

Kerala University of Digital Sciences, Innovation and Technology



M.Tech Computer Science and Engineering

&

M.Sc Computer Science

Scheme and Syllabus
2025 Admission onwards

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 at the Technopark Phase IV, Thiruvananthapuram. The School offers the academic programmes M.Tech Computer Science and Engineering, M.Sc Computer Science, and PhD.

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

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

Master of Science (M.Sc) in Computer Science

M.Sc in Computer Science has two specializations: Cyber Security and Artificial Intelligence. The students must choose one of the specializations while taking admission. The admission and eligibility requirements for both specializations are the same.

Programme Structure

The Minimum credit requirement for the award of the Two Years Masters programme will be 80 credits. However, the student may be allowed to opt for upto 90 credits through additional courses/projects.

One credit is defined as 1 hr of contact (lectures/tutorials) per week or 2 hrs of student workload (labs, projects, homework) per week. As there will be 15 teaching weeks in a semester, 1 credit is equated to 15 hours of contact classes per semester or 30 hours of student workload per semester.

A post graduate degree programme can be completed in a minimum period of 24 months and a maximum period of 48 months. This can include a zero-year recommended by the academic committee and approved by the Vice Chancellor of the University as per the Post Graduate Regulations, 2024 (KUDSIT-PG Regulations 2024).

The credit distribution requirements across various types of courses:

| Programme courses (45 credits) | | | University courses (15 credits) | | Final year Projects (20 credits) | Additional credits beyond mandatory course work and project |
|-----------------------------------|---------------------------------------|----------------------------------|---|--|---|---|
| Programme Core (Mandatory) | Programme electives (Mandatory) | Open electives (Mandatory) | University Core | University Elective | Capstone Project/ Thesis (Mandatory) | Additional courses (Optional) |
| | | | Digital Access for Community Empowerment - DACE (Mandatory) | Holistic Development (Mandatory) | | |
| 18 credits | 15 credits | 12 credits | 6 credits | 9 credits | 20 credits | 10 credits |

The semester-wise breakup of credit requirements across various types of courses

| Year-wise course levels & credit distribution | Semest er | University Core (500 level) | Programme Core/Program me Elective/Open Elective 400/500 level | Capstone Project/ Thesis 500 level | Holistic Developme nt 500 level | Minimum credits required | Maximum allowable credits |
|--|--------------|-----------------------------------|---|---|--|--------------------------------|---------------------------------|
| 1 st year 400 level courses-24 credits + 500 level courses- 16 credits | S1 | 3 credits | 15- 19 credits | 0 credit | 2 credits | 20 credits | 24 credits |
| | S2 | 3 credits | 15- 19 credits | 0 credit | 2 credits | 20 credits | 24 credits |
| 2 nd year 500 level courses/project/ thesis- 40 credits | S3 | 0 | 15- 19 credits | 0-4 credits | 5 credits | 20 credits | 24 credits |
| | S4 | 0 | 0 - 4 credits | 20 credits | 0 credits | 20 credits | 24 credits |

Credit Requirements for the Master Programme

- A. The students are allowed to take a maximum of 24 Credits (inclusive of both audit & credits courses) in a semester. However, this credit limit restriction may be exempted for accommodating the repeat attempt of the failed courses.
- B. The minimum aggregate of attendance during a semester shall be 75%. This is not applicable to project-based courses, fieldwork-based courses, and research works done outside the university. Any exemptions shall be defined by the course lecturers in the course description document.
- C. Students must earn a minimum of 24 credits in 400-level courses and at least 56 credits in 500-level courses.
- D. The students are allowed to take a maximum of 12 Credits through audit courses. These credits do not count toward the total credits for the programme.
- E. The students are allowed to obtain a maximum of 12 Credits through challenge exams. These credits count towards total credits for the programme.
- F. At least 35 credits (programme electives + project/thesis) are required for a major specialization and 9 credits (defined streams of specialization as specified through open electives in programme outline) for minor specialization (equivalent to three 3 credit courses or equivalent). The specialization credits consist of projects, courses, activities etc.
- G. Up to 16 credits may be obtained through SWAYAM or other online courses approved by the school (Programme Elective/Open Elective/Holistic Development). However, a maximum of 9 credits can be earned as Programme Elective through this mode.
- H. Individual/Group Mini-projects are allowed as programme electives/open electives. However, a maximum of 15 credits may be allowed in this mode. Mini Projects are allowed for research explorations/practical implementations in a specialized subject area relevant to the specialization in the masters programme.

Mode of Instructions

A wide variety of modern teaching and learning methods are expected to be used in the delivery of the courses.

| Course Level | Teaching | Evaluations |
|--------------|---|--|
| 400 level | Lecture courses with practicum, seminar-based courses, term papers, research methodology, advanced laboratory experiments/software training, research projects, hands-on-training, internship/apprenticeship projects | As per the University Examination Manual and as decided by the Controller of the Examinations of the University. |

| | | |
|-----------|---|--|
| 500 level | Original study or investigation in a major field of specialization, by an individual or a group | As per the University Examination Manual and as decided by the Controller of the Examinations of the University. |
|-----------|---|--|

Pass Criteria

As stipulated in the University Examination Manual.

**M.Tech in Computer Science and Engineering with Specialization in
Artificial Intelligence/Connected Systems and Intelligence/Cyber Security
Engineering (AY 2025-26 Onwards)**

| Semester 1 | | | | |
|-----------------------|--|----------------|--|--------------|
| Course Code | Title of the Course | Credits | Credit Split Lecture/Lab/ Seminar/Project | Level |
| M5010000 | Digital Access for Community Empowerment I | 3 | | 500 |
| M4010000/ M4010001 | AI and Machine Learning/ Introduction to Cyber Security | 4 | 3-1-0-0 | 400 |
| M4010002 | Advanced Data Structures and Algorithms | 3 | 2-1-0-0 | 400 |
| | Open Elective | 3 | | |
| M4010003 | Mathematical Foundations for Computer Science | 3 | 1-1-0-1 | 400 |
| M4010004 | Programming in Python | 2 | 1-1-0-0 | 400 |
| | Holistic Development (HD-1) | 2 | | 500 |
| Total Credits | | 20 | | |

| Semester 2 | | | | |
|-----------------------|---|----------------|--|--------------|
| Course Code | Title of the Course | Credits | Credit Split Lecture/Lab/ Seminar/Project | Level |
| M5010001 | Digital Access for Community Empowerment II | 3 | | 500 |
| M4010005/ M4010006 | Advanced Distributed Systems/Data and Intelligence | 3 | 2-0-1-0 | 400 |
| M4010007/ M4010008 | Data Analytics/Computer Networks and Security | 3 | 2-1-0-0 | 400 |
| | Programme/Open Elective | 9 | | 400/500 |
| | Holistic Development (HD-2) | 2 | | 500 |
| Total Credits | | 20 | | |

| Semester 3 | | | | |
|--------------------|-----------------------------|----------------|--|--------------|
| Course Code | Title of the Course | Credits | Credit Split Lecture/Lab/ Seminar/Project | Level |
| | Programme/Open Elective | 15 | | 500 |
| | Holistic Development (HD-3) | 5 | | 500 |
| Total Credits | | 20 | | |

| Semester 4 | | | | |
|--------------------|----------------------------|----------------|--|--------------|
| Course Code | Title of the Course | Credits | Credit Split Lecture/Lab/ Seminar/Project | Level |
| M5010002 | Thesis | 20 | 0-0-0-20 | 500 |
| Total Credits | | 20 | | |

| Programme Electives for Artificial Intelligence (Minimum 15 Credits Required) | | | | |
|--|--|----------------|--|--------------|
| Course Code | Title of the Course | Credits | Credit Split Lecture/Lab/ Seminar/Project | Level |
| M4010009 | Robotics | 3 | 2-1-0-0 | 400 |
| M4010010 | Deep Learning | 3 | 2-1-0-0 | 400 |
| M4010011 | Natural Language Processing | 3 | 2-1-0-0 | 400 |
| M5010004 | Stochastic Processes and Models | 3 | 1-1-0-1 | 500 |
| M5010005 | Digital Image and Video Processing | 3 | 1-1-0-1 | 500 |
| M5010006 | Reinforcement Learning | 3 | 1-1-0-1 | 500 |
| M5010007 | Computer Vision | 3 | 1-1-0-1 | 500 |
| M5010008 | Soft Computing | 3 | 1-1-0-1 | 500 |
| M5010009 | Speech Processing | 3 | 1-1-0-1 | 500 |
| M5010010 | Cognitive Computing | 3 | 1-1-0-1 | 500 |
| M5010011 | Big Data Technologies | 3 | 1-1-0-1 | 500 |
| M5010012 | Optimization Techniques | 3 | 1-1-0-1 | 500 |
| M5010030 | Federated Learning | 3 | 1-1-0-1 | 500 |
| | Emerging Topics in Artificial Intelligence | | | |
| | Approved Swayam Courses | | | |
| M5010031 | Individual/Group Mini-projects/Research Activity | 3 | 0-0-0-3 | 500 |

| Programme Electives for Cyber Security Engineering (Minimum 15 Credits Required) | | | | |
|---|--|----------------|--|--------------|
| Course Code | Title of the Course | Credits | Credit Split Lecture/Lab/ Seminar/Project | Level |
| M4010012 | Cryptography | 3 | 1-1-0-1 | 400 |
| M4010013 | Hardware Security | 3 | 2-1-0-0 | 400 |
| M4010014 | Ethical Hacking and Penetration Testing | 3 | 2-1-0-0 | 400 |
| M4010015 | Digital Forensics | 3 | 1-1-0-1 | 400 |
| M5010013 | Cloud Security | 3 | 1-1-0-1 | 500 |
| M5010014 | IoT Networks and Endpoint Security | 3 | 1-1-0-1 | 500 |
| M5010015 | Systems Security and Risk Analysis | 3 | 1-1-0-1 | 500 |
| M5010016 | Cyber Analytics | 3 | 1-1-0-1 | 500 |
| M5010017 | Malware Analysis and Reverse Engineering | 3 | 1-1-0-1 | 500 |
| M5010018 | AI for Cyber Security | 3 | 1-1-0-1 | 500 |
| M5010020 | Database Security | 3 | 1-1-0-1 | 500 |
| M5010021 | Mobile Application Security | 3 | 1-1-0-1 | 500 |
| M5010022 | Information Security Management System | 3 | 1-1-0-1 | 500 |
| | Emerging Topics in Cyber Security Engineering | | | |
| | Approved Swayam Courses | | | |
| M5010031 | Individual/Group Mini-projects/Research Activity | 3 | 0-0-0-3 | 500 |

**Programme Electives for Connected Systems and Intelligence
(Minimum 15 Credits Required)**

| Course Code | Title of the Course | Credits | Credit Split Lecture/Lab/ Seminar/Project | Level |
|--------------------|---|----------------|--|--------------|
| M4010012 | Cryptography | 3 | 1-1-0-1 | 400 |
| M4010013 | Hardware Security | 3 | 2-1-0-0 | 400 |
| M4010016 | Software Defined Networking | 3 | 2-1-0-0 | 400 |
| M5010013 | Cloud Security | 3 | 1-1-0-1 | 500 |
| M5010014 | IoT Networks and Endpoint Security | 3 | 1-1-0-1 | 500 |
| M5010015 | Systems Security and Risk Analysis | 3 | 1-1-0-1 | 500 |
| M5010023 | Social Network Analytics and Security | 3 | 1-1-0-1 | 500 |
| M5010024 | Wireless Sensor Networks | 3 | 1-1-0-1 | 500 |
| M5010025 | Connected Environments and Enabling Technologies | 3 | 1-1-0-1 | 500 |
| | Emerging Topics in Connected Systems and Intelligence | | | |
| | Approved Swayam Courses | | | |
| M5010031 | Individual/Group Mini-projects/Research Activity | 3 | 0-0-0-3 | 500 |

M. Sc. in Computer Science with Specialization in Cyber Security/Artificial Intelligence (AY 2025-26 Onwards)

| Semester 1 | | | | |
|-----------------------|---|---------|---|-------|
| Course Code | Title of the Course | Credits | Credit Split Lecture/Lab/ Seminar/Project | Level |
| M5020000 | Digital Access for Community Empowerment I | 3 | | 500 |
| M4020000/ M4020001 | AI and Machine Learning/Introduction to Cyber Security | 4 | 3-1-0-0 | 400 |
| M4020002/ M4020005 | Advanced Data Structures and Algorithms / Data Structures and Algorithms | 3 | 2-1-0-0 | 400 |
| M4020006 | Database Systems | 3 | 2-1-0-0 | 400 |
| M4020003 | Mathematical Foundations for Computer Science | 3 | 1-1-0-1 | 400 |
| M4020004 | Programming in Python | 2 | 1-1-0-0 | 400 |
| | Holistic Development (HD-1) | 2 | | 500 |
| Total Credits | | 20 | | |

| Semester 2 | | | | |
|-----------------------|---|---------|---|---------|
| Course Code | Title of the Course | Credits | Credit Split Lecture/Lab/ Seminar/Project | Level |
| M5020001 | Digital Access for Community Empowerment II | 3 | | 500 |
| M4020007/ M4020008 | Data Analytics/Computer Networks and Security | 3 | 2-1-0-0 | 400 |
| | Programme / Open Elective | 12 | | 400/500 |
| | Holistic Development (HD-2) | 2 | | 500 |
| Total Credits | | 20 | | |

| Semester 3 | | | | |
|---------------|-----------------------------|---------|---|-------|
| Course Code | Title of the Course | Credits | Credit Split Lecture/Lab/ Seminar/Project | Level |
| | Programme / Open Elective | 15 | | 500 |
| | Holistic Development (HD-3) | 5 | | 500 |
| Total Credits | | 20 | | |

| Semester 4 | | | | |
|---------------|---------------------|---------|---|-------|
| Course Code | Title of the Course | Credits | Credit Split Lecture/Lab/ Seminar/Project | Level |
| M5020002 | Project | 20 | 0-0-0-20 | 500 |
| Total Credits | | 20 | | |

| Programme Electives for Artificial Intelligence (Minimum 15 Credits Required) | | | | |
|--|--|----------------|--|--------------|
| Course Code | Title of the Course | Credits | Credit Split Lecture/Lab/ Seminar/Project | Level |
| M4020009 | Robotics | 3 | 2-1-0-0 | 400 |
| M4020010 | Deep Learning | 3 | 2-1-0-0 | 400 |
| M4020011 | Natural Language Processing | 3 | 2-1-0-0 | 400 |
| M4020016 | Data and Intelligence | 3 | 2-0-1-0 | 400 |
| M5020004 | Stochastic Processes and Models | 3 | 1-1-0-1 | 500 |
| M5020005 | Digital Image and Video Processing | 3 | 1-1-0-1 | 500 |
| M5020006 | Reinforcement Learning | 3 | 1-1-0-1 | 500 |
| M5020007 | Computer Vision | 3 | 1-1-0-1 | 500 |
| M5020008 | Soft Computing | 3 | 1-1-0-1 | 500 |
| M5020009 | Speech Processing | 3 | 1-1-0-1 | 500 |
| M5020010 | Cognitive Computing | 3 | 1-1-0-1 | 500 |
| M5020011 | Big Data Technologies | 3 | 1-1-0-1 | 500 |
| M5020012 | Optimization Techniques | 3 | 1-1-0-1 | 500 |
| M5020030 | Federated Learning | 3 | 1-1-0-1 | 500 |
| | Emerging Topics in Artificial Intelligence | | | |
| | Approved Swayam Courses | | | |
| M5020031 | Individual/Group Mini-projects/Research Activity | 3 | 0-0-0-3 | 500 |

| Programme Electives for Cyber Security (Minimum 15 Credits Required) | | | | |
|---|--|----------------|--|--------------|
| Course Code | Title of the Course | Credits | Credit Split Lecture/Lab/ Seminar/Project | Level |
| M4020012 | Cryptography | 3 | 1-1-0-1 | 400 |
| M4020013 | Hardware Security | 3 | 2-1-0-0 | 400 |
| M4020014 | Ethical Hacking and Penetration Testing | 3 | 2-1-0-0 | 400 |
| M4020015 | Digital Forensics | 3 | 1-1-0-1 | 400 |
| M5020013 | Cloud Security | 3 | 1-1-0-1 | 500 |
| M5020014 | IoT Networks and Endpoint Security | 3 | 1-1-0-1 | 500 |
| M5020015 | Systems Security and Risk Analysis | 3 | 1-1-0-1 | 500 |
| M5020016 | Cyber Analytics | 3 | 1-1-0-1 | 500 |
| M5020017 | Malware Analysis and Reverse Engineering | 3 | 1-1-0-1 | 500 |
| M5020018 | AI for Cyber Security | 3 | 1-1-0-1 | 500 |
| M5020020 | Database Security | 3 | 1-1-0-1 | 500 |
| M5020021 | Mobile Application Security | 3 | 1-1-0-1 | 500 |
| M5020022 | Information Security Management System | 3 | 1-1-0-1 | 500 |
| | Emerging Topics in Cyber Security | | | |
| | Approved Swayam Courses | | | |
| M5020031 | Individual/Group Mini-projects/Research Activity | 3 | 0-0-0-3 | 500 |

Open Electives offered by SoCSE

| Course Code M. Tech/M. Sc | Title of the Course | Credits | Credit Split Lecture/Lab/ Seminar/Project | Level |
|--------------------------------------|--|----------------|--|--------------|
| M4010017/ M4020017 | Technical Communication | 2 | 1-1-0-0 | 400 |
| M4020018 | Operating Systems | 3 | 2-1-0-0 | 400 |
| M4020019 | Computer Architecture | 3 | 2-1-0-0 | 400 |
| M5020023 | Web Technology | 3 | 1-1-0-1 | 500 |
| M5020024 | OOPS and JAVA | 3 | 1-1-0-1 | 500 |
| M5020025 | Object Oriented Software Engineering | 3 | 1-1-0-1 | 500 |
| M5010026/ M5020026 | Blockchain Technology | 3 | 1-1-0-1 | 500 |
| M5010027/ M5020027 | Augmented and Virtual Reality | 3 | 1-1-0-1 | 500 |
| M5010028/ M5020028 | Quantum Computing | 3 | 1-1-0-1 | 500 |
| M5010029/ M5020029 | Cloud and Edge Computing | 3 | 1-1-0-1 | 500 |
| | Courses from other specializations (within the school) | | | |
| | Emerging Topics in Computer Science | | | |
| | Approved SWAYAM Courses | | | |
| M5010032/ M5020032 | Individual/Group Mini-projects/Research Activity | 3 | 0-0-0-3 | 500 |
| M5010003/ M5020003 | Project/Thesis in AI/Cyber Security Engineering | 9 | 0-0-0-9 | 500 |

Course Syllabus

MATHEMATICAL FOUNDATIONS FOR COMPUTER SCIENCE

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|-----------------------|---|---|-------------------------|
| M4010003/ M4020003 | Mathematical Foundations for Computer Science | 1-1-0-1 | 2025 |

Prerequisites: Nil

Course Objectives:

- Develop a strong foundational understanding of discrete mathematics, probability, linear algebra, and graph theory to address complex computational problems.
- Apply mathematical principles and techniques to model, analyze, and solve real-world problems in computer science and related fields.
- Integrate theoretical concepts with practical applications through problem-solving and hands-on exercises to prepare for advanced research and industry challenges.

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

CO1: Apply mathematical principles from discrete mathematics, probability, linear algebra, and graph theory to solve real-world computational problems.

CO2: Construct mathematical models for analyzing complex problems in computer science, such as network optimization, machine learning, and cryptographic systems.

CO3: Illustrate key concepts in probability, linear algebra, and graph theory through practical experimentation and computational techniques.

CO4: Analyze algorithms and their performance using graph theory, combinatorics, and probability-based approaches.

CO5: Develop innovative solutions for computer science challenges by integrating concepts from different areas of mathematics and articulating their implications.

