# Post Graduates Course of Study
## (For batch 2025 onwards)

**M. Tech. (Computer Science and Engineering)**
**M. Tech. (Information and Cyber Security)**
**(Department of Computer Science and Engineering)**

**M. Tech. (Information Technology)**
**M. Tech. (Wireless Networks and Computing)**
**(Department of Information Technology)**

**M. Tech. (IC Design and Technology)**
**M. Tech. (Autonomous Systems and Machine Intelligence)**
**(Department of Electrical and Electronics Engineering)**

**M.S. (Artificial Intelligence and Data Science)**
**(Department of Engineering Science)**

**Master of Business Administration**
**(Department of Management Studies)**

**Dual Degree (M.Tech. and PhD)**

**ATAL BIHARI VAJPAYEE-**
**INDIAN INSTITUTE OF INFORMATION TECHNOLOGY AND MANAGEMENT,**
**GWALIOR (MADHYA PRADESH)**
(AN INSTITUTE OF NATIONAL IMPORTANCE, MINISTRY OF EDUCATION, GOVT. OF INDIA)

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Curriculum & Contents

# M. Tech.
# (Computer Science and Engineering)

**Department of Computer Science and Engineering**

विश्वजीवनामृतं ज्ञानम्

ABV-Indian Institute of Information Technology & Management, Gwalior

# SCHEMA

**Name of the program: M. Tech. (Computer Science and Engineering)**

**(Credits: 70)**

**Name of the Department: Computer Science and Engineering**

| **SEMESTER-I** | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject Code** | **Title of the course** | **L-T-P** | **Credits** |
| **1.** | MCSE-501 | Machine Learning Techniques | 3-0-2 | 4 |
| **2.** | MCSE-502 | Modelling and Simulation | 3-0-2 | 4 |
| **3.** | MCSE-503 | Advanced Data Structure and Algorithms | 3-0-2 | 4 |
| **4.** | MCSE-504 | Distributed Systems | 3-0-2 | 4 |
| **5.** | MCSE-50X | Elective-I | 3-0-0 | 3 |
| **6.** | MCSE-510 | Seminar* | 0-1-0 | 1 |
| | | | **Total credits** | **20** |

| **SEMESTER-II** | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject code** | **Title of the course** | **L-T-P** | **Credits** |
| **1.** | MCSE-512 | Cyber Physical Systems | 3-0-2 | 4 |
| **2.** | MCSE-513 | Complex Networks | 3-0-2 | 4 |
| **3.** | MCSE-514 | Optimization Techniques | 3-0-0 | 3 |
| **4.** | MCSE-5XX | Elective-II | 3-0-0 | 3 |
| **5.** | MCSE-5XX | Elective-III | 3-0-0 | 3 |
| **6.** | MCSE-524 | Engineering Research Methodology | 2-1-0 | 3 |
| | | | **Total credits** | **20** |

EXIT AFTER YEAR-1: Post Graduate Diploma in Computer Science and Engineering

| SEMESTER-III | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject code** | **Title of the course** | **L-T-P** | **Credits** |
| **1** | MCSE-523 | Elective-IV | 3-0-0 | 3 |
| **2** | MCSE-598 | Dissertation Part - I | | 12 |
| | | | **Total credits** | **15** |

| SEMESTER-IV | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject Code** | **Title of the course** | **L-T-P** | **Credits** |
| **1** | MCSE-599 | Dissertation Part – II | | 15 |
| | | | **Total credits** | **15** |

| SEMESTER-I | SEMESTER-II | SEMESTER-III | SEMESTER-IV | TOTAL CREDITS |
|---|---|---|---|---|
| 20 | 20 | 15 | 15 | **70** |

## Electives Courses

| S. No. | Electives I, II, III, and IV Category: Computer Science and Engineering |
|---|---|
| 1 | Cryptography and Network Security |
| 2 | Modern Cryptography |
| 3 | Formal Verification of Security Protocols |
| 4 | IoT and its security |
| 5 | Data privacy in Social Networks |
| 6 | Cyber Forensics: Tools and Techniques |
| 7 | Malware Analysis |
| 8 | Big Data and Cyber fraud analysis |
| 9 | Hardware Security |
| 10 | Fault Tolerant Systems |
| 11 | Secure System Engineering |
| 12 | Blockchain Technology |
| 13 | AI and ML Techniques for Cyber Security |
| 14 | Natural Language Processing |
| 15 | Information Retrieval |
| 16 | Recommender Systems |
| 17 | Reinforcement Learning |
| 18 | Graphical Neural Networks |
| 19 | Nature Inspired Computing |
| 20 | Meta-Heuristics for Multi-Objective Optimization |
| 21 | Distributed Machine Learning |
| 22 | Fair, Accountable, Transparent AI |
| 23 | Machine Learning System Optimization |
| 24 | Computational Biology |

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|---|---|
| 25 | Pattern Recognition |
| 26 | Deep Learning Techniques |
| 27 | Cognitive Science |
| 28 | Data Mining Techniques |
| 29 | Cloud Computing |
| 30 | Advanced Software Engineering |
| 31 | Machine Learning for Operations (MLOps) |
| 32 | Data Science |
| 33 | Data Visualization and Explainable Model |
| 34 | Time Series Data Analysis |
| 35 | Quantum Computing |
| 36 | Robotics and Intelligent Systems (Multi-Agents) |
| 37 | Big Data Analytics |
| 38 | Complexity and Advanced Algorithms |
| 39 | Randomized Algorithms |
| 40 | Algorithmic Game Theory |
| 41 | Computational Learning Theory |
| 42 | Biometric Image Processing |
| 43 | Perception for Autonomous Systems |
| 44 | Computer Vision |
| 45 | Remote Sensing and Satellite Image Processing |
| 46 | Human-Computer Interaction |
| 47 | Medical Imaging |
| 48 | Virtual Reality and Augmented Reality |
| 49 | Speech Processing |
| 50 | Digital Signal Processing |

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| 51 | Multimedia Systems |
| 52 | Digital Watermarking & Steganalysis |
| 53 | Video Analytics |
| 54 | Visual Saliency and Attention Modelling |

# Course Contents

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|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | MCSE-501 |
| 4 | **Title of the subject** | Machine Learning Techniques |
| 5 | **Any prerequisite** | Nil |
| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning Objectives of the subject** | ● To understand popular ML algorithms with their associated mathematical foundations for appreciating these algorithms.<br>● To help connect real-world problems to appropriate ML algorithm(s) for solving them and to enable formulating real world problems as machine learning tasks. |
| 8 | **Brief Contents** | Introduction to ML, Fundamentals of ML - PCA and Dimensionality reduction, Nearest neighbours and KNN, Linear regression, Decision tree classifiers, Notion of generalization and concern of overfitting, Notion of training, Validation, and testing; Connect to generalization and overfitting. Selected algorithms - ensembling and RF, Linear SVM, K means, Logistic regression, Naive bayes, Neural network learning - Role of loss functions and optimization, Gradient descent and Perceptron/Delta learning, MLP, Backpropagation, MLP for classification and regression, Regularization, Early Stopping, Kernels (with SVM), Bayesian methods, Generative methods, HMM, EM, PAC learning, Introduction to Deep Learning, CNNs, Popular CNN architectures, RNNs, GANS and Generative models, Advances in backpropagation and optimization for neural networks adversarial learning. |
| 9 | **Contents for lab** | To implement basic algorithms using basic machine learning libraries mostly in python. Gain hands-on experience in applying ML to problems encountered in various domains. In addition, obtain exposure to high-level ML libraries or frameworks such as TensorFlow, PyTorch. |
| 10 | **Books** | 1. A. Géron, Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow, 3rd ed. Sebastopol, CA: O'Reilly Media, 2022.<br>2. C. M. Bishop, Pattern Recognition and Machine Learning. New York, NY: Springer, 2006. |

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| | | 3. T. Hastie, R. Tibshirani, and J. Friedman, The Elements of Statistical Learning: Data Mining, Inference, and Prediction, 2nd ed. New York, NY: Springer, 2009. |

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|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | MCSE-502 |
| 4 | **Title of the subject** | Modelling and Simulation |
| 5 | **Any prerequisite** | Basic Mathematics |
| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning Objectives of the subject** | Develop mathematical models to represent real-world systems and problems.<br>Apply simulation tools to solve complex problems in engineering, science, and management.<br>Develop critical thinking skills in problem-solving and model validation. |
| 8 | **Brief Contents** | Introduction to probability: Joint and Conditional Probability, Random Variables, Bayesian Networks. Optimization: System Modelling and Optimization, Optimizing Linear Systems, Nonlinear Constrained Optimization. Game Theory: Concepts and Terminology, Solving a Game, Mechanism Design, Limitations of Game Theory. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. Simulation Modeling and Analysis by Averill M. Law<br>2. Operations Research: An Introduction by Taha H. A. |

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|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | MCSE-503 |
| 4 | **Title of the subject** | Advanced Data Structures and Algorithms |
| 5 | **Any prerequisite** | Discrete Mathematics, Algorithms and Data Structures |

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| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning Objectives of the subject** | ● Learn and implement advanced data structures<br>● Analyze algorithm complexity using amortized analysis and lower-bound proofs.<br>● Apply network flow and matching algorithms. |
| 8 | **Brief Contents** | Advanced data structures: Fibonacci heaps, splay trees, self-adjusting search trees, and linking/cutting trees.<br>Algorithm design and analysis: amortized complexity, and lower-bound proofs, shortest path problems, minimum spanning trees, and network flows, including preflow-push, max flow, and scaling techniques, Matching algorithms, including the Micali-Vazirani algorithm and blossom structures. |
| 9 | **Contents for lab** | The lab content for the syllabus includes hands-on implementation and analysis of algorithms and data structures, starting with basic algorithm analysis and amortized complexity through dynamic array resizing and simple data structures like stacks and queues. Students will then implement advanced data structures such as Fibonacci heaps, splay trees, and linking/cutting trees, comparing their performance and behavior. Further labs focus on efficient algorithms for shortest path problems (Dijkstra's and Bellman-Ford) and minimum spanning trees (Kruskal's and Prim's), followed by network flow algorithms like Ford-Fulkerson, preflow-push, and scaling techniques. |
| 10 | **Books** | 1. R. E. Tarjan. Data structures and Network Algorithms, SIAM Press, 1983.<br>2. J. H. Hastad.Computational Limitations for Small-Depth Circuits, MIT Press, 1987.<br>3. K. Melhorn.Data Structures and Algorithms, Vol. 1: Sorting and Searching, Springer Verlag, 1984.<br>4. T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein. Introduction to Algorithms, 3rd Edition, MIT Press, 2009. |

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| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | MCSE-504 |
| 4 | **Title of the subject** | Distributed Systems |
| 5 | **Any prerequisite** | Basics of Operating systems and computer networks |

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| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning Objectives of the subject** | ● Understand the fundamental principles and challenges of distributed systems.<br>● Analyze synchronization, coordination, and consensus mechanisms in distributed environments.<br>● Evaluate distributed transaction management, concurrency control, and blockchain-based consensus models |
| 8 | **Brief Contents** | Fundamentals of Distributed Systems, Synchronization and clocks, Mutual Exclusion and Coordination, Consensus and Agreement Protocols, Distributed Transactions and Concurrency Control, Application of distributed systems: consensus mechanisms (Proof of Work and Proof of Stake ) and their security properties. |
| 9 | **Contents for lab** | The lab will cover hands-on implementation and simulation of fundamental distributed system concepts, including process communication, synchronization, and logical clocks. Further, implementation of mutual exclusion algorithms. Practical exercises will include concurrency control mechanisms in distributed databases, evaluating consensus mechanisms like Proof of Work (PoW) and Proof of Stake (PoS), and analyzing their security properties. The lab will involve coding assignments, simulations, and performance evaluations using distributed computing frameworks. |
| 10 | **Books** | 1. Tanenbaum, A. S., & Van Steen, M. (2017). Distributed Systems: Principles and Paradigms (3rd ed.). Pearson.<br>2. Ghosh, S. (2014). Distributed Systems: An Algorithmic Approach (2nd ed.). CRC Press.<br>3. Cachin, C., Guerraoui, R., & Rodrigues, L. (2011). Introduction to Reliable and Secure Distributed Systems. Springer.<br>4. Drescher, D. (2017). Blockchain Basics: A Non-Technical Introduction in 25 Steps. Apress.<br>5. Lynch, N. A. (1996). Distributed Algorithms. Morgan Kaufmann. |

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| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | MCSE-512 |
| 4 | **Title of the subject** | Cyber Physical Systems |

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| 5 | **Any prerequisite** | 1. Basic Programming Knowledge<br>2. Fundamental Mathematics |
| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning Objectives of the subject** | ● To develop the student's ability to understand the concept of cyber physical systems' characteristics, requirements and architecture.<br>● To develop the student's ability to understand the concepts of cyber physical system software with special emphasis on real time operating system and particularly real time job scheduling.<br>● To provide the students with some basic knowledge of power aware architecture & hardware software co design. |
| 8 | **Brief Contents** | CPS : Motivational examples and compute platforms, Cyber-Physical Systems (CPS) in the real world Basic principles of design and validation of CPS, Industry 4.0,Real time sensing and communication for CPS, Real time task scheduling for CPS, Dynamical Systems and Stability, Controller Design Techniques, Performance under Packet drop and Noise, CPS implementation issues, Intelligent CPS, Attack Detection and Mitigation in CPS |
| 9 | **Contents for lab** | To implement basic algorithms and concept using Cyber-Physical Systems (CPS). Implement CPS real world Basic principles of design and validation. Case study and implementation of Intelligent CPS, Attack Detection and Mitigation in CPS. |
| 10 | **Books** | 1. Cyber-Physical Systems: From Theory to Practice by Rajeev Alur<br>2. Cyber-Physical Systems: Design and Application by Dinesh Samuel T., Rajeev Alur, and Shalabh Agarwal |

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| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | MCSE-513 |
| 4 | **Title of the subject** | Complex Networks |
| 5 | **Any prerequisite** | Graph Theory and Linear Algebra |
| 6 | **L-T-P** | 3-0-2 |

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| 7 | **Learning Objectives of the subject** | ● Analyze network structures using graph theory and centrality measures.<br>● Apply spectral graph theory and matrix-based techniques for network analysis.<br>● Model competition and economic networks using game-theoretic approaches. |
| 8 | **Brief Contents** | Graph theory fundamentals, centrality measures, and network properties. Matrix-based approaches for graph analysis, including Laplacian matrices and spectral graph theory. Game-theoretic models for market competition and network formation in economic systems. Applications of graph theory in market structure analysis, trade networks, and systemic risk. Community detection, network resilience, cascading failures, and algorithms for web search and ranking. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. Newman, M. E. J. (2010). Networks: An Introduction. Oxford University Press.<br>2. Easley, D., & Kleinberg, J. (2010). Networks, Crowds, and Markets: Reasoning About a Highly Connected World. Cambridge University Press.<br>3. Barabási, A.-L. (2016). Network Science. Cambridge University Press.<br>4. Langville, A. N., & Meyer, C. D. (2011). Google's PageRank and Beyond: The Science of Search Engine Rankings. Princeton University Press. |

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| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | MCSE-514 |
| 4 | **Title of the subject** | Optimization Techniques |
| 5 | **Any prerequisite** | Nil |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | ● Learn the fundamental principles of optimization, including linear, nonlinear, and dynamic programming techniques.<br>● Explore various optimization algorithms (e.g., gradient descent, simplex method) and their applications in real- |

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| | | world problems.<br>● Use optimization techniques to improve decision-making processes in engineering, business, and data science by maximizing efficiency and minimizing costs. |
| 8 | **Brief Contents** | Mathematical foundations and basic definitions: concepts from linear algebra, geometry, and multivariable calculus. Linear optimization: formulation and geometrical ideas of linear programming problems, simplex method, revised simplex method, duality, sensitivity snalysis, transportation and assignment problems. Nonlinear optimization: basic theory, method of Lagrange multipliers, Karush-Kuhn-Tucker theory, convex optimization. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. Introduction to Operations Research by Frederick S. Hillier & Gerald J. Lieberman<br>2. Convex Optimization by Stephen Boyd & Lieven Vandenberghe |

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| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | MCSE-524 |
| 4 | **Title of the subject** | Engineering Research Methodology |
| 5 | **Any prerequisite** | Nil |
| 6 | **L-T-P** | 2-1-0 |
| 7 | **Learning Objectives of the subject** | ● To enable a student to develop their theoretical, methodological and research skills to enhance their ability to conduct rigorous research and reach to sound evidence-based conclusions.<br>● Understanding the nature of problem to be studied and identifying the related area of knowledge.<br>● Reviewing literature to understand how others have approached or dealt with the problem.<br>● Collecting data in an organized and controlled manner to arrive at valid decisions. |

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| 8 | **Brief Contents** | Introduction to research, An empirical research framework, Research problems, Literature reviews, Introduction to quantitative research, Study designs, Controlled experiments, Elements and methods, Example experiments, Data collection techniques, Analysis and interpretation of quantitative data, Descriptive statistics, sampling, Sampling distribution, Parameter estimation, statistical inference, Confidence interval and hypothesis testing, Tests of significance, Test of difference of mean and proportions, T-tests, ANOVA, Chi-square tests, Correlation, and regression, Review process, Review guidelines, Validity threats, Review decisions, Qualitative methods, Study designs, Elements, and methods, Data collection methods, Types of data analysis methods, Survey research, Case studies, Writing research papers, Purpose, nature and evaluation, Content and format, Research presentations, The art of scientific and technical writing. Research tools, formatting, plagiarism. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. Research Methodology: Methods and Techniques by C.R. Kothari<br>2. Fundamentals of Research Methodology and Data Collection by Ranjit Kumar |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Cryptography and Network Security |
| 5 | **Any prerequisite** | Computer networks, Information systems security |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | ● To create a framework for comprehending and using cryptographic concepts.<br>● To improve one's capacity for problem analysis and to recognize and specify the computational needs for data protection<br>● To give students studying computer science a foundation in abstract and critical thinking. |
| 8 | **Brief Contents** | Classical Encryption Techniques, Symmetric Cipher and Public Key Encryption, Cryptographic Protocols, Authentication Function, MAC, Hash Functions, Security of Hash Function, Digital |

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| | | Signatures, Network Security and Applications, Kerberos – X.509 Authentication services, Public Key Infrastructure, SSL/TLS, IPSec, Pretty Good Privacy, S/MIME. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. "Cryptography and Network Security: Principles and Practice", 7th ed. by William Stallings<br>2. "Network Security Essentials: Applications and Standards" ,6th Ed, by William Stallings |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Modern Cryptography |
| 5 | **Any prerequisite** | Fundamental knowledge of cryptography |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To learn the basic concepts of cryptography, including encryption, decryption, and cryptographic protocols.<br>To explore common cryptographic attacks, including brute force attacks, side-channel attacks, and cryptanalysis techniques. |
| 8 | **Brief Contents** | Classical encryption techniques, Security attacks, AES, DES, Blowfish, RC4 algorithm, RSA, Diffie Hellman key exchange, ElGamal Encryption, Elliptic curve cryptography, Authentication, MAC, Hash functions, Digital signatures, Authentication protocols, SHA, MD5, Zero-knowledge proof systems, Oblivious transfer, Multiparty secret sharing, Two-party computation using garbled circuits, fully homomorphic encryption. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. "Understanding Cryptography: A Textbook for Students and Practitioners",2nd Ed, by Christof Paar and Jan Pelzl<br>2. "Introduction to Modern Cryptography", 3rd ed., by Jonathan Katz and Yehuda Lindell |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Formal Verification of Security Protocols |
| 5 | **Any prerequisite** | Basic knowledge of computer security and discrete mathematics |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To comprehend how a security protocol is theoretically based. to comprehend formal verification's fundamentals and how security procedures use them. to be aware of the different kinds of security systems and the weaknesses in each. to gain knowledge on how to define security attributes and use formal verification methods to confirm that they are right. |
| 8 | **Brief Contents** | Basic of Logics: BNF, Labelled transition systems, Operational semantics, Protocol specification, describing protocol execution, Security properties: secrecy, authentication, Aliveness, Synchronization, the analysis of security protocols: abstract state machines, Belief logics, Constraint, Provable security, modeling guessable numbers, Modelling time, The BAN Kerberos Protocol. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. "Security Protocols: Principles and Practice" by Pierangela Samarati, Sergio D. Gallegos, and Roberto Di Pietro<br>2. "Verification of Cryptographic Protocols" by Peter Ryan, Shamal F. B., and Renata M. P. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | IoT and its security |
| 5 | **Any prerequisite** | Computer Networks, Cryptography and Network Security, Programming (C/Python/Embedded C) |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Understand IoT Architecture & Security Needs. Analyse IoT Privacy and Security Issues, Identify and Classify IoT Attack |

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| | | Models, Implement Security Measures for IoT Components, Enhance Security in Cyber-Physical and Hardware Systems, Strengthen Networking & Communication Security in IoT, Secure Back-End and Data Management in IoT, and Assess Existing IoT Security Testbeds and Products. |
| 8 | **Brief Contents** | Architecture of IoTs, IoT security requirements, IoT privacy preservation issues, Attack Models – attacks to sensors in IoTs, Attacks to RFIDs in IoTs, Attacks to network functions in IoTs, Attacks to backend systems, Security in front-end sensors and equipment, Prevent unauthorized access to sensor data, M2M security, RFID security, Cyber-physical object security, Hardware security, Front-end system privacy protection, Networking function security- IoT networking protocols, Secure IoT lower layers, Secure IoT higher layers, Secure communication links in IoTs, Back-end security -secure resource management, Secure IoT databases, Security products-existing testbed on security and privacy of IoTs. |
| 9 | **Contents for lab** | Installing IoT frameworks (Node-RED, Mosquitto MQTT, Raspberry Pi setup). Simulating IoT devices (using IoT platforms like Arduino, ESP8266, and Raspberry Pi). Exploring IoT protocols (MQTT, CoAP, Zigbee, LoRaWAN). Extracting and analysing firmware using Binwalk and Firmadyne. Capturing and analysing MQTT/CoAP traffic using Wireshark. Detecting unauthorized access attempts. Capturing logs from IoT devices and cloud servers. Monitoring AWS IoT Core and Azure IoT Hub logs. Detecting unauthorized cloud access attempts. |
| 10 | **Books** | 1. Practical Internet of Things Security Brian Russell and Drew Van Duren Packt publishing<br>2. IoT Security Issues Alasdair Gilchrist De Gruyter, Inc. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Data Privacy in Social Networks |
| 5 | **Any prerequisite** | Computer networks, Data Security concepts, Social network platforms |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning Objectives of the subject** | ● Understand the key concepts related to data privacy in social networks.<br>● Analyze the privacy risks associated with sharing personal information on social platforms. |
| 8 | **Brief Contents** | Various privacy breaches and their effects; Privacy cases, litigations, and outcomes, Difference between data security and data privacy; Contextual integrity theory and applications, Online Social Networks (OSN), Data collection from social networks, Challenges, Opportunities, and pitfalls in online social networks, Image and location privacy; Ethics; Conducting studies; Privacy from 3rd party trackers and advertisers, Phishing in OSM and identifying fraudulent entities in online social networks, Privacy policies |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. "Data Privacy in the Internet Age" by M. L. K. and A. A. Iyer<br>2. "Security and Privacy in Social Networks" by Shancang Li and Li Da Xu |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Cyber Forensics: Tools and Techniques |
| 5 | **Any prerequisite** | Computer networks, Information systems security |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | ● Gain a solid understanding of the role and scope of cyber forensics in investigating digital crimes.<br>● Learn how to identify, preserve, and acquire digital evidence from various sources (computers, mobile devices, networks, etc.). |
| 8 | **Brief Contents** | Windows Forensics - Volatile data collection, Non-volatile data collection, Registry Analysis, Browser Usage, Hibernate File Analysis, Crash Dump Analysis, File System Analysis, File Metadata and Timestamp Analysis, Memory Forensics -Volatility Framework & plugins Memory acquisition, File Formats – PE/ELF/MachO, Processes and process injection, Command execution and User activity, Networking, sockets, paged memory |

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| | | and advanced registry artifacts, Virtual Machine Forensics - Types of Hypervisors, Hypervisor Files and Formats, Use and Implementation of Virtual Machines in Forensic Analysis, Use of VMware to establish a working version of suspect's machine, Networking and virtual networks within Virtual Machine, Forensic Analysis of a Virtual Machine |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. "Guide to Computer Forensics and Investigations" by Bill Nelson, Amelia Phillips, Christopher Steuart<br>2. "Practical Guide to Computer Forensics Investigations" by Darren R. Hayes |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Malware Analysis |
| 5 | **Any prerequisite** | Familiarity with programming languages |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | ● Understand the fundamental concepts of malware, its types, and its impact on cybersecurity.<br>● Identify and classify different types of malware based on their characteristics and behavior.<br>● Utilize static and dynamic analysis techniques to investigate malware samples.<br>● Reverse-engineer malware to analyze its internal structure and behavior.<br>● Apply debugging and sandboxing techniques to analyze malware in a controlled environment.<br>● Understand the ethical and legal considerations of malware analysis. |
| 8 | **Brief Contents** | Introduction to Malware, Malware Classification and Characteristics, Static and Dynamic Malware Analysis, Reverse Engineering Malware, Malware Detection and Evasion Techniques, Memory and Forensic Analysis, Mitigation and |

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|---|---|---|
| | | Prevention Strategies, Ethical and Legal Considerations in Malware Analysis. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. M. Sikorski and A. Honig, Practical Malware Analysis: The Hands-On Guide to Dissecting Malicious Software. No Starch Press, 2012.<br>2. M. Egele, D. Brumley, E. C. Kruegel, and G. Vigna, A Survey on Automated Dynamic Malware-Analysis Techniques and Tools, Springer, 2012. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Big Data and Cyber Fraud Analysis |
| 5 | **Any prerequisite** | Basic knowledge of Data Science and Programming |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | ● Understand the fundamentals of big data and its role in cyber fraud detection.<br>● Analyze various types of cyber fraud, including financial fraud, identity theft, and phishing attacks.<br>● Utilize big data tools and machine learning techniques for fraud detection.<br>● Apply anomaly detection techniques to uncover fraudulent activities.<br>● Explore real-world case studies and implement fraud detection models.<br>● Implement ethical and legal considerations in cyber fraud analysis. |
| 8 | **Brief Contents** | Overview of big data technologies (Hadoop, Spark, NoSQL databases), Data Acquisition and Processing for Fraud Analysis, Fraud Detection Techniques, Machine Learning for Cyber Fraud Analysis, Big Data Tools and Technologies for Fraud Analysis, Graph analytics for fraud networks (Neo4j, NetworkX), Case Studies and Emerging Trends, Ethical and Legal Considerations in Fraud Analysis. |
| 9 | **Contents for lab** | Nil |

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| 10 | **Books** | 1. A. Dehghantanha and K.-K. R. Choo, Eds., Handbook of Big Data Analytics and Forensics. Cham, Switzerland: Springer, 2021.<br>2. S. Kumar Shandilya, D. Gupta, and S. Sujay, Eds., Advancements in Cyber Crime Investigations and Modern Data Analytics. Boca Raton, FL: CRC Press, 2025. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Hardware Security |
| 5 | **Any prerequisite** | Basic knowledge of Digital Logic Design, Computer Architecture and Cryptography |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | ● Understand security threats and vulnerabilities in hardware systems.<br>● Analyze various hardware-based attacks and their countermeasures.<br>● Design and implement secure hardware architectures.<br>● Evaluate side-channel analysis techniques and defenses.<br>● Explore hardware trojans, backdoors, and mitigation strategies.<br>● Implement cryptographic hardware and analyze its security features.<br>● Understand physical security measures for embedded systems and IoT devices.<br>● Explore emerging trends in hardware security research. |
| 8 | **Brief Contents** | Digital system design: Basics and vulnerabilities, Hardware-Based Attacks, Secure Hardware Design Principles, Cryptographic Hardware and Implementations, Hardware Trojans and Backdoors, Physical Security and Embedded Systems, Emerging Trends in Hardware Security. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. M. Tehranipoor and C. Wang, Introduction to Hardware Security and Trust. New York, NY, USA: Springer, 2011.<br>2. R. Karri, O. Sinanoglu, A. Rajendran, and M. Tehranipoor, Trustworthy Hardware: Design, Security, and Verification. Cham, Switzerland: Springer, 2018. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Fault Tolerant Systems |
| 5 | **Any prerequisite** | Basic knowledge of computer architecture, operating systems and networking. |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | ● Understand the fundamentals of fault tolerance and reliability in computing systems.<br>● Analyze different types of faults, errors, and failures in computing systems.<br>● Implement fault detection, fault masking, and recovery techniques.<br>● Design and evaluate redundancy techniques, such as hardware, software, and time redundancy.<br>● Explore fault-tolerant network protocols and distributed computing mechanisms.<br>● Develop and assess checkpointing and recovery strategies.<br>● Apply real-world fault-tolerant system design principles in practical scenarios. |
| 8 | **Brief Contents** | Introduction to Fault Tolerance, Reliability, Availability, and Maintainability (RAM), Fault Detection and Diagnosis, Built-In Self-Test (BIST), Fault Masking and Recovery Mechanisms, Voting Mechanisms and Majority Logic, Fault Tolerant Architectures, Dependable Distributed Systems (Paxos, RAFT), Fault Tolerant Network and Storage Systems, Cloud Computing and Fault Tolerance, Case Studies and Applications. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. D. K. Pradhan and T. N. Vijaykumar, Fault-Tolerant Computing: Theory and Applications. Singapore: World Scientific, 2023.<br>2. I. Koren and C. M. Krishna, Fault-Tolerant Systems, 2nd ed. San Francisco, CA, USA: Morgan Kaufmann, 2020.<br>3. P. Jalote, Fault Tolerance in Distributed Systems. Upper Saddle River, NJ, USA: Prentice Hall, 1994. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Secure System Engineering |
| 5 | **Any prerequisite** | Computer Security Fundamentals or equivalent |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | ● Understand core security principles and apply them in system design.<br>● Identify and mitigate security threats and vulnerabilities.<br>● Implement secure software development and system hardening techniques.<br>● Apply risk assessment and management strategies in system engineering.<br>● Design secure architectures for applications, networks, and infrastructures.<br>● Utilize security tools for threat detection, prevention, and response.<br>● Evaluate compliance with security policies and regulatory frameworks. |
| 8 | **Brief Contents** | Software vulnerabilities, Software security and software quality assurance, Security requirement gathering principals and guidelines, Secure software architecture, Architecture risk analysis, Software security knowledge for architecture and design, Security guideline and attack patterns, testing software vulnerability in SDLC, Mitigating Software Vulnerabilities in SDLC, Static analysis techniques, Security testing, Operating software security, Maintaining software security. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. R. Anderson, Security Engineering: A Guide to Building Dependable Distributed Systems, 3rd ed. Hoboken, NJ, USA: Wiley, 2020.<br>2. C. P. Pfleeger and S. L. Pfleeger, Security in Computing, 5th ed. Upper Saddle River, NJ, USA: Pearson, 2015.<br>3. W. Stallings, Cryptography and Network Security: Principles and Practice, 8th ed. Upper Saddle River, NJ, USA: Pearson, 2023. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Blockchain Technology |
| 5 | **Any prerequisite** | Basic cryptography and data structure |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Get an overview of blockchain technology, its history, benefits, drawbacks, and future. Examine the nascent blockchain technology and make an initial pass at identifying some of its major vulnerabilities. Design, build, and deploy distributed applications. Equip students with the skills necessary to create e-governance applications for the public good. |
| 8 | **Brief Contents** | Overview of blockchain technology, Peer-to-Peer networking, Blockchain categories, Mining mechanism, Blockchain architecture: Pros & Cons, Bitcoin & protocol, Architecture of blockchain- Block, Byzantine General problem and Fault tolerance, Merkle tree, transactions and fee, Anonymity, Reward, Private and public blockchain, Bitcoin transaction structure, Double spending problem, Introduction to consensus Problem real-time of application of blockchain. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, and Steven Goldfeder. Bitcoin and cryptocurrency technologies: a comprehensive introduction. Princeton University Press, 2016.<br>2. Amrendra Singh Yadav et al, Applications of Blockchain Technology taylor and francis 2025, ISBN 9781032899862<br>3. R.Pass et al, Analysis of Blockchain protocol in Asynchronous networks, EUROCRYPT 2017, ( eprint.iacr.org/2016/454) . A significant progress and consolidation of several principles). |

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| **1** | **Semester** | **-** |
| **2** | **Type of course** | Elective |
| **3** | **Code of the subject** | MCSE-5XX |

