web servers, HTML, PHP, Scripting languages: - Python, Bash, IoT application development for Android and iOS phones, Embedded Linux and Applications, Cotiki OS, Cooja Simulator, IoT Database management: MySQL, MongoDB
3	IoT programming languages for Edge devices, gateways and cloud applications, System on Chip (SoC) Technologies and Tools including NVIDIA® Jetson, REST Application programming interfaces (APIs) for Device and Cloud Services, Intelligent IoT Devices and Applications through AI Processing, IoT Data Analytics Platforms, IoT Data Virtualization Platforms, IoT Data Visualization Platform, IoT Edge Data Analytics, IoT-Cloud Integration through AWS IoT for the Edge, Lambda@Edge, etc.

4	IoT-enabled Applications: Smart Home, Smart Building, Smart City, Smart Health, Smart Transportation, Environmental Monitoring, Smart Industry, Smart Grid, Smart Farming, Public Safety, Case Studies.

Books and other resources:

1. Recent Publications from top-Tier Conferences and Journals.
2. A. McEwen and H. Cassimally, *Designing the Internet of Things*, ISBN: 978-1-118-43062-0, Wiley, 2013.
3. D. Parker, *Arduino Programming*, ISBN-13: 978-1801128001, New Begin Ltd., 2020.
4. D. Hanes *et al*., *IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things*, Cisco Press, ISBN-13: 978-1-58714-456-1, 2017.
5. D. S. Dawoud and P. Dawoud, *Microcontroller and Smart Home Networks*, ISBN-13: 978-8770221566, River Publishers, 2020.
6. H. Fairhead, *Raspberry Pi IoT In C*, 2020, ISBN-13: 978-1871962635, I/O Press, 2020.
7. J.-P. Vasseur and A. Dunkels, *Interconnecting Smart Objects with IP: The Next Internet*, ISBN-13: 978-0123751652, Morgan Kuffmann, 2010.
8. M. Lin and Q. Lin, *Internet of Things Ecosystem*, ISBN-13: 979-8597147208, 2021.
9. O. Vermesan and P. Friess, *Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems*, ISBN: 9788792982735, River Publishers, 2013.
10. P. Raj and A. C. Raman, *The Internet of Things Enabling Technologies, Platforms, and Use Cases*, ISBN 9781498761284, Taylor and Francis, 2017.
11. Q. Tang and F. Du, *Internet of Things Security: Principles and Practice*, Springer, 2021.
12. R. Singh *et al*., *Internet of Things with Raspberry Pi and Arduino*, ISBN 9780367248215, CRC Press, 2019.
13. T. Lynn *et al*., *The Cloud-to-Thing Continuum: Opportunities and Challenges in Cloud, Fog and Edge Computing*, ISBN-13: 978-3030411091, Palgrave Macmillan, 2020.
14. A. Bahga and V. K. Madisetti, *Internet of Things: A Hands-on-Approach*, ISBN-13:978-8173719547, Orient Blackswan Private Limited - New Delhi, 2015,
15. Z. Shelby and C. Bormann, *6LoWPAN: The Wireless Embedded Internet*, ISBN: 978-0-470-74799-5, Wiley, 2009.

OPERATING SYSTEMS

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000037	**Operating System**	**2-1-0-0**	**2023**

Prerequisites: Nil

Course Objectives:

1. To help students understand the necessity and fundamental concepts of an Operating System.
2. To explore all the essential building blocks in an Operating System.
3. To build practical skills for developing application programming in an Operating System.

4. Explore the different types of Operating Systems in different domains and analyse the security aspects.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Analyze various concepts and building blocks associated with Operating Systems.

CO2: Apply the concepts, building blocks, principles, and best practices to the software development.

CO3: Illustrate security aspects in the Operating System through its predefined features.

CO4: Design application programming with multi-processing concepts.

CO5: Analyze different types of Operating Systems available and develop applications.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences;

PLO 5 Practice ethical standards of professional conduct and research;

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	3			2	
CO2	2	3	3		3	3
CO3		3			3	3
C04	2	3	3		3	3
C05	3	3	3		3	3

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	**Introduction**: Basic OS functions, evaluation of OS, different types of OS, computer system operation, I/O structure, system protection, OS services, Processor and user modes, kernels, system calls and system programs. **Process Management:** Concept of processes, I/O and CPU bound process, process hierarchy, co-operating processes, inter-process communication.

	Process scheduling: Scheduling criteria, preemptive and non-preemptive scheduling, scheduling algorithms, multiprocessor scheduling. **Threads:** Overview, benefits of threads, user and kernel threads. **Process Synchronization:** Background, concurrent processes, critical section problem, classical problems of synchronization, semaphores.
2	**Deadlocks:** Characterization, detection, prevention, avoidance, recovery. **Memory Management:** Background, logical vs. physical address, swapping, paging, segmentation. **Virtual Memory:** Background, demand paging, page replacement algorithms, thrashing. **Disk Management:** Disk structure, disk scheduling, boot block and bad blocks. Characteristics of Embedded Systems, Embedded Linux, and Application specific OS. Basic services of NACH Operating System, Principles of protection, domain of protection, access matrix, access control, language based protection, program threats, system and network threats, user authentication, implementing security defenses, firewalling, exercises - man-in-the middle attacks.
3	**File Systems:** File concept, access methods, file system structure, allocation methods, free-space management, directory structure, efficiency and performance. **I/O Management:** I/O hardware, polling, interrupts, DMA, application I/O interface, performance. **Protection and Security:** Goals of protection, security problem, authentication, program threats, system threats, threat monitoring, encryption.
4	**FreeRTOS:** architecture, distribution, management of heap memory, task, queue, software timer, interrupt, resource management, memory management, task notification, low power support, porting.