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 | 1 | 1 | 1 |
| CO2 | 3 | 3 | 2 | 2 | 1 | 2 |
| CO3 | 2 | 3 | 2 | 2 | 1 | 1 |
| CO4 | 3 | 2 | 2 | 2 | 1 | 2 |
| CO5 | 3 | 3 | 3 | 3 | 2 | 2 |

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

Syllabus

| Module | Content |
|---------------|--|
| 1 | Propositional logic, predicate logic, set theory, relations and functions, combinatorics, recurrence relations, modular arithmetic Practicum: Symbolic computation, solving recurrence relations, applications in cryptography and algorithm design |
| 2 | Probability axioms, conditional probability, Bayes' theorem, random variables, probability distributions, expectation, variance, hypothesis testing, entropy, and mutual information. Practicum: Simulating random variables, data analysis, applications of entropy |
| 3 | Matrix operations, vector spaces, eigenvalues and eigenvectors, diagonalization, singular value decomposition (SVD), orthogonality Practicum: Matrix manipulations, applications of eigenvalues and eigenvectors applications of SVD, vector space modeling. |
| 4 | Graphs, Graph representations, special types of graphs, connectivity, isomorphism of graphs, graph centrality values, Euler and Hamilton paths Practicum: Graph implementation and modeling with graphs, analyzing algorithms and their performance using graphs, applications of graph centrality values |

Text Books

1. Kenneth H. Rosen, Discrete Mathematics and Its Applications, McGraw Hill; 8th edition, 2021
2. Neal Koblitz,. A Course in Number Theory and Cryptography, Springer Verlag (low price edition), 2nd Edition, 1994
3. Kenneth Hoffman, Ray Kunze, Linear Algebra, Prentice-Hall of India Pvt.Ltd.
4. Hsu HP. Theory and problems of probability, random variables, and random processes. New York: McGraw-Hill; May 2014.
5. M. Mignotte, Mathematics for computer algebra, Springer-Verlag, 1992.
6. Suvrit Sra, Sebastian Nowozin, and Stephen J. Wright. Optimization for Machine Learning. The MIT Press, 2011.

References

1. Bertsimas, D. & Tsitsiklis, J., Introduction to linear optimization, Athena Scientific, 1997.
2. An Introduction to Optimization- E. Chong, S. Zak, Wiley, 2013.
3. Hastie, T.; Tibshirani, R. & Friedman, J., The Elements of Statistical Learning, Springer New York Inc., New York, NY, USA, 2001.
4. Donald F. Stanat and David F. McAllister, Discrete mathematics in Computer Science, Prentice-Hall, 1977.
5. Thomas Koshy, Elementary number theory with Applications, Elsevier, 2007.
6. G. Chartrand and P. Zhang, Introduction to Graph Theory, McGraw-Hill Companies, 2005.
7. Douglas B. West, Introduction to Graph Theory, Prentice Hall of India, 2001.

PROGRAMMING IN PYTHON

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|-----------------------|--------------------------|---|-------------------------|
| M4010004/ M4020004 | Programming in Python | 1-1-0-0 | 2025 |

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 in computational problem-solving through Programming in Python, Capstone Projects and Case Studies.

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

CO1: Apply foundational Python programming constructs—including data types, control flow, and collections—to implement structured and efficient code for solving computational problems.

CO2: Design modular programs using user-defined functions, object-oriented principles, and file operations to enhance code reusability, abstraction, and data handling.

CO3: Perform advanced programming using NumPy and Pandas by creating, manipulating, and aggregating arrays and data frames to extract meaningful insights from structured data.

CO4: Develop and customize interactive data visualizations using libraries such as Matplotlib, Seaborn, and Plotly, and integrate data from relational databases using SQL and Python.

CO5: Create end-to-end Python applications by combining programming constructs, data analysis tools, and visualization techniques to solve real-world problems, as demonstrated through capstone projects.

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,

Mapping of course outcomes with program learning outcomes:

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

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

Syllabus:

| Module | Content |
|---------------|--|
| 1 | Introduction to Python, Real-world Applications of Python, Features and Implementations of Python, Running and Using Jupyter Notebooks, Basic Data Types, Input and Output Operations, Basic Operators, Comparison, and Logical Operators, Lists and Indexing, Advanced Indexing and Updating Data in a List, Tuples and Dictionaries, Conditional Execution, Loops, Looping through a Dictionary. |

| | |
|---|--|
| 2 | Writing and Using Functions: Function Arguments, User-Defined Functions, Methods, Global vs Local Scope, Nested Functions, Default and Flexible Arguments, Lambda Functions; Modules and Packages, String and List Methods, Exception Handling; File Handling in Python; Object-Oriented Programming: Classes, Methods, and Objects, Introduction to Object-Oriented Design. |
| 3 | Introduction to NumPy: 1D and 2D Arrays, Looping over Arrays, Statistical Tools; Introduction to Pandas: Series and DataFrames, Creating, Slicing, and Filtering, Importing and Exporting Data, Indexing and Selecting Data; Editing DataFrames: Setting and Transforming Columns; Combining and Reshaping. DataFrames: Grouping and Aggregating, Common Functionalities |
| 4 | Introduction to Matplotlib: Line, Bar, Scatter, Histogram, Box, Pair, and Time Series Plots, 3D Plotting, Line of Best Fit, Customising and Exporting Graphs, Introduction to Seaborn, Introduction to Plotly (for interactive visualizations), Database Concepts and SQL, SQL using Python, Capstone Projects and Case Studies. |

Lab Exercises

Module 1

1. Write programs to practice basic data types, input/output operations, and operators. Include arithmetic, logical, and comparison operations.
2. Implement scripts using conditional execution. Add meaningful comments for readability and maintainability.
3. Practice loops and nested loops with control statements (break, continue). Examples: check for prime numbers, generate Fibonacci series, compute factorial, check for Armstrong and palindrome numbers.
4. Explore built-in data structures such as lists, tuples, sets, and dictionaries. Perform operations like insertion, deletion, and searching.

Module 2

5. Programs to write user-defined functions to compute factorial, Fibonacci series, and sum of squares. Use default and keyword arguments.
6. Use lambda functions with map() and filter() to process lists. Examples: square even numbers, filter prime numbers.
7. Define a class Employee with methods to set and display employee details. Demonstrate class variables, constructors, and method overriding.
8. Create a Python script for file handling. Read from and write to a text file, and include exception handling for file-not-found and incorrect format.
9. Create a module with reusable mathematical functions. Import the module into another script and use its functions in computations.

Module 3

10. Use NumPy to create 1D and 2D arrays. Perform reshaping, slicing, and compute statistical measures such as mean, median, and standard deviation.
11. Load a CSV file using Pandas and perform operations such as filtering rows, slicing columns, and handling missing values.
12. Group and aggregate data in a DataFrame. Compute aggregate statistics like mean, count, and max; then sort the results.
13. Edit and transform a DataFrame. Add, rename, or drop columns, and apply filters based on conditions.
14. Combine multiple DataFrames using concatenation and merging. Reshape data using pivot and melt operations.

Module 4

15. Create plots using Matplotlib: line, histogram, and scatter plots. Customize axis labels, legends, titles, and styles.
16. Visualize data using Seaborn: generate pair plots, box plots, and heatmaps using built-in datasets.
17. Use Plotly to build interactive visualizations such as bar charts and time series plots. Export the results as HTML.
18. Connect to an SQLite database using Python. Retrieve student data with SQL queries and display results using Pandas.
19. Capstone Mini Project: Load a real-world dataset (e.g., COVID-19, sales, or student performance), clean and analyze it using Pandas and NumPy, visualize insights using at least two plotting libraries, and summarize findings in output or comments.

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, 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: Essential Tools for Working with Data*, O'Reilly, 2016.
5. F. Nelli, *Python Data Analytics: With Pandas, NumPy, and Matplotlib*, 2nd ed., Apress, 2018.

AI AND MACHINE LEARNING

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction | | | |
|---|-------------------------|---|-------------------------|-------------|-------------|-------------|
| M4010000/ M4020000 | AI and Machine Learning | 3-1-0-0 | 2024 | | | |
| 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 capability in AI/Machine Learning | | | | | | |
| CO2: Algorithm analysis capability in AI/Machine Learning | | | | | | |
| CO3: Problem analysis skills in AI/Machine Learning Applications | | | | | | |
| CO4: Solution design capability in AI/machine learning Applications | | | | | | |
| CO5: Solution illustration capability in AI/Machine Learning 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 | 3 | 2 | 2 | 2 |
| CO2 | 3 | 3 | 3 | 2 | 2 | 2 |
| CO3 | 2 | 3 | 3 | 3 | 3 | 3 |
| CO4 | 2 | 3 | 3 | 2 | 3 | 3 |
| CO5 | 2 | 3 | 3 | 3 | 3 | 3 |
| (Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)) | | | | | | |

| Syllabus | |
|-----------------|----------------|
| Module | Content |

| | |
|---|--|
| 1 | Artificial Intelligence - Turing Test, Knowledge Representation, Rule/Logic based AI and Machine Learning Based AI, Importance of search in AI - 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 tradeoffs, Feature Engineering - relevance, feature extraction - PCA. Supervised Learning:- Classification - Bayesian, Decision Tree and Random Forests, Ensemble Methods - Boosting, Regression - linear, logistic. |
| 3 | Unsupervised Learning - Density Estimation - Maximum Likelihood and Parzen Windows, Clustering- Partition Based, Subspace Clustering - CLIQUE, Incremental Clustering - Leader and BIRCH. 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. |
| Lab Exercises Module 1: Experiments on Google AI Experiments platform, Implementation of Perceptron Module 2: Implementation 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 <ol style="list-style-type: none"> 1. S. Russell and P. Norvig, <i>Artificial Intelligence: A Modern Approach</i>, 4th ed., Pearson, 2020. 2. S. Shalev-Shwartz and S. Ben-David, <i>Understanding Machine Learning: From Theory to Algorithms</i>, Cambridge University Press, 2014. 3. I. Goodfellow, Y. Bengio, and A. Courville, <i>Deep Learning</i>, MIT Press, 2016. References <ol style="list-style-type: none"> 1. S. Haykin, <i>Neural Networks and Learning Machines</i>, 3rd ed., Pearson, 2009. 2. G. Bonaccorso, <i>Mastering Machine Learning Algorithms</i>, Packt Publishing, 2018. | |

ADVANCED DATA STRUCTURES AND ALGORITHMS

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|--|---|---|----------------------|
| M4010002/ M4020002 | Advanced Data Structures and Algorithms | 2-1-0-0 | 2024 |
| Prerequisites: Students should possess the fundamental programming skills in Computer Programming Languages such as Python. | | | |
| Course Objective: <ol style="list-style-type: none"> 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: Analyse existing algorithms to identify their efficiency and evaluate the suitability of advanced data structures in problem-solving.
CO2: Design and create algorithms for novel computational problems while evaluating their correctness and performance.
CO3: Evaluate the complexity of algorithms using advanced concepts, including NP-completeness, randomization, approximation, and parameterized techniques.
CO4: Create optimized algorithmic solutions tailored for specific applications, justifying the choice of data structures and techniques.
CO5: Analyse algorithmic trade-offs and design strategies to address computational challenges with improved efficiency and scalability.

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,

Mapping of course outcomes with program learning outcomes:

| | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 |
|------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | 1 | 2 | 1 | 3 | 1 | 1 |
| CO2 | 1 | 2 | 2 | 2 | 3 | 2 |
| CO3 | 2 | 1 | 3 | 3 | 2 | 2 |
| CO4 | 2 | 1 | 3 | 3 | 3 | 2 |
| CO5 | 1 | 2 | 2 | 2 | 3 | 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 | Trees: Balanced Binary Search Trees (AVL trees) and Splay Trees. Graphs: Weighted graphs, 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 |
| 4 | Overview of P, NP Problems, NP-Completeness and a brief introduction to Randomization, Approximation and Parameterized Complexity. |

Lab Exercises

Solving various problems using appropriate data structures. Use of recursion. Solving problems with Greedy, Divide and Conquer, and Dynamic programming techniques. Solving other interesting problems 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*, Asia: Pearson Education, 2004.
2. A. Drozdek, *Data Structures and Algorithms in JAVA*, 2nd ed., Brooks/Cole, 2002.
3. J. Kleinberg and E. Tardos, *Algorithm Design*, Pearson Education, 2006.
4. S. Dasgupta *et al.*, *Algorithms*, New York: McGraw-Hill Higher Education, 2008.

DATA STRUCTURES AND ALGORITHMS

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|-------------|-----------------------------------|---|-------------------------|
| M4020005 | Data Structures and Algorithms | 2-1-0-0 | 2024 |

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: Develop algorithms for searching and sorting problems.

CO2: Formulate/Apply the solution using the concepts of Stack, Queue, Linked List, Recursion and Tree

CO3: Evaluate algorithms to assess their performance based on time and space complexity.

CO4: Implement programs and some application using different Data Structures

CO5: Utilize the acquired skills of algorithms and data structures for creating better quality 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 | 1 | 1 | 1 | 1 |
| CO2 | 3 | 2 | 3 | 1 | 1 | 1 |
| CO3 | 3 | 1 | 3 | 1 | 1 | 1 |
| CO4 | 3 | 1 | 3 | 1 | 1 | 1 |
| CO5 | 3 | 1 | 3 | 1 | 1 | 1 |

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

Syllabus

| Module | Content |
|--------|---|
| 1 | Introduction to ADT and Algorithms: Data types, Data structures, Abstract data types, Algorithms, Algorithm analysis, Best case, worst case and average case complexities, Big-O notation, Analysis of Python List and Dictionary operations. Introduction to complexity classes. |
| 2 | Stacks: Introduction to stack, the stack abstract data type, basic operations, Algorithm analysis and implementation of stack in Python, expression representation using prefix and postfix notations, Evaluation of expression using stack. Queues: Introduction to queues, the queue ADT, basic operations, Algorithm and computational problems related to queue. Linked List: The unordered list ADT, linked list operations, doubly linked list, applications. |
| 3 | Recursion: The laws of recursion, format of a recursive function, applications of recursion such as Fibonacci series, Towers of Hanoi. Searching: Sequential and binary search, hashing. Sorting: Selection, bubble, insertion, quick, merge, heap sorts. |
| 4 | Trees: Vocabulary, Definitions, Tree operations, Implementation of tree, Binary trees, Balanced binary tree, Complete binary tree, binary search tree, balanced binary search tree, tree traversals. Heap: Introduction to binary heap, max heap, min heap, representation. |

Lab Exercises

Module 1: Computation of complexities of various algorithms.

Module 2: Implementation stack, queue, linked list.

Module 3: Solving problems using recursion and implementation of all the sorting and searching algorithms.

Module 4: Implementation of tree, balanced tree, BST and heap structure.

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*, Asia: Pearson Education, 2004.
2. A. Drozdek, *Data Structures and Algorithms in JAVA*, 2nd ed., 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.

DATABASE SYSTEMS

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|-------------|------------------|---|-------------------------|
| M4020006 | Database Systems | 2-1-0-0 | 2024 |

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: Analyse the basic concepts and applications of Database Management System.

CO2: Create Entity – Relationship diagram and convert into the corresponding logical schema.

CO3: Create SQL queries based on the given requirements and get practical knowledge on data modeling, data manipulation and data retrieval.

CO4: Evaluate the architecture and features of distributed databases and get the knowledge on distributed databases

CO5: Analyse the different NoSQL databases and its 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 | 2 | 2 | 1 | 1 | 1 | 1 |

| | | | | | | |
|--|--|---|---|---|---|---|
| C02 | 2 | 2 | 3 | 1 | 1 | 2 |
| C03 | 2 | 3 | 2 | 1 | 1 | 1 |
| C04 | 2 | 3 | 2 | 1 | 1 | 2 |
| C05 | 2 | 3 | 2 | 1 | 1 | 1 |
| (Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)) | | | | | | |
| Syllabus | | | | | | |
| Module | Content | | | | | |
| 1 | Introduction to Database Management Systems: Data, Information, Database, File Server Model, Client Server Model, Components of DBMS, DBMS Features, Transaction and ACID properties, Data Abstraction and data independence. | | | | | |
| 2 | Data Modeling: Logical and Physical Data Models, E-R Modeling A detailed study, Record Based Models, Relational Model - overview, Relational Concepts, Tables, Keys, Constraints, Data Integrity and Constraints, Integrity Rules, Database Objects, Schema and Non-schema, Database Normalization, Codd's Rules, Functional dependency. | | | | | |
| 3 | Introduction to SQL: 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, Queries, Correlated Sub-queries, Joins, Hierarchical Queries, Bind Variables, Cursors, Views, Functions, Stored Procedures and Triggers. | | | | | |
| 4 | Distributed Databases: Architectures for parallel databases, Parallel query evaluation; Parallelizing individual operations, Distributed database concepts, Data fragmentation, Replication, and allocation techniques for distributed database design; Query processing in distributed databases; Concurrency Control and Recovery in distributed databases. NoSQL- The Emergence and relevance of NoSQL, Types of NoSQL Databases, MongoDB, Cassandra, HBASE, Neo4j use and deployment, Application, Challenges NoSQL approach, Key-Value store and Document Data Models, Column-Family Store and graph database. | | | | | |
| Text Books and References | | | | | | |
| <ol style="list-style-type: none"> 1. R. Elmasri and S. B. Navathe, <i>Fundamentals of Database Systems</i>, Pearson, 2000. 2. A. Silberschatz et al., <i>Database System Concepts</i>, 4th ed., McGraw-Hill, 2002. 3. S. Ceri and G. Pelagatti, <i>Distributed Databases: Principles and Systems</i>, Universities Press, 2000. 4. A. Meier and M. Kaufmann, <i>SQL and NoSQL Databases: Models, Languages, Consistency Options and Architectures for Big Data Management</i>, Springer, 2019. 5. P. J. Sadalage and M. Fowler, <i>NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence</i>, Addison Wesley Professional, 2012. 6. S. Acharya, <i>Demystifying NoSQL</i>, India: Wiley, 2020. | | | | | | |