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| 4 | **Title of the subject** | AI and ML Techniques for Cyber Security |
| 5 | **Any prerequisite** | Machine Learning |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The AI and ML Techniques for Cyber Security course aims to equip students with the knowledge and skills to apply artificial intelligence (AI) and machine learning (ML) to enhance cybersecurity. The objectives of the course typically include:<br>1. Understanding AI & ML Fundamentals in Cybersecurity<br>2. Identifying and Mitigating Cyber Threats<br>3. Implementing AI-Based Threat Intelligence<br>4. Developing Automated Cyber Defense Mechanisms<br>5. Exploring Ethical, Privacy, and Security Challenges<br>6. Hands-on Experience with AI/ML Tools<br>7. Enhancing Cyber Resilience and Risk Management<br>8. Develop risk assessment models using AI techniques.<br>By the end of the course, students should be able to apply AI/ML methods to real-world cybersecurity challenges, build intelligent defense systems, and understand the evolving role of AI in cybersecurity. |
| 8 | **Brief Contents** | Introduction: Artificial Intelligence in Cyber Security, Challenges and Promises, Security Threats of Artificial Intelligence, Use-Cases: Artificial Intelligence Email Observing. Machine Learning in Security: Applications of Machine Learning in Cyber Security Domain, Machine Learning: tasks and Approaches, Anomaly Detection, Privacy-Preserving Nearest Neighbour Search, Machine Learning Applied to Intrusion Detection, Online Learning Methods for Detecting Malicious Executables. Deep Learning in Security: Cyber Security Mechanisms Using Deep Learning Algorithms, Applying Deep Learning in Various Use Cases, Network Cyber threat Detection. Artificial Intelligence in Cyber Security: Model Stealing & Watermarking, Network Traffic Analysis, Malware Analysis. |
| 9 | **Contents for lab** | Gain hands-on experience with AI security tools like TensorFlow, Scikit-Learn, and other cybersecurity frameworks. Implementing an ML-based Intrusion Detection System, AI-driven Malware Classification and Detection, Using AI for Phishing URL Detection, Real-time Log Analysis and Threat Hunting with AI. |

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| **10** | **Books** | 1. "Machine learning for computer and cyber security: principle, algorithms, and practices", Brij B Gupta and Quan Z. Sheng, CRC Press.<br>2. "Machine Learning in Cyber Trust Security, Privacy, and Reliability, Philip S. Yu, Jeffrey J. P. Tsai, Springer New York, NY.<br>3. "Machine Learning and Security: Protecting Systems with Data and Algorithms", Clarence Chio, David Freeman,<br>4. "Artificial Intelligence in Cybersecurity", Kim-Kwang Raymond Choo, Ali Dehghantanha, Publisher: Springer. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Natural Language Processing |
| 5 | **Any prerequisite** | Machine Learning, Probability & Statistics |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | ● To understand the fundamentals of natural language processing (NLP) and its applications.<br>● To explore various computational linguistics techniques and machine learning methods for NLP.<br>● To develop proficiency in implementing NLP models using libraries such as NLTK, SpaCy, and Transformers. |
| 8 | **Brief Contents** | Introduction and Basic Text Processing, Spelling Correction, Language Modeling, Advanced smoothing for language modeling, POS tagging<br><br>Models for Sequential tagging – MaxEnt, CRF, Syntax – Constituency Parsing, Dependency Parsing<br><br>Distributional Semantics, Lexical Semantics, Topic Models<br><br>Entity Linking, Information Extraction, Text Summarization, Text Classification, Sentiment Analysis and Opinion Mining |
| 9 | **Contents for lab** | Hands-on implementation of text preprocessing, POS tagging, Named Entity Recognition, Word embeddings, and Transformer-based models using Python-based NLP frameworks. |
| 10 | **Books** | 1. Speech and Language Processing: An Introduction to Natural |

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| | | Language Processing, Computational Linguistics, and Speech Recognition by Daniel Jurafsky & James H. Martin<br>2. Foundations of Statistical Natural Language Processing by Christopher D. Manning & Hinrich Schütze |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Information Retrieval |
| 5 | **Any prerequisite** | Nil |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning objectives of the subject** | Some key learning objectives of Information Retrieval (IR) are as follows.<br>Understand the basics, search engine architecture, retrieval models, query processing, text classification and clustering, web search, retrieval evaluation, IR applications, practical implementation, and current trends and research |
| 8 | **Brief contents** | Overview of text retrieval systems, Search engine architecture, Retrieval models and implementation: Vector Space Models, Query expansion and feedback, Probabilistic models; statistical language models Text classification & Text clustering, Web search basics, crawling, indexes, Link analysis, Retrieval evaluation, IR applications |
| 9 | **Content for lab** | Nil |
| 10 | **Books** | 1. Introduction to Information Retrieval by Christopher D. Manning, Prabhakar Raghavan, and Hinrich Schütze<br>2. Text Information Retrieval Systems by Charles T. Meadow, Bert R. Boyce, and Donald H. Kraft<br>3. Information Retrieval: Implementing and Evaluating Search Engines by Stefan Büttcher, Charles L. A. Clarke, and Gordon V. Cormack<br>4. Modern Information Retrieval: The Concepts and Technology behind Search by Ricardo Baeza-Yates and Berthier Ribeiro-Neto<br>5. Search Engines: Information Retrieval in Practice by W. Bruce Croft, Donald Metzler, and Trevor Strohman |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Recommender Systems |
| 5 | **Any prerequisite** | Nil |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning objectives of the subject** | Some key learning objectives of Recommender Systems (RS) are as follows.<br>Understand fundamental concepts, recommendation data, introductory approaches, mathematical foundations, collaborative filtering, content-based recommendation, knowledge-based recommendation, evaluation, advanced topics, practical implementation, and case studies |
| 8 | **Brief contents** | Fundamental Elements of Recommendation, Recommendation Data, Introductory Approaches, Vectors and Neighbourhoods, Matrices, Embeddings, and Optimization, Collaborative Filtering, Content-based recommendation, Knowledge based recommendation, Evaluating Recommender System, Other aspects of recommender systems, Case studies. |
| 9 | **Contant for lab** | Nil |
| 10 | **Books** | 1. Recommender Systems: The Textbook by Charu C. Aggarwal<br>2. Recommender Systems Handbook edited by Francesco Ricci, Lior Rokach, and Bracha Shapira<br>3. Practical Recommender Systems by Kim Falk<br>4. Building Recommendation Engines by Suresh Kumar Gorakala and Michael R. Lakshmanan |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Reinforcement Learning |
| 5 | **Any prerequisite** | Machine Learning, Probability & Statistics |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | ● To understand the concepts of Markov Decision Processes and reinforcement learning algorithms. |

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| | | ● To explore value-based and policy-based reinforcement learning methods. |
| 8 | **Brief Contents** | Introduction, Bandit algorithms – UCB, PAC, Bandit algorithms – Median Elimination, Policy Gradient<br>Full RL & MDPs, Bellman Optimality, Dynamic Programming & TD Methods<br>Eligibility Traces, Function Approximation, Least Squares Methods<br>Fitted Q, DQN & Policy Gradient for Full RL, Hierarchical RL, POMDPs |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. Reinforcement Learning: An Introduction by Richard S. Sutton & Andrew G. Barto<br>2. Deep Reinforcement Learning Hands-On by Maxim Lapan |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Graphical Neural Networks |
| 5 | **Any prerequisite** | Machine Learning, Deep Learning, Graph Theory |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | ● To explore the fundamentals of graph representation learning and Graph Neural Networks (GNNs).<br>● To understand different types of GNN architectures and their applications.<br>● To implement GNN models using frameworks like PyTorch Geometric and DGL. |
| 8 | **Brief Contents** | ● Graph representation learning, Message Passing Neural Networks, Spectral and spatial GNNs, Graph Convolutional Networks (GCN), Graph Attention Networks (GAT), GraphSAGE, Graph autoencoders, Applications in bioinformatics, social networks, and recommendation systems. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. Graph Neural Networks: Foundations, Frontiers, and |

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| | | Applications by Zhou, Cheng, and Song<br>2. Deep Learning on Graphs by Yao Ma, Suhang Wang, Jure Leskovec |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Nature Inspired Computing |
| 5 | **Any prerequisite** | Linear Algebra, AI, Machine Learning |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The Nature Inspired Computing course aims to equip students with the knowledge and skills required to design, implement, and optimize nature-inspired computing models that run efficiently across various domains, including optimization, machine learning, robotics, and complex problem-solving. Students will explore biologically inspired algorithms, such as evolutionary computing, swarm intelligence, artificial immune systems, and neural models, understanding their theoretical foundations and practical applications.. The key learning objectives include:<br>1. Understand the Fundamentals of Nature-Inspired Computing<br>2. Explore Evolutionary Algorithms – Study Genetic Algorithms (GA), Differential Evolution (DE), and Evolutionary Strategies.<br>3. Learn Swarm Intelligence Techniques – Understand Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), and Artificial Bee Colony (ABC).<br>4. Study Artificial Immune Systems & Neural Models – Explore immune-based optimization and biologically inspired neural networks.<br>5. Apply Nature-Inspired Techniques to Real-World Problems – Solve optimization, classification, and clustering problems in AI and ML. |
| 8 | **Brief Contents** | Module 1: Introduction to Nature-Inspired Computing:<br>Overview of Bio-Inspired Computing, Natural Systems as Computational Models, Optimization vs. Heuristic Approaches |

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| | | Module 2: Evolutionary Algorithms (EAs): Genetic Algorithms (GA): Selection, Crossover, Mutation, Evolutionary Strategies & Differential Evolution, Real-world Applications of EAs<br>Module 3: Swarm Intelligence-Based Optimization: Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), Artificial Bee Colony (ABC) Algorithm<br>Module 4: Hybrid and Advanced Nature-Inspired Models: Hybridization of Nature-Inspired Algorithms<br>Firefly, Bat, and Cuckoo Search Algorithms, Quantum and Memetic Algorithms<br>Module 5: Applications of Nature-Inspired Computing: Machine Learning & Data Science, Robotics and Image Processing, Healthcare, Engineering, and Financial Modeling |
| 9 | **Contents for lab** | Implementation & Case Studies: Hands-on with Python-based NIC Libraries (DEAP, Inspyred), Applications of Nature-Inspired Computing in Machine Learning & Data Science, Robotics and Image Processing, Healthcare, Engineering, and Financial Modeling |
| 10 | **Books** | 1. "Nature-Inspired Optimization Algorithms" – Xin-She Yang<br>2. "Swarm Intelligence" – James Kennedy & Russell Eberhart<br>3. "Introduction to Evolutionary Computing" – Agoston E. Eiben & J.E. Smith<br>4. "Artificial Immune Systems: A New Computational Intelligence Approach" – Leandro N. de Castro & Jonathan Timmis<br>5. "Bio-Inspired Artificial Intelligence: Theories, Methods, and Technologies" – Dario Floreano & Claudio Mattiussi |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Meta-Heuristics for Multi-Objective Optimization |
| 5 | **Any prerequisite** | |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning objectives of the subject** | Some key learning objectives of Meta-Heuristics for Multi-Objective Optimization are as follows.<br>Understand basic concepts, familiarize with various meta-heuristic algorithms, application of meta-Heuristic algorithms in solving real-world multi-objective optimization problems in various domains, e.g., engineering, computer science, law economics. |

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| 8 | **Brief contents** | Introduction to multi-objective optimization: definition and importance of multi-objective optimization, real-world applications and challenges; pareto optimality: concept of pareto optimality, pareto front and pareto dominance; fundamentals of meta-heuristics: overview of meta-heuristic algorithms, comparison with traditional optimization methods; genetic algorithms: basics of genetic algorithms, application to multi-objective optimization; particle swarm optimization: fundamentals of particle swarm optimization, multi-objective particle swarm optimization techniques; ant colony optimization: introduction to ant colony optimization. application to multi-objective optimization problems; artificial bee colony algorithm: basics of artificial bee colony algorithm, multi-objective artificial bee colony algorithm; differential evolution algorithms: overview of differential evolution, multi-objective differential evolution; evaluation and comparison: methods for evaluating multi-objective optimization algorithms, performance metrics and benchmarking; case studies and applications: real-world case studies, applications in various fields; advanced topics: constraint handling, visualization techniques, hybrid meta-heuristics, recent trends and research direction. |
| 9 | **Content for lab** | Nil |
| 10 | **Books** | 1. A Guide to Meta-Heuristic Algorithms for Multi-objective Optimization: Concepts and Approaches by Archisman Banerjee, Sankarshan Pradhan, Bitan Misra, and Sayan Chakraborty<br>2. Applied Multi-objective Optimization edited by Nilanjan Dey<br>3. Metaheuristics for Multiobjective Optimisation by Springer-Verlag Berlin and Heidelberg GmbH & Co. KG |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Distributed Machine Learning |
| 5 | **Any prerequisite** | Machine Learning |

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| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The Distributed Machine Learning (DML) course aims to equip students with the knowledge and skills required to design, implement, and optimize ML models that run on distributed computing platforms. The key learning objectives include:<br><br>1. Understand Distributed ML Fundamentals<br>2. Explore Distributed Computing Frameworks<br>3. Implement Parallel and Distributed Training<br>4. Optimize Distributed Deep Learning<br>5. Manage Scalability and Resource Allocation<br>6. Gain Hands-on Experience – Work with TensorFlow, PyTorch, Horovod, and cloud-based ML platforms.<br>7. Explore Real-World Applications – Apply distributed ML in healthcare, finance, recommendation systems, etc. |
| 8 | **Brief Contents** | Fundamentals of distributed systems and parallel computing, Distributed Systems for ML, distributed optimization algorithms, decentralized learning frameworks, distributed deep learning architectures, fault tolerance and resilience in distributed ML systems, scalable data processing frameworks, distributed training of deep neural networks, communication-efficient algorithms for distributed learning, model aggregation methods, and case studies of real-world distributed ML applications across various domains like healthcare, finance, and IoT. |
| 9 | **Contents for lab** | Implementing Distributed Training with TensorFlow and PyTorch, Real-time ML Model Deployment on Cloud Services, Federated Learning Prototype on Edge Devices, Optimizing Distributed ML on GPUs and TPUs |
| 10 | **Books** | 1. "Distributed Machine Learning: Foundations, Trends, and Applications", Qiang Yang, Yang Liu, Yong Cheng, Publisher: Springer<br>2. "Distributed Machine Learning with Python", Guanhua Wang, Publisher: Packt Publishing<br>3. "Scaling Machine Learning with Spark", Adi Polak, Publisher: O'Reilly Media<br>4. "Hands-On Machine Learning with Scalable Python Libraries", Tarek Amr, Publisher: Packt Publishing |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Fair, Accountable, Transparent AI |
| 5 | **Any prerequisite** | Machine Learning |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The Fair, Accountable, Transparent AI course aims to equip students with the knowledge and skills required to apply fairness, accountability, and transparency principles in AI systems through real-world datasets and tools. The key learning objectives include:<br>1. Understand AI Ethics and Bias – Learn about fairness, accountability, and transparency in AI models.<br>2. Detect and Mitigate Bias in AI Systems – Study bias in datasets, algorithms, and decision-making.<br>3. Ensure Explainability and Interpretability – Explore techniques for making AI decisions understandable.<br>4. Implement Fair and Accountable AI Models – Learn fairness-aware ML techniques and responsible AI practices.<br>5. Study AI Governance and Regulations – Understand legal, ethical, and societal implications of AI.<br>6. Apply Responsible AI to Real-World Domains – Address fairness in healthcare, hiring, finance, and law enforcement. |
| 8 | **Brief Contents** | Introduction to responsible AI and the challenges, need of Responsible AI, principles of Responsible AI. Fairness and bias mitigation: fairness and values within AI, different forms of biases, Fairness & Bias in Networks, Researcher Bias, Algorithmic Bias and Feedback, Debiasing Methods, techniques for bias mitigation and measurement, transparency in AI and its importance, transparency in data and models. accountability in AI and its significance, concept of drift, including its various types, techniques for detecting drift in AI systems, data privacy in AI, Explore Privacy by Design, Understand AI security and the concept, robust and private AI applications. |
| 9 | **Contents for lab** | Nil |

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| 10 | **Books** | 1. "Fairness and Machine Learning: Limitations and Opportunities" – Solon Barocas, Moritz Hardt, Arvind Narayanan<br>2. "The Ethical Algorithm: The Science of Socially Aware Algorithm Design" – Michael Kearns, Aaron Roth<br>3. "Responsible AI: Implementing Ethical and Unbiased Algorithms" – Virginia Dignum<br>4. "Weapons of Math Destruction" – Cathy O'Neil<br>5. "Artificial Unintelligence: How Computers Misunderstand the World" – Meredith Broussard |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Machine Learning System Optimization |
| 5 | **Any prerequisite** | Machine Learning |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The Machine Learning System Optimization course aims to provide a comprehensive understanding of optimization techniques across different stages of the ML pipeline, including hyperparameter tuning, regularization, model compression, and hardware utilization. The key learning objectives include:<br>1. Understand Optimization in ML Systems<br>2. Optimize Model Training and Inference<br>3. Apply Hyperparameter Tuning<br>4. Enhance Hardware Utilization<br>5. Implement Regularization and Gradient Optimization<br>6. Use Model Compression and Quantization |
| 8 | **Brief Contents** | Module 1: Introduction to ML System Optimization: Challenges in Machine Learning Optimization, Trade-offs: Accuracy vs. Efficiency vs. Cost, Case Studies in ML System Optimization<br><br>Module 2: Optimization Algorithms in ML: Gradient Descent Variants (Batch, Stochastic, Mini-batch), Momentum, RMSprop, |

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| | | Adam, and Adaptive Learning Rates, Second-Order Optimization: Newton's Method<br><br>Module 3: Hyperparameter Tuning and Model Selection: Grid Search, Random Search, Bayesian Optimization<br><br>Automated Hyperparameter Optimization (Optuna, Hyperopt), Cross-Validation Strategies for Model Selection<br><br>Module 4: Regularization Techniques: L1, L2 (Ridge and Lasso), and ElasticNet Regularization, Dropout, Batch Normalization, and Early Stopping<br><br>Module 5: Model Compression and Quantization: Pruning and Knowledge Distillation, Quantization (Post-training vs. Quantization-aware training), TensorRT and ONNX for Optimized Model Deployment |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. C. Huyen, Machine Learning System Design, 2020.<br>2. A. Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 2nd ed., Sebastopol, CA: O'Reilly Media, 2019.<br>3. S. Sra, S. Nowozin, and S. Wright, Optimization for Machine Learning, Cambridge, MA: MIT Press, 2012.<br>4. A. Torfi, Efficient Deep Learning: Optimization, Inference and Model Compression, New York, NY: Springer, 2020. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Computational Biology |
| 5 | **Any prerequisite** | Algorithms, Probability & Statistics |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | ● To understand computational methods in biological data analysis.<br>● To explore sequence alignment, gene prediction, and biological network analysis. |

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| | | • To apply machine learning approaches in bioinformatics problems. |
| 8 | **Brief Contents** | Introduction to Mathematical Modelling, Introduction to Static Networks, Network Biology and Applications<br><br>Reconstruction of Biological Networks, Dynamic Modelling of Biological Systems: Introduction, Solving ODEs & Parameter Estimation, Evolutionary Algorithms, Guest Lectures on Modelling in Drug Development<br><br>Constraint-based approaches to Modelling Metabolic Networks, Perturbations to Metabolic Networks, Elementary Modes, Applications of Constraint-based Modelling<br><br>Constraint-based Modelling Recap, 13C Metabolic Flux Analysis, Modelling Regulation, Host-pathogen interactions, Robustness of Biological Systems, Advanced topics: Robustness and Evolvability, Introduction to Synthetic Biology, Perspectives & Challenges |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. Bioinformatics: Sequence and Genome Analysis by David W. Mount<br>2. Computational Biology: A Practical Introduction to BioData Processing and Analysis with Linux, MySQL, and R by Röbbe Wünschiers |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Pattern Recognition |
| 5 | **Any prerequisite** | Probability, Statistics, and Linear Algebra |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • To understand the basic concepts, scope, and applications of pattern recognition.<br>• To apply machine learning models to real-world pattern recognition tasks. |

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| 8 | **Brief Contents** | Module-1: The classification process: features, training and learning, approaches to classification Non metric methods: Information, Entropy and Impurity, decision tree classifier- ID3, C4.5.<br>Module-2: Discriminant functions: linear discriminant functions, piece-wise linear discriminant functions, generalized discriminant functions.<br>Module-3: Statistical pattern recognition: measured data and measurement errors, probability theory, conditional probability and Bayes rule, Naive Bayes classifier, Continuous random variables, The multivariate Gaussian, Covariance matrix and Mahalanobis distance Parametric learning: Bayesian decision theory, discriminant functions and decision boundaries, MAP (Maximum A Posteriori Estimator)<br>Module-4: Non Parametric learning: Histogram estimator and Parzen windows, k-NN classification, Artificial Neural Networks, Kernel Machines, SVM. Feature extraction and selection: reducing dimensionality, feature selection- Inter/Intra class distance,<br>Module-5: Feature extraction: Principal component analysis, Linear discriminant analysis. Unsupervised learning: Clustering, K- Means clustering, Fuzzy c-Means clustering,(Agglomerative) Hierarchical clustering Estimating and Comparing Classifiers: No free lunch, Bias and variance trade-off, cross-validation and resampling methods, Measuring classifier performance, Comparing classifiers- ROC curves, McNemar's test, other statistical tests |
| 9 | **Contents for lab** | Introduction to Pattern Recognition & Environment Setup, Data Preprocessing & Feature Extraction, Statistical Decision Theory & Bayes Classifier, Supervised Classification Methods, Neural Networks for Pattern Recognition¸ Hidden Markov Models (HMM) for Sequential Data, Real-World Applications & Project Work |
| 10 | **Books** | 1. R. O. Duda, P. E. Hart, and D. G. Stork, Pattern Classification, New York, NY, USA: Wiley, 2001.<br>2. G. Dougherty, Pattern Recognition and Classification, Berlin, Germany: Springer, 1995.<br>3. A. R. Webb, Statistical Pattern Recognition, New York, NY, USA: Wiley, 2002.<br>4. C. M. Bishop, Pattern Recognition and Machine Learning, New York, NY, USA: Springer, 2006. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Deep Learning Techniques |
| 5 | **Any prerequisite** | Linear Algebra, Machine Learning basics |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | ● To understand popular DL algorithms with their associated mathematical foundations for appreciating these algorithms.<br>● To help connect real-world problems to appropriate DL algorithm(s) for solving them and to enable formulating real world problems as deep learning tasks. |
| 8 | **Brief Contents** | Module-1: Course Overview: Introduction to Deep Learning and its Applications. Introduction to Statistical Learning: Multi-Layer Perceptron, Back Propagation, Linear Regression, Loss Functions and Optimization: Optimization, stochastic gradient descent, dropout, batch normalization, etc.<br><br>Module-2: Convolutional Neural Networks: Convolution, pooling, Activation Functions, Back propagation of CNN, Weights as templates, Translation invariance, Training with shared parameters. CNN Architecture Design and Discussion: AlexNet, VGG, GoogLeNet, ResNet, Capsule Net, etc. Visualization and Understanding: Visualizing intermediate features and outputs, Saliency maps, Visualizing neurons, Cam-Grad, etc.<br><br>Module-3: Sequential Modelling: Recurrent and Recursive Nets, RNN, LSTM, GRU, Image captioning, visual question answering, etc.<br><br>Module-4: Generative Models: Encoder, Decoders, Variational Autoencoders, Generative Adversarial Networks like pix2pix, CycleGAN, etc. Transformers based Models<br><br>Module-5: Deep Learning Applications: Object Detection: RCNN, Fast RCNN, Faster RCNN, YOLO and variants, Retina Net, etc., Adversarial Attacks on CNN Deep learning for NLP, Deep learning Libraries and Frameworks: Keras, TensorFlow, PyTorch, AutoML, etc. |
| 9 | **Contents for lab** | Introduction to Deep Learning & Environment Setup, Neural Networks and Backpropagation, Convolutional Neural Networks |

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| | | (CNNs), Recurrent Neural Networks (RNNs) & LSTMs, Transfer Learning & Pretrained Models, Generative Adversarial Networks (GANs), Autoencoders and Dimensionality Reduction, Reinforcement Learning Basics, Deployment of Deep Learning Models |
| 10. | **Books** | 1. I. Goodfellow, Y. Bengio, and A. Courville, Deep Learning. Cambridge, MA, USA: MIT Press, 2016.<br>2. M. A. Nielsen, Neural Networks and Deep Learning. [Online]. Available: http://neuralnetworksanddeeplearning.com, 2015. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Cognitive Science |
| 5 | **Any prerequisite** | |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | ● To Gain foundational knowledge about cognitive processing and its underlying neural mechanisms.<br>● To Explore different methodologies used to study cognition and brain activity.<br>● To Study the structure and function of neural circuits involved in cognitive processes.<br>● To Understand speech, language, and emotion processing – Analyze cognitive and neural mechanisms behind communication and decision-making. |
| 8 | **Brief Contents** | Introduction to cognition, the brain's structure, and cognitive processing fundamentals. Techniques for measuring cognition and brain activity (EEG, fMRI, etc.).<br><br>Basics of neural computation, neuron models, and information processing. Structure and function of neural circuits involved in cognition. |

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| | | Attention and perception mechanisms, their neural correlates. Learning and memory processes, synaptic plasticity, and cognitive models.<br><br>Speech and language processing in the brain. Emotion, decision-making, and their neural basis. Current research, emerging challenges, and future directions in cognitive science. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. Cognitive Science: An Introduction to the Study of Mind by Jay Friedenberg, Gordon Silverman<br>2. Principles of Neural Science by Eric R. Kandel, James H. Schwartz, Thomas M. Jessell |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Data Mining Techniques |
| 5 | **Any prerequisite** | Nil |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning objectives of the subject** | Some key learning objectives of data mining techniques are follows.<br><br>Understand fundamental concepts, data preprocessing, association analysis, classification techniques, clustering techniques, anomaly detection, dimensionality reduction, evaluation and validation, practical implementation, current trends and research |
| 8 | **Brief contents** | Introduction to data mining: definition and significance of data mining, applications and real-world examples; data preprocessing: data cleaning, data integration and transformation, data reduction; association analysis: basic concepts and algorithms, mining frequent patterns, associations, and correlations, advanced association analysis; classification: basic concepts and techniques, model evaluation and validation, handling imbalanced data, clustering: basic concepts and technique, cluster evaluation, |

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| | | advanced clustering techniques; anomaly detection: types of anomalies, detection techniques; dimensionality reduction: PCA, LDA, t-SNE etc.; text mining: text preprocessing, text representation, text classification and clustering; web Mining: web content mining, web structure mining, web usage mining; evaluation and Validation: cross-validation techniques, performance metrics for different data mining tasks, overfitting and underfitting issues; data mining tools and software; current trends and research |
| 9 | **Content for lab** | Nil |
| 10 | **Books** | 1. Data Mining: Concepts and Techniques by Jiawei Han, Micheline Kamber, and Jian Pei<br>2. Introduction to Data Mining by Pang-Ning Tan, Michael Steinbach, Anuj Karpatne, and Vipin Kumar<br>3. Data Mining: Practical Machine Learning Tools and Techniques by Ian H. Witten, Eibe Frank, Mark A. Hall, and Christopher J. Pal<br>4. Data Mining Techniques by Arun K. Pujari |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Cloud Computing |
| 5 | **Any prerequisite** | Computer Networks, OS, DBMS, Distributed Systems |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The Cloud Computing course aims to provide students with a comprehensive understanding of cloud technologies, architectures, and services.<br>This course covers fundamental cloud computing concepts, virtualization, containerization, cloud service models (IaaS, PaaS, SaaS), storage solutions, security, and cost optimization. Students will gain hands-on experience with leading cloud platforms for real-world cloud applications and industry certifications. The key learning objectives include: |

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| | | 1. Understand Cloud Computing Fundamentals<br>2. Explore Cloud Service and Deployment Models<br>3. Implement Virtualization and Containerization<br>4. Design and Deploy Scalable Cloud Applications<br>5. Manage Cloud Storage and Databases<br>6. Explore Emerging Cloud Trends |
| 8 | **Brief Contents** | Introduction to Cloud Computing, Cloud Types and Models: Private Cloud, Community Cloud, Public Cloud, Hybrid Clouds. Benefits and Challenges of Cloud Computing, Cloud Computing Deployment Models, Cloud Computing Service Models, Cloud Computing Architecture, Overview of Virtualization, Server Virtualization, Network Virtualization, Application Virtualization, Cloud Computing Services, Cloud Computing Security, Challenges, Issues, Public and Private, Cloud Computing Management, Cloud Computing Performance Management |
| 9 | **Contents for lab** | Setting up cloud accounts on AWS, Google Cloud, and Microsoft Azure, Exploring cloud service models (IaaS, PaaS, SaaS) and deployment models (Public, Private, Hybrid), Basic cloud CLI and SDK operations (AWS CLI, Azure CLI, GCP SDK)<br><br>Virtualization & Containerization: Creating and managing virtual machines (VMs) on AWS EC2, Google Compute Engine, and Azure VM, Implementing containerization using Docker (container creation, networking, and volumes), Deploying and managing Kubernetes clusters on cloud platforms<br><br>Cloud Storage & Databases: Configuring object storage (AWS S3, Google Cloud Storage, Azure Blob Storage)<br><br>Setting up and working with cloud-based relational databases (Amazon RDS, Google Cloud SQL, Azure SQL Database), Implementing NoSQL databases in the cloud (MongoDB Atlas, DynamoDB, Firebase) |
| 10 | **Books** | 1. "Cloud Computing: Principles and Paradigms" – Rajkumar Buyya, James Broberg, Andrzej M. Goscinski<br>2. "Cloud Computing: Theory and Practice" – Dan C. Marinescu<br>3. "Mastering Cloud Computing: Foundations and Applications Programming" – Rajkumar Buyya, Christian Vecchiola, Thamarai Selvi |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Advanced Software Engineering |
| 5 | **Any prerequisite** | Nil |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To provide practical knowledge in advanced software engineering, equipping students with skills in architecture, quality assurance, distributed systems, DevOps, and emerging technologies. |
| 8 | **Brief Contents** | Module 1: Introduction to Software Architecture, Architectural Styles (Layered, Client-Server, Microservices, Event-Driven), Architectural Decisions & Trade-offs Design Patterns, Creational Patterns (Singleton, Factory, Builder), Structural Patterns (Adapter, Composite, Proxy), Behavioral Patterns (Observer, Strategy, Command), Model-Driven Architecture (MDA), Component-Based Software Engineering (CBSE), Architectural Documentation and Evaluation<br><br>Module-2: Software Quality Attributes (Reliability, Maintainability, Security), Software Testing Fundamentals, Unit Testing, Integration Testing, System Testing, Functional vs Non-functional Testing Automated Testing & Test-Driven Development (TDD) Static and Dynamic Code Analysis, Software Process Improvement (CMMI, ISO Standards), Performance Testing & Security Testing<br><br>Module-3: DevOps Fundamentals, CI/CD Pipelines (Jenkins, GitHub Actions), Infrastructure as Code (Terraform, Ansible), Version Control Systems (Git, GitLab, GitHub), Automated Deployment & Monitoring, Cloud Deployment Strategies (Blue-Green, Canary), Logging & Monitoring (Prometheus, ELK Stack), Agile and Lean Software Development Site Reliability Engineering (SRE)<br><br>Module-4: AI-Driven Software Development AI in Code Generation (GPT-based Coding Assistants) Automated Bug Detection & Resolution Blockchain-Based Software Engineering |

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| | | Smart Contracts & Decentralized Applications Quantum Software Engineering Edge Computing & IoT Software Development Ethical and Sustainable Software Development. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. L. Bass, P. Clements, and R. Kazman, Software Architecture in Practice, 3rd ed. Boston, MA, USA: Addison-Wesley, 2012.<br>2. E. Gamma, R. Helm, R. Johnson, and J. Vlissides, Design Patterns: Elements of Reusable Object-Oriented Software. Boston, MA, USA: Addison-Wesley, 1994.<br>3. D. Galin, Software Quality Assurance: From Theory to Implementation. Upper Saddle River, NJ, USA: Prentice Hall, 2004.<br>4. G. Kim, J. Humble, P. Debois, and J. Willis, The DevOps Handbook. New York, NY, USA: IT Revolution Press, 2016.<br>5. G. Bonaccorso, AI for Software Engineers. Sebastopol, CA, USA: O'Reilly Media, 2019. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Machine Learning for Operations (MLOps) |
| 5 | **Any prerequisite** | Nil |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | ● To understand MLOps principles and lifecycle management.<br>● To implement and automate ML pipelines using orchestration tools.<br>● To deploy and scale ML models effectively in production.<br>● To apply MLOps best practices to real-world industry use cases. |
| 8 | **Brief Contents** | Module 1: Introduction to MLOps & ML Lifecycle: Introduction to MLOps, What is MLOps? Differences between ML development and ML operations, Benefits of MLOps in production, Overview of the ML Lifecycle, Data collection, model training, validation, deployment, and monitoring, |