Text Books:

1. W. Stallings, *Operating System: Internals and Design Principles*, Eighth Edition, Prentice Hall, 2014.
2. A. Silberschatz *et al.*, *Operating System Concepts*, Ninth Edition, John Wiley and Sons, 2012.
3. M. J. Bach, *The Design of the UNIX Operating System*, People's Posts and Telecommunications Publishing House, 2003.
4. L. Qing and C. Yao, *Real-time concepts for embedded systems*, CRC press, 2003.
5. R. Barry, *Mastering the FreeRTOS™ Real Time Kernel -A Hands-On Tutorial Guide*.
6. W. Mauerer, *Professional Linux® Kernel Architecture*.

References:

1. E. Siever *et al.*, *Linux in a nutshell*, O'Reilly Media, 2005.
2. D. P. Bovet and M. Cesati, *Understanding the Linux Kernel*, O'Reilly Media, 2005.
3. F. Mayer *et al.*, *SELinux by Example: Using Security Enhanced Linux*, Pearson Education, 2006.

Web References:

1. https://freertos.org/FreeRTOS-Plus/index.html
2. http://www.sl2.hu/sexample.pdf
3. https://tldp.org/LDP/lkmpg/2.6/lkmpg.pdf
4. https://www.ibm.com/docs/en/aix/7.2?topic=programming-writing-reentrant-threadsafe-code
5. https://www.omscs-notes.com/operating-systems/distributed-file-systems/
6. https://searchstorage.techtarget.com/definition/RAID
7. https://www.unf.edu/public/cop4610/ree/Notes/PPT/PPT8E/CH15-OS8e.pdf
8. https://people.cs.rutgers.edu/~pxk/416/notes/content/21-crypto-slides.pdf
9. https://www.jigsawacademy.com/blogs/cyber-security/symmetric-and-asymmetric-key-cryptography
10. https://bootlin.com/doc/training/linux-kernel/linux-kernel-slides.pdf
11. http://www.cs.unca.edu/~bruce/Fall14/360/RPiUsersGuide.pdf
12. https://www.raspberrypi.org/help/

BLOCKCHAIN TECHNOLOGY

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000038	**Blockchain Technology**	**2-1-0-0**	**2023**
Prerequisites: Nil			

Course Objectives:

1. To provide students with a deeper understanding of the concepts of blockchain technology with due focus on decentralized computing and distributed systems described in the syllabus.
2. To help the students develop the ability to address real-world problems using the learned concepts of smart contracts and Dapps.
3. To connect the learned concepts with other business domains having opportunities for disruptive innovation with blockchain
4. To make students aware of the existing challenges of blockchain and focus on contributing revolutionary solutions of the same

Course Outcomes: After completion of this course, the students will be able to:

CO1: Apply the science of blockchain technology in modelling better solutions for distributed computing.

CO2: Analyze the variants of blockchain/DLT and their adoption in respective domains

CO3: Visualize the use of blockchain technology and its potential disruptions in multiple business domains in the coming era.

Program Learning Outcomes:

PLO 1 Develop strong fundamental knowledge about the underlying concepts of blockchain technology

PLO 2 Demonstrate in-depth understanding of different blockchain types, architectures and
distributed consensus methods.

PLO 3 Critically compare and evaluate the need of Blockchain/DLT in industry

PLO 4 Alert the problems and challenges in deploying blockchain based Dapps and Smart Contracts with a deeper understanding of the multiple tradeoffs in the proposed product.

PLO 5 Demonstrates the disruptive potential of blockchain technology in revolutionizing the existing business models.

PLO 6 Acquire research skills to propose better algorithms/solutions for the existing challenges and contribute to the upcoming blockchain protocols.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	3	2	2	2	3
CO2	2	3	3	3	3	2
CO3	2	3	3	3	3	2