INTRODUCTION TO CYBER SECURITY

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|--|-----------------------------------|---|-------------------------|------|------|------|------|------|------|------|-----|---|---|---|---|---|---|-----|---|---|---|---|---|---|-----|---|---|---|---|---|---|-----|---|---|---|---|---|---|-----|---|---|---|---|---|---|
| M4010001/ M4020001 | Introduction to Cyber Security | 3-1-0-0 | 2024 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Prerequisites: Nil | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Course Objectives: <ol style="list-style-type: none"> 1. Establish foundational cybersecurity knowledge across digital systems. 2. Introduce threat models, vulnerabilities, and protective mechanisms. 3. Build early hands-on familiarity with security tools and protocols. 4. Embed awareness of future-oriented topics like post-quantum cryptography and AI threats. 5. Prepare students for industry-aligned roles and advanced specialization in later semesters. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Course Outcomes: After completion of this course, the students will be able to: CO1: Articulate key principles of cybersecurity, threat models, and security goals. CO2: Classify common cyberattacks and evaluate their impact in real-world contexts. CO3: Apply core security techniques (encryption, access control, backups) to simulated environments. CO4: Analyze privacy and ethical considerations, including emerging Indian cyber laws. CO5: Use baseline diagnostic and security tools to audit and secure digital 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: <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 10px;"> <thead> <tr> <th></th> <th>PLO1</th> <th>PLO2</th> <th>PLO3</th> <th>PLO4</th> <th>PLO5</th> <th>PLO6</th> </tr> </thead> <tbody> <tr> <td>CO1</td> <td style="text-align: center;">3</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> <td style="text-align: center;">2</td> <td style="text-align: center;">1</td> <td style="text-align: center;">1</td> </tr> <tr> <td>CO2</td> <td style="text-align: center;">3</td> <td style="text-align: center;">3</td> <td style="text-align: center;">3</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> <td style="text-align: center;">1</td> </tr> <tr> <td>CO3</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> <td style="text-align: center;">3</td> <td style="text-align: center;">3</td> <td style="text-align: center;">2</td> <td style="text-align: center;">1</td> </tr> <tr> <td>CO4</td> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> <td style="text-align: center;">3</td> <td style="text-align: center;">2</td> </tr> <tr> <td>CO5</td> <td style="text-align: center;">1</td> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> <td style="text-align: center;">3</td> <td style="text-align: center;">2</td> </tr> </tbody> </table> <p style="text-align: center; margin-top: 5px;">3 (Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High))</p> | | | | | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | CO1 | 3 | 2 | 3 | 2 | 1 | 1 | CO2 | 3 | 3 | 3 | 2 | 3 | 1 | CO3 | 2 | 3 | 3 | 3 | 2 | 1 | CO4 | 1 | 2 | 2 | 3 | 3 | 2 | CO5 | 1 | 1 | 2 | 3 | 3 | 2 |
| | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CO1 | 3 | 2 | 3 | 2 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CO2 | 3 | 3 | 3 | 2 | 3 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CO3 | 2 | 3 | 3 | 3 | 2 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CO4 | 1 | 2 | 2 | 3 | 3 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CO5 | 1 | 1 | 2 | 3 | 3 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Syllabus | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Module | Content | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| | |
|---|---|
| 1 | <p>Foundations of Cybersecurity and Threat Landscape CIA triad and core security principles Threats, vulnerabilities, attack surfaces, and risk Cyber adversaries: cybercrime, hacktivists, insiders, APTs Security in the Indian context: IT Act, CERT-IN, DPDP Act 2023 Post-Quantum Context: Why quantum computers threaten today’s cryptography (RSA/ECC) Case study: Data breaches (Equifax), ransomware (WannaCry), Aadhaar implications</p> |
| 2 | <p>Systems, Network, and Web Security Operating System Security: file permissions, privilege management Network fundamentals: TCP/IP, DNS, ports, firewalls Common attacks: sniffing, spoofing, scanning, MITM Web vulnerabilities: OWASP Top 10, XSS, SQLi Hands-on tools: nmap, netstat, iptables, browser security settings Zero Trust Principle: Perimeter vs. identity-based defense</p> |
| 3 | <p>Cryptography and Secure Communication Foundations of cryptography: classical to modern Symmetric (AES) and Asymmetric (RSA, ECC) encryption Hashing, digital signatures, PKI, TLS/SSL Hands-on Labs: GPG, encrypting messages, verifying signatures Intro to PQC: quantum threat to RSA/ECC, NIST PQC, Kyber/Dilithium India’s PQC readiness and hybrid crypto adoption</p> |
| 4 | <p>Cyber Hygiene, Privacy, and Emerging Security Domains Email and phishing security, password managers, 2FA Mobile & IoT Security: app permissions, insecure defaults, update hygiene Cloud security basics: shared responsibility model, IAM AI in Security: role of ML in threat detection, adversarial attacks Blockchain and Security: cryptographic primitives, tamper-proof logs Career pathways: Blue team vs Red team, certifications, CTFs</p> |
| <p>Lab Topics:</p> <ul style="list-style-type: none"> • OS-level permissions & hardening (Linux) • Basic packet sniffing and port scanning • Password audit and manager setup • GPG encryption & digital signatures • Simulated phishing and secure browsing exercises | |
| <p>Text Books</p> <ol style="list-style-type: none"> 1. William Stallings, Network Security Essentials, 6th Ed., Pearson, 2021. 2. Charles J. Brooks et al., Cybersecurity Essentials, 2nd Ed., Pearson, 2020. 3. Mark Ciampa, Security+ Guide to Network Security Fundamentals, Cengage. 4. Daniel Bernstein et al., Post-Quantum Cryptography, Springer (selected chapters). | |

BLOCKCHAIN TECHNOLOGY

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|---|-----------------------|---|-------------------------|
| M5010026/ M5020026 | Blockchain Technology | 1-1-0-1 | 2024 |
| Prerequisites: Nil | | | |
| <p>Course Objectives:</p> <ol style="list-style-type: none"> 1. To provide students with a deeper understanding of the concepts of blockchain technology with due focus on decentralized computing and distributed systems. 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. | | | |
| <p>Course Outcomes: After completion of this course, the students will be able to:</p> <p>CO1: Analyse the security challenges in blockchain systems and evaluate various strategies.</p> <p>CO2: Analyze the variants of blockchain/DLT and their adoption in respective domains.</p> <p>CO3: Evaluate the scalability and performance of different programmable blockchains.</p> <p>CO4: Develop and evaluate blockchain-based frameworks to ensure transparency and efficiency in supply chain management.</p> <p>CO5: Analyse the integration of blockchain with emerging technologies to create advanced systems for data integrity and automation.</p> | | | |
| <p>Program Learning Outcomes:</p> <p>PLO 1 Develop strong fundamental disciplinary knowledge.</p> <p>PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature.</p> <p>PLO 3 Apply for a scholarship to conduct independent and innovative research.</p> <p>PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences.</p> <p>PLO 5 Practice ethical standards of professional conduct and research.</p> <p>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.</p> | | | |

Mapping of course outcomes with program learning outcomes:

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

(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 Ethereum 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, 3rd ed., Packt Publishing, 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.
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.

QUANTUM COMPUTING

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|--|-------------------|---|-------------------------|
| M5010028/ M5020028 | Quantum Computing | 1-1-0-1 | 2025 |
| Prerequisites: Basic linear algebra | | | |
| <p>Course Objectives:</p> <ol style="list-style-type: none"> 1. To provide students with a solid foundation in quantum mechanics, including wave-particle duality, quantum tunneling, and the Schrödinger equation. 2. To enable students to effectively manipulate and analyze qubits, quantum gates, and circuits using foundational principles and visualization techniques. 3. To equip students with the skills to apply quantum algorithms to solve real-world problems in computation, cryptography, and other domains. | | | |
| <p>Course Outcomes: After completion of this course, the students will be able to:</p> <p>CO1. Evaluate the fundamental principles of quantum mechanics, to understand their role in quantum computation.</p> <p>CO 2. Analyze and evaluate the efficiency of quantum algorithms, including Grover’s search, Shor’s factoring, and Deutsch-Jozsa algorithms, in solving computational problems.</p> <p>CO3. Design and create quantum circuits and gates using qubits, Bloch sphere representation, and quantum entanglement.</p> <p>CO4. Integrate and develop solutions involving advanced quantum concepts like teleportation, superdense coding, and the no-cloning theorem.</p> <p>CO5. Formulate and create quantum computing models to address challenges in classical and quantum problem-solving.</p> | | | |
| <p>Program Learning Outcomes:</p> <p>PLO 1 Develop strong fundamental disciplinary knowledge.</p> <p>PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature.</p> <p>PLO 3 Apply for a scholarship to conduct independent and innovative research.</p> <p>PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences.</p> <p>PLO 5 Practice ethical standards of professional conduct and research.</p> <p>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.</p> | | | |

Mapping of course outcomes with program learning outcomes:

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

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 Research topics: quantum tunneling in nanoscale devices, uncertainty in quantum sensors, wave function interpretations. |
| 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. Research topics: error mitigation in qubits, novel tensor product models, enhanced qubit visualizations. |
| 3 | Quantum gates, Quantum circuits, Quantum entanglement, No cloning theorem, Quantum teleportation, Super dense coding, Quantum parallelism, DiVincenzo's criteria for quantum computation Research topics: circuit optimization, non-standard gates, practical teleportation methods |
| 4 | Quantum Fourier transform, Deutsch's Algorithm, Deutsch-Jozsa Algorithm, Simon's periodicity algorithm, Grover's search algorithm, Shor's Factoring algorithm. Research topics: hybrid quantum-classical algorithms, advanced factorization methods, cryptographic applications. |

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 Practice*, Springer, 2021.
3. M. Nakahara and T. Ohmi, *Quantum Computing*, CRC Press, 2008.
4. M. Mosca, *An Introduction to Quantum Computing*, New York: Oxford University Press, 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: Springer, 1993.
4. N. D. Mermin, *Quantum Computer Science*, Cambridge University Press, 2007.

TECHNICAL COMMUNICATION

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|---|-------------------------|---|-------------------------|
| M4010017/ M4020017 | Technical Communication | 1-1-0-0 | 2025 |
| Prerequisites: Basic English, Grammar rules. | | | |
| <p>Course Objectives:</p> <ol style="list-style-type: none"> 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. | | | |
| <p>Course Outcomes: After completion of this course, the students will be able to:</p> <p>CO1: Interpret the nature, objective, and importance of Technical Communication.</p> <p>CO2: Develop technical write-ups effectively.</p> <p>CO3: Boost their confidence in public speaking.</p> <p>CO4: Plan and deliver presentations in front of a diverse audience.</p> <p>CO5: Evaluate and improve communication efficiency through mastery of voice dynamics.</p> | | | |
| <p>Program Learning Outcomes:</p> <p>PLO 1 Develop strong fundamental disciplinary knowledge.</p> <p>PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature.</p> <p>PLO 3 Apply for a scholarship to conduct independent and innovative research.</p> <p>PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences.</p> <p>PLO 5 Practice ethical standards of professional conduct and research.</p> <p>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.</p> | | | |

Mapping of course outcomes with program learning outcomes:

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

(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*, McGraw-Hill, 2001.
3. L. U. B. Pandey, *Practical Communication: Process and Practice*, India: A.I.T.B.S. Publications, 2014.
4. T. A. Sherman *et al.*, *Modern Technical Writing*, Apprenctice 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.

ROBOTICS

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|-------------------------------|-----------------|---|-------------------------|
| M4010009/ M4020009 | Robotics | 2-1-0-0 | 2025 |

Prerequisites: Prior knowledge of undergraduate level Mathematics, Programming

Course Objectives:

1. To impart a comprehensive and in-depth understanding of Robotics, 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 Robotics while providing sufficient foundations for further study and research.

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

CO1: Analyze the foundations of robotics, including mechanics, planning, and control, and apply knowledge through assessments such as quizzes and examinations.

CO2: Design and implement robotics projects to prepare for industrial automation environments.

CO3: Evaluate and critique current literature in robotics to identify advancements and trends in the field.

CO4: Conduct research on robotics algorithms and demonstrate findings.

CO5: Integrate and apply theoretical and practical knowledge to solve real-world robotics challenges.

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 | 3 | 2 | 1 | 1 |
| CO2 | 1 | 3 | 3 | | 3 | |
| CO3 | 4 | | 1 | 3 | 2 | |
| CO4 | 3 | 3 | 4 | 1 | 1 | |
| CO5 | 2 | 1 | 2 | 2 | | 2 |

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

Syllabus:

| Module | Content |
|---------------|---|
| 1 | Introduction to the subject, automation, Industrial robots, Serial, parallel robots, configuration space, rigid body motion, kinematics, Inverse and forward kinematics, dynamics, trajectory planning, Applications. Configuration space: degrees of freedom (dof), robot joints, Grubler, s formula, Open and close chains, configuration space and its representation. Configuration and velocity constraints, taskspace and workspace |
| 2 | Rigid body motion: rigid body motion in plane, mathematical description of position and orientation, rotation and angular velocities, changing the coordinate frames, representations of rotation, homogenous transformation matrix, rotating and translating a vector or frame, twists, wrenches. Forward Kinematics: DH parameters, examples of DH parameters, product of exponential formulas, |
| 3 | Velocity, kinematics and statics: Jacobian, space jacobian, body jacobian, singularity analysis, manipulability, Inverse kinematics: Analytical and numerical inverse kinematics, kinematics of closed chains (parallel robots), Stewart-Gaugh platform. Manipulator dynamics: Acceleration of rigid body, mass distribution, Newton's equation, Example of close form dynamic equations, Lagrangian formulation of manipulator dynamics. |

| | |
|--|---|
| 4 | Trajectory generation: Point to point trajectory, polynomial via point trajectory, time scaling, Manipulator-mechanism design: basing design on task requirements, kinematic configuration, redundant and closed-chain structures, Actuation schemes, gears, shafts, links, Actuators, pneumatic cylinders, motors, position sensing, force sensing |
| Text Books | |
| <ol style="list-style-type: none"> 1. J. J. Craig, <i>Introduction to Robotics: Mechanics and Control</i>, 3rd ed., Pearson, 2004. 2. K. M. Lynch and F. C. Park, <i>Modern Robotics: Mechanics, Planning, and Control</i>, Cambridge University Press, 2017. 3. D. Fox and S. Thrun, <i>Probabilistic Robotics</i>, MIT Press, 2005. 4. S. K. Saha, <i>Introduction to Robotics</i>, McGraw-Hill Education, 2008. | |

ADVANCED DISTRIBUTED SYSTEMS

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|---|-------------------------------------|---|----------------------|
| M4010005 | Advanced Distributed Systems | 2-0-1-0 | 2025 |
| Prerequisites: Prior Knowledge of operating systems, computer networks, distributed systems, DBMS, Graph Theory. | | | |
| Course Objectives: | | | |
| <ol style="list-style-type: none"> 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: | | | |
| CO1: Apply the fundamental concepts and algorithms of distributed systems to solve real-world problems. | | | |
| CO2: Analyse the various solution algorithms in distributed systems to develop efficient software solutions. | | | |
| CO3: Evaluate and implement state-of-the-art solutions for distributed systems configurations. | | | |
| CO4: Create and present a term project, including independent research, analysis, and programming on the latest advancements in Distributed Systems. | | | |
| CO5: Create a comprehensive distributed software solution, integrating key concepts and state-of-the-art tools in the field. | | | |

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 | 1 | 1 | 1 |
| CO2 | 1 | 2 | 2 | 1 | 2 | 1 |
| CO3 | 1 | 3 | 2 | 2 | 2 | 1 |
| CO4 | | 3 | 3 | 3 | 3 | 3 |
| CO5 | | 3 | 3 | 3 | 3 | 3 |

(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 <i>Cloud:</i> Introduction to Cloud Computing, Cloud Computing Platforms, Parallel Programming in the Cloud, Distributed Storage Systems, Virtualization (Multicore Operating Systems). <i>Distributed Database Management Systems:</i> 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

Text Books

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

DATA AND INTELLIGENCE

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|---|--------------------------|---|-------------------------|
| M4010006/ M4020016 | Data and Intelligence | 2-0-1-0 | 2025 |
| 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. | | | |

| | | | | | | |
|---|---|-------------|-------------|-------------|-------------|-------------|
| <p>Course Outcomes: After completion of this course, the students will be able to:</p> <p>CO1: Data Problem identification capability in various domains</p> <p>CO2: Analysis capability in data problems</p> <p>CO3: Knowledge in Computational Methods/Algorithms used to solve data problems</p> <p>CO4: Solution design capability in data problems</p> <p>CO5: Knowledge in solution analysis and impact study in data problems</p> | | | | | | |
| <p>Program Learning Outcomes:</p> <p>PLO 1 Develop strong fundamental disciplinary knowledge.</p> <p>PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature.</p> <p>PLO 3 Apply for a scholarship to conduct independent and innovative research.</p> <p>PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences.</p> <p>PLO 5 Practice ethical standards of professional conduct and research.</p> <p>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.</p> | | | | | | |
| Mapping of course outcomes with program learning outcomes: | | | | | | |
| | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 |
| CO1 | 3 | 3 | 2 | 3 | 2 | 3 |
| CO2 | 3 | 3 | 3 | 2 | 2 | 3 |
| CO3 | 3 | 3 | 3 | 2 | 3 | 3 |
| CO4 | 3 | 3 | 3 | 2 | 3 | 3 |
| CO5 | 2 | 2 | 3 | 3 | 3 | 3 |
| (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, 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*, India: Pearson Education, 2016.
2. S. Stephens-Davidowitz, *Everybody Lies: Big Data, New Data, and What the Internet Can Tell Us About Who We Really Are*, Harper Luxe, 2017.
3. Ravi Bapna, Anindya Ghose, *Thrive: Maximizing Well-being in the Age of AI*, MIT Press, 2024

CLOUD AND EDGE COMPUTING

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|--|-----------------------------|---|-------------------------|
| M5010029/ M5020029 | Cloud and Edge Computing | 1-1-0-1 | 2025 |
| Prerequisites: Basic knowledge in Computer Systems and Concepts | | | |
| <p>Course Objectives:</p> <ol style="list-style-type: none"> 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. | | | |
| <p>Course Outcomes: After completion of this course, the students would be able to:</p> <p>CO1: Analyze cloud computing architectures, service models, and deployment strategies to assess their applications and limitations.</p> <p>CO2: Design cloud and edge computing solutions using the tools such as Cloud SIM ,AWS and Google Cloud.</p> <p>CO3: Evaluate cloud technologies and edge computing frameworks by exploring real-world case studies and emerging trends.</p> <p>CO4: Integrate concepts like IoT services to develop interdisciplinary solutions for computing challenges.</p> <p>CO5: Develop and present a research project demonstrating expertise in Cloud application design, implementation, and critical analysis.</p> | | | |
| <p>Program Learning Outcomes:</p> <p>PLO 1 Develop strong fundamental disciplinary knowledge.</p> <p>PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature.</p> <p>PLO 3 Apply for a scholarship to conduct independent and innovative research.</p> <p>PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences.</p> <p>PLO 5 Practice ethical standards of professional conduct and research.</p> <p>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.</p> | | | |

| Mapping of course outcomes with program learning outcomes: | | | | | | | | |
|--|--|------|------|------|------|------|------|--|
| | | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | |
| | CO1 | 3 | 2 | 1 | 2 | 1 | 2 | |
| | CO2 | 3 | 2 | 2 | 2 | 1 | 2 | |
| | CO3 | 2 | 2 | 2 | 2 | 2 | 1 | |
| | CO4 | 2 | 2 | 2 | 3 | 3 | 1 | |
| | CO5 | 2 | 2 | 2 | 2 | 2 | 2 | |
| (Correlation: 1: Slight (Low) 2: Moderate (Medium)3: Substantial (High)) | | | | | | | | |
| Syllabus | | | | | | | | |
| Module | Content | | | | | | | |
| 1 | Introduction to cloud computing – Definition – Characteristics – Cloud Service Models: IaaS, PaaS and SaaS – Deployment Models: Public, Private, Hybrid and Community – Cloud Services Examples – Cloud Architecture – Cloud Reference Model (NIST Architecture) - Cloud Computing Characteristics and Applications | | | | | | | |
| 2 | Cloud Concepts and Technologies: Virtualization – Load Balancing – Scalability – Elasticity – Deployment – Replication – Monitoring – Software Defined Networking – Network Function Virtualization – Map Reduce – Identity and Access Management – Service Level Agreements – Billing – Service Oriented Architecture – RESTful Web Services – Publish Subscribe Model | | | | | | | |
| 3 | Exploring Cloud Services and Platforms: Compute Services – Storage Services – Database Services – Application Services – Content Delivery Services – Analytics Services – Deployment and Management Services – Identity and Access Management Services – Open-Source Private Cloud Softwares. | | | | | | | |
| 4 | Edge Computing: Definition – Scope – Key Difference between Cloud and Edge Computing – Evolution – Edge Devices and Hardware – Communication Protocols and Networking in Edge Computing – Overview of Edge Computing Frameworks: Kubernetes, Open Horizon, AWS IoT Greengrass - Programming Models for Edge Computing Applications – Future Research Directions in Edge Computing. Case Studies and Use Cases of Cloud and Edge Computing | | | | | | | |

Text Books

1. K. Chandrasekaran, Essentials of Cloud Computing, CRC Press, 2015.
2. Arshdeep Bahga, Vijay Madisetti, Cloud Computing: A Hands-On Approach, Universities Press (India) Private Limited, 2014.
3. R. Buyya et al., Mastering Cloud Computing, McGraw-Hill, 2013.
4. C. Surianarayanan and P. Chelliah, Essentials of Cloud Computing: A Holistic Perspective, 1st ed., Springer, 2019.
5. Rajkumar Buyya and Satish Narayana Srirama, Fog and Edge Computing: Principles and Paradigms, Wiley, 2019.
6. Elias Krishnasamy et al., Edge Computing: An Overview of Framework and Applications, PRACE Technical Report, 2020.
7. R. Buyya, S. N. Srirama, Fog and Edge Computing: Principles and Paradigms, Wiley, 2019.
8. J. R. Vacca, Cloud Computing Security: Foundations and Challenges, CRC Press, 2016.
9. B. Burns et al., Kubernetes: Up and Running: Dive Into the Future of Infrastructure, O'Reilly, 2019.
10. A. A. A. Donovan and B. W. Kernighan, The Go Programming Language, Addison-Wesley, 2015.
11. S. Klabnik, C. Nichols, The Rust Programming Language, No Starch Press, 2018.
12. J. S. Chelladhurai, V. Singh, and P. Raj, Learning Docker, 2nd ed., Packt Publishing, 2017.
13. A. Kurniawan, Learning AWS IoT, Packt Publishing, 2018.
14. E. Krishnasamy et al., Edge Computing: An Overview of Framework and Applications, PRACE Technical Report, 2020.