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| | | Reproducibility & Version Control for ML Models, Model and data versioning (DVC, MLflow), Experiment tracking<br>Module-2: ML Pipelines and CI/CD for ML: Automating ML Pipelines, Pipeline orchestration tools (Kubeflow, Apache Airflow, Prefect), DAG-based workflow management, Continuous Integration & Continuous Deployment (CI/CD) for ML, Automated testing for ML models, Model validation and rollback strategies, Feature Stores and Data Engineering for ML, Feature extraction, storage, and retrieval ,Tools: Feast, Tecton<br>Module-3: ML Model Deployment Strategies Batch vs real-time (online) inference REST API-based deployments (Flask, FastAPI), Scaling ML Models Model serving frameworks (TensorFlow Serving, TorchServe, KServe), Load balancing and autoscaling (Kubernetes, AWS Lambda), Edge AI and Model Optimization, Deploying models on edge devices (TensorFlow Lite, ONNX), Model quantization and pruning<br>Module-4: ML Model Monitoring & Observability Detecting model drift and concept drift, Tools: Evidently AI, WhyLabs, Arize AI, Logging and Debugging ML Models, Logging ML predictions and performance metrics, Tools: MLflow, Prometheus, Grafana, ML Governance, Security, and Compliance, Bias and fairness in ML models GDPR and responsible AI practices<br>Module-5: Advanced MLOps Architectures, Multi-cloud and hybrid MLOps, Serverless ML and , Kubernetes-based deployments, Case Studies & Industry Applications, MLOps in healthcare, finance, and eCommerce, Real-world challenges in ML deployment, Future of MLOps, AI-assisted MLOps (AutoML, AI-powered monitoring), Ethical considerations and sustainability in MLOps |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. N. Gift and A. Deza, Practical MLOps: Operationalizing Machine Learning Models. Sebastopol, CA, USA: O'Reilly Media, 2022.<br>2. H. Hapke and C. Nelson, Building Machine Learning Pipelines. Sebastopol, CA, USA: O'Reilly Media, 2020.<br>3. C. Osipov, MLOps Engineering at Scale. Sebastopol, CA, USA: O'Reilly Media, 2022.<br>4. R. Gao, Accelerating AI with MLOps. Birmingham, UK: Packt Publishing, 2021. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Data Science |
| 5 | **Any prerequisite** | Nil |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Understand Core Data Science Concepts Apply Statistics & Probability in Data Science Implement Machine Learning Models Develop Data-Driven Applications |
| 8 | **Brief Contents** | Module 1: Descriptive Analysis: Introduction to Descriptive Statistics, Measures of Central Tendency, Measures of Dispersion, Shape of Distributions, Visualization Techniques, Data Summarization Techniques<br><br>Module 2: Statistical and Inference Analysis: Basic Probability Theory, Probability Rules, Hypothesis Testing, Null and Alternative Hypothesis, Type I and Type II Errors, One-tailed Vs Two tailed test, Parametric and non-parametric tests, Paired and Independent tests (T-tests, Chi-Square Test, ANOVA, Wilcoxon Test, etc.), Sampling and Estimation, Correlation and Covariance.<br><br>Module 3: Regression Analysis: Linear Regression, Simple Linear Regression, Multiple Linear Regression, Assumptions in Linear Regression<br><br>Module 4: Data Preprocessing: Data Cleaning, Handling Missing Data (Imputation, Dropping), Handling Duplicates, Data Normalization, Dimensionality Reduction (PCA, LDA),<br><br>Module 5: Machine Learning Classification: Introduction to Classification, Difference Between Regression and Classification, Classification vs. Clustering, Supervised Learning, Neural Networks, Multilayer Perceptron, Backpropagation, Activation Functions , Model Building and Evaluation |
| 9 | **Contents for lab** | Nil |

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| 10 | **Books** | 1. T. Hastie, R. Tibshirani, and J. Friedman, The Elements of Statistical Learning: Data Mining, Inference, and Prediction, 2nd ed. New York, NY, USA: Springer, 2009.<br>2. A. Géron, Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow. Sebastopol, CA, USA: O'Reilly Media, 2019.<br>3. A. Zheng and A. Casari, Feature Engineering for Machine Learning. Sebastopol, CA, USA: O'Reilly Media, 2018.<br>4. J. Daniel, Data Science at Scale with Python and Dask. Sebastopol, CA, USA: O'Reilly Media, 2020. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Data Visualization and Explainable Model |
| 5 | **Any prerequisite** | Nil |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | ● Design effective and interactive data visualizations using Python, R, and BI tools.<br>● Interpret machine learning models using SHAP, LIME, and PDP.<br>● Identify and mitigate bias in AI models for fair decision-making.<br>● Debug models using interpretability techniques for better performance.<br>● Apply XAI techniques to real-world case studies in healthcare, finance, and other industries. |
| 8 | **Brief Contents** | Module 1: Fundamentals of Data Visualization: Principles of Effective Data Visualization, Importance of data visualization, Cognitive perception and visual encoding, Types of Data Visualizations,<br><br>Module 2: Advanced Visualization Techniques, Interactive and Dynamic Visualizations |

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| | | Module 3: Introduction to Explainable AI (XAI) and Model Interpretability: Introduction to Explainability in Machine Learning, SHAP (Shapley Additive Explanations) & LIME (Local Interpretable Model-agnostic Explanations), Understanding SHAP values, Local vs. global interpretability<br><br>Module 4: Model Debugging, Bias Detection, and Fairness<br><br>Module 5: Case Studies & Real-World Applications of XAI |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. E. R. Tufte, The Visual Display of Quantitative Information. Cheshire, CT, USA: Graphics Press, 1983.<br>2. C. N. Knaflic, Storytelling with Data: A Data Visualization Guide for Business Professionals. Hoboken, NJ, USA: Wiley, 2015.<br>3. K. Healy, Data Visualization: A Practical Introduction. Princeton, NJ, USA: Princeton University Press, 2018.<br>4. W. Samek and G. Montavon, Explainable AI: Interpreting, Explaining and Visualizing Deep Learning. Cham, Switzerland: Springer, 2019.<br>5. S. Barocas and M. Hardt, Fairness and Machine Learning: Limitations and Opportunities. Cambridge, MA, USA: Cambridge University Press, 2020. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Time Series Data Analysis |
| 5 | **Any prerequisite** | Statistics, Machine Learning Concepts |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | ● Understand time series components (trend, seasonality, noise).<br>● Preprocess, visualize, and test for stationarity in time series data.<br>● Apply statistical models (ARIMA, SARIMA) and machine learning techniques. |

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| | | ● Evaluate model performance using error metrics (RMSE, MAE, MAPE). |
| 8 | **Brief Contents** | An introduction to time-series and stationary data, descriptive methods, plots, smoothing, differencing; the autocorrelation function, the correlogram and variogram, the periodogram; estimation and elimination of trend and seasonal components; stationary processes, modelling and forecasting with autoregressive moving average (ARMA) models; spectral analysis, the fast Fourier transform, periodogram averages and other smooth estimates of the spectrum; time-invariant linear filters; non-stationary and seasonal time series models; ARIMA processes, identification, estimation and diagnostic checking, forecasting, including extrapolation of polynomial trends, exponential smoothing, and the Box-Jenkins approach, Advanced time-series concepts |
| 9 | **Contents for lab** | Tentative list:<br>Lab 1: Load, visualize, and identify components of time series data.<br>Lab 2: Preprocess data (handle missing values, stationarity testing with ADF test).<br>Lab 3: Time series visualization (line plots, ACF/PACF, smoothing techniques).<br>Lab 4: Implement ARIMA and SARIMA models for forecasting.<br>Lab 5: Apply machine learning (Regression, Random Forest) and deep learning (LSTM).<br>Lab 6: Evaluate model performance (RMSE, MAE, MAPE) and work on real-world datasets. |
| 10 | **Books** | 1. R. H. Shumway and D. S. Stoffer, Time Series Analysis and Its Applications: With R Examples, 4th ed. New York, NY, USA: Springer, 2017.<br>2. W. A. Woodward, H. L. Gray, and A. C. Elliott, Applied Time Series Analysis, 2nd ed. Boca Raton, FL, USA: Chapman & Hall/CRC, 2011. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |

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| 4 | **Title of the subject** | Quantum Computing |
| 5 | **Any prerequisite** | Probability and Statistics, Algorithms & Complexity Theory, Quantum Mechanics |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | ● Understand qubits, superposition, and entanglement.<br>● Master quantum algorithms like Shor's and Grover's.<br>● Develop skills in quantum programming using Qiskit or Cirq.<br>● Explore quantum complexity and the difference between classical and quantum computing.<br>● Investigate quantum hardware and practical applications (cryptography, optimization). |
| 8 | **Brief Contents** | Introduction to Quantum Information, Quantum Algorithms Basic, Quantum Cryptanalysis Electronic, Post-Quantum Cryptography, Introduction and IBM Quantum Perspective, Quantum Algorithms Advanced: Implication of Shor's algorithm towards factorization and Discrete Logarithm based classical public key, Cryptosystems, Basic Quantum key distribution, Advanced Quantum key distribution |
| 9 | **Contents for lab** | Tentative list:<br>Lab 1: Introduction to Qubits and Quantum Gates – Simulate basic quantum gates (X, H, CNOT).<br>Lab 2: Implement Superposition and Entanglement – Create and manipulate entangled states.<br>Lab 3: Simulate Quantum Algorithms – Implement Grover's Search algorithm on a quantum simulator.<br>Lab 4: Implement Shor's Algorithm – Factor small numbers using quantum computing techniques.<br>Lab 5: Quantum Teleportation – Demonstrate quantum teleportation on a simulator.<br>Lab 6: Explore Quantum Error Correction – Simulate simple quantum error correction codes.<br>Lab 7: Run Quantum Algorithms on Real Quantum Hardware – Use IBM Quantum Experience or similar platforms.<br>Lab 8: Quantum Cryptography – Implement basic quantum key distribution protocols (e.g., BB84). |
| 10 | **Books** | 1. Quantum Computation and Quantum Information by Michael A. Nielsen, Isaac L. Chuang<br>2. Quantum Computing: A Gentle Introduction by Eleanor G. Rieffel, Wolfgang H. Polak |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Robotics and Intelligent Systems (Multi-Agents) |
| 5 | **Any prerequisite** | Kinematics, Dynamics & Control, Algorithms, Engineering Mathematics |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | ● Understand the fundamentals of robotics and intelligent systems.<br>● Learn about multi-agent systems and their applications.<br>● Develop skills in robot motion planning and control algorithms.<br>● Study sensor integration and perception for autonomous systems.<br>● Implement multi-agent coordination and collaboration strategies.<br>● Explore reinforcement learning in the context of multi-agent environments.<br>● Investigate decision-making processes in intelligent systems.<br>● Apply concepts to real-world problems in areas like autonomous vehicles and smart manufacturing. |
| 8 | **Brief Contents** | System Modelling: Declarative-Procedural-Reflexive Hierarchy for Decision-Making and Control, Control System Principles, Computing, Measurement, State, and Parameter Estimation, Decision-Making and Machine Learning: Classification of Data Sets, Task Planning for Individual and Multiple Agents, Numerical Methods for Evaluation and Search, Expert Systems, Neural Networks for Classification and Control |
| 9 | **Contents for lab** | Tentative list:<br>Lab 1: Introduction to Robotic Kinematics – Simulate robot arm movement using forward and inverse kinematics.<br>Lab 2: Implementing Path Planning Algorithms – Use A* and Dijkstra's Algorithm for robot navigation.<br>Lab 3: Simulate Sensor Integration – Integrate sensors (LIDAR, cameras) for obstacle detection and localization. |

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| | | Lab 4: Multi-Agent Coordination – Implement multi-agent systems (MAS) for task allocation and pathfinding.<br>Lab 5: Swarm Robotics – Simulate swarm behaviors using simple rules (e.g., flocking, foraging).<br>Lab 6: Robot Localization & Mapping – Implement SLAM (Simultaneous Localization and Mapping).<br>Lab 7: Autonomous Navigation – Develop an autonomous robot using PID control and state estimation.<br>Lab 8: Multi-Agent Communication – Simulate multi-agent communication protocols for coordination and negotiation. |
| 10 | **Books** | 1. Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations – Yoav Shoham, Kevin Leyton-Brown<br>2. Robot Modeling and Control – Mark W. Spong, Seth Hutchinson, M. Vidyasagar<br>3. Multiagent Systems: A Modern Approach to Distributed Artificial Intelligence – Jacques Ferber |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Big Data Analytics |
| 5 | **Any prerequisite** | Mathematics (Linear Algebra, Probability & Statistics)<br>Algorithms & Data Structures, Database Management Systems (SQL, NoSQL) |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | ● Understand the fundamentals of Big Data and its characteristics (volume, velocity, variety).<br>● Learn data storage techniques and tools for handling large datasets (e.g., Hadoop, NoSQL databases).<br>● Explore data processing frameworks like MapReduce, Spark, and Hadoop Ecosystem.<br>● Master data analysis techniques for big data using tools like R, Python, and SQL. |

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| | | ● Apply machine learning and data mining algorithms to big data for predictive analytics.<br>● Understand data visualization tools and techniques for large-scale datasets.<br>● Explore cloud computing and distributed systems for big data processing.<br>● Develop skills to handle data security and privacy issues in big data environments. |
| 8 | **Brief Contents** | Foundations of Scalable and Distributed Storage and Computation, Distributed Storage, Distributed Batch Processing, High-level Dataflow Languages, Streaming Analytics, Distributed Transaction Processing, Streaming and Real-time Messaging Systems in Big Data, Data Visualization with Power BI, Case Study: Spark vs Kafka and when to use them, Case Studies |
| 9 | **Contents for lab** | Tentative list:<br>Lab 1: Introduction to Big Data Tools – Explore tools like Hadoop, Spark, and Hive.<br>Lab 2: Data Collection and Storage – Work with NoSQL databases (e.g., MongoDB, Cassandra).<br>Lab 3: Data Preprocessing – Clean and transform large datasets using Pandas and Spark.<br>Lab 4: Distributed Data Processing with Hadoop MapReduce – Implement simple word-count algorithm.<br>Lab 5: Parallel Computing with Apache Spark – Perform data analysis using RDDs and DataFrames.<br>Lab 6: Machine Learning with Big Data – Train machine learning models using Spark MLlib.<br>Lab 7: Data Visualization – Visualize large datasets using tools like Tableau or Matplotlib.<br>Lab 8: Real-time Data Analytics – Analyze streaming data using Apache Kafka and Spark Streaming. |
| 10 | **Books** | 1. Introduction to Autonomous Robots: Mechanisms, Sensors, Actuators, and Algorithms by Nikolaus Correll, Bradley Hayes, and others<br>2. Multi-Agent Systems: A Modern Approach to Distributed Artificial Intelligence by Gerhard Weiss |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Complexity and Advanced Algorithms |
| 5 | **Any prerequisite** | Discrete Mathematics, Algorithms and Data Structures |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | ● Understand the Church–Turing Thesis, decidability, and reducibility in computability theory.<br>● Analyze time and space complexity, and classify problems into complexity classes like P, NP, and NP-complete.<br>● Formulate and solve optimization problems using LP relaxation, duality, and approximation algorithms.<br>● Design and analyze graph algorithms for maxflow and bipartite matching problems.<br>● Cultivate Critical Thinking and Problem-Solving Skills |
| 8 | **Brief Contents** | Computability Theory: The Church–Turing Thesis, Decidability, Reducibility.<br>Complexity Theory: Time Complexity, Space Complexity, Intractability.<br>Linear thinking: LP Relaxations & Approximation Algorithms, Linear Programming Duality.<br>Graph Algorithms: Maxflow, bipartite matching |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. Introduction to the Theory of Computation, M. Sipser, 2nd edition.<br>2. Algorithms. Jeff Erickson. 1$^{st}$ edition 2023.<br>3. Computational Complexity, Christos H. Papadimitriou, 1$^{st}$ edition 1994 |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Randomized Algorithms |
| 5 | **Any prerequisite** | Discrete Mathematics, Algorithms |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | ● Design and analyze randomized algorithms for hashing, fingerprinting, and random walks.<br>● Apply randomized techniques to solve number-theoretic problems and approximate counting. |
| 8 | **Brief Contents** | Discrete Probability and Randomized Algorithms: Review of Discrete Probability, Introduction to randomized algorithms, Markov, Chebyshev Inequalities, Chernoff Bounds; Probabilistic Techniques in Specific Algorithms: Hashing and Fingerprinting, random walks and Markov chains; Randomized Algorithms in Specific Problem Domains: Program Checkers, Polynomial Identities, Randomized Complexity Classes; Number Theoretic Problems and Approximate Counting: Some Number Theoretic Problems, Approximate Counting |
| 9 | **Contents for lab** | Nil |
| **10** | **Books** | 1. Probability and Computing: Randomized Algorithms and Probabilistic Analysis, Michael Mitzenmacher and Eli Upfal (2005, 1st Edition)<br>2. Randomized Algorithms, Rajeev Motwani and Prabhakar Raghavan (1995, 1st Edition)<br>3. Algorithm Design, Jon Kleinberg and Éva Tardos (2005, 1st Edition)<br>4. Randomized Algorithms for Matrices and Data, Michael W. Mahoney (2021, 1st Edition)<br>5. Approximation Algorithms, Vijay V. Vazirani (2003, 1st Edition) |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Algorithmic Game Theory |
| 5 | **Any prerequisite** | Basic knowledge of probability and Linear Algebra |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | ● Understand the Church–Turing Thesis, decidability, and reducibility in computability theory.<br>● Analyze time and space complexity, and classify problems into complexity classes like P, NP, and NP-complete.<br>● Formulate and solve optimization problems using LP relaxation, duality, and approximation algorithms.<br>● Design and analyze graph algorithms for maxflow and bipartite matching problems.<br>● Cultivate Critical Thinking and Problem-Solving Skills |
| 8 | **Brief Contents** | Non-cooperative game theory: Extensive Form Games, Strategic Form Games, Matrix Games, Bayesian Games; Complexity of Computing a Nash Equilibrium: The Class PPAD , NASH is PPAD-complete; MECHANISM DESIGN: Basics of mechanism design, Myerson's lemma, Stable matching; Selfish routing and Price of anarchy, No regret dynamics |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. Nisan/Roughgarden/Tardos/Vazirani (eds), Algorithmic Game Theory, Cambridge University, 2007 (available for free from here).<br>2. Game Theory by Michael Maschler, Eilon Solan, and Shmuel Zamir.<br>3. Game Theory and Mechanism Design by Y. Narahari.<br>4. Twenty Lectures on Algorithmic Game Theory, Tim Roughgarden, Cambridge University Press, Year: 2016 |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Computational Learning Theory |
| 5 | **Any prerequisite** | Probability and Statistics, Linear Algebra, Calculus, Discrete Mathematics, Algorithms and Complexity Theory, Formal Languages and Automata Theory, Machine Learning |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | ● Understand the fundamental concepts of computational learning theory, including PAC learning, VC dimension, and hypothesis classes.<br>● Analyze the efficiency and limitations of different learning algorithms in terms of sample complexity and computational complexity.<br>● Apply mathematical frameworks to evaluate the generalization ability of machine learning models.<br>● Explore key learning paradigms such as supervised learning, unsupervised learning, and reinforcement learning from a theoretical perspective. |
| 8 | **Brief Contents** | Introduction to Machine Learning: Types of Machine Learning Algorithms, Basics of Supervised Learning, Unsupervised Learning Approaches; Model Complexity and Overfitting: Understanding Overfitting in Machine Learning, Bias-Variance Trade-off, Regularization Techniques; Statistical and Computational Learning Models: Overview of Statistical Learning Models, Computational Models in Machine Learning, Relationships between Statistical and Computational Models; PAC Learning: Definition and Concepts of PAC Learning, Sample Complexity in PAC Learning, Algorithmic Aspects of PAC Learning. |
| 9 | **Contents for lab** | Tentative list:<br>Lab 1: Introduction to Learning Theory<br>Lab 2: PAC Learning Model<br>Lab 3: VC Dimension & Sample Complexity<br>Lab 4: Learning with Noise & Statistical Learning<br>Lab 5: Online Learning & Mistake Bound Model |

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| | | Lab 6: Boosting & Ensemble Learning<br>Lab 7: SVMs & Kernel Methods<br>Lab 8: Bayesian Learning & Probabilistic Models<br>Lab 9: Deep Learning & Neural Networks |
| 10 | **Books** | 1. Learning Theory: An Approximation Theory Viewpoint by Manfred K. Warmuth, David L. D. Lee<br>2. Machine Learning: A Probabilistic Perspective by Kevin P. Murphy |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Biometric Image Processing |
| 5 | **Any prerequisite** | Signal Processing |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To understand popular image processing methods/algorithms with their associated mathematical foundations for real-world applications to person identification and access control. With this knowledge, the student can work in a variety of sectors that need to maintain accuracy, security, and trust in identification systems. |
| 8 | **Brief Contents** | Biometric System Components, Performance Metrics, Biometric Applications, Face Recognition Fundamentals, Preprocessing and Feature Extraction, Challenges in Face Recognition, Exploration of Other Biometric Modalities, Iris Recognition, Voice Recognition, Hand Recognition, Advanced Concepts and Techniques, Fusion Strategies, Hidden Biometrics, Machine Learning in Biometrics, Applications and Contextualization, Biometric Standards, Liveness Detection, Privacy and Ethical Considerations |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. Anil K. Jain, Arun A. Ross, and Karthik Nandakumar, “Introduction to Biometrics,” Springer Publishing Company<br>2. D. Jhang, X. Jing,and J. Yang, “ Biometric Image Discrimination Technologies: Computational Intelligence and its Applications Series,” IGI Global. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Perception for Autonomous Systems |
| 5 | **Any prerequisite** | Introduction to robotics |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To understand the major hurdles in building autonomous systems. In this course, some fundamental measurement concepts will be reviewed considering the autonomous systems domain, with an emphasis on localization and positioning problems. To discuss the main issues and concepts that build around the statistical approach to measure the main role of uncertainties. |
| 8 | **Brief Contents** | Overview, History, Visual Abstraction, Driving Policy, Reinforcement Learning, Markov Decision Processes, Bellman Optimality and Q-Learning, Deep Q-Learning, Vehicle Control, Optimal Control, Odometry, SLAM and Localization, Simultaneous Localization and Mapping, Stereo Matching, Freespace and Stixels, Optical Flow, Scene Flow, Object Detection and Tracking, LiDAR and Vision sensors, Performance Evaluation, Sliding Window Object Detection, Region Based CNNs, 3D Object Detection, Filtering, Association, Holistic Scene Understanding. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. Shaoshan Liu , Liyun Li , Jie Tang , Shuang Wu , and Jean-Luc Gaudiot, “Creating Autonomous Vehicle Systems,” Springer Nature, Switzerland.<br>2. Rui Fan, Sicen Guo, Mohammud Junaid Bocus, “Autonomous Driving Perception: Fundamentals and Applications,” Springer.<br>3. Yue Yufeng and Wang Danwei, “Collaborative Perception, Localization and Mapping for Autonomous Systems,” Springer. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Computer Vision |
| 5 | **Any prerequisite** | Signal Processing |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | This area is one of the most growing areas and need trained professional. Industries like healthcare, automotive, retail, agriculture, and security increasingly use computer vision. In this course the students will be exposed to methods/algorithms used in the field of object detection & recognition, image formation, regression analysis, image/video analysis, texture analysis etc, With a Computer Vision course, one can pursue various roles such as: Computer Vision Engineer, Machine Learning Engineer, Data Scientist, Robotics Engineer and AI Researcher. |
| 8 | **Brief Contents** | Image Formation, Image acquisition, Image representation, Basic image processing, Feature Extraction and Matching, Interest point detection, Camera calibration, Feature descriptors, Feature matching and image correspondence, Object Detection and Recognition, Template matching and sliding window detection, Hough transforms for shape detection, Introduction to classification-based detection, Image Segmentation, Thresholding and region growing, Edge-based segmentation, Graph-based segmentation methods, 3D Vision, Stereo vision and depth estimation, Structure from motion, Basic concepts of 3D reconstruction techniques, Image registration, Applications of Computer Vision. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. Richard Szeliski, "Computer Vision: Algorithms and Applications," Springer-Verlag, London<br>2. Dana H. Ballard, and Christopher M. Brown, "Computer Vision," Prentice Hall.<br>3. David A. Forsyth and Jean Ponce, "Computer Vision: A Modern Approach," Pearson<br>4. Rajalingappaa Shanmugamani, "Deep Learning for Computer Vision," Packt Publishing |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Remote Sensing and Satellite Image Processing |
| 5 | **Any prerequisite** | Image Processing |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Studying Remote Sensing and Satellite Image Processing is motivated by the ability to gather data about large areas of the Earth's surface from a distance, which significantly contributes to various real-world applications such as land cover monitoring, disaster management, urban planning, traffic control, and so on. The proposed course provides basic understanding about digital image processing of Remote Sensing datasets / images acquired by different earth resources satellites. It will improve understanding about overall remote sensing data processing leading to the job opportunities in the as satellite or geospatial engineers. |
| 8 | **Brief Contents** | Introduction to Interaction Design, Understanding Users: Cognitive psychology, perception, human capabilities and limitations, Design Principles, Guidelines, and Heuristics, The Interaction Design Process, Requirement Gathering Techniques, Prototyping Methods, Evaluation of Interactive Systems, Traditional GUIs: Desktop, windows, menus, controls, Web Interaction Design, Mobile and Wearable Interfaces, Beyond the Screen: Tangible interaction, Introduction to virtual/augmented reality, Social and Collaborative Interaction, Designing for Social Interaction: Communication, awareness, social affordances, Accessibility and Inclusive Design: Universal design principles, assistive technologies. Computer-Supported Cooperative Work. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. Thomas M. Lillesand, Ralph W. Kiefer, Jonathan W. Chipman, “Remote Sensing and Image Interpretation,” Wiley<br>2. Siamak Khorram , Cynthia F. van der Wiele , Frank H. Koch , Stacy A. C. Nelson , Matthew D. Potts, “Principles of Applied Remote Sensing,” Springer Nature.<br>3. Surekha Borra, Rohit Thanki, Nilanjan Dey, “Satellite Image Analysis: Clustering and Classification,” Springer |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Human-Computer Interaction |
| 5 | **Any prerequisite** | Image Processing/ Computer Vision |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The primary focus here is on understanding and improving the interaction between humans and different technologies, such as traditional desktop computers, smartphones, and smart appliances. This course offers a comprehensive exploration of human-computer interaction (HCI) design and practical applications. In this course key topics such as user-centered design thinking, usability principles, interface development, rapid prototyping methodologies, and evaluation techniques will be explored and students will be equipped to differentiate between human-computer interaction, user experience design, and design thinking concepts. Moreover, students will gain proficiency in applying user-centered design strategies, data gathering techniques, rapid prototyping tools, and methods for effectively communicating design concepts. |
| 8 | **Brief Contents** | Introduction to Interaction Design, Understanding Users: Cognitive psychology, perception, human capabilities and limitations, Design Principles, Guidelines, and Heuristics, The Interaction Design Process, Requirement Gathering Techniques, Prototyping Methods, Evaluation of Interactive Systems, Traditional GUIs: Desktop, windows, menus, controls, Web Interaction Design, Mobile and Wearable Interfaces, Beyond the Screen: Tangible interaction, Introduction to virtual/augmented reality, Social and Collaborative Interaction, Designing for Social Interaction: Communication, awareness, social affordances, Accessibility and Inclusive Design: Universal design principles, assistive technologies. Computer-Supported Cooperative Work. |
| 9 | **Contents for lab** | Nil |

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| 10 | **Books** | 1. Serengul Smith-Atakan, "Human--Computer Interaction: Basics and Practice," Cengage Learning.<br>2. Helen Sharp, Yvonne Rogers, Jenny Preece, "Interaction Design: Beyond Human-Computer Interaction," Wiley.<br>3. Don Norman, "The Design of Everyday Things," Basic Books.<br>4. Ben Shneiderman, Catherine Plaisan,Maxine Cohen, Steven Jacobs, Niklas Elmqvist, and Nicholas Diakopoulos, "Designing the User Interface: Strategies for Effective Human-Computer Interaction," Pearson |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Medical Imaging |
| 5 | **Any prerequisite** | Image Processing |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Medical Imaging course attempts to provide an introduction to the different commonly used medical imaging systems suitable for students seeking to expand their horizons and pursue a career field related to medical research & development or technological research in companies that lead to a breakthrough in diagnostic imaging. The students will not only acquire a broad & detailed knowledge in medical imaging and will have the opportunity to develop important practical skills in organising radiological data. The course will prepare the students to pursue their career in nationally and internationally growing healthcare industry. |
| 8 | **Brief Contents** | Introduction to Medical Imaging, Types, Different types of medical images, Image Processing and Registration, Image acquisition system, enhancement, filtering, restoration, registration, Image Segmentation: Statistical shape models, PDE-based methods, Applications and demonstration, Computer-Aided Diagnosis, Case studies, Deep Learning for Medical Image |

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| | | Analysis, 3D convolutional neural networks, Generative models for synthetic data applications |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. Paul Suetens, "Fundamentals of Medical Imaging," Cambridge University Press.<br>2. Andreas Maier, Stefan Steidl, Vincent Christlein, Joachim Hornegger, "Medical Imaging: An Introductory Guide," Springer.<br>3. Donald R. Peterson, Joseph D. Bronzino, Mostafa Analoui, " Medical Imaging: Principle and Practices, Taylor and Francis |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Virtual Reality and Augmented Reality |
| 5 | **Any prerequisite** | Basic Computer Graphics or equivalent |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | ● To understand the fundamental concepts and principles of Virtual Reality (VR) and Augmented Reality (AR).<br>● To learn the geometric foundations and transformations essential for creating virtual and augmented environments. To explore the visual perception and tracking techniques used in VR/AR systems.<br>● To gain knowledge about the components and technologies of VR/AR, including Head Mounted Displays and other interfaces.<br>● To investigate the frontiers and emerging areas in VR/AR, such as haptics, telepresence, and brain-machine interfaces. |
| 8 | **Brief Contents** | Introduction to X-Reality (XR), Definitions of VR and AR, Virtual experiences, Historical perspective and Components of VR/AR systems. Geometry of Visual World: Geometric modelling, 3D rotations, Inverses and conversions, Transforms, Transforms to displays, Look-at and eye transform, Canonical view and |

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| | | perspective transform, Viewport transforms. Visual Perception and Tracking: Principles of visual perception, Tracking methods in VR/AR. Head Mounted Display (HMD): Optics of HMDs, Inertial Measurement Units (IMUs), Orientation Tracking, Panoramic Imaging and Cinematic VR. Audio in VR/AR environments.Frontiers of VR/AR: Touch and haptics, Taste and smell interfaces, Robotic interfaces and telepresence, Case studies of VR/AR applications, Brain-machine interfaces. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. S. M. LaValle, Virtual Reality, 1st ed. Boston, MA: Pearson, 2017.<br>2. D. Schmalstieg and T. Hollerer, Augmented Reality: Principles and Practice, 1st ed. Boston, MA: Addison-Wesley, 2016.<br>3. W. R. Sherman and A. B. Craig, Understanding Virtual Reality: Interface, Application, and Design, 1st ed. San Francisco, CA: Morgan Kaufmann, 2003. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Speech Processing |
| 5 | **Any prerequisite** | Signals and Systems or Digital Signal Processing Fundamentals |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To understand the speech production model and digital representation of speech signals. To learn time-domain and frequency-domain analysis techniques for speech signals.To explore speech feature extraction methods like LPC and MFCC. To gain knowledge about speech enhancement and noise reduction techniques. To understand the principles of speech coding and automatic speech recognition (ASR). To introduce speaker identification and verification methods. |

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| 8 | **Brief Contents** | The speech production model: Source-filter model. Digital representation of speech: Sampling, quantization. Time domain analysis of speech signals: Short-time energy, zero-crossing rate. Short-time Fourier Transform and Spectrograms: Frequency domain representation of speech. Speech Feature Extraction: Linear Prediction Coding (LPC), Mel Frequency Cepstral Coefficients (MFCC). Speech Enhancement: Types of noise in speech signals, Noise reduction techniques, Evaluation methods. Speech Coding: Lossy and lossless coding, Coding standards. Introduction to Automatic Speech Recognition (ASR): Overview of ASR Systems, Hidden Markov Models (HMMs), Acoustic and Language modeling. Introduction to Deep Neural Network based ASR. Speaker Identification and Verification: Features for speaker representation, Speaker modeling techniques, Speaker verification methods. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. T. Virtanen, M. D. Plumbley, and D. P. W. Ellis, Computational Analysis of Sound Scenes and Events, 1st ed. Cham, Switzerland: Springer, 2018.<br>2. J. Benesty, M. M. Sondhi, and Y. Huang, Springer Handbook of Speech Processing, 1st ed. Berlin, Germany: Springer, 2008.<br>3. D. Jurafsky and J. H. Martin, Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition, 3rd ed, 2023.<br>4. P. Taylor, Text-to-Speech Synthesis, 1st ed. Cambridge, UK: Cambridge University Press, 2009.<br>5. J. H. L. Hansen and B. Pellom, Advanced Topics in Speech Recognition, 1st ed. Boston, MA: Springer, 2018. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Digital Signal Processing |
| 5 | **Any prerequisite** | Signals and Systems or Basic Signals Processing |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning Objectives of the subject** | To understand the fundamentals of digital signals and their processing techniques. To learn the Discrete Fourier Transform (DFT) and wavelet transforms for signal analysis. To explore time-frequency analysis and statistical signal processing methods. To gain knowledge of Z-transforms and adaptive filtering. To introduce the application of neural networks, including deep learning concepts, in DSP. To apply DSP techniques for signal classification, separation, denoising, and image/audio processing. |
| 8 | **Brief Contents** | Fundamentals of digital signals: Sampling, quantization, discrete-time signals and systems. The Discrete Fourier Transform (DFT): Properties, Fast Fourier Transform (FFT). Wavelet transforms: Introduction to wavelets, Continuous and Discrete Wavelet Transform. Time-frequency analysis: Short-Time Fourier Transform (STFT), Spectrogram. Statistical signal processing: Random processes, Correlation, Power spectral density. Z-transforms: Definition, Region of Convergence (ROC), Properties, Inverse Z-transform. Adaptive filtering: Principles of adaptive filtering, LMS algorithm, applications. Neural networks in DSP: Introduction to neural networks, Concepts from deep learning relevant to DSP. Emerging techniques in DSP (brief overview). Applications: Signal classification, Signal separation, Signal denoising, Image processing tasks, Audio processing tasks. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. A. V. Oppenheim and R. W. Schafer, Digital Signal Processing, 1st ed. Englewood Cliffs, NJ: Prentice-Hall, 1975.<br>2. A. V. Oppenheim and R. W. Schafer, Discrete-Time Signal Processing, 3rd ed. Upper Saddle River, NJ: Pearson, 2010.<br>3. J. G. Proakis and D. G. Manolakis, Digital Signal Processing: Principles, Algorithms, and Applications, 4th ed. Upper Saddle River, NJ: Pearson, 2006. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |