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Fundamentals of Blockchain technology: Centralized Vs Decentralized Computing, Concept of Distributed Ledger. Cryptographic principles - Encryption Techniques, Block Ciphers, Hash Functions (SHA), Digital Signatures, Public-Key Cryptography (RSA, ECDSA), Merkle Trees, DAG, PKI. Distributed Systems - Basic principle, design, architecture, Inter-process communication, peer-to-peer networks. Features of Blockchain. Blockchain vs Database, Blockchain vs Internet.
2	Blockchain network: Byzantine Generals Problem, Consensus Approach - PoW, PoS, pBFT. Working of Bitcoin network - Nodes, Forks, Mining, Wallets, UTXO Model. Challenges of Blockchain Technology. Blockchain Architectures: Public, Private, Hybrid. Potential Threats. - 51% attack, Sybil and Eclipse attacks.
3	Programmable Blockchains - Smart Contracts, Dapps. Introduction to Ethereum - Architecture, EVM. Token Standards - Fungible and Non-fungible (ERC). Hyperledger Umbrella Projects. Corda DLT. Why or Why Not Blockchain. Next Generation Blockchains - Cardano, Algorand, Polkadot. Application of Blockchain - Banking, Supply chain, Governance
4	Advanced Concepts - ZKPs, Sharding and sidechains, Layer-2 Protocols solving Blockchain Trilemma. Decentralized Finance (DeFi), Decentralized Autonomous Organizations (DAO). SegWit. BIP and EIP.

Lab Experiments:

Experiments will be done with Ethreum and Hyperledger Fabric

Text Books:

1. I. Bashir, *Mastering Blockchain: A deep dive into distributed ledgers*, *consensus protocols*, *smart contracts*, *DApps*, *cryptocurrencies*, *Ethereum*, *and more*, Third Edition, Packt Publishing Limited 2020
2. D. Tapscott and A. Tapscott, *Blockchain Revolution: How the Technology Behind Bitcoin and Other Cryptocurrencies is Changing the World*, Portfolio Penguin, 2018.
3. A. M. Antonopoulos and G. Wood, *Mastering Ethereum: Building Smart Contracts and DApps*, O´Reilly 2018.

References:

1. S. Nakamoto, *Bitcoin: A Peer-to-Peer Electronic Cash System*, 2009, Available Online: https://bitcoin.org/bitcoin.pdf.
2. A. Lewis, The Basics of Bitcoins and Blockchains: An Introduction to Cryptocurrencies and the Technology that Powers Them (Cryptography, Crypto Trading, Digital Assets, NFT), Mango Media, 2018.

AUGMENTED AND VIRTUAL REALITY

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000039	Augmented and Virtual Reality	2-1-0-0	2023

Prerequisites: Nil

Course Objectives:

1. To provide students with an understanding of concepts and frameworks of immersive technologies.
2. To help students get familiarized with the hardware and software of AR/VR systems.
3. To help the students develop immersive technology applications.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Apply the concepts of immersive technologies to manage large-scale virtual environments in real-time.

CO2: Employ the AR/VR concepts to identify the research gaps.

CO3: Develop AR/VR systems for application in varied areas.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences;

PLO 5 Practice ethical standards of professional conduct and research;

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	1			3		1
CO2		3	3			1
CO3		3	3	3	3	3

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	**Familiarization with Immersive Technologies** Human perception and cognition: Human auditory system, Human visual system, Visual perception, Visual rendering; Motion in real and virtual worlds; 3D

	Computer graphics: virtual world space, virtual observer positioning, 3D clipping, 3D modeling, illumination and reflection models, shading algorithms; Tracking: 2D orientation, 3D orientation, characteristics, types of trackers, SLAM; Sound in immersive environments: evolution, sound design basics, natural vs. real sound; Milgram's Reality-virtuality Continuum; Ethics, scientific concerns, social consequences, health and safety issues.
2	**Augmented Reality** History and evolution of AR; Components for visualizing AR: sensors, processor, display devices; Software components in AR: environmental acquisition, sensor integration, application engine, rendering software; Types of AR experiences: Marker based, marker-less, projection based; Augmented Reality Markup Languages (ARML): Types; Augmented reality content: Content creation, tools; User interface; Computer vision algorithms for AR: Marker tracking, infrared tracking, feature tracking, incremental tracking, localization and mapping, outdoor tracking; Interaction in real world: Manipulation, Navigation, Communication; Types of AR interaction: Browsing, 3D, tangible; Tangible AR; Collaborative AR; Mobile AR: technologies, promises and constraints; Existing challenges; Styles of augmented reality applications: magic books, magic mirrors, magic windows and doors, magic lens, navigation assistance, non-referential augmentation, objective view augmented reality ; Familiarization with Microsoft HoloLens, ARCore.
3	**Virtual Reality** Key elements of VR experience; History and evolution of VR; Virtual reality systems: tracking, Aural display, haptic display, vestibular display, visual displays-stationary, head based, hand-held; Rendering the virtual world- Aural representation, haptic representation, rendering systems- visual, aural, haptic; Interaction with virtual world: Manipulation, Navigation, Communication; Virtual reality experience: immersion, types of virtual world; Designing VR experience; Development tools and framework: software development tool frameworks, X3DStandard; VR software integration, game engines; Existing challenges; Familiarisation with OculusRift and Unity 3D.
4	**Related Technologies, Applications and Potential Research Areas** Related Technologies: Mixed Reality, XR, Comparison of immersive technologies; Areas and industries for immersive technologies: entertainment, education, training, medical, industrial, military; Case-studies: Design and evaluation, Production pipeline: sensing, rendering, mobile, stand alone and high-end computing platforms; Potential research directions: design, prototyping, innovative applications, cloud services, IoT, cyber physical systems.