Online Resources:

1. AWS Whitepapers and Technical Guides: <https://aws.amazon.com/whitepapers/>
2. AWS Documentation : <https://docs.aws.amazon.com/>
3. AWS Architecture Center : <https://aws.amazon.com/architecture/>

CLOUD SECURITY

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|---|----------------|---|-------------------------|
| M5010013/ M5020013 | Cloud Security | 1-1-0-1 | 2025 |
| Prerequisites: Cloud Computing | | | |
| <p>Course Objectives:</p> <ol style="list-style-type: none"> 1. Understand the principles and challenges of cloud computing security, including risk assessment, legal considerations. 2. Learn about the Key strategies and best practices for securing the cloud environment. 3. Gain practical skills in securing cloud environments using Amazon Web Services (AWS), including monitoring, encryption, key management, threat detection, and compliance management. | | | |
| <p>Course Outcomes: After completion of this course, the students will be able to:</p> <p>CO1: Analyse security concerns, risks, and legal aspects of cloud computing, focusing on virtualization, provisioning, storage, and networking, to identify and mitigate vulnerabilities.</p> <p>CO2: Evaluate cloud security architectures and strategies, including encryption methods, sensitive data categorization, and solutions for vendor lock-in, to ensure secure data storage and compliance.</p> <p>CO3: Apply advanced monitoring and auditing practices using AWS tools like CloudWatch, CloudTrail, and AWS Config to gain actionable insights into cloud operations and enhance compliance.</p> <p>CO4: Utilize AWS security tools, including KMS, Web Application Firewall, and Shield, to address modern threats such as DDoS attacks and data breaches.</p> <p>CO5: Create optimized and secure cloud environments by integrating AWS features and adhering to best practices for cloud data protection and system monitoring.</p> | | | |
| <p>Program Learning Outcomes:</p> <p>PLO 1 Develop strong fundamental disciplinary knowledge.</p> <p>PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature.</p> <p>PLO 3 Apply for a scholarship to conduct independent and innovative research.</p> <p>PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences.</p> <p>PLO 5 Practice ethical standards of professional conduct and research.</p> <p>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.</p> | | | |

Mapping of course outcomes with program learning outcomes:

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

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

Syllabus:

| Module | Content |
|--------|--|
| 1 | Cloud Computing Security Concerns, Risk issues and Legal Aspects: Virtualization, Provisioning, Storage, Operation, Security and Networking – Risk Tolerance – Legal and Regulatory Issues. Key Strategies and Best Practices. |
| 2 | Cloud Architecture security – Security Requirements, Security Patterns and Architectural elements, Cloud Security Architecture Cloud Data security – Overview – Data Encryption – Sensitive Data Categorization – Cloud Data Storage – Cloud Lock in |
| 3 | Amazon AWS Monitoring & Auditing: AWS Monitoring Introduction, Cloud watch metrics – Cloud watch Logs, Live Tail, Agents -Cloud watch Alarms, Even Bridge – Cloud Trail – AWS Config |
| 4 | AWS Security – Introduction, Encryption, KMS, Multi-Region Keys, S3 Replication with encryption, Encrypted AMI Sharing process, SSM Parameter Store, AWS secrets Manager, AWS certificate Manager, Web Application Firewall, Shield – DDoS protection, Amazon Guard Duty, Amazon Inspector, Amazon Macie |

Text Books

1. J.R. Winkler, Securing the Cloud: Cloud Computer Security Techniques and Tactics, 1st ed., Elsevier, 2011.
2. T. Mather, S. Kumaraswamy, and S. Latif, Cloud Security and Privacy, 1st ed., O'Reilly, 2009.

References

3. R. Vacca, Cloud Computing Security Foundations and Challenges, CRC Press, 2017.
4. Ronald L. Krutz and Russell Dean Vines, Cloud Security: A Comprehensive Guide to Secure Cloud Computing", Wiley, 2010.
5. Michael J. Kavis, Architecting the Cloud: Design Decisions for Cloud Computing Service Models (IaaS, PaaS, and SaaS), Wiley, 2014.

Online Resources:

1. AWS Security : <https://docs.aws.amazon.com/security/>
2. AWS Monitoring and Observability : <https://docs.aws.amazon.com/monitoring/>
3. AWS Compliance and Legal Resources : <https://aws.amazon.com/compliance/>

COMPUTER NETWORKS AND SECURITY

| Course Code | Course Name | Credit Split | Year of | | | |
|---|---|-----------------------------|--------------|-------------|-------------|-------------|
| | | Lecture/Lab/Seminar/Project | Introduction | | | |
| M4010008/ M4020008 | Computer Networks and Security | 2-1-0-0 | 2025 | | | |
| Prerequisites: Nil | | | | | | |
| Course Objectives: | | | | | | |
| <ol style="list-style-type: none"> 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: | | | | | | |
| <p>CO1: Apply network protocols (TCP, UDP, HTTP) to design and implement basic applications and evaluate their performance using metrics such as delay, throughput, and loss.</p> <p>CO2: Analyze the functionalities of the transport, network, and data link layers, including routing algorithms, congestion control, and error correction methods, to solve communication challenges.</p> <p>CO3: Evaluate error detection, correction techniques, and multiple access protocols for improving network efficiency and reliability.</p> <p>CO4: Analyze and simulate network vulnerabilities and attacks in traditional and IoT environments using tools like NS2/NS3 or Contiki, and propose security solutions.</p> <p>CO5: Analyse the ability to design and implement secure network solutions by applying key management, user authentication protocols, and endpoint security techniques.</p> | | | | | | |
| Program Learning Outcomes: | | | | | | |
| <p>PLO 1 Develop strong fundamental disciplinary knowledge.</p> <p>PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature.</p> <p>PLO 3 Apply for a scholarship to conduct independent and innovative research.</p> <p>PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences.</p> <p>PLO 5 Practice ethical standards of professional conduct and research.</p> <p>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.</p> | | | | | | |
| Mapping of course outcomes with program learning outcomes: | | | | | | |
| | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 |
| CO1 | 3 | 2 | 1 | 1 | 3 | 1 |
| CO2 | 3 | 1 | 2 | 1 | 2 | 2 |
| CO3 | 3 | 2 | 2 | 1 | 2 | 2 |
| CO4 | 3 | 1 | 2 | 1 | 2 | 2 |
| CO5 | 2 | 2 | 3 | 2 | 2 | 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 Security, 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 performance. |
| Text Books | |
| <ol style="list-style-type: none"> 1. J. Kurose and K. Ross, <i>Computer Networking: A Top-Down Approach</i>, 7th ed., Pearson, 2016. 2. A. S. Tanenbaum, <i>Computer Networks</i>, 5th ed., Pearson, 2013. 3. W. Stallings, <i>Cryptography and Network Security Principles and Practice</i>, Prentice Hall, 1998. 4. V. Tsiatsis <i>et al.</i>, <i>Internet of Things: Technologies and Applications for a New Age of Intelligence</i>, Elsevier Academic press, 2018. 5. Z. Mahmood, <i>Connected Vehicles in the Internet of Things: Concepts, Technologies and Frameworks for IoT</i>, Springer, 2020. 6. I. F. Akyildiz and M. Can Vuran, <i>Wireless Sensor Networks</i>, Wiley, 2010. | |
| References | |
| <ol style="list-style-type: none"> 1. L. L. Peterson and B. S. Davie, <i>Computer Networks: A Systems Approach</i>, Morgan Kaufmann, 2011. 2. S. Keshav, <i>An Engineering Approach to Computer Networking</i>, Pearson Education, 2000. 3. S. S. Shinde, <i>Computer Network</i>, New Age International, 2009. 4. P. Raj and A. C. Raman, <i>The Internet of Things: Enabling Technologies, Platforms, and Use Cases</i>, 1st ed., Auerbach Publications, 2017. 5. A. McEwen, <i>Designing the Internet of Things</i>, Wiley, 2013. | |

CRYPTOGRAPHY

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|---|--------------|---|-------------------------|
| M4010012/ M4020012 | Cryptography | 1-1-0-1 | 2025 |
| <p>Prerequisites: A basic understanding of algebra, linear algebra, modular arithmetic</p> | | | |
| <p>Course Objectives:</p> <ol style="list-style-type: none"> 1. To explore and apply modern cryptographic standards and protocols, including symmetric encryption, public-key cryptography, and key management systems, for securing communications and data. 2. To introduce and assess post-quantum cryptographic techniques, including lattice-based, code-based, and hash-based algorithms, to ensure secure systems in the face of quantum computing threats. 3. To develop the skills necessary for implementing cryptographic solutions in real-world applications, evaluate their security, and recommend strategies for transitioning to quantum-safe cryptography. | | | |
| <p>Course Outcomes: After completion of this course, the students would be able to:</p> <p>CO1: Identify and compare modern cryptographic standards, including AES, ChaCha20, RSA, and ECC, assessing their applications and security strengths.</p> <p>CO2: Evaluate the performance of modern cryptographic standards and recommend strategies for their implementation.</p> <p>CO3: Design secure cryptographic systems using hybrid encryption, SHA-2, SHA-3, and HMAC for data integrity and authentication.</p> <p>CO4: Appraise quantum-safe cryptography algorithms (CRYSTALS-Kyber, Dilithium, SPHINCS+) and predict their impact on future security.</p> <p>CO5: Evaluate the transition to post-quantum cryptographic systems and recommend strategies for their implementation.</p> | | | |
| <p>Program Learning Outcomes:</p> <p>PLO 1 Develop strong fundamental disciplinary knowledge.</p> <p>PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature.</p> <p>PLO 3 Apply for a scholarship to conduct independent and innovative research.</p> <p>PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences.</p> <p>PLO 5 Practice ethical standards of professional conduct and research.</p> <p>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.</p> | | | |

Mapping of course outcomes with program learning outcomes:

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

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

Syllabus:

| Module | Content |
|--------|---|
| 1 | Overview of cryptographic standards and protocols, Symmetric encryption: AES and its applications, ChaCha20 and its applications |
| 2 | Key management systems and protocols: Diffie-Hellman, ECDH, Multi-factor authentication (MFA), Public-key cryptography: RSA, ECC, Hybrid encryption systems |
| 3 | Cryptographic hashing and message authentication: SHA-2, SHA-3, HMAC Digital signatures and authentication: RSA, ECDSA, |
| 4 | Post-quantum cryptography, Lattice-based cryptography: CRYSTALS-Kyber, Quantum-safe digital signatures: CRYSTALS-Dilithium, SPHINCS+, Transitioning to post-quantum cryptographic systems |

Text Books:

1. William Stallings, Cryptography and Network Security: Principles and Practice, 8th edition, Pearson, 2024.
2. Christof Paar, Jan Pelzl, Tim Güneysu, Understanding Cryptography: From Established Symmetric and Asymmetric Ciphers to Post-Quantum Algorithms, Springer-Verlag Berlin and Heidelberg GmbH & Co. K; Second Edition, 2024.
3. Jean-Philippe Aumasson, Serious Cryptography: A Practical Introduction to Modern Encryption, No Starch Press, 2017.
4. Douglas Robert Stinson, Cryptography: Theory and Practice, Chapman and Hall/CRC; Standard Edition, 2018.
5. Zhiyong Zheng, Kun Tian, Fengxia Liu, Modern Cryptography Volume 2: A Classical Introduction to Informational and Mathematical Principle, Springer; 1st ed. 2023.

References:

1. Ross Anderson, Security Engineering: A Guide to Building Dependable Distributed Systems, Wiley, 2020.
2. Thomas R. Shemanske, A Beginner's Guide, Modern Cryptography and Elliptic Curves, American Mathematical Society, 2017.
3. NIST Standards, FIPS 203, FIPS 204 and FIPS 205.

CYBER ANALYTICS

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction | | | | |
|---|-----------------|---|----------------------|-------------|-------------|-------------|-------------|
| M5010016/ M5020016 | Cyber Analytics | 1-1-0-1 | 2025 | | | | |
| Prerequisites: Nil | | | | | | | |
| Course Objectives: <ol style="list-style-type: none"> 1. To Introduce various supervises, unsupervised and reinforcement 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 | <p>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</p> |
| 2 | <p>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</p> |
| 3 | <p>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</p> |
| 4 | <p>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:</p> <ul style="list-style-type: none"> • Detecting and Responding to Advanced Threats with Analytics • Analyzing Insider Threats and Unauthorized Data Exfiltration <p>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</p> |

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 E. 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 Cybersecurity, 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 |
|--|---|---|-------------------------|
| M5010017/ M5020017 | Malware Analysis and Reverse Engineering | 1-1-0-1 | 2025 |
| Prerequisites: Nil | | | |
| Course Objectives: | | | |
| <ol style="list-style-type: none"> 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: Analyse the fundamentals of malware analysis, including various types of malware and their families across different operating systems. | | | |
| CO2: Evaluate proficiency in static analysis and reverse engineering techniques for detecting and analysing obfuscated and packed malware. | | | |
| CO3: Analyse malware behavior and evasion techniques through dynamic analysis to understand their operational impact. | | | |
| CO4: Explore and evaluate advanced topics such as IoT malware analysis and using machine learning and deep learning for automated malware detection. | | | |
| CO5: Create an awareness of adversarial evasion techniques and their impact on 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 | 3 | 3 | 1 | 2 | 2 | 1 |
| CO2 | 3 | 3 | 2 | 2 | 3 | 3 |
| CO3 | 3 | 3 | 2 | 2 | 3 | 3 |
| CO4 | 3 | 3 | 3 | 2 | 3 | 3 |
| CO5 | 3 | 3 | 2 | 2 | 3 | 3 |

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

Syllabus

| Module | Content |
|---------------|---|
| 1 | <p>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.</p> |
| 2 | <p>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.</p> |

| | |
|---|---|
| 3 | <p>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.</p> |
| 4 | <p>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.</p> |
| <p>Text Books</p> <ol style="list-style-type: none"> 1. A. Klymenov and A. Thabet, <i>Mastering Malware Analysis: The Complete Malware Analyst's Guide to Combating Malicious Software, APT, Cybercrime, and IoT Attacks</i>, Packt Publication, 2019. 2. K. A. Monappa, <i>Learning Malware Analysis: Explore the Concepts, Tools, and Techniques to Analyze and Investigate Windows Malware</i>, Packt Publication, 2018. 3. A. D. Joseph et al., <i>Adversarial Machine Learning</i>, Cambridge University Press, 2019. 4. T. Thomas et al., <i>Machine Learning Approaches in Cybersecurity Analytics</i>, Springer, 2020. 5. K. Dunham, <i>Android Malware and Analysis</i>, 1st ed., Auerbach Publications, 2014. 6. M. Sikorski and A. Honig, <i>Practical Malware Analysis: The Hands-On Guide to Dissecting Malicious Software</i>, 1st ed., No Starch Press, 2012. <p>References</p> <ol style="list-style-type: none"> 1. M. H. Ligh et al., <i>The Art of Memory Forensics: Detecting Malware and Threats in Windows, Linux, and Mac Memory</i>, 1st ed., Wiley, 2014. 2. C. Chio and D. Freeman, <i>Machine Learning and Security</i>, O'Reilly, 2018. | |

ETHICAL HACKING AND PENETRATION TESTING

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|--|--|---|-------------------------|
| M4010014/ M4020014 | Ethical Hacking and Penetration Testing | 2-1-0-0 | 2025 |
| Prerequisites: Nil | | | |
| <p>Course Objectives:</p> <ol style="list-style-type: none"> 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. | | | |
| <p>Course Outcomes: After completion of this course, the students will be able to:</p> <p>CO1: Apply the fundamental principles and legal aspects of ethical hacking and penetration testing to real-world scenarios.</p> <p>CO2: Analyse various information security threats and vulnerabilities, and assess their potential impact using appropriate techniques.</p> <p>CO3: Apply techniques such as password cracking, social engineering, and authentication mechanisms to enhance system security.</p> <p>CO4: Evaluate and counter network-level attacks, web application vulnerabilities, and insider threats through practical methods.</p> <p>CO5: Create effective security solutions and strategies to mitigate identified vulnerabilities and security risks in systems.</p> | | | |
| <p>Program Learning Outcomes:</p> <p>PLO 1 Develop strong fundamental disciplinary knowledge.</p> <p>PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature.</p> <p>PLO 3 Apply for a scholarship to conduct independent and innovative research.</p> <p>PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences.</p> <p>PLO 5 Practice ethical standards of professional conduct and research.</p> <p>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.</p> | | | |

Mapping of course outcomes with program learning outcomes:

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

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

Syllabus

| Module | Content |
|--------|---|
| 1 | <p>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</p> |
| 2 | <p>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</p> |
| 3 | <p>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</p> |
| 4 | <p>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</p> |

Text Books

1. M. Walker, *Certified Ethical Hacker All-in-One Exam Guide*, 4th ed., McGraw-Hill Education, 2020.
2. J. Erickson, *Hacking: The Art of Exploitation*, 2nd ed., No Starch Press,

- 2021.
3. W. Stallings, *Network Security Essentials: Applications and Standards*, 7th ed., 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 Publishing, 2015
2. M. T. Simpson, *Hands-On Ethical Hacking and Network Defense*, 2nd ed., 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 ed., No Starch Press, 2018.

DIGITAL FORENSICS

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|--|-------------------|---|----------------------|
| M4010015/ M4020015 | Digital Forensics | 1-1-0-1 | 2025 |
| Prerequisites: Nil | | | |
| Course Objectives: | | | |
| <ol style="list-style-type: none"> 1. To provide students with a solid understanding of digital forensics principles and evidence analysis techniques. 2. To equip students with skills for applying forensic methods in real-world investigations across various platforms. 3. To develop critical thinking and communication skills in reporting forensic findings and collaborating on investigations. | | | |
| Course Outcomes: After completion of this course, the students will be able to: | | | |
| CO1: Solve complex digital forensic cases by employing systematic investigation processes, including evidence handling, data acquisition, and advanced forensic analysis techniques. | | | |
| CO2: Demonstrate proficiency in analyzing storage media and operating systems to identify, extract, and interpret critical digital evidence across diverse platforms. | | | |
| CO3: Identify patterns and anomalies in network and mobile device data to assess security incidents, reconstruct events, and support intrusion detection efforts. | | | |
| CO4: Appraise the legal, ethical, and technical implications of forensic practices, including evidence admissibility, collaboration with law enforcement, and privacy concerns. | | | |
| CO5: Develop innovative approaches and frameworks, such as blockchain-based custody or AI-driven forensic tools, to enhance the accuracy and efficiency of digital forensic 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 | 3 | 2 | 2 | 2 |
| CO2 | 3 | 2 | 3 | 2 | 2 | 1 |
| CO3 | 3 | 3 | 3 | 2 | 2 | 1 |
| CO4 | 2 | 2 | 2 | 3 | 3 | 2 |
| CO5 | 3 | 3 | 3 | 2 | 1 | 3 |

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

Syllabus:

| Module | Content |
|---------------|--|
| 1 | Foundations of Digital Forensics Computer Forensics Fundamentals, Digital Evidence and Handling, Forensic Investigation Process, Legal and Ethical Considerations, Collaboration with Law Enforcement, Reporting and Communication, Blockchain for Custody, AI in Analysis, Forensic Visualization, Evidence Admissibility Frameworks. |
| 2 | Storage Media Analysis Characteristics of Disk Drive Types, Logical Disk Structure, Booting Processes of Windows, Linux, and Mac OS; File Systems and Examination Techniques for Windows, Linux, and Mac OS; Fundamentals of Data Acquisition and Duplication, Acquisition Formats and Methodologies, Advanced Disk Drive Forensics, Cross-Platform File System Analysis, Novel Data Acquisition Techniques, Automation in Forensic Duplication. |
| 3 | Operating System Forensics Volatile and Non-Volatile Information, Windows Memory Forensics, Registry Analysis, Web Browser Cache, Cookie, and History Analysis, Windows File and Metadata Analysis, Hibernation File Analysis, Crash Dump Analysis, File System Analysis. Linux and Mac Forensics: Volatile and Non-Volatile Data in Linux, Filesystem Image Analysis Using Sleuth Kit, Memory Forensics, Mac Forensics, Advanced Memory Forensics Techniques, Cross-Platform Volatile Data Analysis, Automation in Filesystem Image Examination, Novel Methods in Metadata and Registry Analysis. |
| 4 | Network and Mobile Forensics Network Forensics: Protocols and Packet Capturing with Wireshark, tshark, tcpdump; PCAP Filtering, Network Logs Analysis (Apache, IIS, System), Event Correlation, IoCs Detection, Traffic Investigation, and Intrusion Detection. Mobile Forensics: Data Extraction, Call Logs, Messages, Emails, Media, App Data, and Social Media Analysis, Advanced PCAP Techniques, IoC Detection, Social Media Forensics, Mobile Data Integrity. |

Text Books:

1. B. Nelson *et al.*, *Guide to Computer Forensics and Investigations*, Sixth Edition, 2020.
2. Nour Moustafa, *Digital Forensics in the Era of Artificial Intelligence*, Taylor & Francis; 1st edition, 2024
3. J. Sammons, *The Basics of Digital Forensics: The Primer for Getting Started in Digital Forensics*, Elsevier, 2014.
4. A. M. Marshall, *Digital Forensics: Digital Evidence in Criminal Investigation*, John – Wiley and Sons, 2008.
5. N. Reddy, *Practical Cyber Forensics: An Incident-Based Approach to Forensic Investigations*, New York, Apress, 1st Edition, 2019.
6. 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 |
|-----------------------|-------------------|---|-------------------------|
| M5010020/ M5020020 | Database Security | 1-1-0-1 | 2025 |

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: Analyse various database models, design processes, and the ACID properties to evaluate their impact on data consistency and security.