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| 4 | **Title of the subject** | Multimedia Systems |
| 5 | **Any prerequisite** | Basic Computer Networking or Signals and Systems |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To gain an overview of multimedia systems and processing techniques. To understand lossy and lossless compression systems and quantization theory. To learn about transform coding, DCT, and wavelet-based compression methods. To explore still image and video coding standards and motion estimation techniques. To understand audio coding methods and psychoacoustic models. To introduce multimedia synchronization, video indexing, and retrieval concepts. |
| 8 | **Brief Contents** | Overview of multimedia systems and processing: Introduction to multimedia elements. Lossy/Lossless compression systems: Principles of compression, Lossless compression techniques, Lossy compression techniques. Theory of quantization: Uniform and non-uniform quantization, Quantization noise, Delta modulation. Transform coding and K-L Transforms: Introduction to transform coding, Karhunen-Loeve Transform (KLT), Properties and applications. Discrete Cosine Transforms (DCT): DCT basis functions, DCT for image and video compression. Subband coding, Discrete Wavelet Transform (DWT), Multi-resolution analysis, Zerotree coding, SPIHT (Set Partitioning in Hierarchical Trees) algorithm, Still Image Compression Standards, Video Coding Standards and Motion Estimation, Audio Coding, Multimedia synchronization, Video Indexing and Retrieval. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. F. Halsall, Multimedia Communications: Applications, Networks, Protocols, and Standards, 1st ed. Boston, MA: Pearson, 2001.<br>2. Y. Wang, J. Ostermann, and Y.-Q. Zhang, Video Processing and Communications, 1st ed. Upper Saddle River, NJ: Prentice-Hall, 2002.<br>3. A. M. Tekalp, Digital Video Processing, 2nd ed. Upper Saddle River, NJ: Prentice-Hall, 2015. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Digital Watermarking & Steganalysis |
| 5 | **Any prerequisite** | Basic Image Processing or Cryptography |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To introduce the fundamental concepts of digital watermarking and steganography. To understand the classification and applications of these techniques. To learn about mathematical preliminaries relevant to watermarking and steganography. To explore various watermarking techniques in spatial and transform domains. To gain knowledge about watermarking attacks, tools, and advanced watermarking methods. To understand the principles of steganography, steganalysis, and their techniques. To explore the applications and emerging trends in digital watermarking and steganography. |
| 8 | **Brief Contents** | Introduction to Watermarking and Steganography, Classification and applications of digital watermarking and steganography, Mathematical preliminaries, Fundamentals of Watermarking Techniques, Transform domain watermarking techniques, Spatial domain watermarking techniques, Watermarking attacks and tools, Advanced Watermarking Techniques, Steganography, Steganalysis, Steganography using evolutionary algorithms, Applications and Emerging Trends, Applications of watermarking and steganography in copyright protection, authentication, secure communication, etc., Emerging trends and research directions in the field. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. I. J. Cox, M. L. Miller, J. A. Bloom, L. Carney, and T. K. Mohan, Digital Watermarking and Steganography, 2nd ed. Burlington, MA: Morgan Kaufmann, 2007.<br>2. M. S. Kankanhalli and R. R. Karmakar, Handbook of Digital Watermarking and Content Protection, 1st ed. Burlington, MA: Elsevier, 2015. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Video Analytics |
| 5 | **Any prerequisite** | Image Processing or Computer Vision Fundamentals |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To understand the foundational concepts of Image Processing and Computer Vision relevant to Video Analytics. To learn spatial and frequency domain image processing techniques. To explore feature detection, object recognition, and background modeling methods in video. To gain knowledge of object detection, recognition, and tracking techniques in video sequences. To understand video representation, motion analysis, and action recognition. To introduce advanced topics in 3D vision, including stereo and monocular depth estimation. |
| 8 | **Brief Contents** | Image Processing and Computer Vision Foundations, Spatial and Frequency Domain Processing, Image Enhancement and Filtering, Feature Detection and Object Recognition, Background Modeling, Local Features, Object Detection and Recognition, Video representation, Face Detection and Recognition, Image Segmentation, Unsupervised Segmentation: Clustering-based segmentation, Tracking and Motion Analysis, Kalman and Particle Filters, Single and Multi-Target Tracking, Action Recognition, Advanced Topics in 3D Vision: Stereo Depth Estimation, Monocular Depth Estimation techniques. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. R. Szeliski, Computer Vision: Algorithms and Applications, 2nd ed. Cham, Switzerland: Springer, 2022.<br>2. R. C. Gonzalez and R. E. Woods, Digital Image Processing, 4th ed. Hoboken, NJ: Pearson, 2018.<br>3. R. Hartley and A. Zisserman, Multiple View Geometry in Computer Vision, 2nd ed. Cambridge, UK: Cambridge University Press, 2004. |

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|---|---|---|
| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MCSE-5XX |
| 4 | **Title of the subject** | Visual Saliency and Attention Modelling |
| 5 | **Any prerequisite** | Mathematics (Linear Algebra, Calculus, Probability)<br>Computer Vision, Neuroscience (Basic understanding of visual perception and attention), Machine Learning |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | ● Understand the concepts of visual saliency and its role in human vision.<br>● Learn how attention mechanisms are modeled in computational systems.<br>● Explore different saliency detection algorithms and their applications.<br>● Implement models for bottom-up and top-down attention.<br>● Analyze and evaluate the performance of saliency models using real-world datasets.<br>● Study the relationship between visual saliency and cognitive processes. |
| 8 | **Brief Contents** | Introduction to attention, Computational Foundations of Visual Attention, Relevance of computational complexity for natural systems, Feature Integration Theory, Guided Search Model family, Experiments demonstrating breadth of visual search tasks and results, Attention within scene perception and set perception, Saliency Map Models, Koch and Niebur models, Attention via Information Maximization, Dynamical Systems Models, The Roles of GIST, Context and task in attention, Overview of approaches Evaluation and performance, Bayesian Methods for Attention. |
| 9 | **Contents for lab** | Lab 1: Introduction to Visual Saliency – Explore basic saliency maps and models (e.g., Itti-Koch model). |

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| | | Lab 2: Implementing Bottom-Up Saliency Models – Develop saliency maps based on low-level features (color, intensity, orientation).<br><br>Lab 3: Top-Down Attention Mechanisms – Simulate the effect of context or task-driven attention on visual scenes.<br><br>Lab 4: Computational Models of Attention – Implement a computational model of attention based on neural networks.<br><br>Lab 5: Eye Tracking Data Analysis – Use real-world eye-tracking data to analyze fixation patterns.<br><br>Lab 6: Deep Learning for Saliency – Apply CNN-based models for saliency detection in images.<br><br>Lab 7: Attention Networks – Implement and test attention mechanisms in neural networks for image processing tasks.<br><br>Lab 8: Explore Dynamic Attention Models – Simulate attention shifts in dynamic visual environments (e.g., video). |
| 10 | **Books** | 1. R. Szeliski, Computer Vision: Algorithms and Applications, 2nd ed. Cham, Switzerland: Springer, 2022.<br>2. L. Itti, G. Rees, and J. K. Tsotsos, Neurobiology of Attention, 1st ed. Burlington, MA: Elsevier, 2005.<br>3. R. C. Gonzalez and R. E. Woods, Digital Image Processing, 4th ed. Hoboken, NJ: Pearson, 2018.<br>4. R. Hartley and A. Zisserman, Multiple View Geometry in Computer Vision, 2nd ed. Cambridge, UK: Cambridge University Press, 2004. |

Curriculum & Contents

# M. Tech.
# (Information and Cyber Security)

**Department of Computer Science and Engineering**

विश्वजीवनामृतं ज्ञानम्

ABV-Indian Institute of Information Technology & Management, Gwalior

# SCHEMA

**Name of the program: M. Tech. (Information and Cyber Security)**

**(Credits: 72)**

**Name of the Department: Computer Science and Engineering**

| **SEMESTER-I** | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject Code** | **Title of the course** | **L-T-P** | **Credits** |
| **1.** | CS-601 | Modelling and Simulation | 3-0-0 | 3 |
| **2.** | CS-602 | Fundamentals of Cryptography | 3-1-0 | 4 |
| **3.** | CS-604 | Advanced Data Structures and Algorithms | 3-0-2 | 4 |
| **4.** | CS-605 | Cyber Laws and Information Crime | 3-0-0 | 3 |
| **5.** | CS-607 | Machine Learning Techniques | 3-0-2 | 4 |
| **6.** | CS-6XX | Elective-I | 3-0-0 | 3 |
| | | | **Total credits** | **21** |

| **SEMESTER-II** | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject code** | **Title of the course** | **L-T-P** | **Credits** |
| **1.** | CS-603 | Advanced Computer Networks and Security | 3-0-2 | 4 |
| **2.** | CS-606 | Engineering Research Methodology | 2-1-0 | 3 |
| **3.** | CS-608 | Cyber Forensics: Tools and Techniques | 3-0-2 | 4 |

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| **4.** | CS-609 | Information Privacy and Security | 3-1-0 | 4 |
| **5.** | CS-6XX | Elective-II | 3-0-0 | 3 |
| **6.** | CS-6XX | Elective-III | 3-0-0 | 3 |
| | | | **Total credits** | **21** |

EXIT AFTER YEAR-1: Post Graduate Diploma in Information and Cyber Security

| **SEMESTER-III** | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject code** | **Title of the course** | **L-T-P** | **Credits** |
| **1** | CS-6XX | Elective-III/MOOC | 3-0-0 | 3 |
| **2** | CS-698 | Dissertation Part - I | | 12 |
| | | | **Total credits** | **15** |

| **SEMESTER-IV** | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject Code** | **Title of the course** | **L-T-P** | **Credits** |
| **1** | CS-699 | Dissertation Part – II | | 15* |
| | | | **Total credits** | **15** |

***For students going on internship in Semester IV: Major Project Part II: 12 credits and additional Colloquium/Industrial Seminar: 3 credits.***

| **SEMESTER-I** | **SEMESTER-II** | **SEMESTER-III** | **SEMESTER-IV** | **TOTAL CREDITS** |
|---|---|---|---|---|
| 21 | 21 | 15 | 15 | **72** |

<u>**Electives Courses**</u>

| S. No. | Electives I,II,III, and IV Category: Information and Cyber Security |
|---|---|
| 1 | Wireless & Mobile Security |
| 2 | Intrusion Detection and Prevention |
| 3 | Web application and Cloud Security |
| 4 | Malware Analysis |
| 5 | Authentication and Access Control |
| 6 | Digital Watermarking and Steganalysis |
| 7 | IoT Protocols and Security |
| 8 | Data Privacy in Social Networks |
| 9 | Blockchain Technology |
| 10 | Software System Design |
| 11 | Modern Cryptography |
| 12 | Database Security |
| 13 | Hardware Security |
| 14 | Operating Systems Security |
| 15 | Fault Tolerant System |
| 16 | Quantum Cryptography |
| 17 | Big Data and Cyber fraud analysis |
| 18 | Secure System Engineering |
| 19 | Formal Verification of Security Protocols |
| 20 | Digital Forensics |
| 21 | Natural Language Processing |
| 22 | Information Retrieval |
| 23 | Recommender Systems |
| 24 | Reinforcement Learning |

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| 25 | Fair, Accountable, Transparent AI |
| 26 | Machine Learning System Optimization |
| 27 | Pattern Recognition |
| 28 | Deep Learning Techniques |

# Course Contents

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| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | CS-601 |
| 4 | **Title of the subject** | Modelling and Simulation |
| 5 | **Any prerequisite** | Basic Mathematics |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Develop mathematical models to represent real-world systems and problems.<br>Apply simulation tools to solve complex problems in engineering, science, and management.<br>Develop critical thinking skills in problem-solving and model validation. |
| 8 | **Brief Contents** | Introduction to probability: Joint and Conditional Probability, Random Variables, Bayesian Networks. Optimization: System Modelling and Optimization, Optimizing Linear Systems, Nonlinear Constrained Optimization. Game Theory: Concepts and Terminology, Solving a Game, Mechanism Design, Limitations of Game Theory. |
| 9 | **Contents for lab** | Nil |
| 10 | **Text Books** | Jerry Banks, John S. Carson II, Barry L. Nelson, David M. Nicol: Discrete-Event System Simulation, 5th Edition, Pearson Education, 2010.<br>Lawrence M. Leemis, Stephen K. Park: Discrete – Event Simulation: A First Course, Pearson Education, 2006. |

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|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | CS-602 |
| 4 | **Title of the subject** | Fundamentals of Cryptography |
| 5 | **Any prerequisite** | Knowledge of Calculus and Linear Algebra |
| 6 | **L-T-P** | 3-1-0 |
| 7 | **Learning Objectives of the subject** | To provide the basic paradigm and principles of modern cryptography |
| 8 | **Brief Contents** | Course Overview, Symmetric-key Encryption, Historical Ciphers, Perfect Security and Its Limitations. Computational Security, Semantic Security and Pseudorandom Generators (PRGs).<br>Stream Ciphers, Provably-secure Instantiation of PRG, Practical Instantiation of PRG, CPA-security and Pseudo-random Functions (PRFs).<br>CPA-Secure Ciphers from PRF, Modes of Operations of Block Ciphers, Theoretical Constructions of Block Ciphers and Practical Constructions of Block Ciphers<br>DES, AES and Message Authentication Codes (MAC). Information-theoretic Secure MAC, Cryptographic Hash Functions, Ideal-Cipher Model, Davies-Meyer construction and Merkle-Damgård Paradigm.<br>Birthday Attacks on Cryptographic Hash Functions, Applications of Hash Functions, Random Oracle Model and Authenticated Encryption.<br>Generic Constructions of Authenticated Encryption Schemes, Key-exchange Problem, One-way Trapdoor Functions and Cyclic Groups.<br>Discrete-Logarithm Problem, Computational Diffie-Hellman Problem, Decisional Diffie-Hellman Problem, Elliptic-Curve Based Cryptography and Public-Key Encryption. El Gamal Encryption Scheme, RSA Assumption, RSA Public-key Cryptosystem, KEM-DEM Paradigm and CCA-security in the Public-key Domain<br>CCA-secure Public-key Hybrid Ciphers Based on Diffie-Hellman Problems and RSA-assumption, Digital Signatures, RSA Signatures and Schnorr Identification Scheme. Schnorr |

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| | | Signature, Overview of TLS/SSL, Number Theory, Interactive Protocols and Firewall. |
| 9 | **Contents for lab** | NIL |
| 10 | **Book** | Hans Delfs, Helmut Knebl, "Introduction to Cryptography, Principles and Applications", Springer Verlag.<br>Jonathan Katz, Yehuda Lindell, "Introduction to Modern Cryptography", Chapman \& Hall/CRC.<br>Wenbo Mao, "Modern Cryptography, Theory and Practice", Pearson Education (Low Priced Edition) |

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| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | CS-604 |
| 4 | **Title of the subject** | Advanced Data Structures and Algorithms |
| 5 | **Any prerequisite** | Discrete Mathematics, Algorithms and Data Structures |
| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning Objectives of the subject** | ● Learn and implement advanced data structures<br>● Analyze algorithm complexity using amortized analysis and lower-bound proofs.<br>● Apply network flow and matching algorithms. |
| 8 | **Brief Contents** | Advanced data structures: Fibonacci heaps, splay trees, self-adjusting search trees, and linking/cutting trees.<br>Algorithm design and analysis: amortized complexity, and lower-bound proofs, shortest path problems, minimum spanning trees, and network flows, including preflow-push, max flow, and scaling techniques, Matching algorithms, |

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| | | including the Micali-Vazirani algorithm and blossom structures. |
| 9 | **Contents for lab** | The lab content for the syllabus includes hands-on implementation and analysis of algorithms and data structures, starting with basic algorithm analysis and amortized complexity through dynamic array resizing and simple data structures like stacks and queues. Students will then implement advanced data structures such as Fibonacci heaps, splay trees, and linking/cutting trees, comparing their performance and behavior. Further labs focus on efficient algorithms for shortest path problems (Dijkstra's and Bellman-Ford) and minimum spanning trees (Kruskal's and Prim's), followed by network flow algorithms like Ford-Fulkerson, preflow-push, and scaling techniques. |
| 10 | **Text Books** | R. E. Tarjan. Data structures and Network Algorithms, SIAM Press, 1983.<br>J. H. Hastad.Computational Limitations for Small-Depth Circuits, MIT Press, 1987.<br>K. Melhorn.Data Structures and Algorithms, Vol. 1: Sorting and Searching, Springer Verlag, 1984.<br>T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein. Introduction to Algorithms, 3rd Edition, MIT Press, 2009. |

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| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | CS-605 |
| 4 | **Title of the subject** | Cyber Laws and Information Crime |
| 5 | **Any prerequisite** | NIL |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning Objectives of the subject** | 1. To acquaint with the basic concepts of Cyber Law and also puts those concepts in practical perspective.<br>2. To provide an understanding of the authorities under IT Act as well as penalties and offences under IT Act.<br>3. To provide overview of Intellectual Property Right and Trademark Related laws with respect to Cyber Space.<br>4. To study the E- Governance policies of India. |
| 8 | **Brief Contents** | INTRODUCTION OF CYBER CRIMES & CYBER LAW : Understanding Cyber Crimes and Cyber Offences, Crime in context of Internet, Types of Crime in Internet, Crimes targeting Computers: Definition of Cyber Crime & Computer related Crimes, Constraint and Scope of Cyber Laws, Social Media and its Role in Cyber World, Fake News, Defamation, Online Advertising. PREVENTION OF CYBER CRIMES & IT ACT Prevention of Cyber Crimes & Frauds, Evolution of the IT Act , Genesis and Necessity. Critical analysis & loop holes of The IT Act in terms of cyber-crimes, Cyber Crimes: Freedom of speech in cyber space & human right issues.<br><br>FEATURES OF IT ACT & AMENDMENTS: Salient features of the IT Act, Cyber Tribunal & Appellate Tribunal and other authorities under IT Act and their powers, Penalties & Offences under IT Act, Amendments under IT Act and Impact on other related Acts (Amendments): (a) Amendments to Indian Penal Code. (b) Amendments to Indian Evidence Act. (c) Amendments to Bankers Book Evidence Act. (d) Amendments to Reserve Bank of India Act.<br><br>INDIAN PENAL LAW : Indian Penal Law and Cyber Crimes: (i) Fraud, (ii) Hacking, (iii) Mischief, Trespass (iv) Defamation (v) Stalking (vi) Spam, Issues of Internet Governance: (i) Freedom of Expression in Internet (ii) Issues of Censorship (iii) Hate Speech (iv) Sedition (v) Libel (vi) Subversion (vii) Privacy, Cyber Appellate Tribunal with Special Reference to the Cyber Regulation Appellate Tribunal (Procedures).<br><br>GLOBAL IT RULES & IPR: The Information Technology (Procedures and Safeguards for Interception, Monitoring and Decryption of Information) Rules. The Information Technology (Procedures and Safeguards for Blocking the access of Information by Public) Rules. The Information Technology (Reasonable Security Practices and Procedures and Sensitive Personal Data or Information) Rules. |

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| | | Books: CYBER LAW & CYBER CRIMES SIMPLIFIED by Adv. Prashant Mali |
| 9 | **Contents for lab** | Nil |
| 10 | **Text Books** | Cyberspace and International Relations Toward an Integrated System NazliChoucri, David Clark<br>What Larry Doesn't Get: Code, Law, and Liberty in Cyberspace Author(s): David G. Post,Stanford Law Review, Vol. 52, No. 5, Symposium: Cyberspace and Privacy: A New Legal Paradigm? |

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| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | CS-607 |
| 4 | **Title of the subject** | Machine Learning Techniques |
| 5 | **Any prerequisite** | NIL |
| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning Objectives of the subject** | To understand popular ML algorithms with their associated mathematical foundations for appreciating these algorithms.<br>To help connect real-world problems to appropriate ML algorithm(s) for solving them and to enable formulating real world problems as machine learning tasks. |
| 8 | **Brief Contents** | Introduction to ML, Fundamentals of ML - PCA and Dimensionality reduction, Nearest neighbours and KNN, Linear regression, Decision tree classifiers, Notion of generalization and concern of overfitting, Notion of training, Validation, and testing; Connect to generalization and overfitting. Selected algorithms - ensembling and RF, Linear SVM, K means, Logistic regression, Naive bayes, Neural network learning - Role of loss functions and optimization, Gradient descent and Perceptron/Delta learning, MLP, Backpropagation, MLP for |

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| | | classification and regression, Regularization, Early Stopping, Kernels (with SVM), Bayesian methods, Generative methods, HMM, EM, PAC learning, Introduction to Deep Learning, CNNs, Popular CNN architectures, RNNs, GANS and Generative models, Advances in backpropagation and optimization for neural networks adversarial learning. |
| 9 | **Contents for lab** | To implement basic algorithms using basic machine learning libraries mostly in python. Gain hands-on experience in applying ML to problems encountered in various domains. In addition, obtain exposure to high-level ML libraries or frameworks such as TensorFlow, PyTorch. |
| 10. | **Books** | Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow" by Aurélien Géron (3rd Edition).<br><br>Pattern Recognition and Machine Learning" by Christopher M. Bishop.<br><br>The Elements of Statistical Learning: Data Mining, Inference, and Prediction" by Trevor Hastie, Robert Tibshirani, and Jerome Friedman.<br><br>Machine Learning: A Probabilistic Perspective" by Kevin P. Murphy. |

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| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | CS-603 |
| 4 | **Title of the subject** | Advanced Computer Networks and Security |
| 5 | **Any prerequisite** | Computer Networks; Ciphers etc |
| 6 | **L-T-P** | 3-0-2 |

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| 7 | **Learning Objectives of the subject** | 1. To understand advanced concepts of network security, computer and network security threats.<br>2. To study existing authentication and key agreement protocols and to identify weaknesses of these protocols.<br>3. To enhance the skills of secure network systems and network security. |
| 8 | **Brief Contents** | Introduction – Overview of Network Attacks, Network Protection -IDS, Types of IDS's, Issues in Intrusion Detection, Challenges in Intrusion Detection, Taint Analysis, Network Based IDS, Problems in NIDS, Impact Analysis,<br><br>Packet Sniffing, Detecting Sniffers on your network, IP Spoofing, ARP Poisoning, UDP Hijacking, Fragmentation Attack- Ping of Death, Evasion & Denial of Service, UDP Hijacking, TCP Spoofing, TCP Hijacking – Mitnick attack, Joncheray attack, Various network attacks<br><br>WLAN, 802.11, Wireless Security Overview, Attacks Against Wireless Networks – Eavesdropping, WEP Attacks, Injection Attacks -, WEP Encryption, WEP Attacks,<br><br>Overview of Attacks Against Applications, Attacking SUID Programs, Environment Attacks, Input Argument Attacks, File Access Attacks<br><br>Books;<br><br>1. Advance Computer Networks and Security by A.Gautam.<br><br>2. Computer Network Security by Ali Sadiqui |
| 9 | **Contents for lab** | Experiments on Network and Penetration Testing and security |
| 10 | **Books** | James F Kurose and Keith W Ross, Computer Networking, A Top-Down Approach, Sixth edition, Pearson,2017 .<br><br>Nader F Mir, Computer and Communication Networks, 2nd Edition, Pearson, 2014. |

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|---|---|---|
| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | CS-606 |
| 4 | **Title of the subject** | Engineering Research Methodology |
| 5 | **Any prerequisite** | NIL |
| 6 | **L-T-P** | 2-1-0 |
| 7 | **Learning Objectives of the subject** | To enable a student to develop their theoretical, methodological and research skills to enhance their ability to conduct rigorous research and reach to sound evidence-based conclusions.<br>Understanding the nature of problem to be studied and identifying the related area of knowledge.<br>Reviewing literature to understand how others have approached or dealt with the problem.<br>Collecting data in an organized and controlled manner to arrive at valid decisions. |
| 8 | **Brief Contents** | Introduction to research, An empirical research framework, Research problems, Literature reviews, Introduction to quantitative research, Study designs, Controlled experiments, Elements and methods, Example experiments, Data collection techniques, Analysis and interpretation of quantitative data, Descriptive statistics, sampling, Sampling distribution, Parameter estimation, statistical inference, Confidence interval and hypothesis testing, Tests of significance, Test of difference of mean and proportions, T-tests, ANOVA, Chi-square tests, Correlation, and regression, Review process, Review guidelines, Validity threats, Review decisions, Qualitative methods, Study designs, Elements, and methods, Data collection methods, Types of data analysis methods, Survey research, Case studies, Writing research papers, Purpose, nature and evaluation, Content and format, |

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| | | Research presentations, The art of scientific and technical writing. Research tools, formatting, plagiarism. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | Kothari, C. R. and Garg, G. Research Methodology: Methods and Techniques. 4th MultiColour Edition, New Age International Publishers, 2019.<br><br>Davis, G. B. and Parker, C. A. Writing the Doctoral Dissertation: A Systematic Approach. 3 rd Edition, Barron's Educational Series, 2012. |

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| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | CS-608 |
| 4 | **Title of the subject** | Cyber Forensics: Tools and Techniques |
| 5 | **Any prerequisite** | Knowledge of programming; Virtual Machines |
| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning Objectives of the subject** | 1. To study the fundamentals of Computer Forensics.<br>2. To learn, analyze and validate Forensics Data.<br>3. To study the tools and tactics associated with Cyber Forensics. |
| 8 | **Brief Contents** | Windows Forensics - Volatile data collection, Non-volatile data collection, Registry Analysis, Browser Usage, Hibernate File Analysis, Crash Dump Analysis, File System Analysis, File Metadata and Timestamp Analysis, Memory Forensics - Volatility Framework & plugins Memory acquisition, File Formats – PE/ELF/MachOS, Processes and process injection, Command execution and User activity, Networking, sockets, paged memory and advanced registry artifacts, Virtual Machine Forensics - Types of Hypervisors, Hypervisor Files and Formats, Use and Implementation of Virtual Machines in Forensic Analysis, Use of VMware |

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| 1 | **Semester** | II |
| | | to establish a working version of suspect's machine, Networking and virtual networks within Virtual Machine, Forensic Analysis of a Virtual Machine.<br>Books : Cyber Forensics by Vashishth |
| 9 | **Contents for lab** | Forensics Tools Study and experiments |
| 10 | **Books** | Practical Cyber Forensics: An incident- Based Approach to Forensic Investigations, by Niranjan Reddy<br>Digital evidence and computer crime: Forensic science, computers and the internet by Casey, E, Academic Press |

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|---|---|---|
| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | CS-609 |
| 4 | **Title of the subject** | Information Privacy and Security |
| 5 | **Any prerequisite** | NIL |
| 6 | **L-T-P** | 3-1-0 |
| 7 | **Learning Objectives of the subject** | 1 To understand the principles of Information Security & Privacy management.<br>2 To understand the basic concepts of the technical components involved in implementing of the security & privacy.<br>3 To understand that ensuring information security & privacy in a modern organization is a problem for the management to solve and not one that the technology alone can address.<br>4 To analyze the important economic and commercial consequences of devising security and privacy solutions in an enterprise or the lack thereof. |
| 8 | **Brief Contents** | INTRODUCTION : Introduction to Information Security and Privacy: Review of the essential terminologies, basic concepts of security and privacy. Relation or lack thereof between the Information Security, Network Security, |

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|---|---|---|
| | | Systems Security and the Cyber Security. Key principles of Information Security in terms of Security mechanisms, security attributes and the security attacks. Role of National Security Systems (CNSS) and CERTIN. The McCumbers Cube for Security. Introduction to the Security Systems Development Life Cycle and the difference between the Software Security and the Security Software. Classical Security Models.<br>SECURITY THREATS AND SECURITY ATTACKS : Taxonomy of Security attacks. Illustrations of typical attacks. Cyber security threats. The basic terminologies viz. threats, defects, vulnerabilities, exploits, attacks, bugs.<br>INTRODUCTION TO INFORMATION PRIVACY: The importance of Data privacy; Privacy rules; Data Protection – Organization Roles. Approaches to protect sensitive data. Personally Identifiable Information and Sensitive Data. Data Privacy And Protection Responsibilities. Consequences Of Privacy Unawareness. Overview Of Global Data Privacy Laws. The DSCI Privacy Framework for global privacy best practices and frameworks.<br>Security Mechanisms: The Symmetric and Asymmetric Key Cryptography, Ciphers: Cryptographic Algorithms and the Cryptosystems, Mechanisms for Data Integrity and Entity Authentication, Access Control mechanisms, Virtual Private Networks. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | Security in Computing, Fourth Edition, by Charles P. Pfleeger, Pearson Education<br>Cryptography And Network Security Principles And Practice, Fourth or Fifth Edition, William Stallings, Pearson<br>Modern Cryptography: Theory and Practice, by Wenbo Mao, Prentice Hall. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | CS-6XX |
| 4 | **Title of the subject** | Wireless and Mobile Security |

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| 5 | **Any prerequisite** | Computer Networks, Network Security Fundamentals |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Understand fundamental concepts of wireless and mobile security.<br>Identify security vulnerabilities in wireless and mobile networks.<br>Analyze and evaluate various security threats, including attacks on Wi-Fi, Bluetooth, and cellular networks.<br>Implement security mechanisms such as encryption, authentication, and access control.<br>Assess the security of mobile applications and mobile operating systems.<br>Conduct hands-on security analysis of wireless networks through practical labs.<br>Explore emerging security trends in 5G, IoT, and mobile cloud computing. |
| 8 | **Brief Contents** | Overview of wireless and mobile security, Wireless LAN Security (Wi-Fi), WEP, WPA, WPA2, WPA3 security protocols, Common Wi-Fi attacks (e.g., Evil Twin, Man-in-the-Middle, DoS), Cellular Network Security, Mobile Application and OS Security, Bluetooth and IoT Security, Zigbee, Z-Wave, and LPWAN security concerns, Encryption and Authentication in Wireless Networks, Wireless Intrusion Detection Systems (WIDS), Emerging Security Trends in Wireless and Mobile Networks. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | M. Barbeau and J. M. Robert, *Mobile Networks Security: Issues, Techniques, and Tools*, Cham, Switzerland: Springer, 2010.<br>I. T. Almalki, *Wireless and Mobile Device Security*, Boca Raton, FL, USA: CRC Press, 2020.<br>M. J. Bishop and S. S. Panwar, *Security in Wireless and Mobile Computing Systems*, New York, NY, USA: Springer, 2016. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | CS-6XX |
| 4 | **Title of the subject** | Intrusion Detection and Prevention |
| 5 | **Any prerequisite** | Computer networks, Operating systems, Information systems security |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To give students practical, working knowledge in intrusion detection and traffic analysis. To gain an understanding of the workings of TCP/IP, methods of network traffic analysis and popular network intrusion detection systems. |
| 8 | **Brief Contents** | IDS/IPS definition and classification -Basic elements of attacks and their detection -Misuse detection systems, Anomaly detection systems and supervised learning in IDS, Testing IDS and measuring their performances, Computational complexity, Theoretic IDS models and quality criteria, Intrusion detection in virtual networks, Law Enforcement / Criminal Prosecutions – Standard of Due Care – Evidentiary Issues. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | Ali A. Ghorbani, Wei Lu, “Network Intrusion Detection and Prevention: Concepts and Techniques”, Springer, 2010.<br>Carl Enrolf, Eugene Schultz, Jim Mellander, “Intrusion detection and Prevention”, McGraw Hill, 2004<br>Paul E. Proctor, “The Practical Intrusion Detection Handbook “,Prentice Hall , 2001. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | CS-6XX |
| 4 | **Title of the subject** | Web application and cloud security |
| 5 | **Any prerequisite** | Operating system, Distributed system, Information security |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Cloud services facilitate access to server infrastructure which is managed by the provider, which includes data storage and access, security and scalability and updates. This course aiAuthentication and Access Controlms at providing the students an insight into the operations of cloud and introduces them to different cloud providers available. |
| 8 | **Brief Contents** | Introduction to cloud computing, Cloud service delivery models, Cloud deployment models, Cloud computing security, Scalable application on AWS, Provisioning application resources with cloud formation, AWS security, AWS directory service, AWS key management service, Cloud deployment models – Public, Private and hybrid, Trusted cloud initiative (TCI) and cloud trust protocol (CTP), Transparency as a service (TaaS) and Security as a service (SaaS), cloud security, Top threats to cloud security, Comparison of traditional it and cloud security. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | Bryan Sullivan, Vincent Liu, Web Application Security: A Beginners Guide, 2012, The McGraw-Hill Companies.<br>Wenliang Du, Computer Security – A hands-on Approach , First Edition, Createspace Independent Pub, 2017 |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | CS-6XX |
| 4 | **Title of the subject** | Malware Analysis |
| 5 | **Any prerequisite** | Familiarity with programming languages |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | By the end of the course, students will be able to:<br>1. Understand the fundamental concepts of malware, its types, and its impact on cybersecurity.<br>2. Identify and classify different types of malware based on their characteristics and behavior.<br>3. Utilize static and dynamic analysis techniques to investigate malware samples.<br>4. Reverse-engineer malware to analyze its internal structure and behavior.<br>5. Apply debugging and sandboxing techniques to analyze malware in a controlled environment.<br>6. Understand the ethical and legal considerations of malware analysis. |
| 8 | **Brief Contents** | Introduction to Malware, Malware Classification and Characteristics, Static and Dynamic Malware Analysis, Reverse Engineering Malware, Malware Detection and Evasion Techniques, Memory and Forensic Analysis, Mitigation and Prevention Strategies, Ethical and Legal Considerations in Malware Analysis. |
| 9 | **Contents for lab** | Setting Up a Safe Malware Analysis Environment, Basic Static Analysis of Malware Samples, Dynamic Analysis of Malware Behavior, Reverse Engineering with Disassemblers, Debugging and Code Analysis, Analyzing Network Traffic of Malware, Memory Forensics and Rootkit Detection, Writing YARA Rules for Malware Detection. |