Text Books:

1. Burdea, G. C. and P. Coffet. Virtual Reality Technology, Second Edition. Wiley-IEEE Press, 2003/2006.
2. Alan B. Craig, Understanding Augmented Reality, Concepts and Applications, Morgan Kaufmann, 2013.
3. A. B. Craig and W. R. Sherman, Understanding Virtual Reality: Interface, Application, and Design, 2002.
4. S. M. LaValle. Virtual Reality. Cambridge University Press, 2017.
5. J. G. Tromp *et al.*, *Emerging Extended Reality Technologies for Industry 4.0 Early Experiences with Conception, Design, Implementation, Evaluation and Deployment*, Wiley, ISBN: 978-1-119-65463-6, 2020.
6. S. Aukstakalnis, *Practical Augmented Reality: A Guide to the Technologies, Applications, and Human Factors for AR and VR*, Pearson Education, 2016.

References:

1. A. B. Craig *et al.*, *Developing Virtual Reality Applications: Foundations of Effective Design*, Morgan Kaufmann, 2009.
2. T. Jung and M. Cluaudia tom Dieck, *Augmented Reality and Virtual Reality, Empowering Human, Place and Business*, Springer International Publishing, 2018.
3. D. Schmalstieg and T. Höllerer, *Augmented Reality: Principles and Practice*, Addison-Wesley, Boston, 2016.
4. S. Greengard, *Virtual Reality*, MIT Press, 2019.
5. D. Vroegop, *Microsoft HoloLens Developer's Guide*, Packt Publishing, 2017.
6. M. Lanham, *Learn ARCore — Fundamentals of Google ARCore: Learn to build augmented reality apps for Android, Unity, and the web with Google ARCore 1.0*, Packet Publishing, 2018.
7. S. Ong, *Beginning Windows Mixed Reality Programming: For HoloLens and Mixed Reality Headsets*, 2021.
8. P. Fuchs, *Virtual Reality Headsets - A Theoretical and Pragmatic Approach*, CRC Press, 2017.

OPTIMIZATION TECHNIQUES

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000040	**Optimization Techniques**	**2-1-0-0**	**2023**

Prerequisites: Nil

Course Objectives:

1. To provide students with a good understanding of optimization techniques described in the syllabus.
2. To help the students develop the ability to solve problems using the learned

concepts.

3. Connect the concepts to other domains, such as machine learning and pattern recognition, within and without optimization techniques.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Understand the optimization techniques problem and state-of-the-art solutions.

CO2: Analyze and evaluate critically the building and integration of optimization techniques.

CO3: Design and demonstrate optimization techniques through team research projects, project reports, and presentations.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences;

PLO 5 Practice ethical standards of professional conduct and research;

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	2	3	2		
CO2	3	3	3	2		
CO3	2	3	3	2		

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Optimization - sequences and limits, derivative matrix, level sets and gradients, Taylor series.
2	Unconstrained optimization - necessary and sufficient conditions for optima, convex sets, convex functions, optima of convex functions, steepest descent, Newton and quasi Newton methods, conjugate direction methods.
3	Constrained optimization - linear and non-linear constraints, equality and inequality constraints, optimality conditions.
4	Constrained convex optimization, projected gradient methods, penalty methods.

Text Books:

1. E. K. P. Chong and S. H. Zak, An Introduction to Optimization, 2nd Edn., Wiley India Pvt. Ltd., 2010.
2. D. G. Luenberger and Y. Ye, Linear and Nonlinear Programming, 3rd Edn., Springer, 2010.

References:

1. Suvrit Sra, Sebastian Nowozin and Stephen J. Wright Optimization for Machine Learning. MIT Press, 2012.
2. Roberto Battiti, Mauro Brunato. The LION Way: Machine Learning plus Intelligent Optimization. Createspace Independent Pub, 2014.

COMPUTER ARCHITECTURE

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000041	**Computer Architecture**	**2-1-0-0**	**2023**

Prerequisites: Nil

Course Objectives:

1. To help students understand the fundamentals behind a computer and its architecture.
2. To explore the working principles of a computer's essential building blocks.
3. To understand how these building blocks are assembled to design a so-called computer.
4. To explore a few advanced topics in computer architecture.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Know how different components of a computer system are working.

CO2: Apply the knowledge of computer architecture while modelling systems for security analysis.

CO3: Compare various types of computer architectures and can analyze the design principles.