CO2: Create advanced SQL queries, including secure practices to prevent SQL injection and ensure data integrity.

CO3: Compare and evaluate traditional RDBMS and NoSQL databases for handling structured, semi-structured, and unstructured data.

CO4: Apply access control mechanisms like Role-Based Access Control (RBAC) and Attribute-Based Encryption in database systems to ensure secure data management.

CO5: Create comprehensive database security strategies incorporating authentication, encryption, and auditing techniques to address emerging security challenges.

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 | 3 | 2 | |
| CO2 | 3 | 2 | 2 | 2 | 2 | 1 |
| CO3 | 2 | 2 | 2 | 2 | 2 | 1 |
| CO4 | 3 | 1 | 2 | 1 | 3 | 1 |
| CO5 | 2 | 2 | 2 | 2 | 2 | 1 |

(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), Data Redaction, Sensitive Data Protection. |

| | |
|---|---|
| 4 | Authentication and Authorization in DBMS, Properties and Basic Principles of Access Control Mechanisms, Views for Access Control, Classical Database Access Control: Discretionary Access Control, Role-Based Access Control and Mandatory Access Control; Access Control in Open Environments 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., 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 ed., 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*, 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. Ramakrishnan 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.

HARDWARE SECURITY

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|-----------------------|-------------------|---|----------------------|
| M4010013/ M4020013 | Hardware Security | 2-1-0-0 | 2025 |

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:
CO1: Analyse the vulnerabilities in the current digital system design flow and evaluate the physical attacks on these systems.
CO2: Apply knowledge to evaluate hardware security issues and understand their implications.
CO3: Create secure and trusted hardware solutions using the relevant tools and techniques.
CO4: Analyse recent trends in hardware security and apply this knowledge in research and development.
CO5: Evaluate the effectiveness of various hardware security methods in addressing modern challenges.

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 | 2 | 3 | 1 | 2 | 2 | 1 |
| CO2 | 2 | 3 | 1 | 2 | 2 | 2 |
| CO3 | 3 | 3 | 2 | 2 | 3 | 3 |
| CO4 | 2 | 3 | 3 | 2 | 2 | 3 |
| CO5 | 3 | 3 | 1 | 2 | 3 | 3 |

(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 Trust Zone, 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. |
| Text Books <ol style="list-style-type: none"> 1. D. Mukhopadhyay and R. S. Chakraborty, <i>Hardware Security: Design, Threats, and Safeguards</i>, Chapman and Hall/CRC, 2014. 2. Y. Jin, <i>Introduction to Hardware Security</i>, Electronics, MDPI, 2015. 3. S. Sidhu et al., <i>Hardware Security in IoT Devices with Emphasis on Hardware Trojans</i>, Journal of Sensor and Actuator Networks, 2019. 4. I. Butun et al., <i>Hardware Security of Fog End-Devices for the Internet of Things</i>, Sensors, 2020. 5. P. Prinetto and G. Roascio, <i>Hardware Security, Vulnerabilities, and Attacks: A Comprehensive Taxonomy</i>, ITASEC, 2020. | |

IOT NETWORKS AND ENDPOINT SECURITY

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|--|---------------------------------------|---|-------------------------|
| M5010014/ M5020014 | IoT Networks and Endpoint Security | 1-1-0-1 | 2025 |
| Prerequisites: Prior knowledge of distributed systems, computer networks, cryptography, sensor networks and basics of connected systems. | | | |
| Course Objectives: <ol style="list-style-type: none"> 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:

CO1: Analyze the vulnerabilities in traditional and modern networks, including IoT networks, and evaluate the effectiveness of various security mechanisms in defending critical infrastructure.

CO2: Evaluate IoT architecture, communication protocols, and security challenges, applying advanced techniques to predict and mitigate threats to IoT endpoints.

CO3: Create and implement security frameworks for IoT networks, leveraging lightweight cryptography, key management, and privacy-enhancing techniques to address complex challenges.

CO4: Evaluate real-world case studies of IoT network security (e.g., IoV, UAV networks, Industrial IoT), identifying research opportunities and advancing solutions for future security needs.

CO5: Design and simulate secure IoT environments using advanced tools and frameworks, assessing the impact of simulated attacks on network performance and security 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 | 3 | 2 | 1 | 3 | 2 | |
| CO2 | 3 | 2 | 2 | 2 | 2 | 1 |
| CO3 | 2 | 2 | 2 | 2 | 2 | 1 |
| CO4 | 3 | 1 | 2 | 1 | 2 | 1 |
| CO5 | 2 | 2 | 2 | 2 | 2 | 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, <i>Security Analytics and Threat Prediction</i> . 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. |

Text Books

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

MOBILE APPLICATION SECURITY

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|----------------------------|--------------------------------|---|-------------------------|
| M5010021/ M5020021 | Mobile Application Security | 1-1-0-1 | 2025 |
| 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:

CO1: Analyse the fundamental concepts of mobile application security, the importance of securing smartphone devices, and the various types of mobile applications.

CO2: Evaluate the architecture and components of the Android OS, including activities, services, content providers, broadcast receivers, fragments, and intents.

CO3: Analyse Android security models, app sandboxing, permissions, and data encryption techniques to assess their effectiveness in protecting mobile applications.

CO4: Create secure Android applications using best practices, including app signing, secure communication, and root protection mechanisms.

CO5: Analyse and evaluate mobile application vulnerabilities through static and dynamic analysis, malware analysis, and runtime manipulation, and create mitigation 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 | 3 | 1 | 2 | 2 | 1 |
| CO2 | 3 | 3 | 1 | 2 | 2 | 2 |
| CO3 | 3 | 3 | 2 | 2 | 3 | 3 |
| CO4 | 2 | 3 | 2 | 2 | 3 | 3 |
| CO5 | 3 | 3 | 2 | 2 | 3 | 3 |

(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 | <p>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.</p> |
| 3 | <p>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.</p> |
| 4 | <p>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.</p> |
| <p>Text Books</p> <ol style="list-style-type: none"> 1. M. Swamynathan and J. Mannino, <i>Mobile Security and Privacy: A Hands-On Guide</i>, O'Reilly, 2019. 2. H. Dwivedi, <i>Mobile Application Security</i>, Packt Publishing, 2019. 3. Tim Speed <i>et al.</i>, <i>Mobile Security: How to Secure, Privatize, and Recover Your Devices</i>, Apress, 2019. 4. V. K. Velu, <i>Mobile Application Penetration Testing</i>, Packt Publishing, 2020. 5. N. Elenkov, <i>Android Security Internals: An In-Depth Guide to Android's Security Architecture</i>, 1st ed., No Starch Press, 2014. 6. D. Thiel, <i>iOS Application Security: The Definitive Guide for Hackers and Developers</i>, 1st ed., O'Reilly, 2016. 7. N. Bergman <i>et al.</i>, <i>Hacking Exposed Mobile: Security Secrets and Solutions</i>, 2nd ed., McGraw-Hill Education, 2020. <p>References</p> <ol style="list-style-type: none"> 1. A. Hoog and K. Strzempka, <i>Android Forensics: Investigation, Analysis, and Mobile Security for Google Android</i>, 1st ed., Elsevier, 2011. 2. C. Miller <i>et al.</i>, <i>iOSHacker's Handbook</i>, 1st ed., Wiley, 2012. 3. D. Chell <i>et al.</i>, <i>The Mobile Application Hacker's Handbook</i>, 1st ed., Wiley, 2015. | |

SYSTEMS SECURITY AND RISK ANALYSIS

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|---|---------------------------------------|---|-------------------------|
| M5010015/ M5020015 | Systems Security and Risk Analysis | 1-1-0-1 | 2025 |
| <p>Prerequisites: Prior Knowledge of operating systems, computer networks, web technology, DBMS, security fundamentals, mathematics.</p> | | | |

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: Analyse the threat landscape to identify and evaluate potential security risks in an IT organization.

CO2: Analyse the risk factors and vulnerabilities within an IT organization to assess potential threats.

CO3: Create comprehensive defense strategies to mitigate identified risks and enhance the organization's security posture.

CO4: Evaluate security emergency scenarios and respond with appropriate countermeasures and recovery strategies.

CO5: Evaluate the effectiveness of security protocols and response strategies to ensure organizational resilience.

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 | 1 | 2 | 2 | 1 |
| CO2 | 3 | 3 | 1 | 2 | 2 | 2 |
| CO3 | 3 | 3 | 2 | 2 | 3 | 3 |
| CO4 | 3 | 3 | 2 | 2 | 3 | 3 |
| CO5 | 3 | 3 | 2 | 2 | 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! |
| <p>Text Books</p> <ol style="list-style-type: none"> 1. T. UcedaVelez and M. Morana, <i>PASTA: Risk Centric Threat Modeling: Process for Attack Simulation and Threat Analysis</i>, John Wiley and Sons, 2015. 2. J. Freund and J. Jones, <i>Measuring and Managing Information Risk: A FAIR Approach</i>, Butterworth-Heinemann., 2014. 3. W. Du, <i>Computer Security: A Hands-on Approach</i>, CreateSpace Independent Publishing, 2017. <p>References</p> <ol style="list-style-type: none"> 1. A. Hoffman, <i>Web Application Security</i>, O'Reilly, 2020. 2. P. Ackerman, <i>Industrial Cybersecurity: Efficiently Secure Critical Infrastructure Systems</i>, Packt Publishing, 2017. 3. W. Stallings, <i>Cryptography and Network Security: Principles and Practice</i>, Prentice Hall, 2017. 4. M. Ekstedt, Z. Afzal, P. Mukherjee et al., <i>Yet Another Cybersecurity Risk Assessment Framework</i>, International Journal of Information Security, Springer, 2023. | |

INFORMATION SECURITY MANAGEMENT SYSTEM

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|--|--|---|-------------------------|
| M5010022/ M5020022 | Information Security Management Systems | 1-1-0-1 | 2025 |
| Prerequisites: Nil | | | |
| Course Objectives: | | | |
| <ol style="list-style-type: none"> 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: Analyse the security requirements of an organization to identify vulnerabilities and manage the overall security strategy. | | | |
| CO2: Evaluate risk management frameworks and create a comprehensive risk treatment plan to address organizational security needs. | | | |
| CO3: Create security policies, procedures, and guidelines to support the organization's risk management and compliance efforts. | | | |
| CO4: Analyse security systems and evaluate their effectiveness through regular audits to ensure compliance with industry standards. | | | |
| CO5: Evaluate and create effective security response strategies, ensuring they align with organizational goals and regulatory requirements. | | | |

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 | 3 | 3 |
| CO2 | 3 | 3 | 2 | 2 | 3 | 3 |
| CO3 | 3 | 3 | 2 | 2 | 3 | 3 |
| CO4 | 3 | 3 | 2 | 2 | 3 | 3 |
| CO5 | 3 | 3 | 2 | 2 | 3 | 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. W. Siler, *Information Security Management Systems: A Novel Framework and Software as a Tool for Compliance with Information Security Standard*, CRC Press, 2013.
4. A. Nair, G. M. R., *Mastering Information Security Compliance Management*, Packt Publication, 2023.
5. K. C. Laudon and J. P. Laudon, *Management Information System*, Pearson Education, 2022.
6. S. Nadkarni, *Fundamentals of Information Security*, BPB Publications, 2020.

References

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.
5. *ISO, ISO/IEC 27001:2022 - Information Security Management System - Requirements*, ISO, 2013.

DATA ANALYTICS

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|-----------------------|----------------|---|-------------------------|
| M4010007/ M4020007 | Data Analytics | 2-1-0-0 | 2025 |

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.
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: Interpret the data analytics techniques and evaluate state-of-the-art solutions.

CO2: Infer real-life problems and adapt data analytics techniques to solve them.

CO3: Design, organize, and demonstrate data analytics solutions through team research projects.

CO4: Outline project outcomes and prioritize key findings for effective reporting.

CO5: Integrate analyses and present project reports to connect analytical insights with actionable recommendations.

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 out comes with program learning out comes:

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

(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 <ol style="list-style-type: none"> 1. J. Leskovec, A. Rajaraman and J. Ullman, <i>Mining of Massive Datasets</i>, Cambridge University Press, 2014. 2. S. Ozdemir, <i>Principles of Data Science</i>, 2nd ed., Packt Publishing, 2018. 3. S. Lau, J. Gonzalez, and D. Nolan, <i>Principles and Techniques of Data Science</i>, UC Berkeley. 4. J. S. Saltz and J. M. Stanton, <i>An Introduction to Data Science</i>, Sage Publications, 2017. References <ol style="list-style-type: none"> 1. R. V. Hogg, J. W. McKean and A. Craig, <i>Introduction to Mathematical Statistics</i>, 6th ed., India: Pearson Education, 2006. 2. D. Cielen, A. D.B. Meysman, and M. Ali, <i>Introducing Data Science: Big Data, Machine Learning, and More, Using Python Tools</i>, Simon and Schuster, 2016. 3. G. Golemund and H. Wickham, <i>R for Data Science</i>, O'Reilly, 2017. 4. N. Zumel and J. Mount, <i>Practical Data Science with R</i>, Simon and Schuster, 2014. | |

DIGITAL IMAGE AND VIDEO PROCESSING

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|---|---------------------------------------|---|-------------------------|
| M5010005/ M5020005 | Digital Image and Video Processing | 1-1-0-1 | 2025 |
| Prerequisites: Nil | | | |
| <p>Course Objectives:</p> <ol style="list-style-type: none"> 1. To provide students with a good understanding of the concepts of image and video processing tasks. 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. | | | |
| <p>Course Outcomes: After completion of this course, the students will be able to:</p> <p>CO1: Assess the effectiveness of various image enhancement, restoration, and segmentation techniques to support informed decision-making in specific applications.</p> <p>CO2: Design and formulate innovative solutions using morphological image processing techniques for tasks like object detection and region-based segmentation.</p> <p>CO3: Design and formulate innovative solutions using morphological image processing techniques for tasks like object detection and region-based segmentation.</p> <p>CO4: Invent and build systems that integrate advanced image and video processing techniques with emerging technologies like machine learning for applications such as object recognition and pattern analysis.</p> <p>CO5: Derive and compose solutions by connecting digital image and video processing with interdisciplinary fields, including human visual perception and computational modeling, to address complex real-world problems.</p> | | | |
| <p>Program Learning Outcomes</p> <p>PLO 1 Develop strong fundamental disciplinary knowledge.</p> <p>PLO 2 Demonstrate research skills that are of an experimental, computational, or theoretical nature.</p> <p>PLO 3 Apply for a scholarship to conduct independent and innovative research.</p> <p>PLO 4 Show communication skills in various formats (oral, written) and to expert and non-expert audiences.</p> <p>PLO 5 Practice ethical standards of professional conduct and research.</p> <p>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.</p> | | | |

Mapping of course outcomes with program learning outcomes:

| | PLO1 | PL02 | PL03 | PL04 | PLO5 | PL06 |
|-----|------|------|------|------|------|------|
| C01 | 3 | 2 | 3 | 2 | 2 | 1 |
| CO2 | 3 | 3 | 3 | 2 | 2 | 2 |
| CO3 | 3 | 3 | 2 | 2 | 2 | 2 |
| CO4 | 2 | 2 | 2 | 2 | 2 | 2 |
| CO5 | 2 | 2 | 2 | 2 | 2 | 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*, Upper Saddle River, N.J: Prentice Hall, 2008.
2. A. K. Jain, *Fundamentals of Digital Image Processing*, USA: Prentice Hall, 1989.
3. J. W. Woods, *Multidimensional Signal, Image, and Video Processing and Coding*, 2nd ed. USA: Academic Press, 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*, USA: Wiley-Inter Science, 2007.
2. S. E. Umbaugh, *Digital Image Processing and Analysis: Human and Computer Vision Applications with CVIP Tools*, 2nd ed. USA: CRC Press, 2010.
3. A. M. Tekalp, *Digital Video Processing*, 2nd ed. USA: Prentice Hall Press, 2015.
4. A. C. Bovik, *Handbook of Image and Video Processing (Communications, Networking and Multimedia)*, USA: Academic Press, 2005.

SOFT COMPUTING

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|-----------------------|----------------|---|-------------------------|
| M5010008/ M5020008 | Soft Computing | 1-1-0-1 | 2025 |

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: Inter application domains that require soft computing techniques.

CO2: Analyze algorithms to evaluate their effectiveness in solving soft computing problems.

CO3: Focus and construct solutions by applying appropriate soft computing methods.

CO4: Consider problem-solving approaches and justify the use of soft computing in specific scenarios.