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| 10 | **Books** | Michael Sikorski and Andrew Honig, " Practical Malware Analysis", No Starch Press,2012<br>Jamie Butler and Greg Hoglund, "Rootkits: Subverting the Windows Kernel", Addison-Wesley, 2005<br>Dang, Gazet and Bachaalany, "Practical Reverse Engineering",Wiley,2014 |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | CS-6XX |
| 4 | **Title of the subject** | Authentication and Access Control |
| 5 | **Any prerequisite** | Information system security |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Introduce the concept of access control to information systems in applications, authentication, and accounting for end users and system administrators. Learn the security controls for access control including tokens, biometrics, and use of public key infrastructures (PKI). |
| 8 | **Brief Contents** | Access control and assessing risk, Business drivers and access control policies standards, Procedure and guidelines, unauthorized access – security breaches and mapping business challenges, Human nature – organizational behaviour and access control for information systems, Physical security and access control in the enterprise, Access control implementation for systems and remote workers, PKI infrastructure and encryption, Testing access control systems and assurance |
| 9 | **Contents for lab** | Nil |

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| 10 | **Books** | M. Whitman and H. Mattord. Principles of Information Security, 2nd Edition (Course Technology, 2005).<br><br>Bruce Schneier, "Secrets and Lies: Digital Security in a Networked World," Wiley, ISBN 0- 471-25311-1,<br><br>Applied Cryptography: Protocols, Algorithms, and Source Code in C,Wiley, ISBN 0 471-11709-9. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | CS-6XX |
| 4 | **Title of the subject** | Digital Watermarking & Steganalysis |
| 5 | **Any prerequisite** | Basic Image Processing or Cryptography |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To introduce the fundamental concepts of digital watermarking and steganography. To understand the classification and applications of these techniques. To learn about mathematical preliminaries relevant to watermarking and steganography. To explore various watermarking techniques in spatial and transform domains. To gain knowledge about watermarking attacks, tools, and advanced watermarking methods. To understand the principles of steganography, steganalysis, and their techniques. To explore the applications and emerging trends in digital watermarking and steganography. |
| 8 | **Brief Contents** | Introduction to Watermarking and Steganography, Classification and applications of digital watermarking and steganography, Mathematical preliminaries, Fundamentals of Watermarking Techniques, Transform domain watermarking techniques, Spatial domain watermarking techniques, Watermarking attacks and tools, Advanced Watermarking Techniques, Steganography, Steganalysis, Steganography using evolutionary algorithms, Applications and Emerging Trends, Applications of watermarking and steganography in copyright |

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| | | protection, authentication, secure communication, etc., Emerging trends and research directions in the field. |
| 9 | **Contents for lab** | To implement basic spatial domain watermarking techniques. To implement transform domain watermarking techniques (e.g., DCT watermarking). To analyze the robustness of watermarking techniques against common attacks using tools. To experiment with steganographic techniques for data hiding. To use steganalysis tools to detect hidden messages. To explore and implement advanced watermarking or steganography techniques from research papers. |
| 10 | **Books** | Ingemar J. Cox, Mathew L. Miller, Jefrey A. Bloom, Jesica Fridrich, Ton Kalker, "Digital Watermarking and Steganography", Morgan Kaufmann Publishers, New York, 2008.<br><br>Juergen Seits, "Digital Watermarking for Digital Media", IDEA Group Publisher, New York, 2005. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | CS-6XX |
| 4 | **Title of the subject** | IoT Protocols and Security |
| 5 | **Any prerequisite** | Computer Networks, Cryptography and Network Security, Programming (C/Python/Embedded C) |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Understand IoT Architecture & Security Needs. Analyse IoT Privacy and Security Issues, Identify and Classify IoT Attack Models, Implement Security Measures for IoT Components, Enhance Security in Cyber-Physical and Hardware Systems, Strengthen Networking & Communication Security in IoT, Secure Back-End and Data Management in IoT, and Assess Existing IoT Security Testbeds and Products. |

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| 8 | **Brief Contents** | Architecture of IoTs, IoT security requirements, IoT privacy preservation issues, Attack Models – attacks to sensors in IoTs, Attacks to RFIDs in IoTs, Attacks to network functions in IoTs, Attacks to backend systems, Security in front-end sensors and equipment, Prevent unauthorized access to sensor data, M2M security, RFID security, Cyber-physical object security, Hardware security, Front-end system privacy protection, Networking function security- IoT networking protocols, Secure IoT lower layers, Secure IoT higher layers, Secure communication links in IoTs, Back-end security -secure resource management, Secure IoT databases, Security products-existing testbed on security and privacy of IoTs. |
| 9 | **Contents for lab** | Installing IoT frameworks (Node-RED, Mosquitto MQTT, Raspberry Pi setup). Simulating IoT devices (using IoT platforms like Arduino, ESP8266, and Raspberry Pi). Exploring IoT protocols (MQTT, CoAP, Zigbee, LoRaWAN). Extracting and analysing firmware using Binwalk and Firmadyne. Capturing and analysing MQTT/CoAP traffic using Wireshark. Detecting unauthorized access attempts. Capturing logs from IoT devices and cloud servers. Monitoring AWS IoT Core and Azure IoT Hub logs. Detecting unauthorized cloud access attempts. |
| 10 | **Books** | Hu, Fei. Security and privacy in Internet of things (IoTs): Models, Algorithms, and Implementations, 1st edition,CRC Press, 2016.<br>Russell, Brian, and Drew Van Duren. Practical Internet of Things Security, 1st edition, Packt Publishing Ltd, 2016. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | CS-6XX |
| 4 | **Title of the subject** | Data Privacy in Social Networks |
| 5 | **Any prerequisite** | Computer networks, Data Security concepts, Social network platforms |

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| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Understand the key concepts related to data privacy in social networks.<br>Analyze the privacy risks associated with sharing personal information on social platforms. |
| 8 | **Brief Contents** | Various privacy breaches and their effects; Privacy cases, litigations, and outcomes, Difference between data security and data privacy; Contextual integrity theory and applications, Online Social Networks (OSN), Data collection from social networks, Challenges, Opportunities, and pitfalls in online social networks, Image and location privacy; Ethics; Conducting studies; Privacy from 3rd party trackers and advertisers, Phishing in OSM and identifying fraudulent entities in online social networks, Privacy policies |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | Yaniv Altshuler, Yuval Elovici, Armin B. Cremers Nadav Aharony, Alex Pentland," Security and Privacy in Social Networks".<br>Privacy and Security in Online Social Media course in NPTEL. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | CS-6XX |
| 4 | **Title of the subject** | Blockchain Technology |
| 5 | **Any prerequisite** | Basic cryptography and data structure |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Get an overview of blockchain technology, its history, |

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| | | benefits, drawbacks, and future. Examine the nascent blockchain technology and make an initial pass at identifying some of its major vulnerabilities. Design, build, and deploy distributed applications. Equip students with the skills necessary to create e-governance applications for the public good. |
| 8 | **Brief Contents** | Overview of blockchain technology, Peer-to-Peer networking, Blockchain categories, Mining mechanism, Blockchain architecture: Pros & Cons, Bitcoin & protocol, Architecture of blockchain- Block, Byzantine General problem and Fault tolerance, Merkle tree, transactions and fee, Anonymity, Reward, Private and public blockchain, Bitcoin transaction structure, Double spending problem, Introduction to consensus Problem real-time of application of blockchain. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, and Steven Goldfeder. Bitcoin and cryptocurrency technologies: a comprehensive introduction. Princeton University Press, 2016.<br>R.Pass et al, Analysis of Blockchain protocol in Asynchronous networks, EUROCRYPT 2017, ( eprint.iacr.org/2016/454) . A significant progress and consolidation of several principles). |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | CS-6XX |
| 4 | **Title of the subject** | Software system design |
| 5 | **Any prerequisite** | Basic software engineering course |

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| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Outline the software design process and demonstrate how the essential design principles are applied within it. Illustrate the essential elements of software structure and architecture in terms of styles, patterns and families of programs and frameworks. Demonstrate the application of quality analysis and evaluation principles. Employ function, object, data-structure, and component-based design methodologies in a typical software design project. |
| 8 | **Brief Contents** | Software design fundamentals, Key issues in software design, Concurrency, Control and handling of events, Error exception handling and fault tolerance, Software structure and architecture, design patterns, architecture design decisions, User interface design, Metaphors and conceptual models, Software design quality analysis and evaluation, Structural descriptions (static view), Behavioural descriptions (dynamic view), Software design strategies and methods |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | 1. Software Engineering: A Precise Approach – Dr. Pankaj Jalote<br>2. Cooperative Software Development – Dr. Amy Ko<br>3. Engineering Software as a Service: An Agile Approach Using Cloud Computing – Armando Fox, David Patterson |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | CS-6XX |
| 4 | **Title of the subject** | Modern Cryptography |
| 5 | **Any prerequisite** | Fundamental knowledge of cryptography |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning Objectives of the subject** | To learn the basic concepts of cryptography, including encryption, decryption, and cryptographic protocols.<br><br>To explore common cryptographic attacks, including brute force attacks, side-channel attacks, and cryptanalysis techniques. |
| 8 | **Brief Contents** | Classical encryption techniques, Security attacks, AES, DES, Blowfish, RC4 algorithm, RSA, Diffie Hellman key exchange, ElGamal Encryption, Elliptic curve cryptography, Authentication, MAC, Hash functions, Digital signatures, Authentication protocols, SHA, MD5, Zero-knowledge proof systems, Oblivious transfer, Multiparty secret sharing, Two-party computation using garbled circuits, fully homomorphic encryption. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | Hans Delfs and Helmut Knebl, Introduction to Cryptography: Principles and Applications, Springer Verlag.<br><br>Wenbo Mao, Modern Cryptography, Theory and Practice, Pearson Education (Low Priced Edition) |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | CS-6XX |
| 4 | **Title of the subject** | Database Security |
| 5 | **Any prerequisite** | Database Management System |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Provide an overview of databases and their associated security challenges. Conduct a detailed comparison of various state-of-the-art database security methods and techniques. Explore the security features implemented in |

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| | | modern databases. Gain an in-depth understanding of database security analysis tools. |
| 8 | **Brief Contents** | Introduction- Database System Applications, Purpose of Database Systems, View of Data - Data Abstraction, Instances and Schemas, ER diagrams, Introduction to the Relational Model - Querying relational data, Form of Basic SQL Query - Examples of Basic SQL Queries. Introduction to database security issues- The role of databases in information systems. Access control management features. Cryptographic data protection. SQL language features, Statistical databases. Database security methods and techniques- Access control to database objects: tables, attributes, records. Triggers, views, data masking. Cryptographic methods of protection. Escaping queries to a database. Change Tracking. Data integrity in the databases. Database backups. Security features in databases- SQL statements for access control. Integrity (domain, attributes, tables, referential). Database monitoring tools. Database security analysis tools- An overview of the main methods for analysing database security. SQL injections. Database security scanners. |
| 9 | **Contents for lab** | NIL |
| 10 | **Books** | Book:<br>1. Database Security by Alfred Basta & Melissa Zgola<br>2. Database Security by Castano, Fugini, Martella, Samarati |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | CS-6XX |
| 4 | **Title of the subject** | Hardware Security |

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| 5 | **Any prerequisite** | Basic knowledge of Digital Logic Design, Computer Architecture and Cryptography |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | By the end of this course, students should be able to:<br>1. Understand security threats and vulnerabilities in hardware systems.<br>2. Analyze various hardware-based attacks and their countermeasures.<br>3. Design and implement secure hardware architectures.<br>4. Evaluate side-channel analysis techniques and defenses.<br>5. Explore hardware trojans, backdoors, and mitigation strategies.<br>6. Implement cryptographic hardware and analyze its security features.<br>7. Understand physical security measures for embedded systems and IoT devices.<br>8. Explore emerging trends in hardware security research. |
| 8 | **Brief Contents** | Digital system design: Basics and vulnerabilities, Hardware-Based Attacks, Secure Hardware Design Principles, Cryptographic Hardware and Implementations, Hardware Trojans and Backdoors, Physical Security and Embedded Systems, Emerging Trends in Hardware Security. |
| 9 | **Contents for lab** | Introduction to Hardware Security Tools, Side-Channel Attack Analysis, Fault Injection Attacks, Hardware Trojan Detection, Secure Boot and Trusted Execution Environments, Cryptographic Hardware Implementations, and Physical Security Testing. |
| 10 | **Books** | Ahmad-Reza Sadeghi and David Naccache, "Towards Hardware-intrinsic Security: Theory and Practice", Springer, 2010.<br>D. Mukhopadhyay and R. S. Chakraborty, "Hardware Security: Design, Threats and Safeguards", CRC Press, 2015. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | CS-6XX |
| 4 | **Title of the subject** | Operating System Security |
| 5 | **Any prerequisite** | Fundamentals of Operating Systems, Basic programming. |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Understand the security aspects of operating systems. Explore essential tools for securing operating systems. Learn how to enforce mandatory access control. Gain knowledge of general information security. |
| 8 | **Brief Contents** | Fundamentals- OS Processes, Synchronization, Memory Management, File Systems Trusted Operating Systems, Assurance in Trusted Operating Systems, Virtualization Techniques. Secure operating systems- Security goals, Trust model, Threat model Access Control Fundamentals – Protection system – Lampson's Access Matrix, Mandatory protection systems, Reference monitor. Multics – Multics system, Multics security, Multics vulnerability analysis Security in Ordinary OS – Unix, Windows. Verifiable security goals – Information flow, Denning's Lattice model, Bell-Lapadula model, Biba integrity model, Covert channels. Security Kernels – Secure Communications processor, Securing Commercial OS Secure Capability Systems – Fundamentals, Security, Challenges Secure Virtual Machine Systems. Case study - Linux kernel, Android, DVL, Solaris Trusted Extensions. |
| 9 | **Contents for lab** | Nil |
| 10 | **Text Books** | 1. Operating System Security by Trent Jaeger<br>2. Operating System Security by David K. Stokes |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | CS-6XX |
| 4 | **Title of the subject** | Fault Tolerant Systems |
| 5 | **Any prerequisite** | Basic knowledge of computer architecture, operating systems and networking. |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | By the end of this course, students will be able to:<br>1. Understand the fundamentals of fault tolerance and reliability in computing systems.<br>2. Analyze different types of faults, errors, and failures in computing systems.<br>3. Implement fault detection, fault masking, and recovery techniques.<br>4. Design and evaluate redundancy techniques, such as hardware, software, and time redundancy.<br>5. Explore fault-tolerant network protocols and distributed computing mechanisms.<br>6. Develop and assess checkpointing and recovery strategies.<br>7. Apply real-world fault-tolerant system design principles in practical scenarios. |
| 8 | **Brief Contents** | Introduction to Fault Tolerance, Reliability, Availability, and Maintainability (RAM), Fault Detection and Diagnosis, Built-In Self-Test (BIST), Fault Masking and Recovery Mechanisms, Voting Mechanisms and Majority Logic, Fault Tolerant Architectures, Dependable Distributed Systems (Paxos, RAFT), Fault Tolerant Network and Storage Systems, Cloud Computing and Fault Tolerance, Case Studies and Applications. |
| 9 | **Contents for lab** | Implementing Parity Checks and Hamming Code for Error Detection and Correction, Simulating Triple Modular Redundancy (TMR) in a Hardware System, Developing a Checkpointing and Rollback Recovery Mechanism in a Software System, Building a Distributed Consensus Protocol (RAFT or |

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| | | Paxos) Simulation, Analyzing Fault Tolerance in a Cloud Computing Environment using Kubernetes, Evaluating the Impact of Byzantine Faults in a Distributed Ledger System. |
| 10 | **Books** | Israel Koren and C. Mani. Krishna, “Fault Tolerant Systems”, Elsevier.2007.<br>P. Jalote, “Fault Tolerance in Distributed Systems”, Prentice-Hall Inc. 1994.<br>D. K. Pradhan, “Fault-Tolerant Computing, Theory and Techniques”, Prentice-Hall, 1998. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | CS-6XX |
| 4 | **Title of the subject** | Quantum Cryptography |
| 5 | **Any prerequisite** | Foundations of Cryptography, Linear Algebra, Probability. |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Understand the Fundamentals of Quantum Computing. Explore Quantum Information Theory. Analyse Quantum Key Distribution (QKD) Protocols. Evaluate the Security of Quantum Cryptography. Investigate Post-Quantum Cryptography & Hybrid Cryptosystems |
| 8 | **Brief Contents** | Introduction to Quantum Computing- Qubits, Superposition, Entanglement, Quantum Gates and Circuits, Measurement in Quantum Systems, Quantum vs Classical Computing, Quantum Parallelism. Quantum Information Theory-Quantum Entropy and Mutual Information, Quantum No-Cloning Theorem, Quantum Teleportation, Superdense Coding. Quantum Key Distribution (QKD) Protocols-BB84 Protocol, E91 Protocol (Entanglement-Based QKD), B92 and Other QKD Variants, Practical Implementations of QKD. Security Analysis of Quantum Cryptography-Information- |

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| | | Theoretic Security vs Computational Security, Shor's Algorithm & Its Impact on RSA, ECC, and Discrete Logarithm-Based Cryptosystems, Grover's Algorithm and Its Effect on Symmetric Cryptography, Device-Independent Quantum Cryptography. Post-Quantum Cryptography & Hybrid Cryptosystems-Lattice-Based Cryptography, Code-Based Cryptography, Hash-Based and Multivariate Cryptography, Quantum-Secure Cryptographic Protocols.<br><br>Books: |
| 9 | **Contents for lab** | Nil |
| 10 | **Text Book:** | 1. An Introduction to Quantum Cryptography by Thomas Vidick |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | CS-6XX |
| 4 | **Title of the subject** | Big Data and Cyber Fraud Analysis |
| 5 | **Any prerequisite** | Basic knowledge of Data Science and Programming |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | By the end of this course, students will be able to:<br><br>1. Understand the fundamentals of big data and its role in cyber fraud detection.<br>2. Analyze various types of cyber fraud, including financial fraud, identity theft, and phishing attacks. |

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| | | 3. Utilize big data tools and machine learning techniques for fraud detection.<br>4. Apply anomaly detection techniques to uncover fraudulent activities.<br>5. Explore real-world case studies and implement fraud detection models.<br>6. Implement ethical and legal considerations in cyber fraud analysis. |
| 8 | **Brief Contents** | Overview of big data technologies (Hadoop, Spark, NoSQL databases), Data Acquisition and Processing for Fraud Analysis, Fraud Detection Techniques, Machine Learning for Cyber Fraud Analysis, Big Data Tools and Technologies for Fraud Analysis, Graph analytics for fraud networks (Neo4j, NetworkX), Case Studies and Emerging Trends, Ethical and Legal Considerations in Fraud Analysis. |
| 9 | **Contents for lab** | Setting up Hadoop/Spark environment, Exploratory data analysis using Python (Pandas, Matplotlib, Seaborn), Implementing Z-score and IQR-based outlier detection Clustering techniques (K-Means, DBSCAN), Building classification models (Logistic Regression, Decision Trees, Random Forests), Streaming data with Apache Kafka and Spark Streaming, Building fraud networks with Neo4j. |
| 10 | **Books** | Sunder Gee, "Fraud and Fraud Detection: A Data Analytics Approach", Wiley, 2014, ISBN: 978-1-118-77965-1<br><br>Bart Baesens, Veronique Van Vlasselaer, Wouter Verbeke, "Fraud Analytics Using Descriptive, Predictive, and Social Network Techniques: A Guide to Data Science for Fraud Detection", Wiley and SAS Business Series, 2015 |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | CS-6XX |
| 4 | **Title of the subject** | Secure System Engineering |

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| 5 | **Any prerequisite** | Computer Security Fundamentals or equivalent |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | By the end of this course, students will be able to:<br>1. Understand core security principles and apply them in system design.<br>2. Identify and mitigate security threats and vulnerabilities.<br>3. Implement secure software development and system hardening techniques.<br>4. Apply risk assessment and management strategies in system engineering.<br>5. Design secure architectures for applications, networks, and infrastructures.<br>6. Utilize security tools for threat detection, prevention, and response.<br>7. Evaluate compliance with security policies and regulatory frameworks. |
| 8 | **Brief Contents** | Software vulnerabilities, Software security and software quality assurance, Security requirement gathering principals and guidelines, Secure software architecture, Architecture risk analysis, Software security knowledge for architecture and design, Security guideline and attack patterns, testing software vulnerability in SDLC, Mitigating Software Vulnerabilities in SDLC, Static analysis techniques, Security testing, Operating software security, Maintaining software security. |
| 9 | **Contents for lab** | Using tools like Microsoft Threat Modeling Tool to analyze security risks, Identifying vulnerabilities in code and applying secure coding techniques, Configuring secure OS settings and disabling unnecessary services, Configuring firewalls and VPNs for secure communication, Hands-on encryption and decryption using OpenSSL, Implementing role-based access control (RBAC) in Linux/Windows environments, Using tools like Wireshark, Snort, and Splunk for threat detection. |
| 10. | **Books** | 1. Software Security Engineering: A Guide for Project Managers" by Julia H. Allen, Sean Barnum, Ruth A. Ellison, Gary McGraw, and Nancy R. Mead<br>2. The Software Security Touchpoints" by Gary McGraw |

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| | | 3. Writing Secure Code" by Michael Howard and David LeBlanc<br>4. Web Application Hacker's Handbook: Finding and Exploiting Security Flaws" by Dafydd Stuttard and Marcus Pinto<br>5. The Art of Software Security Assessment: Identifying and Preventing Software Vulnerabilities" by Mark Dowd, John McDonald, and Justin Schuh |

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|---|---|---|
| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | CS-6XX |
| 4 | **Title of the subject** | Formal Verification of Security Protocols |
| 5 | **Any prerequisite** | Basic knowledge of computer security and discrete mathematics |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To comprehend how a security protocol is theoretically based. to comprehend formal verification's fundamentals and how security procedures use them. to be aware of the different kinds of security systems and the weaknesses in each. to gain knowledge on how to define security attributes and use formal verification methods to confirm that they are right. |
| 8 | **Brief Contents** | Basic of Logics: BNF, Labelled transition systems, Operational semantics, Protocol specification, describing protocol execution, Security properties: secrecy, authentication, Aliveness, Synchronization, the analysis of security protocols: abstract state machines, Belief logics, Constraint, Provable security, modeling guessable numbers, Modelling time, The BAN Kerberos Protocol. |
| 9 | **Contents for lab** | Nil |

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| 10 | **Books** | Security Protocols: Principles and Calculi" – Peter Ryan, Steve Schneider, Michaël Rusinowitch<br><br>The Formal Verification of Security Protocols" – Véronique Cortier, Steve Kremer |

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|---|---|---|
| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | CS-6XX |
| 4 | **Title of the subject** | Digital Forensics |
| 5 | **Any prerequisite** | Operating System, Computer Network, Cybersecurity Concepts |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To understand the basic digital forensics and techniques for conducting the forensic examination on different digital devices. To understand how to examine digital evidences such as the data acquisition, identification analysis. |
| 8 | **Brief Contents** | Computer forensics fundamentals, Benefits of forensics, computer crimes, computer forensics evidence and courts, legal concerns and private issues. Understanding Computing Investigations – Procedure for corporate High-Tech investigations, understanding data recovery work station and software, conducting and investigations. Data acquisition-understanding storage formats and digital evidence, determining the best acquisition method, acquisition tools, validating data acquisitions, performing RAID data acquisitions, remote network acquisition tools, other forensics acquisitions tools. Processing crimes and incident scenes, securing a computer incident or crime, seizing digital evidence at scene, storing digital evidence, obtaining digital hash, reviewing case. Current computer forensics tools- software, hardware tools, validating and testing forensic software, addressing data-hiding techniques, performing remote acquisitions, E-Mail |

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| | | investigations- investigating email crime and violations, understanding E-Mail servers, specialized E-Mail forensics tool. |
| 9 | **Contents for lab** | Installation of forensic tools (Autopsy, FTK Imager, EnCase, Sleuth Kit). Creating a forensic workstation and bootable forensic USB. Disk Imaging and Write Blocking- Creating forensic disk images using FTK Imager/DD tool, verifying integrity using hash functions (MD5, SHA-256). Extracting data from Android and iOS devices using ADB and Cellebrite. Recovering deleted messages, call logs, and GPS locations. Capturing and analysing packets using Wireshark. Identifying malicious activities in network traffic logs. |
| 10 | **Books** | Digital Forensics with Open Source Tools – Cory Altheide & Harlan Carvey<br><br>Incident Response & Computer Forensics – Kevin Mandia, Chris Prosise & Matt Pepe<br><br>Guide to Computer Forensics and Investigations – Bill Nelson, Amelia Phillips & Christopher Steuart |

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|---|---|---|
| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | CS-6XX |
| 4 | **Title of the subject** | Natural Language Processing |
| 5 | **Any prerequisite** | Machine Learning, Probability & Statistics |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To understand the fundamentals of natural language processing (NLP) and its applications.<br><br>To explore various computational linguistics techniques and machine learning methods for NLP. |

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| | | To develop proficiency in implementing NLP models using libraries such as NLTK, SpaCy, and Transformers. |
| 8 | **Brief Contents** | Introduction and Basic Text Processing, Spelling Correction, Language Modeling, Advanced smoothing for language modeling, POS tagging Models for Sequential tagging – MaxEnt, CRF, Syntax – Constituency Parsing, Dependency Parsing Distributional Semantics, Lexical Semantics, Topic Models Entity Linking, Information Extraction, Text Summarization, Text Classification, Sentiment Analysis and Opinion Mining |
| 9 | **Contents for lab** | Hands-on implementation of text preprocessing, POS tagging, Named Entity Recognition, Word embeddings, and Transformer-based models using Python-based NLP frameworks. |
| 10. | **Books** | Speech and Language Processing – Daniel Jurafsky & James H. Martin A comprehensive introduction to NLP, covering both linguistic and statistical approaches.<br><br>Natural Language Processing with Python – Steven Bird, Ewan Klein & Edward Loper A practical book using Python and the NLTK library to build NLP applications. |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | CS-6XX |
| 4 | **Title of the subject** | Information Retrieval |
| 5 | **Any prerequisite** | Web security |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning objectives of the subject** | Some key learning objectives of Information Retrieval (IR) are as follows.<br><br>Understand the basics, search engine architecture, retrieval models, query processing, text classification and clustering, |

| | | |
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| | | web search, retrieval evaluation, IR applications, practical implementation, and current trends and research |
| 8 | **Brief contents** | Overview of text retrieval systems, Search engine architecture, Retrieval models and implementation: Vector Space Models, Query expansion and feedback, Probabilistic models; statistical language models Text classification & Text clustering, Web search basics, crawling, indexes, Link analysis, Retrieval evaluation, IR applications<br><br>**Books:**<br>1. Introduction to Information Retrieval by Christopher D. Manning, Prabhakar Raghavan, and Hinrich Schütze<br>2. Text Information Retrieval Systems by Charles T. Meadow, Bert R. Boyce, and Donald H. Kraft<br>3. Information Retrieval: Implementing and Evaluating Search Engines by Stefan Büttcher, Charles L. A. Clarke, and Gordon V. Cormack<br>4. Modern Information Retrieval: The Concepts and Technology behind Search by Ricardo Baeza-Yates and Berthier Ribeiro-Neto<br>5. Search Engines: Information Retrieval in Practice by W. Bruce Croft, Donald Metzler, and Trevor Strohman |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | Introduction to Information Retrieval – Christopher D. Manning, Prabhakar Raghavan, and Hinrich Schütze<br><br>Modern Information Retrieval: The Concepts and Technology Behind Search – Ricardo Baeza-Yates and Berthier Ribeiro-Neto |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | CS-6XX |
| 4 | **Title of the subject** | Recommender Systems |
| 5 | **Any prerequisite** | Data mining |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning objectives of the subject** | Some key learning objectives of Recommender Systems (RS) are as follows.<br><br>Understand fundamental concepts, recommendation data, introductory approaches, mathematical foundations, collaborative filtering, content-based recommendation, knowledge-based recommendation, evaluation, advanced topics, practical implementation, and case studies |
| 8 | **Brief contents** | Fundamental Elements of Recommendation, Recommendation Data, Introductory Approaches, Vectors and Neighbourhoods, Matrices, Embeddings, and Optimization, Collaborative Filtering, Content-based recommendation, Knowledge based recommendation, Evaluating Recommender System, Other aspects of recommender systems, Case studies.<br><br>**Books:**<br>1. Recommender Systems: The Textbook by Charu C. Aggarwal<br>2. Recommender Systems Handbook edited by Francesco Ricci, Lior Rokach, and Bracha Shapira<br>3. Practical Recommender Systems by Kim Falk<br>4. Building Recommendation Engines by Suresh Kumar Gorakala and Michael R. Lakshmanan |
| 9 | **Contents for lab** | Nil |

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|---|---|---|
| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | CS-6XX |
| 4 | **Title of the subject** | Reinforcement Learning |
| 5 | **Any prerequisite** | Machine Learning, Probability & Statistics |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning Objectives of the subject** | To understand the concepts of Markov Decision Processes and reinforcement learning algorithms.<br><br>To explore value-based and policy-based reinforcement learning methods. |
| 8 | **Brief Contents** | Introduction, Bandit algorithms – UCB, PAC, Bandit algorithms –Median Elimination, Policy Gradient Full RL & MDPs, Bellman Optimality, Dynamic Programming & TD Methods Eligibility Traces, Function Approximation, Least Squares Methods Fitted Q, DQN & Policy Gradient for Full RL, Hierarchical RL, POMDPs |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | Reinforcement Learning: An Introduction" – Richard S. Sutton & Andrew G. Barto<br><br>Algorithms for Reinforcement Learning" – Csaba Szepesvári |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | CS-6XX |
| 4 | **Title of the subject** | Fair, Accountable, Transparent AI |
| 5 | **Any prerequisite** | Machine Learning |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The Fair, Accountable, Transparent AI course aims to equip students with the knowledge and skills required to apply fairness, accountability, and transparency principles in AI systems through real-world datasets and tools. The key learning objectives include:<br><br>1. Understand AI Ethics and Bias – Learn about fairness, accountability, and transparency in AI models. |

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| | | 2. Detect and Mitigate Bias in AI Systems – Study bias in datasets, algorithms, and decision-making.<br>3. Ensure Explainability and Interpretability – Explore techniques for making AI decisions understandable.<br>4. Implement Fair and Accountable AI Models – Learn fairness-aware ML techniques and responsible AI practices.<br>5. Study AI Governance and Regulations – Understand legal, ethical, and societal implications of AI.<br>6. Apply Responsible AI to Real-World Domains – Address fairness in healthcare, hiring, finance, and law enforcement. |
| 8 | **Brief Contents** | Introduction to responsible AI and the challenges, need of Responsible AI, principles of Responsible AI. Fairness and bias mitigation: fairness and values within AI, different forms of biases, Fairness & Bias in Networks, Researcher Bias, Algorithmic Bias and Feedback, Debiasing Methods, techniques for bias mitigation and measurement, transparency in AI and its importance, transparency in data and models. accountability in AI and its significance, concept of drift, including its various types, techniques for detecting drift in AI systems, data privacy in AI, Explore Privacy by Design, Understand AI security and the concept, robust and private AI applications. |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | Fairness and Machine Learning: Limitations and Opportunities" – Solon Barocas, Moritz Hardt, Arvind Narayanan<br><br>The Ethical Algorithm: The Science of Socially Aware Algorithm Design" – Michael Kearns, Aaron Roth |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | CS-6XX |
| 4 | **Title of the subject** | Machine Learning System Optimization |