CO4: Use a computer more confidently with the acquired knowledge of its constituent components.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences;

PLO 5 Practice ethical standards of professional conduct and research;

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3		2			
CO2		3	3	2	3	3
CO3	2	3	2	1	2	1
C04	2	2	3	2	3	2

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Computer Fundamentals: Computer types, functional units, Basic concepts. Von Neumann Architecture Instruction Sets: Machine instructions, Memory operations, addressing modes, Instructions sets, Stacks, Subroutines, RISC & CISC architectures.
2	Processing Unit: Components (Registers, ALU, Datapath), Instruction execution, Control signals, Operations of control unit. Computer Arithmetic: Basic operations on signed numbers, Floating point operations.
3	Memory Management: Memory Hierarchy, Semiconductor based memory (Internal Organization, SRAM, DRAM), Read only memory, Cache memories – mapping techniques, performance, locality of reference, Cache hit / miss, Cache coherence problem Input/output: Accessing I/O devices, Bus Operations, I/O Modules, I/O Control mechanisms – Programmed I/O, Interrupt controlled, Direct Memory Access, I/O Interface (Serial, Parallel), I/O interconnection Standards.
4	Pipelining: Pipeline concept, Speedup, Throughput, Hazards in pipeline – structural hazard, data hazard, control hazard: Branch hazard; Dealing with hazards - Register Renaming, Branch Prediction. Advanced Computer Architecture: Parallel Processing - Flynn's classification, Amdahl's law, Characteristics of Multiprocessors, Interconnection Structures, Interprocessor Arbitration, Interprocessor Communication and Synchronization, Cache Coherence, Vector/Array Processing.

Text Books:

1. C. Hamacher et al., Computer Organization, 6th Edition, McGraw-HillHigher Education, 2011.
2. D. A. Patterson and J. L. Hennessy, Computer Organization and Design – The Hardware/Software Interface, 6th Edition, Morgan Kaufmann, 2020.
3. W. Stallings, Computer Organization & Architecture designing for performance, 8th Ed., Pearson, 2009,

4. P. Pal Chaudhuri, Computer Organization and Design, 3rd Edition, PHI, 2008.
5. A. S. Tanenbaum, Structured Computer Organization, 6th Edition, Pearson, 2012.

References:

1. William Stallings, Computer Organization and Architecture: Designing for Performance (Seventh Edition), Prentice-Hall India.
2. Hamacher C, Z.Vranesic and S.Zaky, Computer Organization, Fifth edition , McGraw Hill.
3. Carl Hamacher, ZvonkoVranesic and SafwatZaky, Computer Organization (Sixth Edition), McGraw Hill.
4. Mano M.M, Digital Logic and Computer Design, Fourth edition, Pearson Education.

QUANTUM COMPUTING

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000042	**Quantum Computing**	**2-1-0-0**	**2023**

Prerequisites: Basic linear algebra

Course Objectives:

1. To provide students with a good understanding of the concepts of quantum computing
2. To help the students develop the ability to solve problems using the learned concepts.
3. To connect the concepts to other domains.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Understand the foundations of quantum computing and familiarize students with well-known quantum algorithms.

CO2: Analyze and critically evaluate various quantum algorithms.

CO3: Apply quantum computing to solve various problems.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge.

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences.

PLO 5 Practice ethical standards of professional conduct and research;

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	1	1	1	2	
CO2	3	3	3	2	2	2
CO3	2	3	3	2	2	3

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Elements of quantum mechanics, Wave-particle duality, Wave functions and probability amplitude, Heisenberg's uncertainty principle, Schrodinger equation, postulates of quantum mechanics, Quantum tunneling
2	Qubits, Combining qubits using the tensor product, Measuring qubits, Performing operations on qubits, Bra-ket notation, Bloch sphere representation, Qubit rotations, Projective measurements, Qubit modalities.
3	Quantum gates, Quantum circuits, Quantum entanglement, No cloning theorem, Quantum teleportation , Super dense coding, Quantum parallelism, DiVincenzo's criteria for quantum computation
4	Quantum Fourier transform, Deutsch's Algorithm, Deutsch-Jozsa Algorithm, Simon's periodicity algorithm, Grover's search algorithm, Shor's Factoring algorithm.

Text Books:

1. M. A. Nielsen and I. L. Chuang. *Quantum Computation and Quantum Information*, Cambridge University Press, 2000.
2. V. Kasirajan, *Fundamentals of Quantum Computing*, Theory and Practicw, Springer, 2021.
3. M. Nakahara and T. Ohmi, *Quantum Computing*, CRC Press, 2008.
4. M. Mosca, *An Introduction to Quantum Computing*, Oxford U. Press, New York, 2007.

References:

1. M. L. Bellac, *A Short Introduction to Quantum Information and Quantum Computation*, Cambridge University Press, 2006.
2. P. Kaye et al., *An Introduction to Quantum Computing*, Oxford, 2007.
3. A. Peres, *Quantum Theory: Concepts and Methods*, New York, NY: Springer, 1993.
4. N. D. Mermin, *Quantum Computer Science*, Cambridge University Press, 2007.

WEB TECHNOLOGY

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction

M3000043	Web Technology	2-1-0-0	2023

Prerequisites: Nil

Course Objectives:

1. To help students understand the web application fundamentals.
2. To explore the architecture and design principles of web-based applications.
3. To understand the most suitable application stack for a requirement and its implementation.
4. To explore a few related concepts like Microservices, common web application security issues, REST API

Course Outcomes: After completion of this course, the students will be able to:

CO1: Understand the web technology fundamentals

CO2: Develop web application using MEAN and MERN stack

CO3: Analyze and evaluate critically the building and integration of different web technology stacks.