CO5: Organize and illustrate the design and analysis of algorithms for soft computing through projects 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 | 1 | 2 | 1 | 2 |
| CO2 | 3 | 3 | 1 | 2 | 1 | 3 |
| CO3 | 3 | 3 | 2 | 1 | 2 | 3 |
| CO4 | 2 | 3 | 1 | 1 | 1 | 3 |
| CO5 | 3 | 3 | 2 | 1 | 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*, India: Prentice Hall, 2011.
2. T. Ross, *Fuzzy Logic with Engineering Applications*, 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 | |
|--|-----------------------------|---|-------------|-------------|----------------------|-------------|
| M4010011/ M4020011 | Natural Language Processing | 2-1-0-0 | | | 2025 | |
| Prerequisites: Prior knowledge of Python, Probability, Statistics and Machine Learning | | | | | | |
| Course Objectives: <ol style="list-style-type: none"> To create significance of Natural Language Processing and to process text and data To infer and analyses the theory behind Language Modeling from an algorithmic point of view. To create application levels of Natural Language Processing. To gain Practical experience using NLP toolkits, | | | | | | |
| Course Outcomes: After completion of this course, the students will be able to: CO1: Analyse linguistic essentials and implement text preprocessing techniques for Natural Language Processing. CO2: Apply various text representation techniques to extract features from text data. CO3: Evaluate deep learning models, Large Language Models (LLMs), and Transformer-based architectures for solving complex NLP tasks, such as sentiment analysis and language generation. CO4: Create practical NLP applications by integrating ethical considerations during the development process. CO5: Apply NLP toolkits and State-of-the-Art models, including LLMs and Generative AI, to demonstrate case studies and real-world 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 | 3 | 1 | 1 | 1 |
| CO2 | 3 | 3 | 3 | 1 | 1 | 1 |
| CO3 | 3 | 3 | 3 | 1 | 1 | 1 |
| CO4 | 3 | 3 | 3 | 1 | 1 | 2 |
| CO5 | 2 | 2 | 3 | 2 | 3 | 2 |
| (Correlation: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)) | | | | | | |
| Syllabus | | | | | | |

| Module | Content |
|--|--|
| 1 | <p>Introduction to Natural Language Processing: Definition, Scope and Applications. Essential Linguistics: Syntax, Semantics and Pragmatics, Morphology, Corpus, Token, Lexicon, Stop Words, Multilingualism, Script Diversity.</p> <p>Classical NLP Paradigms and Methods: Semantic Analysis, Syntactic Analysis. Constituency Grammar, Dependency Grammar, Context Free Grammar, Regular Expressions, Finite-State Automata, Morphological Parsing and analysis, Dependency Parsing, Tokenization, Stemming, Lemmatization, Stop word removal, Parts-of-Speech (POS) Tagging, Named Entity Recognition, Hidden Markov Model (HMM) - Viterbi algorithm and Conditional Random Fields (CRF), Maximum Entropy models.</p> |
| 2 | <p>Language Modeling: Defining language models, distributional semantics, probabilistic n-gram language models, smoothing, interpolation, entropy, perplexity. Text Representation Techniques: Word Embedding - Word2Vec, GloVe, Fastext. Document Embedding- Bag of Words (BoW), Count Vectors, TF-IDF. Topic Modeling, LDA. Word Sense Disambiguation (WSD), Information Retrieval, Practice Sentiment Analysis, Text summarization, Text Classification, Question Answering, Topic Modeling- LDA.</p> |
| 3 | <p>NLP using Deep Learning: RNN, CNN, LSTM, Multilingual Seq2seq Deep Neural Network, Encode-decoder Model, Attention, Self Attention, Transformer Models - BERT, GPT, XLNet, GAN, Generative AI and LLM. Ethics and Bias in NLP.</p> |
| 4 | <p>Applications and Case Studies: Practice Machine Translation - Rule-Based Machine Translation (RBMT), Statistical Machine Translation (SMT), Hybrid Machine Translation, Neural Machine Translation (NMT), LLM based, Machine learning of cross-lingual mappings, learning representations using cross-lingual supervision, Challenges in using NLP with multilingual resources</p> |
| <p>Text Books</p> <ol style="list-style-type: none"> 1. Daniel Jurafsky and James H. Martin, <i>Speech & Language Processing</i>, Pearson Education India, 2000. 2. S. Vajjala et al., <i>Practical Natural Language Processing: A Comprehensive Guide to Building Real-World NLP Systems</i>, O'Reilly, 2020. 3. Christopher Manning, Hinrich Schutze, <i>Foundations of Statistical Natural Language Processing</i>, MIT press, Cambridge, 1999. 4. Li Deng, Yang Liu, <i>Deep Learning in Natural Language Processing</i>, Springer, 2015. | |

SPEECH PROCESSING

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|-----------------------------------|--------------------------|---|---------------------------------|
| M5010009/ M5020009 | Speech Processing | 1-1-0-1 | 2025 |
| Prerequisites: Mathematics | | | |

Course Objectives:

1. To give students a good understanding of speech processing tasks.
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: Analyse the foundations of modern speech processing theory, identify key problems, and explore state-of-the-art solutions.

CO2: Evaluate the effectiveness of speech signal processing algorithms and their integration into complete systems.

CO3: Create a functional speech signal processing system through a team-based research project, supported by a detailed project report and presentation.

CO4: Analyse the challenges in developing robust speech processing systems for diverse applications and environments.

CO5: Create innovative solutions by integrating speech signal processing techniques with advanced tools and technologies to address real-world 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:

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|------------|------------|------------|------------|------------|------------|------------|
| CO1 | 3 | 2 | 1 | 1 | 1 | 1 |
| CO2 | 3 | 3 | 2 | 1 | 1 | 2 |
| CO3 | 2 | 3 | 3 | 3 | 2 | 3 |
| CO4 | 2 | 2 | 2 | 3 | 3 | 3 |
| CO5 | 2 | 3 | 2 | 3 | 3 | 3 |

(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. |
| <p>Text Books</p> <ol style="list-style-type: none"> 1. L. Rabiner and R. Schafer, <i>Theory and Applications of Digital Speech Processing</i>, 1st ed. USA: Prentice Hall Press, 2010. 2. B. Gold et al., <i>Speech and Audio Signal Processing: Processing and Perception of Speech and Music</i>, 2nd ed. USA: Wiley-Interscience, 2011. <p>References</p> <ol style="list-style-type: none"> 1. D. O'Shaughnessy, <i>Speech Communication: Human and Machine</i>, Addison-Wesley, 1987. 2. T. Ogunfunmi et al., <i>Speech and Audio Processing for Coding, Enhancement and Recognition</i>, Springer, 2014. 3. J. Benesty et al., <i>Springer Handbook of Speech Processing</i>, Berlin: Springer, 2008. | |

COGNITIVE COMPUTING

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|--|---------------------|---|-------------------------|
| M5010010/ M5020010 | Cognitive Computing | 1-1-0-1 | 2025 |
| <p>Prerequisites: 10th class biology and chemistry, basic background in simple differential equations and probability theory, interest in neuroscience and cognitive science.</p> | | | |
| <p>Course Objectives:</p> <ol style="list-style-type: none"> 1. To provide students with a basic understanding of the concepts of neuroscience, cognitive science, and cognitive computing. 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: Analyse various cognitive and emotional processes in the brain/mind and evaluate their applications in the computing domain.

CO2: Evaluate cognitive and affective computing models and systems for their design, implementation, and effectiveness.

CO3: Create innovative research ideas by integrating concepts from cognitive science and computing to address complex challenges.

CO4: Analyse the interdisciplinary relationship between cognitive science and computing to identify opportunities for advancing the field.

CO5: Create cognitive and affective computing prototypes or frameworks through collaborative research and development initiatives.

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:

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|------------|------------|------------|------------|------------|------------|------------|
| CO1 | 3 | 2 | 1 | 1 | 1 | 1 |
| CO2 | 3 | 3 | 2 | 1 | 1 | 2 |
| CO3 | 2 | 3 | 3 | 2 | 2 | 3 |
| CO4 | 3 | 2 | 2 | 2 | 1 | 2 |
| CO5 | 2 | 3 | 2 | 3 | 2 | 3 |

(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 <ol style="list-style-type: none"> 1. E. Kandel <i>et al.</i>, <i>Principles of Neural Science</i>, McGraw-Hill Professional, 2012. 2. E. Bruce Goldstein, <i>Cognitive Psychology: Connecting Mind, Research, and Everyday Experience</i>, 4th ed., Cengage Learning, 2014. 3. Rao, R. P. N., <i>Brain Computer Interfacing: An Introduction</i>, Cambridge University Press, 2013. 4. N. Panigrahi and S. P. Mohanty, <i>Brain Computer Interface EEG Signal Processing</i>, CRC Press, 2022. 5. A. Ortony, G. L. Clore, and A Collins, <i>The Cognitive Structure of Emotions</i>, Cambridge University Press, 2011. 6. J. Friedenberg and G. Silverman, <i>Cognitive Science: An Introduction to the Study of Mind</i>, Sage Publications, 2021. 7. M. Gazzaniga, <i>Cognitive Neuroscience: The Biology of the Mind</i>, W. W. Norton, 2018. | |

BIG DATA TECHNOLOGIES

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|---|-----------------------|---|-------------------------|
| M5010011/ M5020011 | Big Data Technologies | 1-1-0-1 | 2025 |
| Prerequisites: Nil | | | |
| Course Objectives: <ol style="list-style-type: none"> 1. Introduce the fundamental concepts, challenges, and tools of Big Data technologies. 2. Equip students with skills to design, develop, and deploy Big Data solutions. 3. Familiarize students with distributed computing frameworks like Hadoop and Spark. 4. Prepare students to solve real-world problems using scalable Big Data architectures. | | | |
| Course Outcomes: After completion of this course, the students will be able to: CO1: Analyse the key concepts and ecosystem of Big Data technologies. CO2: Develop and deploy applications using distributed computing frameworks such as Hadoop and Spark. CO3: Apply data preprocessing, storage, and retrieval techniques in large-scale data management. CO4: Implement machine learning algorithms and data analytics on Big Data platforms. CO5: Evaluate and optimize the performance of Big Data systems for real-world 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 | PL02 | PL03 | PL04 | PLO5 | PL06 |
|------------|------|------|------|------|------|------|
| C01 | 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 | 2 |
| CO5 | 3 | 3 | 2 | 2 | 2 | 2 |

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

Syllabus

| Module | Content |
|--------|--|
| 1 | Introduction: Overview of Big Data - Characteristics, challenges, and applications - Big Data ecosystem and architecture - Overview of Hadoop: HDFS, MapReduce, and YARN- Introduction to NoSQL databases: Types, examples, and use cases. |
| 2 | Distributed Computing Frameworks: Deep dive into Hadoop: Advanced HDFS and MapReduce concepts - Apache Spark: Architecture, RDDs, DataFrames, and Datasets. Spark Streaming and GraphX - Introduction to Apache Kafka and its integration with Spark. |
| 3 | Data Analytics and Machine Learning in Big Data - Data preprocessing and exploratory data analysis (EDA) on Big Data -Machine learning with Spark MLlib: Classification, regression, and clustering -Introduction to deep learning frameworks for Big Data -Visualization tools for Big Data analytics (e.g., Tableau, Power BI). |
| 4 | Big Data Platforms and Case Studies: Overview of cloud-based Big Data platforms (e.g., AWS, Google Cloud, Azure). Data governance, security, and ethical considerations in Big Data. Performance optimization and benchmarking. Case studies: Big Data solutions in industry (e.g., finance, healthcare, e-commerce). |

Reference Books

1. White, T. *Hadoop: The Definitive Guide*. O'Reilly Media, 2015.
2. Lam, C. *Hadoop in Action*. Manning Publications, 2011.
3. Karau, H., Konwinski, A., Wendell, P., & Zaharia, M. *Learning Spark: Lightning-Fast Big Data Analysis*. O'Reilly Media, 2015.
4. Hurwitz, J., Nugent, A., Halper, F., & Kaufman, M.. *Big Data For Dummies*. Wiley, 2013.
5. Maheshwari, A. *Data Analytics Made Accessible*. Kindle Edition, 2017.
6. Berman, J. J. *Big Data: Principles and Best Practices of Scalable Real-Time Data Systems*. Elsevier, 2018.

SOFTWARE DEFINED NETWORKING

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | | | Year of Introduction | |
|--|--|---|-------------|-------------|-------------------------|-------------|
| M4010016 | Software Defined Networking | 2-1-0-0 | | | 2025 | |
| 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: | | | | | | |
| CO1: Analyse the evolution of Software-Defined Networks (SDNs), explain their components, and evaluate their uses in the current networking landscape. | | | | | | |
| CO2: Analyse Network Functions Virtualization (NFV) and investigate emerging SDN models and security aspects of SDN and NFV. | | | | | | |
| CO3: Apply the knowledge of SDNs and NFV to develop various applications that improve network performance and security. | | | | | | |
| CO4: Create and present a comprehensive paper review on SDN, its components, and its use in modern networking. | | | | | | |
| CO5: Evaluate the effectiveness of SDN in real-world applications and develop a final course project showcasing the application of SDN and NFV concepts. | | | | | | |
| 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 | 3 | 2 |
| CO2 | 3 | 3 | 1 | 2 | 3 | 2 |
| CO3 | 2 | 2 | 2 | 2 | 3 | 3 |
| CO4 | 3 | 3 | 1 | 2 | 3 | 3 |
| CO5 | 3 | 3 | 3 | 2 | 3 | 3 |
| (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. |
| Text Books | |
| <ol style="list-style-type: none"> 1. P. Goransson and C. Black, <i>Software Defined Networks: A Comprehensive Approach</i>, Morgan Kaufmann Publications, 2017. 2. N. Thomas and K. Gray, <i>SDN - Software Defined Networks</i>, O'Reilly, 2013. 3. K. Gray and T. D. Nadeau, <i>Network Function Virtualization</i>, Morgan Kaufmann, 2016. 4. S. Zhu <i>et al.</i>, <i>Guide to Security in SDN and NFV: Challenges, Opportunities, and Applications</i>, Springer, 2017. 5. D. Huang <i>et al.</i>, <i>Software-Defined Networking and Security from Theory to Practice</i>, CRC Press, 2021. 6. J. Gooley <i>et al.</i>, <i>Cisco Software-Defined Wide Area Networks: Designing, Deploying and Securing Your Next Generation WAN with Cisco SD-WAN</i>, Cisco Press, 2020. | |

STOCHASTIC PROCESSES AND MODELS

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|-----------------------|------------------------------------|---|-------------------------|
| M5010004/ M5020004 | Stochastic Processes and Models | 1-1-0-1 | 2025 |

Prerequisites: Mathematics

Course Objectives:

1. To give students a good understanding of the concepts of information-theoretic methods, stochastic processes, and models.
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 stochastic processes and models.

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

CO1: Analyse the mathematical foundations of modern stochastic models, their associated problems, and state-of-the-art solutions.

CO2: Evaluate the design, development, and integration of stochastic models, algorithms, and systems.

CO3: Create and demonstrate a functional stochastic model through collaborative research projects and project report presentations.

CO4: Analyse real-world scenarios to identify opportunities for applying stochastic modelling techniques.

CO5: Create innovative stochastic models and algorithms by integrating advanced mathematical concepts and computational 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 | 1 | 1 | 1 | 1 |
| CO2 | 3 | 3 | 2 | 1 | 1 | 2 |
| CO3 | 2 | 3 | 3 | 3 | 2 | 3 |
| CO4 | 3 | 2 | 2 | 2 | 1 | 2 |
| CO5 | 2 | 3 | 3 | 2 | 2 | 3 |

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

| Syllabus | |
|---|--|
| Module | Content |
| 1 | Concepts of multiple random variables. Bayesian belief networks (BBN): Representation, Independence and conditional independence, Partial independence and other structure. Exact inference in BBN: Variable elimination, Pearl's algorithm, Junction tree, Recursive decomposition, Using additional structure. |
| 2 | Approximate inference: Monte Carlo approximations, Loopy belief propagation, Variational methods. Learning of BBNs: learning parameters, learning structure, Bayesian averaging, EM (learning with hidden variables and missing values), structural EM. |
| 3 | Dynamic belief networks: Particle filtering. Markov random fields (Markov networks): Representation (potentials), Independence and conditional independence, Trees, Boltzman machines, Conditional Markov random fields. |
| 4 | Inference in Markov networks. Learning Markov networks: Iterative proportional fitting, Cluster variational methods, Other approximations. Relational graphical models. |
| Text Books <ol style="list-style-type: none"> 1. D. Koller and N. Friedman, <i>Probabilistic Graphical Models: Principles and Techniques</i>, MIT Press, 2009. 2. D. Barber, <i>Bayesian Reasoning and Machine Learning</i>, Cambridge University Press, 2012. 3. D. J. C. Mackay, <i>Information Theory, Inference, and Learning Algorithms</i>, UK: Cambridge University Press, 2003 4. J. Pearl, <i>Probabilistic Reasoning in Intelligent Systems</i>, Morgan Kaufman, 1997. | |

DEEP LEARNING

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|---|----------------------|---|---------------------------------|
| M4010010/ M4020010 | Deep Learning | 2-1-0-0 | 2025 |
| Prerequisites: AI and Machine Learning | | | |
| Course Objectives: <ol style="list-style-type: none"> 1. To provide students with a good understanding of the concepts of the deep learning. 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: Analyse the foundations of modern deep learning theory, identify key challenges, and evaluate state-of-the-art solutions.

CO2: Apply deep learning algorithms and techniques to solve complex computational problems.

CO3: Evaluate the design, development, and integration of deep learning models and systems.

CO4: Create and demonstrate a functional deep learning system through collaborative research projects and comprehensive presentations.

CO5: Analyse real-world applications of deep learning to explore innovative opportunities for system 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) 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 | 1 | 1 | 1 |
| CO2 | 3 | 3 | 2 | 1 | 1 | 2 |
| CO3 | 2 | 3 | 3 | 3 | 2 | 3 |
| CO4 | 2 | 3 | 3 | 3 | 2 | 3 |
| CO5 | 3 | 2 | 2 | 2 | 1 | 2 |

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

Syllabus

| Module | Content |
|--------|--|
| 1 | Deep Feed forward 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, 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 |
|--|---------------------------|---|-------------------------|
| M5010006/ M5020006 | Reinforcement Learning | 1-1-0-1 | 2025 |
| Prerequisites: Mathematics | | | |
| Course Objectives: | | | |
| <ol style="list-style-type: none"> 1. To provide students with a good understanding of the concepts of the reinforcement learning. 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: Analyse the foundations of modern reinforcement learning theory, identify key challenges, and evaluate state-of-the-art solutions. | | | |
| CO2: Evaluate the design, implementation, and integration of reinforcement learning algorithms and systems. | | | |
| CO3: Analyse real-world scenarios to identify opportunities for applying reinforcement learning techniques effectively. | | | |
| CO4: Create and demonstrate a functional reinforcement learning system through collaborative research projects and detailed presentations. | | | |
| CO5: Create innovative reinforcement learning models and frameworks to address complex problems by leveraging advanced computational 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 | 1 | 1 | 1 | 1 |
| CO2 | 3 | 3 | 2 | 1 | 1 | 2 |
| CO3 | 2 | 3 | 2 | 2 | 1 | 2 |
| CO4 | 2 | 3 | 3 | 3 | 2 | 3 |
| CO5 | 2 | 3 | 3 | 3 | 2 | 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 | | | | | | |
| <ol style="list-style-type: none"> 1. R. S. Sutton and A. G. Barto, <i>Reinforcement Learning: An Introduction</i>, MIT Press, 1998. 2. C. Szepesvari, <i>Algorithms for Reinforcement Learning</i>, Morgan and Claypool Publishers, 2010. | | | | | | |
| References | | | | | | |
| <ol style="list-style-type: none"> 1. K. P. Murphy, <i>Machine Learning: A Probabilistic Perspective</i>, MIT Press, 2012. 2. M. L. Puterman, <i>Markov Decision Processes: Discrete Stochastic Dynamic Programming, 1st ed. USA: John Wiley and Sons, 1994.</i> | | | | | | |

COMPUTER VISION

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|---|-----------------|---|-------------------------|
| M5010007/ M5020007 | Computer Vision | 1-1-0-1 | 2025 |
| Prerequisites: Mathematics | | | |
| Course Objectives: | | | |
| <ol style="list-style-type: none"> 1. To provide students with a good understanding of computer vision concepts. 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: Analyse the foundations of modern computer vision theory, identify key challenges, and evaluate state-of-the-art solutions.

CO2: Evaluate the design, development, and integration of computer vision algorithms and systems for their effectiveness and applicability.

CO3: Analyse real-world scenarios to identify opportunities for applying computer vision techniques to solve complex problems.

CO4: Create and demonstrate a functional computer vision system through collaborative research projects, detailed reports, and presentations.

CO5: Create innovative computer vision models and frameworks by leveraging advanced computational and mathematical 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 | 1 | 1 | 1 | 1 |
| CO2 | 3 | 3 | 2 | 1 | 1 | 2 |
| CO3 | 2 | 3 | 2 | 2 | 1 | 2 |
| CO4 | 2 | 3 | 3 | 3 | 2 | 3 |
| CO5 | 2 | 3 | 3 | 3 | 2 | 3 |

(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*, London: Springer, 2011.
2. D. A. Forsyth and J. Ponce, *Computer Vision: A Modern Approach*, Pearson Education, 2003.
3. R. Hartley and A. Zisserman, *Multiple View Geometry in Computer Vision*, 2nd ed., Cambridge University Press, 2004.