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| 5 | **Any prerequisite** | Machine Learning |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The Machine Learning System Optimization course aims to provide a comprehensive understanding of optimization techniques across different stages of the ML pipeline, including hyperparameter tuning, regularization, model compression, and hardware utilization. The key learning objectives include:<br>1. Understand Optimization in ML Systems<br>2. Optimize Model Training and Inference<br>3. Apply Hyperparameter Tuning<br>4. Enhance Hardware Utilization<br>5. Implement Regularization and Gradient Optimization<br>6. Use Model Compression and Quantization |
| 8 | **Brief Contents** | Module 1: Introduction to ML System Optimization: Challenges in Machine Learning Optimization, Trade-offs: Accuracy vs. Efficiency vs. Cost, Case Studies in ML System Optimization<br>Module 2: Optimization Algorithms in ML: Gradient Descent Variants (Batch, Stochastic, Mini-batch), Momentum, RMSprop, Adam, and Adaptive Learning Rates, Second-Order Optimization: Newton's Method<br>Module 3: Hyperparameter Tuning and Model Selection: Grid Search, Random Search, Bayesian Optimization<br>Automated Hyperparameter Optimization (Optuna, Hyperopt), Cross-Validation Strategies for Model Selection<br>Module 4: Regularization Techniques: L1, L2 (Ridge and Lasso), and ElasticNet Regularization, Dropout, Batch Normalization, and Early Stopping<br>Module 5: Model Compression and Quantization: Pruning and Knowledge Distillation, Quantization (Post-training vs. Quantization-aware training), TensorRT and ONNX for Optimized Model Deployment |
| 9 | **Contents for lab** | Nil |
| 10 | **Books** | Efficient Processing of Deep Neural Networks" – Vivienne Sze, Yu-Hsin Chen, Tien-Ju Yang, Joel S. Emer<br><br>Machine Learning Systems: Designs that Scale" – Jeff Smith |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | CS-6XX |
| 4 | **Title of the subject** | Pattern Recognition |
| 5 | **Any prerequisite** | Probability, Statistics, and Linear Algebra |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To understand the basic concepts, scope, and applications of pattern recognition.<br>To apply machine learning models to real-world pattern recognition tasks. |
| 8 | **Brief Contents** | Module-1: The classification process: features, training and learning, approaches to classification Non metric<br>methods: Information, Entropy and Impurity, decision tree classifier- ID3, C4.5.<br>Module-2: Discriminant functions: linear discriminant functions, piece-wise linear discriminant functions, generalized discriminant functions.<br>Module-3: Statistical pattern recognition: measured data and measurement errors, probability theory, conditional probability and Bayes rule, Naive Bayes classifier, Continuous random variables, The multivariate Gaussian, Covariance matrix and MahalanobisdistanceParametric learning: Bayesian decision theory, discriminant functions and decision boundaries, MAP (Maximum A Posteriori Estimator)<br>Module-4: Non Parametric learning: Histogram estimator and Parzen windows, k-NN classification, Artificial Neural Networks, Kernel Machines, SVM. Feature extraction and selection: reducing dimensionality, feature selection-Inter/Intra class distance<br>Module-5: Feature extraction: Principal component analysis, Linear discriminant analysis.Unsupervised learning: Clustering, K- Means clustering, Fuzzy c-Means |

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| | | clustering,(Agglomerative) Hierarchical clustering Estimating and Comparing Classifiers: No free lunch, Bias and variance trade-off, cross-validation and resampling methods, Measuring classifier performance, Comparing classifiers- ROC curves, McNemar's test, other statistical tests |
| 9 | **Contents for lab** | Introduction to Pattern Recognition & Environment Setup, Data Preprocessing & Feature Extraction, Statistical Decision Theory & Bayes Classifier, Supervised Classification Methods, Neural Networks for Pattern Recognition¸ Hidden Markov Models (HMM) for Sequential Data, Real-World Applications & Project Work |
| 10. | **Books** | 1. Pattern Classification, Duda Hart, Wiley<br>2. Pattern Recognition and Classification, Geoff Dougherty, Springer<br>3. Statistical Pattern Recognition, Andrew R Webb, Wiley<br>4. Pattern Recognition and Machine Learning, Christopher Bishop, Springer |

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| 1 | **Semester** | - |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | CS-6XX |
| 4 | **Title of the subject** | Deep Learning Techniques |
| 5 | **Any prerequisite** | Linear Algebra, Machine Learning basics |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To understand popular DL algorithms with their associated mathematical foundations for appreciating these algorithms. |

| | | |
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| | | To help connect real-world problems to appropriate DL algorithms(s) for solving them and to enable formulating real world problems as deep learning tasks. |
| 8 | **Brief Contents** | Module-1: Course Overview: Introduction to Deep Learning and its Applications. Introduction to Statistical Learning: Multi-Layer Perceptron, Back Propagation, Linear Regression, Loss Functions and Optimization: Optimization, stochastic gradient descent, dropout, batch normalization, etc.<br>Module-2: Convolutional Neural Networks: Convolution, pooling, Activation Functions, Back propagation of CNN, Weights as templates, Translation invariance, Training with shared parameters. CNN Architecture Design and Discussion: AlexNet, VGG, GoogLeNet, ResNet, Capsule Net, etc. Visualization and Understanding: Visualizing intermediate features and outputs, Saliency maps, Visualizing neurons, Cam-Grad, etc.<br>Module-3: Sequential Modelling: Recurrent and Recursive Nets, RNN, LSTM, GRU, Image captioning, visual question answering, etc.<br>Module-4: Generative Models: Encoder, Decoders, Variational Autoencoders, Generative Adversarial Networks like pix2pix, CycleGAN, etc. Transformers based Models<br>Module-5: Deep Learning Applications: Object Detection: RCNN, Fast RCNN, Faster RCNN, YOLO and variants, Retina Net, etc., Adversarial Attacks on CNN Deep learning for NLP, Deep learning Libraries and Frameworks: Keras, TensorFlow, PyTorch, AutoML, etc. |
| 9 | **Contents for lab** | Introduction to Deep Learning & Environment Setup, Neural Networks and Backpropagation, Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs) & LSTMs, Transfer Learning & Pretrained Models, Generative Adversarial Networks (GANs), Autoencoders and Dimensionality Reduction, Reinforcement Learning Basics, Deployment of Deep Learning Models |
| 10. | **Books** | 1. Ian Goodfellow and Yoshua Bengio and Aaron Courville, “Deep Learning,” MIT Press.<br>2. Michael A. Nielsen, “Neural Networks and Deep Learning,” Determination Press, 2015. |

# Curriculum & Contents

# M. Tech.
# (Information Technology)

**Department of Information Technology**

विश्वजीवनामृतं ज्ञानम्

# ABV-Indian Institute of Information Technology & Management, Gwalior

# SCHEMA

**Name of the program: M. Tech. (Information Technology)**

**(Credits: 70)**

**Name of the Department: Information Technology**

**Track 1-Smart Mobility Systems Engineering**

| SEMESTER-I | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject Code** | **Title of the course** | **L-T-P** | **Credits** |
| **1.** | IT-701 | Machine Learning Techniques | 3-0-2 | 4 |
| **2.** | IT-702 | Mathematical Foundations for Data Science | 3-0-2 | 4 |
| **3.** | IT-703 | Advanced Data Structures and Algorithms | 3-0-2 | 4 |
| **4.** | IT-704 | Introduction to Robotics | 3-0-2 | 4 |
| **5.** | IT-705 | Design for Reliability: Information and Computer Based Systems | 3-0-2 | 4 |
| | | | **Total credits** | **20** |

| SEMESTER-II | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject code** | **Title of the course** | **L-T-P** | **Credits** |
| **1.** | IT-712 | Deep Learning | 3-0-2 | 4 |
| **2.** | IT-713 | Cyber Physical Systems | 3-0-2 | 4 |
| **3.** | IT-714 | Secure System Design | 3-0-0 | 3 |
| **4.** | IT-XXX | Elective I | 3-0-0 | 3 |

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|---|---|---|---|---|
| **5.** | IT-XXX | Mini Project | 0-0-6 | 3 |
| **6.** | IT-717 | Engineering Research Methodology | 2-2-0 | 3 |
| | | | **Total credits** | **20** |

EXIT AFTER YEAR-1: Post Graduate Diploma in Information Technology

| **SEMESTER-III** | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject code** | **Title of the course** | **L-T-P** | **Credits** |
| **1** | IT-XXX | Elective II/MOOC | 3-0-0 | 3 |
| **2** | IT-698 | Dissertation Part - I | | 12 |
| | | | **Total credits** | **15** |

| **SEMESTER-IV** | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject Code** | **Title of the course** | **L-T-P** | **Credits** |
| **1** | IT-699 | Dissertation Part - II | | 15 |
| | | | **Total credits** | **15** |

| **SEMESTER-I** | **SEMESTER-II** | **SEMESTER-III** | **SEMESTER-IV** | **TOTAL CREDITS** |
|---|---|---|---|---|
| 20 | 20 | 15 | 15 | **70** |

**Track 2- Intelligent Information Systems Engineering**

| SEMESTER-I | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject Code** | **Title of the course** | **L-T-P** | **Credits** |
| **1.** | IT-701 | Machine Learning Techniques | 3-0-2 | 4 |
| **2.** | IT-702 | Mathematical Foundations for Data Science | 3-0-2 | 4 |
| **3.** | IT-703 | Advanced-Data Structures and Algorithms | 3-0-2 | 4 |
| **4.** | IT-706 | Introduction to Natural Language Processing | 3-0-2 | 4 |
| **5.** | IT-705 | Design for Reliability: Information and Computer-Based Systems | 3-0-2 | 4 |
| | | | **Total credits** | **20** |

| SEMESTER-II | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject code** | **Title of the course** | **L-T-P** | **Credits** |
| **1.** | IT-712 | Deep Learning | 3-0-2 | 4 |
| **2.** | IT-715 | Advanced Natural Language Processing | 3-0-2 | 4 |
| **3.** | IT-716 | Social Networks Analysis | 3-0-0 | 3 |
| **4.** | IT-XXX | Elective I | 3-0-0 | 3 |
| **5.** | IT-XXX | Mini Project | 0-0-6 | 3 |
| **6.** | IT-717 | Engineering Research Methodology | 2-2-0 | 3 |
| | | | **Total credits** | **20** |

EXIT AFTER YEAR-1: Post Graduate Diploma in Information Technology

| SEMESTER-III | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject code** | **Title of the course** | **L-T-P** | **Credits** |
| **1** | IT-XXX | Elective II/MOOC | 3-0-0 | 3 |
| **2** | IT-698 | Dissertation Part - I | | 12 |
| | | | **Total credits** | **15** |

| SEMESTER-IV | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject Code** | **Title of the course** | **L-T-P** | **Credits** |
| **1** | IT-699 | Dissertation Part - II | | 15 |
| | | | **Total credits** | **15** |

| SEMESTER-I | SEMESTER-II | SEMESTER-III | SEMESTER-IV | TOTAL CREDITS |
|---|---|---|---|---|
| 20 | 20 | 15 | 15 | **70** |

# Electives Courses

| S. No. | Electives I and II Category: Track in Smart Mobility Systems Engineering |
|---|---|
| IT-001 | Computer Vision |
| IT-002 | Digital Signal Processing |
| IT-004 | Information Retrieval and Extraction |
| IT-005 | Human Computer Interaction |
| IT-006 | Digital Video Processing |
| IT-007 | Advanced Machine Learning |
| IT-008 | Multimedia Processing |
| IT-012 | Next Generation Networks |
| IT-013 | Queuing Theory |
| IT-014 | Network design and Optimization |
| IT-015 | Advanced Wireless |
| IT-016 | Multimedia Networks |
| IT-016 | Distributed Systems |
| IT-020 | Information Theory and Coding |
| IT-022 | Digital Watermarking and Steganalysis |
| IT-023 | Cryptography and Network Security |
| IT-024 | Distributed System Security |
| IT-025 | Cyber Security and Laws |

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|---|---|
| IT-026 | Advanced cryptography |
| IT-027 | Information Security and Secure Coding |
| IT-028 | Malware Analysis |
| IT-029 | Formal methods for Security |
| IT-030 | IoT and its security |
| IT-031 | Blockchain Technologies |
| IT-032 | Convex Optimization |
| IT-033 | Parallel and Concurrent Programming |
| IT-035 | Game Theory |
| IT-036 | Big Data Analytics |
| IT-040 | Nature Inspired computing |
| IT-038 | Program Analysis Verification and Testing |
| IT-039 | Competitive Programming |
| IT-718 | Large Language Models |
| IT-402 | Digital Image Processing |
| EE-057 | Hardware Security |
| IT-706 | Introduction to Natural Language Processing |
| IT-715 | Advanced Natural Language Processing |
| IT-716 | Social Networks Analysis |

| S. No. | Electives I and II Category: Intelligent Information Systems Engineering |
|---|---|
| IT-001 | Computer Vision |
| IT-002 | Digital Signal Processing |
| IT-004 | Information Retrieval and Extraction. |
| IT-005 | Human Computer Interaction |
| IT-006 | Digital Video Processing |
| IT-007 | Advanced Machine Learning |
| IT-008 | Multimedia Processing |
| IT-012 | Next Generation Networks |
| IT-013 | Queuing Theory |
| IT-014 | Network design and Optimization |
| IT-015 | Advanced Wireless |
| IT-016 | Multimedia Networks |
| IT-016 | Distributed Systems |
| IT-020 | Information Theory and Coding |
| IT-022 | Digital Watermarking and Steganalysis |
| IT-023 | Cryptography and Network Security |
| IT-024 | Distributed System Security |
| IT-025 | Cyber Security and Laws |
| IT-026 | Advanced cryptography |
| IT-027 | Information Security and Secure Coding |

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|---|---|
| IT-028 | Malware Analysis |
| IT-029 | Formal methods for Security |
| IT-030 | IoT and its security |
| IT-031 | Blockchain Technologies |
| IT-032 | Convex Optimization |
| IT-033 | Parallel and Concurrent Programming |
| IT-035 | Game Theory |
| IT-036 | Big Data Analytics |
| IT-040 | Nature Inspired computing |
| IT-038 | Program Analysis Verification and Testing |
| IT-039 | Competitive Programming |
| IT-718 | Large Language Models |
| IT-402 | Digital Image Processing |
| EE-057 | Hardware Security |
| IT-704 | Introduction to Robotics |
| IT-713 | Cyber-Physical Systems |
| IT-714 | Secure System Design |

# Course Contents

| | | |
|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | IT-701 |
| 4 | **Title of the subject** | **Machine Learning Techniques** |
| 5 | **Any prerequisite** | |
| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning Objectives of the subject** | To understand popular ML algorithms with their associated mathematical foundations for appreciating these algorithms.<br>To help connect real-world problems to appropriate ML algorithm(s) for solving them and to enable formulating real world problems as machine learning tasks. |
| 8 | **Brief Contents** | Introduction to ML, Fundamentals of ML - PCA and Dimensionality reduction, Nearest neighbours and KNN, Linear regression, Decision tree classifiers, Notion of generalization and concern of overfitting, Notion of training, Validation, and testing; Connect to generalization and overfitting. Selected algorithms - ensembling and RF, Linear SVM, K means, Logistic regression, Naive bayes, Neural network learning - Role of loss functions and optimization, Gradient descent and Perceptron/Delta learning, MLP, Backpropagation, MLP for classification and regression, Regularization, Early Stopping, Kernels (with SVM), Bayesian methods, Generative methods, HMM, EM, PAC learning, Introduction to Deep Learning, CNNs, Popular CNN architectures, RNNs, GANS and Generative models, Advances in backpropagation and optimization for neural networks adversarial learning. |
| 9 | **Contents for lab** | To implement basic algorithms using basic machine learning libraries mostly in python. Gain hands-on |

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| | | experience in applying ML to problems encountered in various domains. In addition, obtain exposure to high-level ML libraries or frameworks such as TensorFlow, PyTorch. |

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|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the Course** | IT-702 |
| 4 | **Title of the Course** | **Mathematical Foundations for Data Science** |
| 5 | **Any prerequisite** | Engineering mathematics |
| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning objectives of the Course (in about 50 words)** | This course aims to provide a comprehensive understanding of the essential mathematical concepts underlying data science and machine learning. By the end of the course, students will have mastered topics such as linear algebra, calculus, probability, and optimization, which are critical for data representation, modeling, and analysis. |
| 8 | **Brief contents** | **Module 1:** Vector and matrices, Solving linear equations, Basis and dimension - What is a basis for a vector space? Finding bases for vector spaces; Rank of a matrix. Higher order partial derivatives and the Hessian matrix<br><br>**Module-2**: Introduction to Probability and Statistics, Random variables (Univariate, Bivariate, and, Multiple random variables), Distribution functions. Transformation of Probability.<br><br>**Module-3:** Linear optimization, linear programming problems, simplex methods for optimization. Nonlinear optimization: basic theory, method of Lagrange multipliers, Karush-Kuhn-Tucker theory, convex optimization |
| 9 | **Contents for lab (If applicable)** | N/A |

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| 10 | **Book suggested** | 1. N. S. Kambo, Mathematical Programming Techniques, East West Press, 1997<br>2. David C. Lay, Steven R. Lay, Judi J. McDonald, Linear Algebra and Its Applications (5th Edition), Pearson, 2015<br>3. Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers, Keying Ye, Probability and Statistics for Engineers and Scientists (9th Edition), Pearson, 2011 |

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| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | IT-703 |
| 4 | **Title of the subject** | **Advanced Data Structure and Algorithms** |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning objectives of the subject (in about 50 words)** | The course aims to provide a solid foundation in designing, implementing, and analysing algorithms and data structures for real-world applications. Students will explore algorithmic paradigms, graph algorithms, balanced trees, NP-completeness, and advanced sorting techniques, equipping them to solve complex computational problems with efficient data structures and algorithmic strategies. |
| 8 | **Brief contents** | Review of order rotation & growth of functions, recurrences, probability distributions, Average case analysis of algorithms, Basic data structures such as stacks, queues, linked lists, and applications. Direct access tables and hash tables, hash functions and relates analysis, Binary Search trees and Operations, AVL Trees and balancing operations, R B Trees, properties, operations. B – Trees – definition – properties, operations, data structures for disjoint sets, Graph algorithms, MST single source all pair shortest paths, BFS, DFS, topological sort, strongly connected components. Quick sort randomized version, searching in linear time, More graph algorithms – maximal independent sets, coloring vertex cover, introduction to perfect graphs. Algorithmic paradigms Greedy Strategy, Dynamic programming, Backtracking, Branch-and-Bound, Randomized algorithms. Classes P, NP, co-NP. NP-Completeness and Reducibility, Cook's Theorem without proof. Example reductions between problems. |

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| | | **Text Book:**<br>1. T. H. Cormen, C. E. Leiserson, R. L. Rivest, Introduction to Algorithms, Prentice hall.<br>2. Data structures and algorithm analysis in C++(Java): Mark Weiss<br>**Reference Book**<br>1. AV Aho, J Hopcroft, and JD Ullman, The Design and Analysis of Algorithms, Addison-Wesley, 1974. |
| 9 | **Contents for lab (If applicable)** | Same as above. |

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|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the Course** | IT-704 |
| 4 | **Title of the Course** | **Introduction to Robotics** |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning objectives of the Course (in about 50 words)** | The course work will be helpful for the students to understand the basic principles of robotics. They will learn about the components, modelling and basic operations of the robots. |
| 8 | **Brief contents** | ● Systems Overview of a Robot, Mechanical Systems, Components, Dynamics and Modeling, Control of Actuators in Robotic Mechanisms, Robotic Sensory Devices.<br>● Performance Definition - Accuracy/ Repeatability/ Precision with respect to Position &Path, payload, speed, acceleration, cycle time<br>● Challenges/applications and uses of Mobile and other robots: wheeled, tracked, legged, aerial, underwater robots, surgical robots, rehabilitation robots, humanoid robots<br>● Introduction to robot manipulation. Forward and inverse kinematics of robots and some case studies. Manipulator dynamics. Basics of robot control.<br>● Autonomous Mobile Robots, Task planning, robot path finding, robot arm reachability, grasp planning etc.<br>● Overview of robot vision. |
| 9 | **Contents for lab (If applicable)** | Transformations, Robotic Simulators, Robot Operating System |

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| 10 | **Book suggested** | Textbook<br>1. J. J. Craig, Introduction to Robotics: Mechanics and Control, Pearson.<br>2. R. Kala, Autonomous Mobile Robots: Planning, Navigation and Simulation, Academic Press References:<br>1. Richard D. Klafter, Robotic Engineering: An Integrated Approach, Phi<br>2. R. J. Schilling, Fundamentals of Robotics: Analysis And Control, Prentice-Hall India<br>3. Francis N. Nagy, Andrassiegler, Engineering Foundation of Robotics, Prentice Hall Inc<br>4. P.A. Janaki Raman, Robotics And Image Processing An Introduction, Tata Mc Graw Hill Publishing Company Ltd.<br>5. Mikell P. Grooyer, Mitchell Weiss, Roger N. Nagel, Nicholas G. Odrey, Industrial Robotics, Technology Programming And Applications, Mc Graw Hill International Edition<br>6. S.R. Deb, Robotics Technology And Flexible Automation, Tata Mc Graw Hill Publishing Company Ltd.<br>7. Carl D. Crane And Joseph Duffy, Kinematic Analysis Of Robot Manipulation, Cambridge University Press |

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| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the Course** | IT-705 |
| 4 | **Title of the Course** | **Design for Reliability: Information and Computer-Based Systems** |
| 5 | **Any prerequisite** | Software Engineering concepts |
| 6 | **L-T-P** | 3-1-0 |

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| 7 | **Learning objectives of the Course (in about 50 words)** | 1. Understanding of reliability engineering on a variety of wireless and wireline products and solutions in the system architecture realm.<br>2. Will be able to understand system's availability expectations, how to frame verifiable availability/robustness requirements, how to methodically architect and design systems that meet robustness requirements, etc.<br>3. Will be able to frame reliability and robustness as a functional aspect of a system rather than an abstract, non-functional notion. |
| 8 | **Brief contents** | Reliability and Availability Concepts, System Basics, Eight-Ingredient Framework, Failure Containment and Redundancy, Robust Design Principles, Error Detection, Analyzing and Modeling Reliability and Robustness, Reliability Requirements, Reliability Analysis, Reliability Budgeting and Modeling, Robustness and Stability Testing, Design for Reliability Case Study. |
| 9 | **Contents for lab (If applicable)** | N/A |
| 10 | **Book suggested** | Design for Reliability: Information and Computer-Based Systems by Eric Bauer. Wiley – IEEE Press. |

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| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the Course** | IT-712 |
| 4 | **Title of the Course** | **Deep learning** |
| 5 | **Any prerequisite** | Machine Learning Technique |
| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning objectives of the Course (in about 50 words)** | The learning objective of this course is to equip students with a comprehensive understanding of deep learning principles, architectures, and applications. Students will gain hands-on |

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| | | experience in building and optimizing neural networks for tasks in computer vision, natural language processing, and more, while understanding state-of-the-art methods and deployment strategies. |
| 8 | **Brief contents** | Basics of Neural Network, McCulloch Pitts Neuron, Perceptron Learning Algorithm, Multilayer Perceptrons (MLPs), Activation functions, Optimization methods like SGD, Adam, Introduction to CNN, Variants of CNN like LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet. Recurrent Neural Networks/LSTM/GRU, Introduction to Transformer and other sequence learning models. |
| 9 | **Contents for lab (If applicable)** | N/A |
| 10 | **Book suggested** | 1. Ian Goodfellow and Yoshua Bengio and Aaron Courville. Deep Learning. An MIT Press book. 2016.<br>2. Charu C. Aggarwal. Neural Networks and Deep Learning: A Textbook. Springer. 2019.<br>3. Dive into Deep Learning |

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| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | IT-713 |
| 4 | **Title of the subject** | **Cyber Physical Systems** |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning objectives of the subject (in about 50 words)** | This course aims to equip students with a comprehensive understanding of Cyber-Physical Systems (CPS) and the Internet of Things (IoT), focusing on their principles, architectures, communication protocols, embedded systems, edge computing, security, and real-world applications in domains like smart cities, healthcare, and industrial automation, enabling hands-on system design and analysis. |
| 8 | **Brief contents** | Fundamentals of IoT: Definitions, Characteristics, and Applications, Overview of Cyber-Physical Systems (CPS): Features, Architecture, and Design Principles, key Differences and Overlaps between IoT and CPS, Case Studies: Smart Cities, Healthcare, and Industrial Automation, **IoT** |

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| | | Architecture and Communication Protocols: IoT Architectures: Layered Models (Perception, Network, Application), Communication Protocols, Wireless Technologies: Wi-Fi, Bluetooth, Zigbee, LoRa, 6LoWPAN, Internet Protocols: MQTT, CoAP, HTTP/HTTPS, Data Acquisition and Sensor Networks in IoT, Real-Time Constraints and Protocol Selection in CPS, Module Embedded Systems and Edge Computing for IoT/CPS: Introduction to Microcontrollers and Embedded Systems (Arduino, Raspberry Pi, etc.), Role of Edge Computing in IoT and CPS, Middleware Platforms for IoT/CPS Integration, Hands-on: Designing a Simple IoT Application, Cloud Computing and Data Management, Security and Privacy in IoT and CPS, CPS Control and Optimization, Advanced Topics and Emerging Trends, IoT and CPS in 5G/6G Networks, Case Studies and Applications.<br><br>Text Book(s)<br><br>1. Srinivasa K G, Siddesh G.M, Hanumantha Raju R, Internet of Things, CENGAGE, 1st Edition, 2017.<br>2. Daniel Minoli, Building the Internet of Things with IPv6 and MIPv6, 1st Edition, John Wiley, & Sons, 2013.<br>3. Shriram K Vasudevan, Abhishek S Nagarajan, RMD Sundaram, Internet of Things, 1st Edition, Wiley Publications, 2019.<br>4. Lee, E.A. and Seshia, S.A., 2017. Introduction to embedded systems: A cyber-physical systems approach. MIT press.<br><br>Reference Books<br><br>1. Sherali Zeadally, Nafaa Jabeur, Cyber Physical System Design with Sensor Networking Technologies, 1st Edition, The Institution of Engineering and Technology, London, UK, 2016.<br>2. K.Daniel Wong, Fundamentals of Wireless Communication Engineering Technologies, 1st, Edition, John Wiley & Sons, 2012.<br>3. Arshdeep Bahga, Vijay Madisetti, Internet of Things: A Hands-on Approach, First Edition, Universities Press, 2015.<br>4. Adrian McEwen & Hakim Cassimally, Designing the Internet of Things, Wiley, 2013.<br>5. Samuel Greengard, The Internet of Things, MIT Press Essential Knowledge series, 2015.<br>6. Olivier Hersent, David Boswarthick, Omar Elloumi, The Internet of Things: Key Applications and Protocols, Wiley, 2012. |
| 9 | **Contents for lab (If applicable)** | N/A |

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| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | IT-714 |
| 4 | **Title of the subject** | **Secure System Design** |
| 5 | **Any prerequisite** | Basic understanding of digital circuits and cryptography. |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning objectives of the subject (in about 50 words)** | Students will learn the different security vulnerabilities, threats, and attacks that can compromise the security of the systems.<br><br>The course will also introduce hardware-assisted security primitives and methodologies/techniques to design secure systems. |
| 8 | **Brief contents** | Introduction to hardware system design and its testing principles. Security threats, attacks, and vulnerabilities in the hardware system design. Physical and Supply chain attacks: hardware Trojan, side channels, IP piracy, overbuilding, reverse engineering, and counterfeiting. Countermeasures for different attacks. Building Secure Systems. Intellectual Property Protection using Watermarking, Fingerprinting, Logic Obfuscation, Logic Locking, etc.<br><br>Hardware Trojan Taxonomy, Hardware Trojan Detection, Design-for-Security, and Online Monitoring Approaches for Hardware Trojan Protection. Side channel Analysis (SCA) attacks and their Countermeasures from software, hardware, and algorithm design. Security issues and possible countermeasures for Quantum-Secure Hardware, AI-enabled hardware design. AI for Secure system design. |
| 9 | **Contents for lab (If applicable)** | N/A |

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| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | IT-706 |
| 4 | **Title of the subject** | **Introduction to Natural Language Processing** |
| 5 | **Any prerequisite** | Basics of data science, probability and statistics |
| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning objectives of the subject (in about 50 words)** | This course will introduce students to techniques for different applications on social network analysis, ranging from data collection. |
| 8 | **Brief contents** | Module I: Human languages, models, ambiguity, processing paradigms; Phases in natural language processing, applications. Text representation in computers, encoding schemes.<br><br>Module II: Introduction to corpus, elements in balanced corpus, TreeBank, PropBank, WordNet, VerbNet etc. Resource management with XML, Management of linguistic data with the help of GATE, NLTK. Regular expressions, Finite State Automata, word recognition, lexicon. Morphology, acquisition models, Finite State Transducer. Ngrams, smoothing, entropy, HMM, ME, SVM, CRF.<br><br>Module III: Part of Speech tagging- Stochastic POS tagging, HMM, Transformation based tagging (TBL), Handling of unknown words, named entities, multi word expressions. A survey on natural language grammars, lexeme, phonemes, phrases and idioms, word order, agreement, tense, aspect and mood and agreement, Context Free Grammar, spoken language syntax.<br><br>Module IV: Parsing- Unification, probabilistic parsing, TreeBank. Semantics- Meaning representation, semantic analysis, lexical semantics, WordNet Word Sense Disambiguation- Selectional restriction, machine learning approaches, and dictionary based approaches. Discourse-Reference resolution, constraints on co-reference, algorithm for pronoun resolution, text coherence, discourse structure, topic modelling |
| 9 | **Contents for lab (If applicable)** | |

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| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | IT-715 |
| 4 | **Title of the subject** | **Advanced Natural Language Processing** |
| 5 | **Any prerequisite** | Introduction to Natural Language Processing |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning objectives of the subject (in about 50 words)** | The objective of this course is to provide an in-depth understanding of advanced NLP techniques, including transformer models, attention mechanisms, and language representation methods through tasks such as sentiment analysis, machine translation, and question answering etc. |
| 8 | **Brief contents** | Introduction to language model (N-gram models), Representing words through embedding, (word2vec, cbow, skipgram model), Neural language models, RNN/LSTM/GRU for text-processing. Deep learning for language processing. attention, transformer models, multi head attention, Transformer and its variants for text processing. State-of-the-art language models like BERT, LLaMA, Chat GPT-3/4. etc. prompt engineering (requirement, objective), design of prompt, learning, Applications of LLM on various NLP tasks as a use case like sentiment analysis, machine translation, and question answering etc. |
| 9 | **Contents for lab (If applicable)** | N/A |
| 10 | **Text/Reference materials** | 1. Jurafsky and Martin, Speech and Language Processing, 3rd ed.<br>2. Research papers from NLP conference papers (e.g., from ACL, NAACL, and EMNLP). We will post all readings as PDFs. |

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| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | IT-716 |
| 4 | **Title of the subject** | **Social Networks Analysis** |
| 5 | **Any prerequisite** | basics of graph theory, algorithms and data structures, probability and statistics |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning objectives of the subject (in about 50 words)** | This course will introduce students to techniques for different applications on social network analysis, ranging from data collection, link prediction, graph embedding, and finally, different applications. |
| 8 | **Brief contents** | **Module I** Introduction to large scale networks (ex : different types of social networks), real-life applications of social networks analysis, challenges, dataset collection, different types of graph representations, social network data handling techniques, centrality<br><br>**Module II** link prediction, community detection, information spread and diffusion, signed networks, multilayer networks<br><br>**Module III** graph based neural networks for social networks applications, link prediction, node embedding, node classification, signed networks<br><br>**Module IV** applications : graph based summarization, social network embedding, misinformation spread, recommender systems, ethics in dataset collection, bias and fairness in social network analysis |
| 9 | **Contents for lab (If applicable)** | 1. Graph Representation Learning by William L. Hamilton<br>2. Networks, Crowds, and Markets: Reasoning About a Highly Connected World by David Easley and Jon Kleinberg<br>3. Network Science by Albert-László Barabási<br>4. Social Network Analysis, Tanmoy Chakraborty, Wiley, 2021<br>5. Social Network Analysis: Methods and Applications, Stanley Wasserman, Katherine Faus |

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| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | IT-717 |
| 4 | **Title of the subject** | **Engineering Research Methodology** |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 2-1-0 |
| 7 | **Learning Objectives of the subject** | To enable a student to develop their theoretical, methodological and research skills to enhance their ability to conduct rigorous research and reach to sound evidence-based conclusions.<br>Understanding the nature of problem to be studied and identifying the related area of knowledge.<br>Reviewing literature to understand how others have approached or dealt with the problem.<br>Collecting data in an organized and controlled manner to arrive at valid decisions. |
| 8 | **Brief Contents** | Introduction to research, An empirical research framework, Research problems, Literature reviews, Introduction to quantitative research, Study designs, Controlled experiments, Elements and methods, Example experiments, Data collection techniques, Analysis and interpretation of quantitative data, Descriptive statistics, sampling, Sampling distribution, Parameter estimation, statistical inference, Confidence interval and hypothesis testing, Tests of significance, Test of difference of mean and proportions, T-tests, ANOVA, Chi-square tests, Correlation, and regression, Review process, Review guidelines, Validity threats, Review decisions, Qualitative methods, Study designs, Elements, and methods, Data collection methods, Types of data analysis methods, Survey research, Case studies, Writing research papers, Purpose, nature and evaluation, Content and format, Research presentations, The art of scientific and technical writing. Research tools, formatting, plagiarism. |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT001 |
| 4 | **Title of the subject** | **Computer Vision** |
| 5 | **Any prerequisite** | Machine learning |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | In this course, students will gain a broad understanding of the algorithms used for image segmentation, feature extraction and object detection. They will also understand the challenges involved in end-to-end machine vision system<br><br>along with image acquisition, model deployment and actuation. |
| 8 | **Brief Contents** | Introduction to Image Processing system- Thresholding, Image Enhancement, Contrast Stretching, Image Histograms, Filters, Image Sharpening, Gradient based Edge Detection, finding corners, Using Scale and Orientation to Build neighborhood, SIFT, SURF, HOG feature detection, Computing local features, and Segmentation, Convolutional Neural Networks, Padding, Strided Convolution, Convolution over Volume, One layer Convolution, Pooling, object localization, object detection, Classic Networks,<br><br>Transfer Learning, ImageNet Challenge, Feature extraction from videos and parallelization, Image Acquisition. |
| 9 | **Contents for lab** | N/A |
| 10 | **List of text books/references** | 1. Forsyth and Ponce, Computer vision: A modern approach, Pearson, 2002.<br>2. Simon J.D. Prince, Computer vision: models, learning and inference, Cambridge University, 2012.<br>3. E. R. Davies, Computer Vision: Principles, Algorithms, Applications, Learning, Academic Press; 5th edition, 2017 |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT002 |
| 4 | **Title of the subject** | **Digital Signal Processing** |
| 5 | **Any prerequisite** | N/A |