CO4: Develop web applications without known/published security risks and issues

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences;

PLO 5 Practice ethical standards of professional conduct and research;

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	1	2	2		
CO2	3	2	3	2	1	
CO3	3	3	1	2	1	
CO4	3	3	2		2	

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content

1	Fundamentals of TCP/IP protocol, Stateless protocol, HTTP, HTTPS, Web servers, Web server architecture, Application Server, Request/response paradigm, The structure of HTTP messages, Request methods, HTTP Header structure, Status codes. Characteristics of Modern Web Applications, HTML Responsive Web Design, HTML5 Elements, Attributes and elements, Type of Style sheets: Internal Style Sheet, Inline Style sheet, External Style Sheet, CSS3 Elements and features, CSS frameworks, Content delivery network, Selectors, XML Schema, Presenting XML Using XML Processors: DOM and SAX.
2	Introduction to Java Script, Object in JavaScript, Dynamic HTML with Java Script, JavaScript Object Notation, JSON vs XML, JSON Parsing, Data types, Arrays, Decisions and Loops, Functions and scope, JavaScript libraries, JavaScript Frameworks, ECMAScript, TypeScript, Single page applications (SPA),Cookies, Sessions management, Cleint side processing. The Web Services based on technologies such as SOAP, REST, WSDL, Django Framework: Architecture, MVT Architecture Pattern in Django Structure
3	Basics of angular Framework, Basics of React Web Framework, Nodejs and Express framework, Introduction to MongoDB, Sample MERN Stack application, Sample MEAN stack application, Node js design patterns – Singleton, Factory, Builder, Prototype,
4	Data Visualization Techniques for small and large data, OWASP Top Ten Web Application Security Risks, Fundamentals of web application architecture (1Tier, 2-Tier,3-Tier, N Tier and MVC) and components, User interface app components, Structural components, Microservices, Monolithic vs. Microservices

Text Books:

1. J. C. Jackson, *Web Technologies - A Computer Science Perspective*, Pearson Education – 2009.
2. A. Q. Haviv *et al*., *Web Application Development with MEAN*, Packt Publishing, 2016.
3. V. Subramanian, *Pro MERN Stack: Full Stack Web App Development with Mongo*, *Express*, *React*, *and Node*, 2nd Edition, 2019.
4. J. B. Mille, *Internet Technologies and Information Services*, ABC-CLIO, 2014.
5. D. Slama *et al*., *Enterprise IoT: Strategies and Best Practices for Connected Products and Services*, O-Reilly Media, 2015.

References:

1. L. Shklar and R. Rosen, Web Application Architecture - Principles, Protocols and Practices, Wiley, 2009.
2. L. Lemay *et al*., *Mastering HTML*, *CSS and Javascript Web Publishing*, BPB Publications, 2016.

3. G. Veneri and A. Capasso, *Hands-On Industrial Internet of Things: Create a powerful Industrial IoT infrastructure using Industry 4.0*, Ingram short title, 2018.
4. K. K. Pabbathi, *Quick Start Guide to Industry 4.0: One-stop reference guide for Industry 4.0*, Createspace Independent Publishing Platform, 2018.

OOPS AND JAVA

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000044	**OOPS and JAVA**	**2-1-0-0**	**2023**

Prerequisites: Basic programming concept.

Course Objectives:

1. To introduce object oriented concepts through Java language.
2. To use object oriented programming in building simple software tools.

Course Outcomes: After completion of this course, the students would be able to:

CO1: Learn object oriented programming concepts.

CO2: Use JAVA for software development.

CO3: Capture the idea of multi-threading and network programming.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences;

PLO 5 Practice ethical standards of professional conduct and research;

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3			3		
CO2	3	3		2		1
CO3	3					

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Object Oriented Paradigm and JAVA overview: Object oriented Concepts:

	Introduction to OOPS, Abstraction, Encapsulation, Objects and Classes, Constructors Inheritance, Polymorphism, Abstract Classes, Interfaces, Introduction to Java, JVM, Primitive data types, Control Statements, Methods, Classes Introduction to Java Compilers and Lab.
2	JAVA statements: selection statements, iteration statements, jump statements, Introduction to classes: Class fundamentals, declaring object reference variable, Introducing methods, constructors, the key word, garbage collection, the finalize (), method. Methods and Classes Overloading methods, using objects as parameters.
3	Java Arrays, Utilities and Packages: Java Arrays, Wrapper Classes, Java IO, Inheritance, Super class, Polymorphism, java Packages, class libraries, Interfaces, Exception Handling, JAVA Strings.
4	Multithreading and JAVA Networking: The Java thread model, the main thread, creating thread, creating multiple thread, using is alive () and join (). Thread priorities, synchronization, Inter thread communications, suspending resuming and stopping thread using multithreading Networking: Networking basics, Java and the Internet Address, TCP/IP client Sockets, URL,URL connection, TCP/IP server Sockets The Applet Class.

Text Books:

1. P. Naughton and H. Schildt, *The Complete Reference JAVA 2*, Tata McGraw-Hill, 1999.
2. C. T. Wu, *Introduction to Java programming*, Second Edition, John Wiley and Sons 2000.
3. M. T. Somashekara *et al.*, *Object Oriented Programming with JAVA*, PHI Learning Pvt. Ltd., 2017.