References

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

SOCIAL NETWORK ANALYTICS AND SECURITY

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|-------------|--|---|-------------------------|
| M5010023 | Social Network Analytics and Security | 1-1-0-1 | 2025 |

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:

CO1: Analyze the graph structure, centrality measures, and community dynamics of social networks to understand their properties and evolution.

CO2: Evaluate the impact of privacy and security threats in online social networks, including malware, phishing, and Sybil attacks, and recommend countermeasures.

CO3: Create advanced tools and solutions for social network analysis, such as data extraction pipelines and visualization frameworks using tools like Gephi, Graphviz, NodeXL, and Neo4j.

CO4: Analyze user behavior and cognitive aspects in social networks, applying theories like TPB, MBTI, and the Five Factor Theory for behavioral prediction.

CO5: Evaluate emerging trends such as decentralized social networks, SIoT, and the application of AI in social network security to propose innovative research directions.

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 | 1 | 1 |
| CO2 | 2 | 2 | 2 | 2 | 1 | 2 |
| CO3 | 2 | 2 | 1 | 2 | 2 | 2 |
| CO4 | 1 | 2 | 2 | 2 | 2 | 2 |
| CO5 | 2 | 2 | 2 | 2 | 2 | 3 |

(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 |

| | |
|--|--|
| | <p>Social Media Analytics – Visualizing data using Ne04j. Challenges in collecting social media data.</p> <p>Research 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.</p> |
| 4 | <p>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.</p> <p>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.</p> |
| <p>Text Books</p> <ol style="list-style-type: none"> 1. M. Cross, <i>Social Media Security - Leveraging Social Networking While Mitigating Risk</i>, 1st ed., Newnes, 2013. 2. P. Kazienko <i>et al.</i>, <i>Applications of Social Media and Social Network Analysis</i>, Springer, 2015. 3. S. Wasserman and K. Faust, <i>Social Network Analysis: Methods and Applications</i>, New York: Cambridge University Press, 1994. 4. P. Federico <i>et al.</i>, <i>Sentiment Analysis in Social Networks</i>, 1st ed., Elsevier, 2016. 5. V. Arnaboldi <i>et al.</i>, <i>Online Social Networks: Human Cognitive Constraints in Facebook and Twitter Personal Graphs</i>, 1st ed., Elsevier, 2015 6. D. Hansen <i>et al.</i>, <i>Analyzing Social Media Networks with NodeXL: Insights from a Connected World</i>, Morgan Kaufmann, 2010. 7. R. Missaoui <i>et al.</i>, <i>Social Network Analysis - Community Detection and Evolution</i>, Springer, 2014. 8. R. Missaoui <i>et al.</i>, <i>Trends in Social Network Analysis - Information Propagation, User Behavior Modeling, Forecasting, and Vulnerability Assessment</i>, Springer, 2017. | |

WIRELESS SENSOR NETWORKS

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|-------------|--------------------------|---|-------------------------|
| M5010024 | Wireless Sensor Networks | 1-1-0-1 | 2025 |

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: Analyze the design challenges, architectures, and performance metrics of Wireless Sensor Networks (WSNs), including operational and computational models.

CO2: Evaluate middleware solutions, protocol stacks, and programming tools to address challenges in network clustering, node discovery, and MAC protocols.

CO3: Create energy-efficient and robust routing solutions, incorporating clustering, fault tolerance, and QoS management in WSN applications.

CO4: Analyze emerging trends such as IoT-enabled sensor networks, underwater acoustic sensor networks, and sensor clouds, emphasizing security, trust, and real-life deployment scenarios.

CO5: Create innovative solutions through independent research and collaborative projects, demonstrating practical applications of Wireless Sensor Networks using advanced simulation tools and programming frameworks.

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 | 1 | 1 | 1 |
| CO2 | 3 | 3 | 2 | 1 | 1 | 2 |
| CO3 | 3 | 3 | 3 | 2 | 2 | 3 |
| CO4 | 3 | 3 | 2 | 2 | 2 | 2 |
| CO5 | 2 | 3 | 3 | 3 | 2 | 3 |
| (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): tinyOS, MANTIS, Contiki, and RetOS. 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. | | | | | |

Text Books

1. A. Prayati, *Problem Solving for Wireless Sensor Networks*, London: Springer, 2008.
2. A. Kurniawan, *Practical Contiki-NG: Programming for Wireless Sensor Networks*, Apress, 2018.
3. A. Forster, *Introduction to Wireless Sensor Networks*, Wiley, 2016.
4. A. Hac, *Wireless Sensor Network Designs*, John Wiley and Sons, 2003.
5. E. H. Callaway *et al.*, *Wireless Sensor Networks: Architectures and Protocols*, CRC Press, 2003.
6. H. Karl and A. Willig, *Protocols and Architectures for Wireless Sensor Networks*, Wiley-Interscience, 2007.
7. H. M. A. Fahmy, *Wireless Sensor Networks: Concepts, Applications, Experimentation and Analysis*, Springer, 2021.
8. I. M. M. El Emary and S. Ramakrishnan, *Wireless Sensor Networks: From Theory to Applications*, CRC Press, 2016.
9. J. Zheng and A. Jamalipour, *Wireless Sensor Networks: A Networking Perspective*, Wiley-IEEE Press, 2009.
10. K. Sohraby and T. Znati, *Wireless Sensor Networks: Technology, Protocols, and Applications*, John Wiley and Sons, 2007.
11. M. Conti, *Secure Wireless Sensor Networks: Threats and Solutions*, New York: Springer, 2015.
12. M. Matin, *Wireless Sensor Networks - Technology and Protocols*, InTech, 2012.
13. S. Yang, *Wireless Sensor Networks: Principles, Design and Applications*, London: Springer, 2013.
14. W. Dargie and C. Poellabauer, *Fundamentals of Wireless Sensor Networks: Theory and Practice*, Wiley, 2010.

CONNECTED ENVIRONMENTS AND ENABLING TECHNOLOGIES

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|---|---|---|-------------------------|
| M5010025 | Connected Environments and Enabling Technologies | 1-1-0-1 | 2025 |
| Prerequisites: Prior knowledge of Computer Networks, Distributed Computing, DBMS, Programming in Python | | | |
| Course Objectives: <ol style="list-style-type: none">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:

CO1: Analyse the various building blocks, characteristics, and application areas of the Internet of Things (IoT).

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

CO3: Create a comprehensive review paper, demonstrate critical analysis through an oral presentation, and design a final course project based on IoT concepts and applications.

CO4: Analyse real-world IoT applications to identify challenges and opportunities for innovation in system design and deployment.

CO5: Evaluate and implement IoT solutions that integrate cloud computing and big data for enhanced performance and scalability in real-time 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 | 1 | 1 | 1 | 1 |
| CO2 | 3 | 3 | 2 | 1 | 1 | 2 |
| CO3 | 3 | 3 | 3 | 2 | 2 | 3 |
| CO4 | 3 | 2 | 2 | 2 | 1 | 2 |
| CO5 | 2 | 3 | 3 | 3 | 2 | 3 |

(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. |

Text Books

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

OPERATING SYSTEMS

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|--------------------|-------------------|---|-------------------------|
| M4020018 | Operating Systems | 2-1-0-0 | 2025 |
| 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 |
| CO4 | 2 | 3 | 3 | | 3 | 3 |
| CO5 | 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, |

| | |
|--|---|
| | <p>Processor and user modes, kernels, system calls and system programs.</p> <p>Process Management: Concept of processes, I/O and CPU bound process, process hierarchy, co-operating processes, inter-process communication.</p> <p>Process scheduling: Scheduling criteria, preemptive and non-preemptive scheduling, scheduling algorithms, multiprocessor scheduling.</p> <p>Threads: Overview, benefits of threads, user and kernel threads.</p> <p>Process Synchronization: Background, concurrent processes, critical section problem, classical problems of synchronization, semaphores.</p> |
| 2 | <p>Deadlocks: Characterization, detection, prevention, avoidance, recovery.</p> <p>Memory Management: Background, logical vs. physical address, swapping, paging, segmentation.</p> <p>Virtual Memory: Background, demand paging, page replacement algorithms, thrashing.</p> <p>Disk Management: Disk structure, disk scheduling, boot block and bad blocks.</p> <p>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.</p> |
| 3 | <p>File Systems: File concept, access methods, file system structure, allocation methods, free-space management, directory structure, efficiency and performance.</p> <p>I/O Management: I/O hardware, polling, interrupts, DMA, application I/O interface, performance.</p> <p>Protection and Security: Goals of protection, security problem, authentication, program threats, system threats, threat monitoring, encryption.</p> |
| 4 | <p>FreeRTOS: architecture, distribution, management of heap memory, task, queue, software timer, interrupt, resource management, memory management, task notification, low power support, porting.</p> |
| <p>Text Books</p> <ol style="list-style-type: none"> 1. W. Stallings, <i>Operating System: Internals and Design Principles</i>, 8th ed., Prentice Hall, 2014. 2. A. Silberschatz <i>et al.</i>, <i>Operating System Concepts</i>, 9th ed., John Wiley and Sons, 2012. 3. M. J. Bach, <i>The Design of the Unix Operating System</i>, People's Posts and Telecommunications Publishing House, 2003. 4. L. Qing and C. Yao, <i>Real-time Concepts for Embedded Systems</i>, CRC press, 2003. 5. R. Barry, <i>Mastering the FreeRTOS™ Real Time Kernel -A Hands-On Tutorial Guide</i>, Real Time Engineers, 2016. | |

6. W. Mauerer, *Professional Linux® Kernel Architecture*, O'Reilly, 2010.

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, 2005.
3. F. Mayer *et al.*, *SELinux by Example: Using Security Enhanced Linux*, Pearson Education, 2006.

AUGMENTED AND VIRTUAL REALITY

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|-----------------------|----------------------------------|---|-------------------------|
| M5010027/ M5020027 | Augmented and Virtual Reality | 1-1-0-1 | 2025 |

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:** Design and manage large-scale immersive virtual environments for real-time applications.
- CO2:** Evaluate research gaps in AR/VR systems and propose innovative solutions for emerging challenges.
- CO3:** Develop and integrate AR/VR technologies for diverse interdisciplinary applications.
- CO4:** Justify the selection of AR/VR tools and techniques for specific real-world problem-solving scenarios.
- CO5:** Critique existing AR/VR systems to recommend enhancements and optimize performance.

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 | 3 | 3 | 1 | 1 |
| CO2 | 1 | 3 | 3 | | 3 | 1 |
| CO3 | 3 | | 3 | 3 | 3 | 3 |
| CO4 | 3 | 3 | 1 | 1 | 1 | 2 |
| CO5 | 3 | 3 | 2 | 3 | | 1 |

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

| Syllabus | |
|-----------------|--|
| Module | Content |
| 1 | Real vs Virtual World, Degree/Level of Immersion (3-DoF vs 6-DoF), Sensory Immersion, Cognitive Immersion, Emotional Immersion, Physical Immersion, Virtual World Coordinate System, Real and Virtual Experiences (Aural, Visual, and Haptic), Historical Background of VR and AR, Importance and Applications of VR and AR, Evolution of VR, Three I's of Virtual Reality, VR-Continuum, XR and Immersive Technologies, Difference between VR, MR, and AR, Methods of Interaction, Key Milestones in VR Development, Concepts in Virtual Reality, Motion Tracking, Rendering Techniques, Depth Perception in the Virtual World, Gestures and Cues, Challenges. |
| 2 | Components of VR, VR Display, VR Development Tools and Technologies, Sensors and Input Devices, VR System Integration, VR System Performance Optimization, Components of XR, Mixed Reality and AR in XR, AR Display, Marker-Based and Markerless AR, AR Development Tools and Technologies, AR System Integration, AR System Performance Optimization, Best Practices in XR Development, Development Practices, AR/VR Development Lifecycle, Prototyping and Storytelling, Understanding the Production Pipeline (Sensing, Rendering, Mobile, Stand-Alone, and High-End Computing Platforms), Testing and Debugging in VR/AR, Project Management in VR/AR Development. |
| 3 | Web-based VR Development, ARML, X3D Standard, WebXR API, Performance Optimization for Web-based VR, Mobile-based VR Development, Using ARCore Framework, Mobile VR Performance Optimization, Mobile VR Interaction Design, Cross-Platform Development Considerations, AR Development, GLTF (and Other Similar Standards), Web AR and Mobile AR, ARKit Framework, AR Content Creation and Management, AR User Interface Design. |
| 4 | Advanced Tools, Unity/Unreal/Blender, Basic VR Solution with Unity, Creating Custom Markers with Unity/Unreal, Marker-Based AR Development, Markerless AR Development, Scripting and Programming in Unity/Unreal, Applications and Trends in XR, Application of XR, Case Studies, Recent Developments in XR, Future Trends in XR, XR and Metaverse, Ethical Considerations in XR, XR Impact on Society and Culture, Security and Privacy in XR, Security in Immersive Technologies, Privacy Concerns in VR/AR, Regulatory and Compliance Issues. |

Text Books

1. G.C. Burdea and P. Coiffet, Virtual Reality Technology, 2nd ed., Wiley-IEEE Press, 2003/2006.
2. A. 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 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. Cluadia, *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*, Boston: Addison-Wesley, 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*, Packt Publishing, 2018.
7. S. Ong, *Beginning Windows Mixed Reality Programming: For HoloLens and Mixed Reality Headsets*, Springer, 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 |
|-----------------------|-------------------------|---|-------------------------|
| M5010012/ M5020012 | Optimization Techniques | 1-1-0-1 | 2025 |
| Prerequisites: Nil | | | |

Course Objectives:

1. To provide students with a good understanding of optimization techniques.
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: Evaluate optimization problems and critically assess state-of-the-art solutions in the context of optimization techniques.

CO2: Design and create optimization algorithms through the integration of classical and modern optimization methods.

CO3: Develop, test, solve optimization techniques within team research projects, and effectively present the findings.

CO4: Critically analyze and compare optimization methods to identify suitable techniques for specific real-world problems.

CO5: Evaluate and defend the selection of optimization techniques for problem solving and research 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 | 1 | 3 | 3 | 1 | 1 |
| CO2 | 2 | 3 | 3 | | 3 | 1 |
| CO3 | 2 | | 3 | 3 | 3 | |
| CO4 | 3 | 3 | 1 | 1 | 1 | |
| CO5 | 2 | 3 | 2 | 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 Optimisation, 2nd ed. India: Wiley, 2010.
2. D. G. Luenberger and Y. Ye, *Linear and Nonlinear Programming*, 3rd ed., Springer, 2010.

References

1. S. Sra, S. Nowozin, and S. J. Wright, Optimization for Machine Learning, MIT Press, 2012.
2. R. Battiti and M. Brunato, The LION Way: Machine Learning Plus Intelligent Optimization, Createspace Independent Publishing, 2014.

COMPUTER ARCHITECTURE

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|-------------|-----------------------|---|-------------------------|
| M4020019 | Computer Architecture | 2-1-0-0 | 2025 |

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: Analyse the functioning of various components in a computer system and evaluate their interactions.

CO2: Apply knowledge of computer architecture to model and analyse systems for security vulnerabilities.

CO3: Compare various types of computer architectures and analyse their design principles, identifying strengths and weaknesses.

CO4: Create efficient models of computer systems based on an understanding of their components and architectures.

CO5: Evaluate the performance and functionality of a computer system, applying acquired knowledge of its components to optimise usage.

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 | 2 | 2 |
| CO2 | 3 | 3 | 2 | 2 | 3 | 2 |
| CO3 | 2 | 3 | 2 | 2 | 3 | 1 |
| CO4 | 2 | 2 | 1 | 3 | 2 | 3 |
| CO5 | 3 | 3 | 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 | <p>Pipelining: Pipeline concept, Speedup, Throughput, Hazards in pipeline – structural hazard, data hazard, control hazard: Branch hazard; Dealing with hazards - Register Renaming, Branch Prediction.</p> <p>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.</p> |
| <p>Text Books</p> <ol style="list-style-type: none"> 1. C. Hamacher et al., <i>Computer Organization</i>, 6th ed., McGraw-Hill Higher Education, 2011. 2. D. A. Patterson and J. L. Hennessy, <i>Computer Organization and Design – The Hardware/Software Interface</i>, 6th ed., Morgan Kaufmann, 2020. 3. W. Stallings, <i>Computer Organization and Architecture: Designing for Performance</i>, 8th ed., Pearson, 2009. 4. P. P. Chaudhuri, <i>Computer Organization and Design</i>, 3rd ed., PHI Learning, 2008. 5. A. S. Tanenbaum, <i>Structured Computer Organization</i>, 6th ed., Pearson, 2012. <p>References</p> <ol style="list-style-type: none"> 1. William Stallings, <i>Computer Organization and Architecture: Designing for Performance</i>, 7th ed., Prentice-Hall India, 2005. 2. C. Hamacher, Z. Vranesic, and S. Zaky, <i>Computer Organization</i>, 6th ed., McGraw Hill, 2012. 3. M. M. Mano, <i>Digital Logic and Computer Design</i>, 4th ed., Pearson Education, 1979. | |

WEB TECHNOLOGY

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|---|-----------------------|---|-------------------------|
| M5020023 | Web Technology | 1-1-0-1 | 2025 |
| Prerequisites: Nil | | | |
| Course Objectives: | | | |
| <ol style="list-style-type: none"> 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: Assess and compare different web server architectures, transmission protocols, and web application structures to justify their use in diverse scenarios.

CO2: Design and develop dynamic web pages using CSS frameworks and advanced JavaScript techniques, incorporating modern libraries and frameworks like React.

CO3: Critically analyze and justify the application of creational design patterns, such as Factory and Singleton, to address complex web application challenges.

CO4: Formulate and implement scalable web applications using Django's MTV architecture, integrating REST APIs and data visualization techniques for effective solutions.

CO5: Derive and create microservices-based solutions by contrasting them with monolithic designs, leveraging MVC and N-tier architecture principles.

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 | 1 | 3 | 3 | 1 | 3 |
| CO2 | 2 | 1 | 3 | 2 | 1 | 2 |
| CO3 | 2 | 1 | 3 | 3 | 1 | 3 |
| CO4 | 1 | 1 | 2 | 3 | 2 | 3 |
| CO5 | 1 | 1 | 2 | 2 | 2 | 1 |

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

Syllabus

| Module | Content |
|--------|---|
| 1 | 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, Data types, Arrays, Decisions and Loops, Functions and scope, JavaScript libraries, JavaScript Frameworks, ECMAScript, TypeScript, Single page applications (SPA), Basics of React Web Framework, Introduction to MERN framework. |

| | |
|---|--|
| 3 | Creational Design Patterns, Factory Pattern, Abstract Factory Pattern, Prototype pattern, Singleton Pattern, Builder Pattern, Dependency Injection pattern, The Web Services based on technologies such as SOAP, REST, WSDL, Django Framework: Architecture, MTV Architecture Pattern in Django Structure. |
| 4 | Data Access with Django and Python, CRUD Operations with Django, Models, Templates, Controllers, Sample Django MTV Web Application, REST API with Django - Advanced, Cache and Sessions with Django, Data Visualization Techniques for small and large data, 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 <ol style="list-style-type: none"> 1. J. C. Jackson, <i>Web Technologies - A Computer Science Perspective</i>, Pearson Education, 2009. 2. William S Vincent, <i>Django for Professionals: Production Websites with Python & Django</i> Paperback, Import - 2019. 3. J. B. Mille, <i>Internet Technologies and Information Services</i>, ABC-CLIO, 2014. | |

OOPS AND JAVA

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|---|---------------|---|-------------------------|
| M5020024 | OOPS and JAVA | 1-1-0-1 | 2025 |
| Prerequisites: Basic programming concept. | | | |
| Course Objectives: | | | |
| <ol style="list-style-type: none"> 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: Analyse the key principles of object-oriented programming (OOP) and evaluate their application in real-world software development. | | | |
| CO2: Apply Java programming language concepts to develop software solutions, demonstrating proficiency in coding and problem-solving. | | | |
| CO3: Evaluate the use of multi-threading and network programming concepts in Java to solve concurrent programming challenges. | | | |
| CO4: Create Java-based applications incorporating object-oriented principles, multi-threading, and network programming for improved system functionality. | | | |
| CO5: Analyse the performance and efficiency of multi-threaded Java applications and evaluate optimisations to improve scalability and resource management. | | | |

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 | 3 | 2 |
| CO2 | 3 | 3 | 2 | 2 | 3 | 3 |
| CO3 | 2 | 3 | 2 | 3 | 2 | 3 |
| CO4 | 3 | 3 | 2 | 3 | 3 | 3 |
| CO5 | 3 | 3 | 3 | 2 | 3 | 2 |

(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 | <p>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</p> <p>Networking: Networking basics, Java and the Internet Address, TCP/IP client Sockets, URL, URL connection, TCP/IP server Sockets The Applet Class.</p> |
| <p>Text Books</p> <ol style="list-style-type: none"> 1. P. Naughton and H. Schildt, <i>The Complete Reference JAVA 2</i>, McGraw-Hill, 1999. 2. C. T. Wu, <i>Introduction to JAVA Programming</i>, 2nd ed., John Wiley and Sons, 2000. 3. M. T. Somashekara <i>et al.</i>, <i>Object Oriented Programming with JAVA</i>, PHI Learning, 2017. <p>References</p> <ol style="list-style-type: none"> 1. B. Eckel and C. Allison, <i>Thinking in JAVA</i>, 2nd ed., Prentice Hall, 2000. 2. C. Horstmann, <i>Computing Concepts with JAVA 2 Essentials</i>, 2nd ed. India: Wiley, 2006. 3. H. Schildt, <i>Java: a Beginner Guide Essential Skills Made Easy</i>, 4th ed., McGraw- Hill Professional, 2007. | |

OBJECT ORIENTED SOFTWARE ENGINEERING

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|-----------------|---|---|-------------------------|
| M5020025 | Object Oriented Software Engineering | 1-1-0-1 | 2025 |

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: Evaluate 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: Plan appropriate testing strategies for validating the developed software system.