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| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The objective of this course to familiarize students with types of filters. Also, they will be able to design task-specific filters at the end of this course. |
| 8 | **Brief Contents** | Review of Signals and Systems: Discrete time complex exponentials and other basic signals-scaling of the independent axis and differences from its continuous-time counterpart-system properties (linearity, time-invariance, memory, causality, BIBO stability)-LTI systems, convolution, correlation, continuous-time Fourier series and Fourier transform. Sampling, Frequency Domain Analysis of LTI Systems, Discrete Fourier Transform (DFT), FIR and IIR Filter design. |
| 9 | **Contents for lab** | N/A |
| 10 | **List of text books/references** | 1. Alan V. Oppenheim and Ronald W. Schafer, Discrete-Time Signal Processing by, 3rd edition, 2010, Prentice Hall, Upper Saddle River, NJ.<br>2. Sanjit Mitra, Digital Signal Processing, 4th edition, 2011, McGrawHill, New York, NY<br>3. John G. Proakis, Dimitris G. Manolakis, Digital Signal Processing, Principles, Algorithms, and Applications, Third Edition. |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT004 |
| 4 | **Title of the subject** | **Information Retrieval and Extraction** |
| 5 | **Any prerequisite** | N/A |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To understand the theoretical basis behind the standard models of information retrieval, challenges. To understand the difficulty of representing and to be familiar with various<br>IR algorithms and IR systems. |
| 8 | **Brief Contents** | Vector Space Model, Probabilistic Retrieval Strategies Language Models, Inference Networks, Extended Boolean Retrieval, Latent Semantic Indexing, Neural Networks Genetic Algorithms, Fuzzy Set retrieval, Fuzzy Information Retrieval System, Relevance feedback Clustering, Fuzzy Clustering, Passage based Retrieval N- |

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| | | grams, Cross-<br>Language Information Retrieval Efficiency. |
| 9 | **Contents for lab** | N/A |
| 10 | **List of text books/references** | 1. David A. Grossman and Ophir Frieder, Information Retrieval- Algorithms and Heuristic, second edition. Publisher: Springer.<br>2. R. Baeza-Yates and B. Ribeiro-Neto, "Modern Information Retrieval".<br>3. S. Büttcher, C. Clarke, and G. Cormack, Information Retrieval: Implementing and Evaluating Search Engines |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT005 |
| 4 | **Title of the subject** | **Human Computer Interaction** |
| 5 | **Any prerequisite** | N/A |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The course is intended to introduce the student to the basic concepts of human-computer interaction. It will cover the basic theory and methods that helps student to design HCI. |
| 8 | **Brief Contents** | Foundations of Human–Computer Interaction: Human Capabilities, The Computer, The Interaction, Paradigms The Design Process: Interaction Design Basics, HCI in the Software Process, Design Rules, Universal Design Implementation Support: Implementation Tools,<br><br>Evaluation and User Support Evaluation, User Support Users Models: Cognitive Models, Socio-organizational Issues and Stakeholder Requirements, Task Models and Dialogs Page: Analysing Tasks, Dialog Notations and Design, Groupware, Ubiquitous Computing, Virtual and Augmented Reality, Hypertext and Multimedia: Groupware and Computer-supported Collaborative Work, Ubiquitous Computing, Virtual Reality and Augmented Reality. |
| 9 | **Contents for lab** | N/A |

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| 10 | **List of text books/references** | 1. Alan Dix, Janet E. Finlay, Gregory D. Abowd, Russell Beale, Human-Computer Interaction. Harlow, England: Prentice Hall, 2004.<br>2. Yvonne Rogers, Helen Sharp, Jenny Preece, Interaction Design: Beyond Human Computer Interaction, 3rd Edition, Wiley, 2011<br>3. Preece, Jenny, et al. Human-computer interaction. Addison-Wesley Longman Ltd., 1994. |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT006 |
| 4 | **Title of the subject** | **Digital Video Processing** |
| 5 | **Any prerequisite** | N/A |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | At the end of this course, students will able to understand the knowledge within the area of intelligent video technology,<br>with emphasis on motion tracking, enhancement and restoration, video segmentation and optimization. |
| 8 | **Brief Contents** | Video Sampling and Interpolation, Basic Linear Filtering with Applications to Image Enhancement, Computational Models of Early Human Vision, Motion Detection and Estimation, Video Enhancement and Restoration, Video Segmentation, Motion Segmentation, Tracking: Motion Tracking in Video, 2D and 3D Motion Tracking in Digital Video, Methods using Point Correspondences, Optical Flow and Direct Methods, Optimization: Pel-Recursive Methods, Bayesian Methods, Applications: Video Stabilization and Mosaicing, A Unified Framework for Video Indexing, Summarization, Browsing and Retrieval, Video Surveillance. |
| 9 | **Contents for lab (If applicable)** | N/A |
| 10 | **List of text books/references** | 1. Alan Bovik, The Essential Guide to Video Processing<br>2. A Murat Tekalp, Digital Video Processing<br>3. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer-Verlag London Limited 2011. |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT007 |
| 4 | **Title of the subject** | **Advanced Machine Learning** |
| 5 | **Any prerequisite** | Machine Learning |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The course objectives are to expose students to learn several advanced machine learning topics including variants of deep-learning models. Also, students will be emphasized to solve several real-time projects based on the concepts learned in the course. |
| 8 | **Brief Contents** | Review of Machine Learning, Neural Network, Learning algorithms – Backpropagation algorithm, Optimization algorithms, Deep Neural Networks and their variants, Convolutional Neural Networks, Generative Adversarial Network, Recurrent Neural Network, Transformer, etc. Projects related to different domains like health care, agriculture, automobile, etc. |
| 9 | **Contents for lab** | N/A |
| 10 | **List of text books/references** | 1. Goodfellow, Ian, Yoshua Bengio, and Aaron Courville. Deep learning. MIT press, 2016.<br>2. David Dietrich, Barry Heller and Beibei Yang, "Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data", EMC Education Services, Reprint 2015, Wiley.<br>3. Tephen Marsland, "Machine Learning – An Algorithmic Perspective", Taylor& Francis Group, Second Edition, 2015, Chapman & Hall / CRC Press. |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT008 |
| 4 | **Title of the subject** | **Multimedia Processing** |
| 5 | **Any prerequisite** | |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The course is intended to introduce the student to the concepts<br>of multimedia systems, various coding, audio and video standards, resolution analysis and synchronization. |

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| 8 | **Brief Contents** | Multimedia Systems and Processing, Lossless Image Compression Systems, Lossy Image Compression Systems: Theory of Quantization, Delta Modulation and DPC, Transform Coding & K-L Transforms, Discrete Cosine Transforms, Multi-Resolution Analysis: Theory of Wavelets, Multi-resolution Analysis: Theory of Sub-band Coding, Multi- resolution Analysis: Discrete Wavelet Transforms, Embedded Wavelet Coding, Image Compression Standards: JBIG and JPEG, JPEG-2000 Architecture and Features, JPEG-2000 Region of Interests Coding, JPEG-2000, Video Coding And Motion Estimation, Video Coding Standards: MPEG-1 standards, MPEG-2 Standard, MPEG-4 Standard, H.261 and<br><br>H.263 Standards, H.264 standard, Audio Coding, Multimedia Synchronization, Video Indexing And Retrieval, state of the art video compression technique. |
| 9 | **Contents for lab** | N/A |
| 1<br>0 | **List of text books/references** | 1 Alan Bovik, The Essential Guide to Video Processing.<br>2 Mark Nelson, *The Data Compression Book*, M&T Books, 1995.<br>3 Khalid Sayood, *Introduction to Data Compression*, Morgan Kaufmann, 1996.<br>4 J.F.K, Buford, Multimedia Systems, ACM Press, 1994 |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT012 |
| 4 | **Title of the subject** | **Next Generation Networks** |
| 5 | **Any prerequisite** | It is desirable to have the knowledge of Data networking and Telecommunications principles. |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | After successful completion of this course, students will able to learn emerging network technologies, their features, challenges, advantages, and disadvantages. To learn how broadband data and multimedia services are carried out to users over a common Multi-Service Infrastructure. |

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| 8 | **Brief Contents** | Introduction To Next Generation Networks (NGN): Communication and Networking in coming Era, Technologies influencing change, NGN Services, Network Infrastructure convergence, services convergence etc., Overview of Wireless network and Technologies GSM, 1G, 2G, 3G and 4G, Bluetooth, Radio frequency, Overview Of TCP/IP, LANs, WANs. Optical Networks, Wire-line and Wireless Networks, General packet radio service (GPRS): GPRS and packet data network, network architecture, operation, and data services in GPRS. Applications of GPRS, Billing, and charging in GPRS, Ad-hoc network: Architecture and Protocols, Wireless LAN, IEEE802.11a, 802.11b standards, Wireless LAN architecture, Mobile ad hoc networks, and sensor network. |
| 9 | **Contents for lab** | N/A |
| 10 | **List of text books/references** | 1. Neill Wilkinson, "Next Generation Networks Services, Technologies, and Strategies", Wiley, 2002.<br>2. Robet Wood, "Next Generation Network Services", Pearson, 2005.<br>3. YB. Lin and I Chlamtac, "Wireless and Mobile Network Architectures", Wiley, 2001<br>4. A.S. Tanenbaum, "Computer Networks", Pearson Education, 2003. |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT013 |
| 4 | **Title of the subject** | **Queuing Theory** |
| 5 | **Any prerequisite** | Basic knowledge of Engineering Mathematics and |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the** | To teach the applications of queuing theory related to |

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| 8 | **Brief Contents** | Basics of Probability and Statistics, Random processes- Introduction, classification, Stationary process – Wide Sense Stationary, Strict Sense Stationary, Markov Process, Markov Chain, Problems based on Markov Process.<br><br>Transition probabilities, Limiting distributions, Poisson Process - Properties, Poisson Process - Problems<br><br>Queuing system – introduction, Markovian Models, Birth and Death Process, Little's Formula, M/M/1, Infinite Capacity, M/M/1, Finite Capacity, M/M/c, Infinite Capacity, M//M/c, Finite Capacity and finite population, M/M/ queue.<br><br>Non Markovian queues- M/G/1 queue, GI/M/1 queue, GI/M/m queue, GI/G/1 queue, M/G/m queue, GI/G/m queue, Pollaczek- Khinchine formula.<br><br>Priority queues-Queues with preemption, queues with time dependent priorities.<br><br>Series queues, Open Networks, Closed Networks, batch service, batch arrival. |
| 9 | **Contents for lab** | N/A |
| 10 | **List of text books/references** | 1. K. S. Trivedi, Probability and Statistics with Reliability, Queuing and Computer Science Applications, John Wiley and Sons, 2nd edition, 2002.<br>2. A.O. Allen, Probability, Statistics and Queuing Theory with Computer Applications, Elsevier, 2nd edition, 2005.<br>3. Srivastava, H. M., & Kashyap, B. R. K. (1982). Special functions in queuing theory and related stochastic processes. ACADEMIC PRESS.<br>4. Dimitri P. Bertsekas and Robert G. Gallager, "Data Networks," (2nd edition) Prentice Hall, 1992<br>5. Leonard Kleinrock, Wiley-Interscience, Queueing Systems, Volume I; 1st edition (1 January 1975). |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT014 |
| 4 | **Title of the subject** | **Network Design and Optimization** |
| 5 | **Any prerequisite** | Basics of wireless communications |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Students will acquire knowledge of the planning and optimization of wireless networks and their specifications. The course will discuss the working principles of different types of networks and their performance optimization. |
| 8 | **Brief Contents** | Review of all Network Technologies, Study of Various Quality of service aspects in wired and wireless Networks based on applicative scenarios and their optimization. |
| 9 | **Contents for lab** | N/A |
| 10 | **List of text books/references** | 1. D. Medhi and K. Ramasamy, Network Routing: Algorithms, Protocols, and Architectures - 2nd Edition, Morgan Kaufmann Publishers (an imprint of Elsevier), publication date: September 11, 2017.<br><br>2. D. Medhi and K. Ramasamy, Network Routing: Algorithms, Protocols, and Architectures, Morgan Kaufmann Publishers (an imprint of Elsevier), publication date: March 29, 2007.<br><br>3. M. Pióro and D. Medhi, Routing, Flow, and Capacity Design in Communication and Computer Networks, Morgan Kaufmann Publishers (an imprint of Elsevier), publication date: July 1, 2004. |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT015 |
| 4 | **Title of the subject** | **Advanced Wireless Communications** |
| 5 | **Any prerequisite** | Introduction to Probability and Statistics, Introduction to |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning Objectives of the subject** | The course provides advanced knowledge in a number of transmission techniques and technologies in wireless communications. It covers the fundamentals of MIMO communications. Other advanced topics are also viewed to update students with emerging techniques and developments in 5G. |
| 8 | **Brief Contents** | Basics of single-user Multiple-Input-Multiple-Output (MIMO) communications – Channel models, outage capacity, ergodic capacity – Diversity techniques: time, frequency, space and diversity combiners – Precoding for spatial multiplexing, optimum, linear and nonlinear receivers – Space-time coding and MIMO decoding. Emerging techniques and applications in 5G– Cooperative communications, Device-to-device (D2D) communications, Green and energy-efficient communications, –Internet of Things (IoT) networks and Low Power Wide Area Network (LPWAN) technologies. |
| 9 | **Contents for lab (If applicable)** | N/A |
| 10 | **List of text books/references** | 1) D. Tse and P. Viswanath, “Fundamentals of wireless communication”, 2005.<br>2) R. W. Heath Jr. and A. Lozano, “Foundations of MIMO Communication”, 2018.<br>3) Liu, KJ Ray, et al. Cooperative communications and networking. Cambridge university press, 2009.<br>4) E. Bjornsson, J. Hoydis, L. Sanguinetti, “Massive MIMO Networks: Spectral, Energy, and Hardware Efficiency”, 2017. |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT-016 |
| 4 | **Title of the subject** | **Multimedia Networks** |
| 5 | **Any prerequisite** | N/A |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The course is aimed at developing students' ability to understand and apply the fundamental ideas that govern the design of the architecture of modern multimedia communication networks to real problems. |

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| 8 | **Brief Contents** | Multimedia networks principles, Audio video streaming, Jitter problems, Multicast, principles, and protocols, Multimedia Protocols – SIP, RTSP, etc., Traffic engineering and Quality of services, Queuing architectures,<br><br>Content in Distributed network, CDN architecture. |
| 9 | **Contents for lab** | N/A |
| 10 | **List of text books/references** | 1. Multimedia Communications: Protocols and Applications, Prentice Hall, 1998<br>2. Multimedia Communications: Protocols and Applications, F. Kuo, W. Effelsberg, andJ.Garcia-Luna-Aceves, Prentice Hall PTR, 2000<br>3. Multimedia over IP and Wireless Networks: Compression, Networking, and Systems, by M. Van der Schaar, P. Chou, Academic Press, 2007.<br>4. Multimedia Communications Applications, Networks, Protocols and Standards Fred Halsall, Addison Wesley, 2001 |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT-019 |
| 4 | **Title of the subject** | **Distributed System** |
| 5 | **Any prerequisite** | Fundamentals of distributed systems, Basic knowledge of software systems. Basic programming skills in a<br><br>mainstream programming language. |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The candidates will learn about the principles of distributed systems and contrast with other forms of computation, identify applications of distributed systems in particular the use of cloud and serverless applications, big data and graph processing applications, interactive and online gaming, etc.; analyze and design core architectures, components, and techniques in distributed systems. |

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| 8 | **Brief Contents** | Introduction to Distributed Systems: Parallel versus distributed systems, challenges, CAP theorem; Functional requirements: Naming, replication, consistency, consensus; Non-functional requirements: Measuring NFRs, scalability and elasticity etc.; Resource management and scheduling: scheduling issues for small and large systems, centralized and decentralized schedulers, portfolio scheduling; System architecture and programming models: Communication, big data, machine learning, layering; Distributed ecosystems: massive processing, the super-distribution principle, cloud, edge, big data, Distributed ecosystems in online gaming etc. |
| 9 | **Contents for lab** | N/A |
| 10 | **List of text books/references** | 1. Von Bochmann, Gregor, "Concepts for distributed systems design", Springer Science & Business Media, 2012.<br>2. Van Steen, Maarten, and Andrew S. Tanenbaum, "Distributed systems".<br>3. Sukumar Ghosh, "Distributed systems", CRC Press<br>4. Ajay D. Kshemkalyani and Mukesh Singhal, "Distributed computing: Principles, algorithms and systems", Cambridge press. |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT020 |
| 4 | **Title of the subject** | **Information Theory and Coding** |
| 5 | **Any prerequisite** | Linear algebra |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | This course gives brief knowledge about the basic algebraic relationships of entropy, relative entropy, and mutual information. In this course students learn how to compress the data using source coding and how to make data transmission reliable using channel coding. It introduces the basic principles of encoding, decoding, error detecting and error correcting techniques. |

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| 8 | **Brief Contents** | Information Theory: Introduction, Discrete memory less source, Binary source. Entropy, Relative Entropy, and Mutual Information, Channel capacity, Data Compression Examples of Codes, Kraft Inequality, Optimal Codes, Bounds on the Optimal Code Length, Kraft Inequality for Uniquely Decodable Codes, Huffman Codes, Shannon– Fano Coding, etc. Error detecting and Error correcting code, Block Codes, Cyclic Codes, Convolution Codes |
| 9 | **Contents for lab** | N/A |
| 10 | **List of text books/references** | 1. Joy A. Thomas and Thomas M. Cover, Elements of Information Theory, John Wiley and Sons.<br>2. John G. Proakis, McGraw Hill, Digital Communication Singapore, 4$^{th}$ Edition, 2001.<br>3. Bernard Sklar, Digital Communications: Fundamentals and Applications, 2nd Ed., Pearson Prentice Hall, 2001. |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT022 |
| 4 | **Title of the subject** | **Digital Watermarking and Steganalysis** |
| 5 | **Any prerequisite** | N/A |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The objective of the course makes students familiar about Digital watermarking and steganography. |
| 8 | **Brief Content** | Information Hiding, Steganography, and Watermarking, Importance of Digital Watermarking, Applications and Properties. Models of Watermarking: Communication-Based Models of Watermarking, Geometric Models of Watermarking, Modelling Watermark Detection by Correlation; Basic Message Coding: Mapping Messages into Message Vectors, Error Correction Coding, Detecting Multi-symbol Watermarks; Watermarking with Side Information: Informed Embedding, Watermarking Using Side Information, Dirty-Paper Codes; Robust Watermarking: Approaches, Robustness to Volumetric Distortions, Robustness to Temporal and Geometric Distortions; Watermark Security: Security Requirements, Watermark Security and Cryptography, Some Significant Known Attacks; Content Authentication: Exact Authentication, Selective Authentication, Localization, Restoration; Notation and Terminology, Information- |

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| | | Theoretic Foundations of Steganography, Practical Steganographic Methods, Minimizing the Embedding Impact; Steganalysis: Steganalysis Scenarios, Some Significant Steganalysis Algorithms. |
| 9 | **Contents for lab (If applicable)** | N/A |
| 10 | **List of text books/references** | 1. Ingemar J. Cox, Matthew L. Miller, Jeffrey A. Bloom, Jessica Fridrich, Ton Kalker, Morgan Kauffman, Digital Watermarking and Steganography.<br>2. Ingemar J. Cox, Matthew L. Miller, Jeffrey A. Bloom, Morgan Kauffman, Digital Watermarking principles<br>3. Frank Y. Shih, Digital Watermarking and Steganography: Fundamentals and Techniques, Second Edition CRC Press. |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT023 |
| 4 | **Title of the subject** | **Cryptography and Network Security** |
| 5 | **Any prerequisite** | Linear Algebra |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To enhance the ability to analyse, identify and define the computing requirements for data security. |
| 8 | **Brief Contents** | Classical Encryption Techniques, Finite Field and Number Theory, Polynomial Arithmetic, Prime Numbers, Fermat‘s And Euler‘s Theorem, Testing For Primality, Key Management, Elliptic Curve Arithmetic, Elliptic Curve Cryptography. Cryptographic Protocols, Digital Signatures. Authentication applications, IP security, Encapsulating Security Payload (ESP)-Internet Key Exchange (Phases of IKE, ISAKMP/IKE Encoding). Web Security: Web Security Considerations, Secure Socket Layer and Transport layer Security. System Security: Intrusion Detection, Virus and related threats, Firewalls, Trusted Systems. |
| 9 | **Contents for lab** | N/A |
| 10 | **List of text books/references** | 1. William Stallings, Cryptography and Network security, 4e, Prentice Hall of India, New Jersey, 2008.<br>2. Christof Paar, Jan Pelzl, Understanding Cryptography, Springer-Verlang, Berlin, 2010<br>3. Behrouz A Forouzan, Cryptography and Network security, Tata Mc-Graw Hill, New York, 2007. |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT024 |
| 4 | **Title of the subject** | **Distributed System Security** |
| 5 | **Any prerequisite** | Basics of Distributed System |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | This is a course that will cover advanced security concepts beyond traditional offerings. Emphasis will be made on all aspects of cyber security including vulnerabilities, threats, attacks and defences in distributed systems. |
| 8 | **Brief Contents** | Security Requirements of Distributed Systems; Security Violations, Security Goals, Security Services, Security Protocols, and Security Mechanisms; Attack on Security Protocols and Security Mechanisms; Secret Sharing Techniques and One-Way Functions; Discrete Logs, Block Encryption/Decryption Functions, Hash Functions, and MAC Functions; Algorithmic Implementation and Security Requirements of One-Way Functions; OS Security Violations and Techniques to Prevent Them; Access Control Models; Authenticated Diffie-Hellman Key Establishment Protocols; Group Key Establishment Protocols; Block Ciphers and Stream Ciphers; Block Cipher Modes of Encryption; Nonce, Timestamps and Authentication Protocols; Digital Page 1/6Signatures and Source Non-Repudiation Protocols; PKI and X.509 Authentication Service; Security Protocol Verification: Strand Space Theory; Kerberos; E-mail Security; Security Issues in Layered Communication Models: IP Security, Secure Socket Layer and Transport Layer Security; Secure Electronic Transactions; Intrusion Detection; Malicious Software Detection; Firewalls. |
| 9 | **Contents for lab** | N/A |
| 10 | **List of text books/references** | 1. Anirban Chakrabarti, Distributed Systems Security: Issues, Processes and Solutions 1st Edition by Abhijit Belapurkar (Author), Wiley, 2009.<br>2. Ajay D. Kshemkalyani and MukeshSinghal, “Distributed Computing: Principles, Algorithms, and Systems”, Cambridge University Press, 2011.<br>3. Andrew S. Tanenbaum and Maarten van Steen, “Distributed Systems: Principles and Paradigms”, Second Edition, Pearson Prentice-Hall, 2007. |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT025 |
| 4 | **Title of the subject** | **Cyber Security and Laws** |
| 5 | **Any prerequisite** | N/A |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To realize the activities carried using forensic technologies in detection of cybercrime. To introduce a novel methodology of performing cyber forensics or system forensics. To relate the laws enforced by the judiciary to handle cybercrimes and cyber |
| 8 | **Brief Contents** | Mobile Forensics, Computer Ethics and Application Programs, Cyber Forensic, Data Recovery, Introduction to Deleted File Recovery, Formatted Partition Recovery, Data Recovery Tools, Data Recovery Procedures and Ethics, file modification and file access, Recover Internet Usage Data, Recover Swap Files/ Temporary Files/Cache Files, Introduction to Encase Forensic Edition, Forensic Tool Kit (FTK), Introduction to IT laws & Cyber Crimes, Introduction to Cyber Forensic Investigation, Investigation Tools, eDiscovery, Digital Evidence Collection, Evidence Preservation, E-Mail Investigation, E-Mail Tracking, IP Tracking, E-Mail Recovery, Encryption and Decryption methods, Search and Seizure of Computers, Recovering deleted evidences, Password Cracking, Introduction to Cyber Security, Implementing Hardware Based Security, Software Based Firewalls, Security Standards, Assessing Threat Levels, Forming an Incident Response Team, Reporting Cyber crime, Operating System Attacks, Application Attacks, Reverse Engineering & Cracking Techniques and Financial Frauds, Security Audit and Standards. |
| | **Contents for lab** | N/A |
| | **List of text books/references** | 1.Raghu Santanam, Sethumadhavan, MohitVirendra, Cyber Security, Cyber Crime and Cyber Forensics: Applications and Perspectives, IGI Global<br>2. Chris Davis, IT Auditing Using controls to protect Information Assets, TMH<br>3. Hamid Jahankhani, Cyber Criminology, Springer. |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT026 |
| 4 | **Title of the subject** | **Advanced Cryptography** |
| 5 | **Any prerequisite** | Basics of Cryptography |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | This course investigates advanced topics in cryptography. It begins with an overview of necessary background in algebra and number theory, private- and public-key cryptosystems, and basic signature schemes. The course will cover number theory and basic theory of Galois fields used in cryptography, discrete logarithm-based cryptosystems including those based on elliptic curves; interactive protocols including the role of zero-knowledge proofs in authentication. |
| 8 | **Brief Contents** | Review of the prerequisite Cryptography: Private-key cryptosystems; Advanced Encryption Standard (AES), Overview of modular arithmetic, discrete logarithms, and primality/factoring, Public-key cryptosystems; ElGamal cryptosystem, Basic signature schemes. Algebra and number theory: Rings of polynomials, Existence and finding primitive roots, Blum integers, Primes; Agrawal, Kayal, Saxena P-time algorithm for recognizing primes, Elliptic curves. Discrete logarithm-based cryptosystems and signatures: Elliptic Curve Cryptosystem (ECC), Digital Signature Standard (DSS), Selection of other signature schemes, Overview of discrete logarithm algorithms, Ethical aspects of public-key cryptosystems and signatures, Hashing, emerging SHA-3 standard. Interactive protocols: Touch of complexity theory, Interactive proof systems, 0-knowledge proof systems, 0-knowledge authentication, Electronic cash; Chaum and Brands schemes. Private information retrieval: AES news, SHA-3 news, Private/public/group/share key generation and management, Digital watermarking, digital fingerprinting, Steganography. Selected topics in quantum computing, Quantum computers, Shor's algorithm, future demise of RSA, Quantum cryptography, Quantum key distribution and reconciliation |
| 9 | **Contents for lab** | N/A |

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| 10 | **List of text books/references** | 1. Douglas R. Stinson, Cryptography: Theory and Practice, CRC Press, fourth edition 2019.<br>2. Alfred J. Menezes, Paul C. van Oorschot and Scott A. Vanstone, CRC Handbook of Applied Cryptography, CRC Press.<br>3. Lawrence C. Washington, Elliptic Curves. Number Theory and Cryptography, Chapman and Hall, CRC Press 2003. |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT027 |
| 4 | **Title of the subject** | **Information Security and Secure Coding** |
| 5 | **Any prerequisite** | Basics of Cyber Security |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To learn how secure coding is important when it comes to lowering risk and vulnerabilities. Identify the insecure coding practices that lead to common software programming errors. Learn about XSS, Direct Object Reference, Data Exposure, Buffer Overflows, Resource Management, Active Defences, and Threat Modelling. |
| 8 | **Brief Contents** | Introduction to Information security and Secure coding, Injections (SQL, command, JSON), defenses, Broken authentication and Session management. Cross-site Scripting (reflected XSS HTML, reflected XSS JS), Insecure direct object reference, Security misconfiguration. Sensitive data exposure, Missing function level access control, Cross-site request forgery. Using components with known vulnerabilities, Invalidated redirects and forwards. Buffer overflows, Insecure interaction between components. Risky resource management, Porous defences, Active defences, Threat modeling. |
| 9 | **Contents for lab** | N/A |
| 10 | **List of text books/references** | 1. "Fundamentals of Cyber Security", Mayank Bhushan, Rajkumar Singh Rathore, Aatif Jamshed, *BPB Publications*.<br>2. "Building Secure Software: How to Avoid Security Problems the Right Way", Viega, John, Gary McGraw, *MAddison-Wesley Professional*.<br>3. "Foundations of Information Security: A Straightforward Introduction", Jason Andress, No Starch Press, US. |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT028 |
| 4 | **Title of the subject** | **Malware Analysis** |
| 5 | **Any prerequisite** | Networks and Operating Systems, Computer security. |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | This course will introduce students to modern malware analysis techniques through readings and hands-on interactive analysis of real-world samples. After successful completion of this course students will be equipped with the skills to analyze advanced contemporary malware using both static and dynamic analysis. |
| 8 | **Brief Contents** | Introduction to malware, Basic Static and Dynamic Analysis, Overview of Windows file format, PEView.exe, Patching Binaries , Disassembly (objdump, IDA Pro), Introduction to IDA, Introduction to Reverse Engineering, Extended Reverse Engineering using GDB and IDA, Advanced Dynamic Analysis - debugging tools and concepts, Malware Behavior - malicious activities and techniques, Knowledge of relevant system internals, and experience in using various malware analysis tools Analyzing Windows programs–WinAPI, Handles ,Networking , COM, Data Encoding, Malware Counter measures, Covert Launching and Execution, Anti Analysis<br><br>- Anti Disassembly, VM, Debugging -, Packers – packing and upacking, Intro to Kernel – Kernel basics, Windows Kernel API, Windows Drivers, Kernel Debugging, Rootkit Techniques- Hooking, Patching, Kernel Object Manipulation , Rootkit Anti-forensics, Covert analysis. |
| 9 | **Contents for lab** | N/A |
| 10 | **List of text books/references** | 1. Michael Sikorski and Andrew Honig, Practical Malware Analysis, No Starch Press,2012<br>2. Reverend Bill Blunden, The Rootkit Arsenal: Escape and Evasion in the Dark Corners of the System, Second Edition<br>3. Jamie Butler and Greg Hoglund, Rootkits: Subverting the Windows Kernel.<br>4. Dang, Gazet, Bachaalany, Practical Reverse Engineering, Wiley,2014 |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT029 |
| 4 | **Title of the subject** | **Formal methods for Security Verifications** |
| 5 | **Any prerequisite** | Operating Systems Concepts, Information System Security |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To make use of mathematical background to understand and use formal methods like set theory, propositional logic and operational semantics |
| 8 | **Brief Contents** | Introduction to Formal Methods, Mathematical Background, Formal Specifications, Case Study Formal Specifications and Models, Model Checking and Formal Verification, Advanced models: Real-time models , Case Study Formal Verification , Static and Dynamic Analysis of programs, temporal logic: CTL and LTL, Buchi automata, Explicit model checking, BDDs and model-checking with BDDs, symbolic model checking, SAT and model-checking with SAT, Security verification, hybrid automata, hybrid system verification, applications of model checking to hardware, software, and protocols verification. |
| 9 | **Contents for lab** | N/A |
| 10 | **List of text books/references** | 1. Edward Griffor, Handbook of System Safety and Security.<br>2. Ulrich Kühne, Rolf Drechsler, Formal Modeling and Verification of Cyber-Physical Systems.<br>3. Michael Huth and Mark Ryan, Logic in Computer Science: Modelling and Reasoning about Systems, Cambridge Univ. Press, 2nd edition |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT030 |
| 4 | **Title of the subject** | **IoT and its security** |
| 5 | **Any prerequisite** | |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning Objectives of the subject** | The objective of this course is to acquaint participants with some of the fundamental concepts and state-of-the-art research in the areas of IoT and its Security. |
| 8 | **Brief Contents** | Introduction to IoT, potential security challenges in IoT paradigm, Architecture, Protocols, Performance Modeling & Analysis, Industrial IoT (IIoT) and the Industrial Internet Consortium (IIC), IoT Security solutions, Emerging IoT<br><br>Standards, Open Problems & Research challenges. |
| 9 | **Contents for lab** | N/A |
| 10 | **List of text books/references** | 1. Chintan Patel Nishant Doshi, Internet of Things Security: Challenges Advances and Analytics, T&F/CRC Press.<br>2. Cheruvu, Apress, Demystifying Internet of Things Security.<br>3. Al-Turjman, Security In Iot-Enabled Spaces, CRC Press.<br>Russell, Brian and Drew Van Duren, Practical Internet of Things Security, Packt Publishing, 2016. |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | Code of the subject | IT031 |
| 4 | **Title of the subject** | **Blockchain Technologies** |
| 5 | **Any prerequisite** | Distributed systems, networking, cryptography, and data structures |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Be able to state core blockchain concepts, the benefits, and the limitations of blockchain technologies. Apply various blockchain concepts to analyze examples, proposals, case studies, and preliminary blockchain system design discussions. |
| 8 | **Brief Contents** | Intro to cryptography & cryptocurrencies, Bitcoin mechanics, Consensus protocols, Ethereum and decentralized applications, Decentralized finance and economics, Privacy on a public blockchain, Scaling the blockchain, Emerging Applications of Blockchain in industry |
| 9 | **Contents for lab** | N/A |