References:

1. B. Eckel and C. Allison, *Thinking in Java*, Edition 2, Prentice Hall, 2000.
2. C. Horstmann, *Computing Concepts With JAVA 2 Essentials*, Edition 2, Wiley-India, 2006.
3. H. Schildt, *Java: a Beginner Guide Essential Skills Made Easy*, 4th Edn, McGraw- Hill Professional, 2007.

OBJECT ORIENTED SOFTWARE ENGINEERING

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction

M3000045	Object Oriented Software Engineering	2-1-0-0	2023

Prerequisites: Nil

Course Objectives:

1. To introduce the fundamental concepts of software engineering and various phases of Software development
2. To introduce various software process models and Object Oriented Technology
3. To build an understanding of various SE models, Object Oriented Designs, and Models.
4. To familiarize testing, Maintenance, and Deployment Models of Software Systems.

Course Outcomes: After completion of this course, the students will be able to:

CO1: Identify suitable software development life cycle models to be used for a project.

CO2: Analyze a problem, identify and define the system requirements to solve the problem, and prepare the Software Requirements Specification.

CO3: Translate the Software Requirement Specification to a design using an appropriate software design methodology and prepare a Software Design Description, including Object Oriented Modeling

CO4: Design software systems based on appropriate technology and programming language by adhering to coding standards, ensuring code quality, and managing resources economically.

CO5: Apply appropriate testing strategy for validating the developed software system..

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge.

PLO 2 Demonstrate Design skills and software modeling using various process and models, that are of are of modeling and designing systems with theoretical, architectural , and practical in nature

PLO 3 Apply scholarship to conduct independent and innovative design patterns and research.

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences.

PLO 5 Practice ethical standards of professional conduct and research.

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3					
CO2	3			3		
CO3	3			3		
CO4	3					
CO5	3					

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	**Introduction to Software Engineering:** History of Software and Software Engineering, Software Crisis and Retrospection, Software Engineering Layers, Software Process, A Generic Process Framework, Software Process Models – Waterfall Model, V-Model, Incremental Model, Spiral Model, Prototyping Model, Rational Unified Process, Iterative Models, Agile Software Development, Software Engineering Ethics.
2	**Requirement Analysis and Specification:** Requirement Engineering processes: Requirement elicitation – Functional and non-functional requirements, Requirement Analysis, Object Oriented Modelling, Developing use cases and Use Case Models, Use case Analysis, Interaction Diagrams. Requirement Specification, IEEE Std 830-1998 Software Requirement Specification (SRS) Preparation, Requirement verification, Requirement Traceability Matrix, Requirement change control.
3	**Software Design:** Design Principles and Concepts, Design methodologies – Structured System Analysis and Design or Function Oriented Design and Object Oriented Analysis and Design Domain Model,- Design Classes, subsystems and Packages, Software Architectural Styles and Design Patterns, Architectural Design-4+1 view Architecture, Data Model, IEEE Std 1016-2009 Software Design Description (SDD) Template. Case Study: Library Management System – Object Oriented Analysis and Design using UML.
4	**Coding, Testing and Deployment:** Introduction to Coding, Selection of Technology/Programming Language, Programming Practices, Coding Standards, Code Verification - Code Review and Static Analysis, Size Measures, Complexity Analysis, Software Verification and Validation, Testing Fundamentals, Software Testing Strategies, Black Box and White Box Testing, Unit Testing, Integration Testing, System Testing, User Acceptance Testing, Testing Process and Test Documentation, Test Case Design

	Techniques for Black Box and White Box Testing, Software Maintenance. Deployment Diagram

Text Books:

1. I. Sommerville, *Software Engineering*, Pearson Education, Tenth Edition, 2015.
2. R. S. Pressman, *Software Engineering: A practitioner's approach*, McGraw Hill publication, Eighth edition, 2014.
3. G. Booch *et al.*, *The United Modeling Language User Guide*, Addison-Wesley, 2005.
4. B. Bruegge and A. H. Dutoit, *Object-Oriented Software Engineering*, Second Edition, Pearson Education, 2004.
5. A. Cockburn, *Agile Software Development*, Second edition, Pearson Education, 2007.

References:

1. R. Mall, *Fundamentals of Software Engineering*, PHI Learning Pvt Ltd., 2014.
2. R. Mall, Software Engineering – Video Lectures: https://www.youtube.com/playlist?list=PL9P1J9q3_9fMqbMfKAqT8vETYCqKxA2YU
3. P. Jalote, *An Integrated Approach to Software Engineering*, Narosa Publishing House, Third Edition, 2009.
4. I. Jacobson *et al.*, *The Unified Software Development Process*, Pearson Education, 1999.
5. IEEE Std 830-1998 – IEEE Recommended Practice for Software Requirements Specifications.
6. IEEE Std 1016-2009 – IEEE Standard for Information Technology – Systems Design – Software Design Descriptions.

CLOUD AND EDGE COMPUTING

Course Code	Course Name	Credit Split Lecture/Lab/Seminar/Project	Year of Introduction
M3000046	**Cloud and Edge Computing**	**2-1-0-0**	**2023**

Prerequisites: Prior knowledge of operating systems, distributed systems, computer networks, machine and deep learning.