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 | 1 | 1 | 1 |
| CO2 | 3 | 3 | 2 | 1 | 1 | 2 |
| CO3 | 3 | 3 | 2 | 2 | 1 | 2 |
| CO4 | 3 | 3 | 3 | 3 | 2 | 3 |
| CO5 | 3 | 3 | 3 | 2 | 3 | 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 | <p>Coding, Testing and Deployment</p> <p>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</p> |
| <p>Text Books</p> <ol style="list-style-type: none"> 1. I. Sommerville, <i>Software Engineering</i>, 10th ed., Pearson Education, 2015. 2. R. S. Pressman, <i>Software Engineering: A Practitioner's Approach</i>, 8th ed., McGraw-Hill, 2014. 3. G. Booch <i>et al.</i>, <i>The Unified Modeling Language User Guide</i>, Addison-Wesley, 2005. 4. B. Bruegge and A. H. Dutoit, <i>Object-Oriented Software Engineering</i>, 2nd ed., Pearson Education, 2004. 5. A. Cockburn, <i>Agile Software Development</i>, 2nd ed., Pearson Education, 2007. <p>References</p> <ol style="list-style-type: none"> 1. R. Mall, <i>Fundamentals of Software Engineering</i>, PHI Learning, 2014. 2. P. Jalote, <i>An Integrated Approach to Software Engineering</i>, 3rd ed., Narosa Publishing House, 2009. 3. I. Jacobson <i>et al.</i>, <i>The Unified Software Development Process</i>, Pearson Education, 1999. 4. IEEE Std 830-1998 – IEEE Recommended Practice for Software Requirements Specifications. 5. IEEE Std 1016-2009 – IEEE Standard for Information Technology – Systems Design – Software Design Descriptions. | |

AI FOR CYBER SECURITY

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|---|-----------------------|---|-------------------------|
| M5010018/ M5020018 | AI for Cyber Security | 1-1-0-1 | 2025 |
| <p>Prerequisites: A basic understanding of algebra, linear algebra, modular arithmetic</p> | | | |
| <p>Course Objectives:</p> <ul style="list-style-type: none"> • To equip students with a solid understanding of rule-based AI, machine learning, and deep learning techniques for addressing various cybersecurity challenges. • To enable students to apply machine learning and AI algorithms effectively in real-world cybersecurity applications such as malware detection, phishing prevention, and threat mitigation. | | | |

- To enhance students' ability to design and implement autonomous systems for cyber defense using advanced AI techniques such as reinforcement learning, and deep learning.

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

CO1: Analyze the effectiveness of rule-based AI and machine learning models in detecting cybersecurity threats and mitigating risks.

CO2: Distinguish between supervised and unsupervised learning approaches for phishing detection, intrusion detection, and anomaly analysis in cybersecurity.

CO3: Evaluate classification algorithms such as Bayesian models, SVMs, Decision Trees, and ensemble methods for malware detection and threat prediction.

CO4: Design deep learning models, including CNNs, RNNs, LSTMs, and GANs, for advanced applications like attack pattern generation and encrypted traffic analysis.

CO5: Integrate feature engineering techniques, such as PCA and reinforcement learning, to construct adaptive and scalable solutions for real-time cyber threat mitigation.

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 | 1 | 1 | 2 |
| CO2 | 3 | 3 | 2 | 1 | 1 | 1 |
| CO3 | 3 | 3 | 3 | 1 | 1 | 2 |
| CO4 | 3 | 3 | 3 | 1 | 2 | 3 |
| CO5 | 3 | 3 | 3 | 1 | 1 | 2 |

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

Syllabus:

| Module | Content |
|----------|---|
| 1 | Rule-Based AI vs. Machine Learning in Threat Detection, Neural Networks and Learning Algorithms for Cybersecurity Applications, Bias-Variance Tradeoffs in Cybersecurity Models, Reinforcement Learning for Adaptive Threat Mitigation, PCA-Based Feature Engineering for Anomaly Detection, Supervised Learning in Phishing Detection, Unsupervised Learning for Intrusion Detection, Automated Cyber Defense with Reinforcement Learning. |
| 2 | Effectiveness of Bayesian, SVM, Decision Tree, and Random Forest classifiers in detecting cyber threats, Performance of ensemble methods in improving malware detection accuracy, Application of linear and logistic regression |

| | |
|---|--|
| | models for predicting security risks, Use of supervised learning algorithms in phishing and APT detection. |
| 3 | Partition-Based and Subspace Clustering for anomaly detection in network traffic, Incremental Clustering techniques for real-time cyber threat detection, Spectral Clustering in identifying hidden attack patterns, Hidden Markov Models for detecting rare cyber-attacks and advanced persistent threats. |
| 4 | Deep neural networks for cyber threat classification, Deep Feed Forward Networks for malware detection, Convolutional Neural Networks for image-based phishing page detection, Recurrent Neural Networks (RNN) and Long Short-Term Memory (LSTM) for time-series anomaly detection, Generative Adversarial Networks (GANs) for generating attack patterns, Autoencoders for unsupervised anomaly detection in network traffic. |
| <p>Text Books:</p> <ol style="list-style-type: none"> 1. Tony Thomas, Athira P. Vijayaraghavan, Sabu Emmanuel, Machine Learning Approaches in Cybersecurity Analytics, Springer 2020. 2. Tony Thomas, Roopak Surendran, Teenu S John, Mamoun Alazab, Intelligent Mobile Malware Detection, CRC Press, Taylor and Francis, 2023. 3. Artificial Intelligence: A Modern Approach 4th Edition, Stuart Russell and Peter Norvig, Pearson, 2020. 4. Understanding Machine Learning: From Theory to Algorithms, ShaiShalevShwartz, ShaiBen-David, Cambridge University Press, 2014. 5. Clarence Chio, David Freeman, Machine Learning & Security, O Reilly, 2018. 6. Deep Learning Applications for Cyber Security, Alazab, Mamoun, Tang, MingJian (Eds.), Springer, 2019. 7. Rakesh M. Verma, David J. Marchette, Cybersecurity Analytics, by Chapman and Hall/CRC, 2019. 8. Charu C. Aggarwal, Neural Networks and Deep Learning: A Textbook (Second Edition), Springer, 2023. | |
| <p>References:</p> <ol style="list-style-type: none"> 1. Alexey Kleymenov, AmrThabet , Mastering Malware Analysis: The complete malware analyst's guide to combating malicious software, APT, cybercrime, and IoT attacks, 2019. 2. Monappa KA, Learning Malware Analysis: Explore the concepts, tools, and techniques to analyze and investigate Windows malware, Packt Publication, 2018. 3. Xin et al, Machine Learning and Deep Learning Methods for Cybersecurity, IEEE Access 2018. 4. Bowei Xi, Adversarial machine learning for cybersecurity and computer vision: Current developments and challenges, WIREs Computational Statistics, April 2020. 5. Mohammad Al-Rubaie, Privacy Preserving Machine Learning: Threats and Solutions, n IEEE Security and Privacy Magazine, 2018. 6. Aiyanyo et al, A Systematic Review of Defensive and Offensive Cybersecurity with Machine Learning, Applied Sciences, MDPI, Aug 2020. 7. Shaukat et al, A Survey on Machine Learning Techniques for Cyber Security in the Last Decade, IEEE Access, Dec 2020. 8. Anthony D. Joseph, Blaine Nelson, Benjamin I. P. Rubinstein, Adversarial Machine Learning, Cambridge University Press, 2019. | |

FEDERATED LEARNING

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|-----------------------|--------------------|---|-------------------------|
| M5010030/ M5020030 | Federated Learning | 1-1-0-1 | 2025 |

Prerequisites: The prerequisite knowledge for this course includes machine learning, basic computer systems and basic programming skills.

Course Objectives:

1. To know the basics of Federated Learning
2. To explore the components of Federated Learning systems.
3. Learn to customize, tune and orchestrate them for better model training.
4. To learn the applications of Federated Learning.

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

CO1: Evaluate the fundamental concepts, architecture, and categories of federated learning by comparing them with traditional AI and big data approaches.

CO2: Design and implement federated learning algorithms using state-of-the-art frameworks such as TensorFlow Federated, PySyft, and Flower to address diverse problem domains.

CO3: Critically analyze privacy-preserving techniques like differential privacy, secure multi-party computation, and homomorphic encryption for federated learning systems.

CO4: Develop simulated federated learning scenarios to compare FL and non-FL approaches and explore their applications in domains like healthcare, finance, and edge computing.

CO5: Create real-world federated learning projects, including workflow design, deployment, and presentation of findings in professional formats.

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 | 2 | 2 | 1 | 1 | 1 | 1 |
| CO2 | 2 | 2 | 3 | 1 | 1 | 2 |
| CO3 | 2 | 3 | 2 | 1 | 1 | 1 |
| CO4 | 2 | 3 | 2 | 1 | 1 | 2 |
| CO5 | 2 | 3 | 2 | 1 | 1 | 1 |

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

| Syllabus: | |
|---|---|
| Module | Content |
| 1 | <p>Introduction: Motivation – Challenges in Bigdata and Traditional AI - Federated Learning (FL) as a Solution – Comparison between Traditional Big data ML and FL systems.</p> <p>FL: Definitions – Process – Architecture - Categories – Current Developments – Research Issues – Open-Source Projects – The Federated AI Eco system - Security for FL Systems – Decentralized FL and Blockchain – Overall architecture of FL Systems.</p> |
| 2 | <p>Federated Learning: Work Flow and Key Elements - Horizontal FL – Definition – Architecture – Federated Averaging Algorithm; Vertical FL – Definition – Architecture – VFL Algorithms; Federated Transfer Learning (FTL) – Heterogeneous FL – Privacy Preserving Techniques: Secure Multi-Party Computation – Homomorphic Encryption – Differential Privacy.</p> |
| 3 | <p>Federated Datasets and Software Frameworks</p> <p>PySyft, TensorFlow Federated, FATE, Paddle FL, Flower, Xaynet, IBM FL, Substra, OpenFL, FedML, FedJax, Backdoors 101, FedLab, SimFL, easyFL, TorchFL.</p> <p>Methodology for Designing a Simulated Federated Learning Scenario - Comparative Study of FL and Non-FL Scenarios.</p> |
| 4 | <p>Case Studies with Use Cases of FL Applications</p> <p>Federated Computer Vision (CV) – Federated Natural Language Processing (NLP) – Federated Recommendation Systems. Applying FL - Healthcare Sector – Financial Sector – FL meets Edge Computing – Internet of Intelligence – Distributed Learning for Bigdata.</p> <p>Future Trends and Developments in Federated Learning – Looking at Future AI Trends.</p> |
| <p>Text Books and References</p> <ol style="list-style-type: none"> 1. Qiang Yang, Yang Liu, Yong Cheng, Yan Kang, Tianjian Chen, Han Yu, Federated Learning, Synthesis Lectures on Artificial Intelligence and Machine Learning, Lecture 43, Springer Series, 2020. 2. K. N., Jenő, G. Federated Learning with Python: Design and Implement a Federated Learning System and Develop Applications Using Existing Frameworks. Germany: Packt Publishing, 2022. 3. Heiko Ludwig, Nathalie Baracaldo, Federated Learning: A Comprehensive Overview of Methods and Applications, Springer International Publishing, 2022. | |

Mathematical Thinking and Problem Solving (Holistic Development)

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|-------------|---|---|----------------------|
| | Mathematical Thinking and Problem Solving (Holistic Development) | 1-0-0-1 | 2025 |

Prerequisites: Nil

Course Objectives:

1. To cultivate a deep understanding of mathematical principles, emphasizing conceptual clarity, logical reasoning, and the ability to articulate the "why" behind mathematical truths.
2. To enhance problem-solving skills through the application of critical and creative thinking, pattern recognition, and abstraction in real-world and interdisciplinary contexts.
3. To develop students' ability to construct, evaluate, and generalize mathematical arguments and models, fostering innovative approaches to complex challenges.

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

- CO1.** Demonstrate conceptual understanding of fundamental principles such as sets, logic, proof strategies, and mathematical truths to analyze and construct valid arguments.
- CO2.** Identify patterns, structures, and relationships in numbers, sequences, and geometric shapes to evaluate solutions and generalize mathematical concepts.
- CO3.** Solve real-world problems through the application of logical, critical, and creative thinking in combinatorics, graph theory, and probability.
- CO4.** Appraise mathematical models in relation to real-world phenomena by applying abstraction and generalization in disciplines like geometry, calculus, and linear algebra.
- CO5.** Develop innovative approaches to interdisciplinary challenges by integrating mathematical reasoning, spatial sense, and problem-solving skills to foster creativity and communication.

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 | 1 | 1 | 1 |
| CO2 | 3 | 2 | 3 | 2 | 1 | 2 |
| CO3 | 3 | 3 | 3 | 1 | 1 | 2 |
| CO4 | 2 | 3 | 3 | 3 | 1 | 2 |
| CO5 | 3 | 3 | 3 | 2 | 1 | 3 |

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

Syllabus:

| Module | Content |
|--------|---|
| 1 | Conceptual understanding of fundamental principles: sets, logic, and proof strategies (direct, indirect, and induction). Exploring the "why" behind mathematical truths. Number and spatial sense through basic arithmetic, geometry, and pattern recognition. Developing logical thinking by analyzing mathematical arguments and identifying fallacies. |
| 2 | Identifying patterns in numbers, sequences, and geometric shapes. Understanding mathematical structures in algebra, number theory, and geometry. Exploring abstraction through generalizing solutions from specific examples. Applications to real-world problems, such as scheduling and optimization, to enhance creative |
| 3 | Applying logical and critical thinking in combinatorics, graph theory, and probability. Creative problem-solving in puzzles, games, and mathematical challenges. Developing reasoning to construct and evaluate arguments. Understanding the relationship between mathematical models and real-world phenomena. |
| 4 | Exploring spatial sense through geometry and visualization. Conceptual approaches to advanced problems in calculus and linear algebra. Refining abstraction and generalization in higher-dimensional reasoning. Applications to technological innovation and interdisciplinary challenges, fostering creativity and communication skills in mathematical problem solving. |

Text Books

1. How to Solve It: A New Aspect of Mathematical Methods, George Pólya, Princeton University Press, 2004.
2. Discrete Mathematics and Its Applications, Kenneth H. Rosen, McGraw-Hill Education, 8th Edition, 2018.
3. Mathematical Thinking: Problem-Solving and Proofs, John P. D'Angelo and Douglas B. West, Pearson, 2nd Edition, 2000.
4. Introduction to the Practice of Statistics, David S. Moore, George P. McCabe, and Bruce A. Craig, W.H. Freeman, 9th Edition, 2016.

5. Linear Algebra and Its Applications, David C. Lay, Steven R. Lay, and Judi J. McDonald, Pearson, 5th Edition, 2015.

Computational Thinking and Problem Solving (Holistic Development)

| Course Code | Course Name | Credit Split Lecture/Lab/Seminar/Project | Year of Introduction |
|-------------|--|---|-------------------------|
| | Computational Thinking and Problem Solving (Holistic Development) | 1-0-0-1 | 2025 |

Prerequisites: Nil

Course Objectives:

1. To Motivate students to develop critical thinking skills for effective problem-solving.
2. To develop a mindset for abstract thinking and algorithmic reasoning.
3. To apply problem-solving methodologies to computational and real-world scenarios.
4. To understand the importance of data, automation, and AI in modern problem solving.
5. To integrate ethical and socio-technical dimensions into problem-solving processes.
6. Develop problem-solving skills through algorithms and flowcharts.
7. Familiarize students with algorithm design and flowchart representation for structured problem-solving.

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

C01. Apply computational thinking principles—such as decomposition, pattern recognition, abstraction, and algorithm design—to analyze and structure every day and scientific problems.

C02. Design and represent solutions using conceptual tools like flowcharts and pseudocode, and explain core algorithmic concepts including decision structures, iteration, and recursion.

C03. Evaluate the use of algorithms in systems by comparing approaches to problem solving.

C04. Analyze real-world scenarios through data abstraction and modeling techniques, and communicate insights using structured data representations.

C05. Develop human-centered, ethical solutions to socio-technical challenges by incorporating sustainability, accessibility, and inclusive design thinking.

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 | 1 | 1 | 1 |
| CO2 | 3 | 3 | 3 | 1 | 1 | 1 |
| CO3 | 3 | 3 | 3 | 1 | 1 | 2 |
| CO4 | 2 | 3 | 3 | 3 | 1 | 2 |
| CO5 | 3 | 3 | 3 | 2 | 1 | 3 |

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

Syllabus:

| Module | Content |
|---------------|---|
| 1 | Computational thinking: Decomposition, pattern recognition, abstraction, and algorithm design, Problem-solving vs. problem posing, Examples from daily life and scientific problems, Mindset of a computational thinker in the age of AI Activities: Identify computational patterns in everyday life, logic-based puzzles, collaborative problem framing. |
| 2 | Fundamentals of algorithms, Flowcharts and pseudocode as thinking tools, Decision structures, iteration, recursion (conceptual focus), Understanding automation through algorithmic workflows, Role of algorithms in AI and machine learning pipelines. Activities: Visual algorithm design, process automation use-cases, compare algorithm vs AI decisions |
| 3 | Importance of data in modern problem solving, Data abstraction and representation (tables, graphs, trees, etc.), Case studies in healthcare, education, climate science, etc., Problem-solving for complexity and scale. Activities: Data storytelling, simplified modeling with spreadsheets or visual tools, simulation-based problem analysis |

| | |
|---|--|
| 4 | Designing with empathy: Human-centered design thinking, Socio-technical systems: sustainability, accessibility, inclusivity, Solving problems responsibly in the AI age. Activities: Role-play on ethical scenarios, design a solution for a social challenge, group ideation |
|---|--|

Text Books:

1. Karl, Beecher. Computational Thinking: A Beginner's Guide to Problem-Solving and Programming. Swindon, UK: BCS, The Chartered Institute for IT (2017).
2. Spraul, V. Anton. Think like a programmer. MITP-Verlags GmbH & Co. KG, 2013.
3. Brown, Stephen I., and Marion I. Walter. The art of problem posing. Psychology Press, 2005.
4. Cormen, Thomas H., et al. Introduction to algorithms. MIT press, 2022.

Online:

5. MIT's Computational Thinking for Problem Solving (edX)