Course Objectives:

1. To impart a comprehensive and in-depth understanding of Cloud and Edge Computing basics, technologies and applications to students by introducing and researching cutting-edge topics, technologies, applications and implementations.
2. To expose the students to frontier areas of Cloud and Edge Computing while providing sufficient foundations for further study and research.

Course Outcomes: After completion of this course, the students would be able to:

CO1: Understand the foundations of distributed algorithms, concepts, and issues

related to cloud and edge computing by completing homework, quizzes, and examinations.

CO2: Prepare students for an industrial programming environment by completing cloud and edge computing programming projects.

CO3: Expose students to current literature in cloud and edge computing.

CO4: Complete a term project, including independent research, oral presentation, and programming on the latest advancement in cloud and edge computing.

Program Learning Outcomes:

PLO 1 Develop strong fundamental disciplinary knowledge

PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature

PLO 3 Apply for a scholarship to conduct independent and innovative research

PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences;

PLO 5 Practice ethical standards of professional conduct and research;

PLO 6 Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the School.

Mapping of course outcomes with program learning outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
CO1	3	2	1	2		
CO2	3	2	2	2		
CO3	2	2	2	2		
CO4	2	2	2	3	3	1

(Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))

Syllabus:

Module	Content
1	Introduction to Distributed Algorithms, Cloud Computing Architecture and Management, Cloud Deployment Models, Cloud Service Models, Cloud Development Process Flows, Cloud Service Providers, Virtualization, Orchestration and Messaging, Networking in Cloud Computing, Cloud Storage, Containers, Micro services and Serverless Computing, Cloud Challenges.
2	Open Source Tools for IaaS, PaaS and SaaS, Open Source Tools for Research such as CloudSim, Aneka, AWS and Google Cloud, Programming Models and Languages for Cloud Computing, Software Defined Compute, Software-Defined Data Centers, Virtual Private Cloud Networking, Hybrid Cloud and Multi-Cloud Environments.

3	Edge/Fog Computing Paradigms, Edge Architecture, Edge computing Applications, Real-Time Data Analytics through Edge Clouds, Edge Computing for 5G/6G, Cognitive Edge Computing, Context-Awareness, Kubernetes Platform for Edge Environments; Cognitive Clouds, Mobile Cloud Computing, Green Cloud Computing. IoT Services on cloud, Components, IoT Core, IoT Examples (AWS IoT), IoT Data Analytics Platform on Cloud Environments, Quantum computing Paradigms and platform.
4	Case studies of Cloud and Edge Computing, Cloud Analytics, AI and ML at the Edge and in the Cloud, Fault Tolerance, Load Balancing, Security, Trust and Privacy in Cloud, Performance and QoS, Future Research Direction/Opportunity in the Cloud and Edge Computing.

Text Books:

1. Recent Publications from top-Tier Cloud/System Conferences and Journals.
2. R. Misra and Y. Singh Patel, *Cloud and Distributed Computing: Algorithms and Systems*, ISBN: 9788126520275, Wiley, 2020.
3. A. S. Tanenbaum and Maarten Van Steen, *Distributed Systems: Principles and Paradigms*, 2nd ed. Prentice Hall, 2007.
4. G. Tel, *Introduction to Distributed Algorithms*, 2nd edition, Cambridge University Press, ISBN:9781139168724, 2000.
5. K. Chandrasekaran, *Essentials of Cloud Computing*, CRC Press, 2015.
6. R. Buyya *et al*., *Mastering Cloud Computing*, McGrawHill, 2013.
7. C. Surianarayanan, P. Chelliah, *Essentials of Cloud Computing: A Holistic Perspective*, Springer, 1st ed. 2019.
8. R. Buyya, Satish N Srirama, *Fog and Edge Computing: Principles and Paradigms*, ISBN: 978-1-119-52498-4, Wiley, 2019.
9. J. R. Vacca, *Cloud Computing Security: Foundations and Challenges*, ISBN-10: 1482260948, CRC Press, 2016.
10. B. Burns *et al*., *Kubernetes: Up and Running: Dive Into the Future of Infrastructure*, O'Reilly Publications, 2019.
11. A. A. A. Donovan and B. W. Kernighan, *The Go Programming Language*, Addison-Wesley, 2015.
12. S. Klabnik, C. Nichols, *The Rust Programming Language*, No Starch Press, 2018.
13. Jeeva S. Chelladhurai, Vinod Singh, Pethuru Raj, Learning Docker, Packt Publishing, 2 editions, 2017.
14. A. Kurniawan, *Learning AWS IoT*, Packt Publishing, 2018.
15. E. Krishnasamya *et al*., Edge Computing: An Overview of Framework and Applications, PRACE aisbl, 2020. Available Online: https://prace-ri.eu/wp-content/uploads/Edge-

Computing-An-Overview-of-Framework-and-Applications.pdf.
16. *Chris Bernhardt, Quantum Computing for Everyone, The MIT Press,Cambridge, 2020.*