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| 1<br>0 | **List of text books/references** | 1. Narayanan, Arvind, et al. Bitcoin and cryptocurrency technologies: a comprehensive introduction. Princeton University Press, 2016.<br>2. Lewis, Antony. The basics of bitcoins and blockchains: an introduction to cryptocurrencies and the technology that powers them. Mango Media Inc., 2018.<br>3. Antonopoulos, Andreas M. Mastering Bitcoin: unlocking digital cryptocurrencies. " O'Reilly Media, Inc.", 2014. |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT021 |
| 4 | **Title of the subject** | **Convex Optimization** |
| 5 | **Any prerequisite** | Basic knowledge of Engineering Mathematics and Statistics |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To learn the concepts and applications of optimization for solving real world problems. |
| 8 | **Brief Contents** | **Linear Programming:** Convex sets, Mathematical Model, Assumptions of linear programming, Graphical method Simplex method, Big M Method, Two-Phase Method, Exceptional cases in LPP.<br><br>**Duality in Linear Programming:** Dual simplex method, revised simplex method, sensitivity or Post-optimal analysis, Transportation problem, Assignment Problem.<br><br>**Integer Programming Problem:** Cutting plane method, Gomory's cut method, Branch and bound technique, Travelling salesman problem, Cargo loading problem.<br><br>**Non-linear Programming:** Quadratic forms and classical methods, Convex functions and Kuhn-Tucker theory, Beale's method, Separable programming.<br><br>**Dynamic Programming and Game Theory:** Bellmen's principle, Recursive relations, Solution of LPP by dynamic programming, Game theory, games with mixed strategy, Stochastic linear programming. |
| 9 | **Contents for lab** | N/A |

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|---|---|---|
| 10 | **List of text books/references** | 1. Taha, H.A., 1992. Operations Research (5th edn), Prentice Hall Publication.<br>2. Hillier, F.S. and Lieberman, G.J., 1967. Introduction to operations research. San Francisco: Holden-Day.<br>3. Ravindran, A, Phillips, DT, Solberg, JJ. 1987. Operations Research: Principles and Practice, John Wiley<br>4. Boyd, Stephen, Stephen P. Boyd, and Lieven Vandenberghe. Convex optimization. Cambridge university press, 2004. |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT033 |
| 4 | **Title of the subject** | **Parallel and Concurrent Programming** |
| 5 | **Any prerequisite** | Advanced Computer Architecture, C/C++ Programming |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the** | The Course exposes the learner to know the various parallel |
| 8 | **Brief Contents** | Introduction to Parallel and Distributed Systems: Parallel Programming Paradigms, Parallel Architecture, Principals of Parallel Programming, Models of Parallel Computation, Complexity, PRAM, Memory Consistency & Performance Issues, Memory Consistency & Performance Issues, Shared Memory & Message Passing. OpenMP: Introduction to OpenMP, Work Sharing, Scheduling, Synchronization, Tasks, Environment Variables, and Run- Time Library Routines, Other Clauses and Directives. MPI: Basics of MPI, Cost Model, One-sided/two-side communication, Hybrid programming (MPI + OpenMP). Introduction to CUDA: GPU architecture, high- performance computing on GPUs, parallel algorithms, CUDA libraries, and applications of GPU computing. Introduction to the design of parallel algorithms and hands- on. |
| 9 | **Contents for lab** | N/A |
| 10 | **List of text books/references** | 1. Chandra et al, ―Parallel Programming in OpenMP, Morgan Kaufmann.<br>2. Chapman, Jost, and van der Pas, ―Using OpenMP: Portable Shared Memory Parallel Programming, MIT Press.<br>3. Tanenbaum, Andrew S. Distributed operating systems. Pearson Education India, 1995.<br>Programming Massively Parallel Processors (3rd Edtion) |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT035 |
| 4 | **Title of the subject** | **Game Theory** |
| 5 | **Any prerequisite** | Basic knowledge of Engineering Mathematics |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To learn the applications of game theory, auction and equilibrium. |
| 8 | **Brief Contents** | Introduction to Game Theory, Dominant Strategies and Nash Equilibrium, Alternate Strategies: Maximin, Maximax, and Minimax Regret Solvability, N-Player Games, Mixed Strategy, Subgame Perfection in Discrete Choice Games, Continuous Games and Imperfect Competition, Infinitely Repeated Games, Tacit Collusion, Simultaneous-play, Bayesian Games, Applications of Bayesian Games: Auctions and Voting, Cournot‘s Duopoly with Imperfect Information, Radio Spectrum, With Arbitrary Distribution of Valuations, Extensive Form Game with Perfect Information, Stackelberg Model of Duopoly, Buying Votes, Committee Decision-Making, Repeated games, The Prisoner‘s Dilemma, General Result, Supermodular Game and Potential Game, Wireless Networks: Resource Allocations, Admission Control, Routing in Sensor and Ad-Hoc Networks, Modeling Network Traffic and Strategic Network Formation, Rubinstein Bargaining Model with Alternating Offers, Nash Bargaining Solution, Multi armed bandit problem |
| 9 | **Contents for lab** | N/A |
| 10 | **List of text books/references** | 1. Martin Osborne, An Introduction to Game Theory, Oxford University Press, 2003 2. Prajit Dutta, Strategies and Games, MIT Press. 3. K H Ericson, Game Theory, Createspace Independent Publishing Platform. |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT036 |
| 4 | **Title of the subject** | **Big Data Analytics** |
| 5 | **Any prerequisite** | N/A |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The course focuses on big data computer system, storage, processing, analysis, visualization, and applications. State- of-the-art computational frameworks for big data. |
| 8 | **Brief Contents** | Overview of Big Data, State-of-the-art computing paradigms/platforms, Big data programming tools (e.g., Hadoop, MongoDB, Spark, etc.), Big data extraction and integration, Big data storage, Scalable big data indexing, Large-scale graph processing techniques, Big data stream techniques and algorithms, Large-scale probabilistic data analysis, Big data privacy, Big data visualizations, problems in real applications. |
| 9 | **Contents for lab** | N/A |
| 10 | **List of text books/references** | 1. Kuan-Ching Li, Hai Jiang, Laurence T. Yang, and Alfredo Cuzzocrea. Big Data: Algorithms, Analytics, and Applications. Chapman & Hall/CRC Big Data Series, 2015.<br>2. Thomas Erl, Wajid Khattak, and Dr. Paul Buhler. Big Data Fundamentals: Concepts, Drivers & Techniques. The Prentice Hall Service Technology Series, 2016.<br>Wajid Khattak, Paul Buhler, Thomas Erl, Big Data Fundamentals: Concepts, Drivers & Techniques, John Wiley & Sons, Inc |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT037 |
| 4 | **Title of the subject** | **Nature Inspired Computing** |
| 5 | **Any prerequisite** | Basic Mathematics, Data Structures, and Algorithms |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning Objectives of the subject** | It introduces a new paradigm of computing and solving problems. It has great applications in Artificial Intelligence, Data Mining, Machine Learning, and real-world design and optimization problems. |
| 8 | **Brief Contents** | Introduction to Evolutionary Computation: Representation, Initial Population, Fitness Function, Selection, Reproduction Operators, Stopping Conditions, Evolutionary versus Classical Computation; Genetic Algorithm: Canonical Genetic Algorithm, Crossover, Mutation, Control Parameters, Genetic Algorithm Variants, Applications; Differential Evolution, Particle Swarm Optimization, Artificial Bee Colony Algorithm. ANN Introduction, Evolution, McCulloh-Pitts Neuron, Linear Separability, Hebb Network; Perceptron Networks, Adaptive Linear Neuron, Multiple Adaptive Linear Neuron, Back-Propagation Network, Radial Basis Function Network; Associative Memory Network, Heteroassociative Memory Network, Bidirectional Associative Memory, Hopfield Network, Iterative Autoassociative Memory Network, Temporal Associative, Self-organizing maps, Linear Vector Quantization, Counter Propagation Network. |
| 9 | **Contents for lab** | N/A |
| 10 | **List of text books/references** | 1. S N Sivanandam and S N Deepa, Principles of Soft Computing, Wiley India<br>2. Andries P. Engelbrecht, Computational Intelligence: An Introduction, Jhon Wiley & Sons.<br>3. S. Rajasekaran and G. A. Vijayalakshmi Pai, Neural Networks, Fuzzy Logic, and Genetic Algorithms: Synthesis and Applications, PHI. |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT039 |
| 4 | **Title of the subject** | **Program Analysis Verification and Testing** |
| 5 | **Any prerequisite** | Discrete Mathematics, Data Structures, Theory of Computation |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To provide overview of the theoretical fundamentals of the subject also to provide information of some of the modern verification and testing tools. |

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| 8 | **Brief Contents** | Dataflow Analysis, Interprocedural Analysis: functional, call-string and graph reachability based approaches; Abstract Interpretation, Weakest Precondition, Floyd-Hoare Logic, Separation Logic; Software Model Checking: symbolic execution, state-space reduction, state-less model checking, counter-example guided abstraction refinement, model checking of concurrent programs; Program Testing: program testing basics, automatic test-case generation, directed testing |
| 9 | **Contents for lab** | N/A |
| 10 | **List of text books/references** | 1. Edsger Wybe Dijkstra. A Discipline of Programming. Prentice Hall PTR, Upper Saddle River, NJ, USA.<br>2. Michael Huth and Mark Ryan. Logic in Computer Science: Modelling and Reasoning about Systems. Cambridge University Press, New York, NY, USA<br>3. Alfred V. Aho, Monica S. Lam, Ravi Sethi, and Jeffrey D. Ullman. Compilers: Principles, Techniques, and Tools (2nd Edition). Addison-Wesley Longman Publishing Co., Inc., Boston, MA, USA, 2006. |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT040 |
| 4 | **Title of the subject** | **Competitive programming** |
| 5 | **Any prerequisite** | Data structures and algorithms |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The focus of the course is the development and implementation of advanced algorithms, as well as the skills required for programming competitions. |

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| 8 | **Brief Contents** | Introduction; Problem formats; Online judging systems; Parsing Input; Formatting Output, Review of Fundamental Data Structures), Divide and Conquer, Greedy, and Dynamic Programming Approaches; Graph Algorithms- search, shortest path, minimum spanning tree, network flow, bipartite graph matching, String Processing- edit distance, subsequences, suffixes) Numerical algorithms and Combinatorics, Chinese Remainder Theorem and modular math, Large number computations, generating and counting permutations and combinations, Applications of Geometric Algorithms 2D line segment and polygon queries –intersection, area; calculations on a sphere; 3D volume calculations; ray-surface intersection; convex hull; spatial subdivisions, Basic heuristic search, Advanced<br><br>search and Simulation problems |
| 9 | **Contents for lab** | N/A |
| 10 | **List of text books/references** | 1. Halim, Steven, Felix Halim, and Suhendry Effendy. Competitive programming 4: The new lower bound of programming contests in the 2020s, 2018.<br>2. Laaksonen, Antti. Guide to competitive programming. Cham: Springer, 2020.<br>3. Skiena, Steven S., and Miguel A. Revilla. "Programming challenges: The programming contest training manual." Acm SIGACT News 34.3 (2003): 68-74. |

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| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | |
| 4 | **Title of the subject** | **Large Language Models** |
| 5 | **Any prerequisite** | Fundamentals of Machine Learning, Deep Learning, and NLP |
| 6 | **L-T-P** | 2-0-1 |
| 7 | **Learning objectives of the subject (in about 50 words)** | This course will introduce students with the foundational and advanced concepts of Large Language Models (LLMs), including deep learning, transformers, and NLP techniques. |
| 8 | **Brief contents** | Neural network fundamentals (Backpropagation, Optimization), Feed Forward Neural Network, Recurrent Neural Network: RNN. LSTM, GRU, Attention Mechanism |

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| | | Traditional Text Representations: One-Hot Encoding, Bag of Words (BoW) and TF-IDF. Word Embeddings Era: Word2Vec Embedding: Continuous Bag of Words (CBOW) & Skip-gram Model; GloVe ; FastText. Contextual Word Embeddings (Modern NLP): ELMo , ULMFiT..<br><br>Transformer architecture (Multi-Head Self Attention, Positional Encoding), Training objectives (Masked Language Modeling, Causal LM). Long-Document Transformers: Reformer, Longformer, BigBird. Multimodal Transformers:CLIP , Flamingo. Vision Transformer (ViT): Swin Transformer, DETR<br><br>BERT (Bidirectional Encoder Representations from Transformers), RoBERTa , DistilBERT, ALBERT. GPT (Generative Pre-trained Transformer): GPT-1, GPT-2 GPT-3, GPT-4.<br><br>Large-scale dataset preparation and preprocessing, Transfer learning & fine-tuning strategies, Metrics: Macro F1, Micro F1, and Weighted Average F1, Perplexity, BLEU, ROUGE, GLUE benchmarks, Explainability techniques (Grad-CAM, SHAP, LIME), Bias, fairness, and ethical AI challenges, Adversarial attacks and robustness of LLMs, Case studies. |
| **9** | **Contents for lab (If applicable)** | Tokenization methods, Creating word embeddings using Word2Vec, GloVe, and FastText, Understanding self-attention and multi-head attention, Building a basic Transformer model using PyTorch/TensorFlow, Hands-on with positional encoding and layer normalization, Using Hugging Face Transformers to load BERT, GPT, and T5, Fine-tuning BERT for text classification, Training GPT for text generation tasks, Data preparation for large-scale training, Training an LLM with mixed precision (FP16) using DeepSpeed, Implementing gradient checkpointing for memory efficiency, Measuring perplexity, BLEU, ROUGE, and GLUE scores, Visualizing attention weights in Transformers, Using SHAP and LIME for explainability in NLP models, Deploying a fine-tuned model using FastAPI/Flask. |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | IT402 |
| 4 | **Title of the subject** | **Digital Image Processing** |

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|---|---|---|
| 5 | **Any prerequisite** | Mathematics |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To introduce the basic concepts of Digital image processing with emphasis on applications in various field of recent research. |
| 8 | **Brief Contents** | Introduction and Fundamentals, Image Enhancement in Spatial Domain, Image Enhancement in Frequency Domain, Image Restoration, Segmentation, Representation and Description. |
| 9 | **Contents for lab** | N/A |
| 10 | **List of text books/references** | 1.Digital Image Processing 2nd Edition, Rafael C. Gonzalvez and Richard E. Woods. Published by: Pearson Education.<br>2.R.J. Schalkoff ,Digital Image Processing and Computer Vision John Wiley and Sons, NY. 3. William K. Prat, Digital Image Processing, John Wiley and Sons, NY |

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| 1 | **Semester** | - |
| 2 | **Type of Course** | Elective |
| 3 | **Code of the subject** | EE057 |
| 4 | **Title of the subject** | **Hardware Security** |
| 5 | **Any prerequisite** | VLSI Design |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Learning the state-of-the-art security methods and devices, better understanding of attacks and providing countermeasures against them, CMOS implementation of hardware security primitives, Attacks on cyber-physical systems |
| 8 | **Brief Contents** | Module I: Fundamentals of hardware security and trust for integrated circuits. Physical and invasive attacks, Side-channel attacks and Countermeasures, Physically unclonable functions, Hardware-based true random number generators, Hardware Trojan, Hardware security primitives, CMOS PUF implementations Module II: Watermarking of Intellectual Property (IP) blocks, FPGA security, Passive and active metering for prevention of piracy, Access control, Hardware Trojan detection and isolation in IP cores and integrated circuits counterfeit ICs |

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| 9 | **Contents for lab** | N/A |
| 10 | **List of text books/references** | |

Curriculum & Contents

# M. Tech.

# (Wireless Networks and Computing)

**Department of Information Technology**

विश्वजीवनामृतं ज्ञानम्

ABV-Indian Institute of Information Technology & Management, Gwalior

# SCHEMA

**Name of the program: M. Tech. (Wireless Networks and Computing)**

**(Credits: 75)**

**Name of the Department: Information Technology**

| **SEMESTER-I** | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject Code** | **Title of the course** | **L-T-P** | **Credits** |
| **1.** | IT 601 | Probability and Stochastic Process | 3-1-0 | 4 |
| **2.** | IT 602 | Wireless Networks | 3-0-0 | 3 |
| **3.** | IT 608 | Machine Learning Techniques | 3-0-2 | 4 |
| **4.** | IT 604 | Modelling and Simulation | 3-0-0 | 3 |
| **5.** | IT 6XX | Elective-I | 3-0-0 | 3 |
| **6.** | IT 605 | Network and Computing Lab | 0-0-6 | 3 |
| | | | **Total credits** | **20** |

| **SEMESTER-II** | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject code** | **Title of the course** | **L-T-P** | **Credits** |
| **1.** | IT 606 | Next Generation Networks | 3-1-0 | 4 |
| **2.** | IT 607 | Graphs and Networks | 3-0-0 | 3 |
| **3.** | IT 603 | Mobile Computing | 3-0-0 | 3 |
| **4.** | IT 609 | Engineering Research Methodology | 2-1-0 | 3 |

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| **5.** | IT 6XX | Elective-II | 3-0-0 | 3 |
| **6.** | IT 6XX | Elective-III | 3-0-0 | 3 |
| | | | **Total credits** | **19** |

EXIT AFTER YEAR-1: Post Graduate Diploma in Wireless Networks and Computing

| **SEMESTER-III** | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject code** | **Title of the course** | **L-T-P** | **Credits** |
| **1** | IT 6XX | Elective-IV/MOOC-I | 3-0-0 | 3 |
| **2** | IT 6XX | Elective-V/MOOC-II | 3-0-0 | 3 |
| **3** | IT 698 | Thesis Part-I/ Internship | 0-0-24 | 12 |
| | | | **Total credits** | **18** |

| **SEMESTER-IV** | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject Code** | **Title of the course** | **L-T-P** | **Credits** |
| **1** | IT 6XX | Elective-VI/MOOC-III | 3-0-0 | 3 |
| **2** | IT 699 | Thesis Part-II | 0-0-3 | 15 |
| | | | **Total credits** | **18** |

| **SEMESTER-I** | **SEMESTER-II** | **SEMESTER-III** | **SEMESTER-IV** | **TOTAL CREDITS** |
|---|---|---|---|---|
| 20 | 19 | 18 | 18 | **75** |

# Electives Courses

| S.No. | Code | Electives I,II,III,IV,V and VI Category: Wireless Networks and Computing |
|---|---|---|
| 1 | IT 611 | Network Design and Optimization |
| 2 | IT 612 | Grid and Peer-To-Peer Computing |
| 3 | IT 613 | Cloud Computing and Security |
| 4 | IT 614 | Iot Protocols and Security |
| 5 | IT 615 | High Speed Network |
| 6 | IT 616 | Machine Vision |
| 7 | IT 617 | Nature Inspired Computing |
| 8 | IT 618 | Computer Graphics and Multimedia |
| 9 | IT 619 | Advance Machine Learning |
| 10 | IT 620 | Special Topics in AI |
| 11 | IT 621 | Information Theory and Coding |
| 12 | IT 622 | Detection and Estimation Theory |
| 13 | IT 623 | Adaptive Signal Processing |
| 14 | IT 624 | Queuing Theory |
| 15 | IT 625 | Digital Signal Processing |
| 16 | IT 626 | Modern Cryptography |
| 17 | IT 627 | Cognitive Radio |
| 18 | IT 628 | Digital Watermarking and Steganalysis |
| 19 | IT 629 | Game Theory and its Application |

# Course Contents

| | | |
|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | IT 601 |
| 4 | **Title of the subject** | Probability and Stochastic Process |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-1-0 |
| 7 | **Learning objectives of the subject (in about 50 words)** | Many complex systems are modeled using stochastic processes. This course will introduce students to basic stochastic processes tools that can be utilized for performance analysis and stochastic modeling. |
| 8 | **Brief contents** | Axioms of probability, Probability space, Conditional probability, Independence, Baye's rule, Random variable, Some common discrete and continuous distributions, Distribution of functions of random variable, Moments, Generating functions, Two and higher dimensional distributions, Functions of random variables, Order statistics, Conditional distributions, Covariance, Correlation coefficient, Conditional expectation, Modes of convergences, Law of large numbers, Central limit theorem. Definition of stochastic process, Classification and properties of stochastic processes, Simple stochastic processes, Stationary processes, Discrete and continuous time Markov chains, Classification of states, Limiting distribution, Birth and death process, Poisson process, Steady state and transient distributions, Simple Markovian queuing models (M/M/1, M/M/1/N, M/M/c/N, M/M/N/N). |
| 9 | **Contents for lab (If applicable)** | N/A |

| | | |
|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | IT 602 |
| 4 | **Title of the subject** | Wireless Networks |
| 5 | **Any prerequisite** | Communication System |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning objectives of the subject (in about 50 words)** | After successful completion of this course, students will come across various wireless technology evolved for wireless transmission/reception. This course also deals an overview of communication theory particularly different modulation schemes, fading due to environment, multiplexing techniques, and role of antennas. |
| 8 | **Brief contents** | Introduction to the course- Wireless network technology; Wireless LANs, Wireless WANs, and Wireless MANs. Wireless vs. wired networks. Antennas- types of antenna, Antenna models, Antenna diversity, Gain. Isotropic radiator vs. Directed radiator. Modes of signal propagation; Modulation schemes -ASK, FSK, PSK, AM, FM, and PM. Multiplexing methods - Frequency multiplex, Time multiplex, and CDMA. Bit error-rate (BER). TCP/IP basics, 802.11 (WiFi)-components and architecture, WLAN: IEEE 802.11b, 802.11a, and 802.16 (WiMaX), Mesh and adhoc networks, 802.16 internals. Frequency hopping spread spectrum (FHSS)-slow and fast hopping, FHSS transmit/receive, OFDM, ALOHA |
| 9 | **Contents for lab (If applicable)** | No lab is associated with the course. |

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|---|---|---|
| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | IT 603 |

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|---|---|---|
| 4 | **Title of the subject** | Mobile Computing |
| 5 | **Any prerequisite** | Computer Networks |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning objectives of the subject (in about 50 words)** | We will cover interesting topics across a variety of mobile systems (wireless LANs, cellular systems, and sensor networks), and revisit the design of the various layers of the networking stack in the context of wireless communication. The course will comprise of lectures, four problem sets, exams (midsem and endsem), and a course project. |
| 8 | **Brief contents (module wise)** | Overview of wireless and mobile systems (wireless LANs, cellular systems, sensor networks, etc.) and the challenges therein. The radio channel and wireless physical layer design. Medium access, Multiplexing, Link adaptation. Multi-hop routing protocols, Routing metrics. Multicast, Multi-hop data forwarding, Opportunistic routing. Solutions to handle mobility at various layers of the networking stack. TCP behavior over wireless, Other transport layer issues. Energy efficiency, Localization, Security. Smartphone-based platform architectures and applications. Future directions: Dynamic spectrum access, Heterogeneous networks, Internet of things. |
| 9 | **Contents for lab (If applicable)** | N/A |

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|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | IT 604 |
| 4 | **Title of the subject** | Modelling and Simulation |
| 5 | **Any prerequisite** | Engineering Mathematics, and Probability and Statistics |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning objectives of the subject (in about 50 words)** | To learn the application of mathematics and statistics in the real-life problems. |
| 8 | **Brief contents (module wise)** | Introduction concept of a system, Modeling and simulation of real world problems, Classification of models and examples, Static and dynamic models, Principles used in modeling. System studies subsystems, Corporate models, Block diagram of modeling and simulation, System analysis, System design. Mathematical models, Mathematical models in population dynamics, Epidemic. System simulation the technique of simulation, The Monte Carlo method, Types of system simulation, Continuous and discrete time simulation. Probability concepts in simulation stochastic variables, Discrete and continuous probability distributions, Measures of probability functions, Random numbers generation, Stochastic processes: Poisson process, Markov process, Queuing theory, Reliability. Linear programming in simulation introduction, Transportation problem, Assignment problem and other simulation techniques in operation research. |
| 9 | **Contents for lab (If applicable)** | No lab is associated with this course. |

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|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | IT 605 |
| 4 | **Title of the subject** | Network and Computing Lab |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 0-0-6 |
| 7 | **Learning objectives of the subject (in about 50 words)** | Understand basics of MATLAB, NS2, OPNET Able to perform basic computational techniques Understand types of computational method |

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| 8 | **Brief Contents (module wise)** | Introduction to MATLAB, Vectors in MATLAB, Efficient programming techniques system of linear equations: Solution for a system of linear equations, Solving a system of linear equations, Inverse matrix, Decomposition (Factorization), Iterative methods to solve equations,<br><br>Interpolation and curve fitting: Interpolation by Lagrange, Newton, and Chebyshev polynomial, Newton Raphson method, Secant method, Newton method for a system of nonlinear equations,<br><br>Numerical differentiation/integration: Difference approximation for first derivative, Approximation error of first derivative, Numerical integration and quadrature, Trapezoidal method and Simpson method,<br><br>Optimization: Unconstrained optimization, Constrained optimization, MATLAB built-In routines for optimization, Matrices and eigenvalues: Eigenvalues and eigenvectors, Power method, Jacobi method partial differential equations: Elliptic, Hyperbolic, and Parabolic PDE,<br><br>Computer networks and the layering concept, Layering concept, OSI and TCP/IP reference models, System modeling, Basics of computer network simulation, Time-dependent simulation, A simulation example: A single channel queuing system.<br><br>Introduction to network simulator 2 (NS2), Basic architecture, Installation, Directories and convention, Running NS2 simulation, A simulation example, Including C++ modules into NS2 and the make utility.<br><br>Introduction of simulation and OPNET, Outline ways to study a system advantages of simulation OPNET modeler main features of OPNET simulator, A simulation example how to use this software for simulating and modeling computer networks. |
| 9 | **Contents for lab (If applicable)** | |

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|---|---|---|
| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | IT 606 |
| 4 | **Title of the subject** | Next Generation Networks |

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| 5 | **Any prerequisite** | It is desirable to have the knowledge of data networking and telecommunications principles. |
| 6 | **L-T-P** | 3-1-0 |
| 7 | **Learning objectives of the subject (in about 50 words)** | After successful completion of this course, students will able to learn emerging network technologies, their features, challenges, advantages, and disadvantages. To learn how broadband data and multimedia services are carried out to users over a common multi-service infrastructure. |
| 8 | **Brief contents** | Introduction To next generation networks (NGN): Communication and networking in coming era, Technologies influencing change, NGN services, Network infrastructure convergence, Services convergence etc., Overview of wireless network and technologies GSM, 1G, 2G, 3G and 4G, Bluetooth, Radio frequency, Overview of TCP/IP, LANs, WANs. Optical networks, Wire-line and wireless networks, General packet radio service (GPRS): GPRS and packet data network, Network architecture, Operation, and data services in GPRS. Applications of GPRS, Billing, and charging in GPRS, Ad-hoc network: Architecture and protocols, Wireless LAN, IEEE802.11a, 802.11b standards, Wireless LAN architecture, Mobile ad hoc networks, and Sensor network. |
| 9 | **Contents for lab (If applicable)** | No lab is associated with this subject. |

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|---|---|---|
| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | IT 607 |
| 4 | **Title of the subject** | Graphs and Networks |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning objectives of the subject (in about 50 words)** | The objective of the course is, in addition to logical foundations, Theoretical developments and development of the basic skills to tackle problems in graph theory. It is also aimed at understanding how various problems arising from real life or sciences as well as recreational puzzles can be converted to graph theoretic |

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| | | problems like shortest paths, network flows, chromatic numbers, connectivity etc. |
| 8 | **Brief contents** | Introduction to graphs, Paths and circuits, Trees and fundamental circuits, Spanning tree, Matrix tree theorem, Euler graph, Hamiltonian graph, Isomorphism, Network flows, Ford-Fulkerson theorem. Cut-sets and cut vertices, Planar and dual graphs, Embedding, Kurtowski theorem, Euler identity, Matrix representation of graphs, Coloring, Edge coloring, Chromatic number, Brooks theorem, Five-color theorem, Matching, Directed graph, Underlying graph, Outdegree, In-degree, Connectivity, Orientation, Eulerian directed graphs, Hamilton directed graphs, Arborescence, Tournament, Acyclization, Applications of graph theory: In switching and coding theory, Electrical network analysis |
| 9 | **Contents for lab (If applicable)** | No lab is associated with this subject. |

| | | |
|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | IT 608 |
| 4 | **Title of the subject** | Machine Learning Techniques |
| 5 | **Any prerequisite** | Introductory courses on probability theory and linear algebra. Knowledge of basic programming languages such as python and MATLAB. |
| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning objectives of the subject (in about 50 words)** | After successful completion of this course, students will able to relate/understand/solve several day-to-day real-time with machine learning algorithms. The objective of this course is to familiarize the students with different machine learning algorithms ranging basic linear classifier/regression modeling problems to non-linear classification problems using deep neural network. |
| 8 | **Brief contents** | Introduction to the course of machine learning (ML): What and why? Classification, Regression, Sequence modeling. Introducing prerequisites of ML, Linear classifier and classification problem, Gradient descent algorithm, Underfitting vs. over-fitting problem, Training, Testing, and Validation process, Supervised vs. unsupervised classification, Bayesian |

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| | | classifier: Decision boundaries; Nearest neighbour methods, and Support vector machine (SVM); Unsupervised learning: k-means and hierarchical clustering, Feature extraction and feature selection; Dimensionality reduction techniques: PCA, LDA and ICA, Introduction to neural networks: Modelling and applications to logic gates. Backpropagation learning algorithm: Training and testing, Introduction to convolution neural network (CNN): AlexNet, VGG architectures. Introduction to auto-encoder and generative adversarial networks (GAN). |
| 9 | **Contents for lab (If applicable)** | Study and demonstration of data preprocessing on the dataset. The aim of this experiment is to illustrate some of the basic data preprocessing such as loading of the dataset, and use of various filters, Implement a project on data mining, which includes the demonstration of data collection and mining process, Building classification models, and performance evaluation of prediction models. |

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| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | IT 609 |
| 4 | **Title of the subject** | Engineering Research Methodology |
| 5 | **Any prerequisite** | Basic mathematics |
| 6 | **L-T-P** | 2-0-0 |
| 7 | **Learning objectives of the subject (in about 50 words)** | To enable researchers (Ph.D. and M. Tech. students), irrespective of their discipline in developing the most appropriate methodology for their research studies. To make them familiar with the art of using different research methods and techniques. |
| 8 | **Brief contents** | Research, Types of research, Research vs. research methods, Research process, Relevant and quality research. Problem-solving in engineering, Identification of research topic, Problem definition, Literature survey, Literature review, Research design, Models in general, Mathematical models, Model classifications, Simulation models, Steps in a simulation study, Simulation software, Validation, Data collection, and Applications, Formulation of hypothesis, Testing of hypothesis, Analysis of variance, Design of experiments, Multivariate analysis, Simple regression and correlation, Measurement and scaling techniques, Data checking, Data analysis, Statistical, Graphical |

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| | | and numerical data analysis, Interpretation of results in research, need for interpretation, Accuracy, Precision, Uncertainty and variability, Repeatability and reproducibility, Error definition and classification, Analysis of errors, Statistical analysis of errors, Basic communication model, Preparing papers for journals, Synopsis of research work, Reference citation, Listing of references. Ethics in research, Intellectual property rights, Copyright laws, Patent rights. |
| 9 | **Contents for lab (If applicable)** | No lab is associated with this subject. |

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|---|---|---|
| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | IT 611 |
| 4 | **Title of the subject** | Network Design and Optimization |
| 5 | **Any prerequisite** | Basics of Wireless Communications |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning objectives of the subject (in about 50 words)** | Students will acquire knowledge of the planning and optimization of wireless networks and their specifications. The course will discuss the working principles of different types of wireless networks and their performance optimization |
| 8 | **Brief contents** | Fundamentals of wireless communications, Networks planning principals for cellular networks, 4G (LTE) architecture, Features and call flow, Network (RAN) performance and optimization, LTE introduction, LTE network design basics, Optimization principles, Coverage optimization, Capacity optimization, Capacity and latency optimization, Energy and spectrum efficient wireless network design and optimization |
| 9 | **Contents for lab (If applicable)** | |

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|---|---|---|
| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | IT 612 |
| 4 | **Title of the subject** | Grid and Peer to Peer Computing |
| 5 | **Any prerequisite** | Operating Systems, Networks |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning objectives of the subject (in about 50 words)** | This course is an advanced elective and covers material relating to distributed computing fundamentals, grid computing middleware, and high-performance applications.<br><br>The prerequisites for the course are operating systems, and networks.<br><br>A prior course on distributed systems is an added advantage. |
| 8 | **Brief contents** | Grid Computing: Introduction to grid computing, Classification of grids, Introduction to service oriented computing. Peer-to-Peer (P2P) concepts in grids: Introduction to P2P systems, Overlays unstructured P2P systems (Gnutella, Freenet), Structured P2P systems (distributed hash tables - chord, pastry), Integrating unstructured and structured P2P systems, Introduction to P2P security - sybil attacks. Grid computing middleware: Vishwa: a reconfigurable P2P middleware for grid computations. Grid security and resource management: grid security-a brief security primer-PKI-X509, Certificates-grid security, Grid scheduling and resource management-scheduling paradigms, Working principles of scheduling, A review of condor, SGE, TPBS and TLSF-grid scheduling with QoS. Current P2P systems: Napster, Gnutella, KazaA, FreeNet, Pastry, Tapestry. |
| 9 | **Contents for lab (If applicable)** | No lab is associated with the course |

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|---|---|---|
| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | IT 613 |
| 4 | **Title of the subject** | Cloud Computing and Security |
| 5 | **Any prerequisite** | |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning objectives of the subject (in about 50 words)** | The course objective is to familiarize the students with the fundamentals of cloud computing architectures, protocols, and best practices intended for delivering cloud based enterprise IT services and business applications. |
| 8 | **Brief contents** | Fundamentals of cloud computing and architectural characteristics: Cloud deployment, Infrastructure as a Service (IaaS), Cloud computing roles, etc. Risks and security concerns. Security design and architecture for cloud computing: Guiding security design principles for cloud computing - Secure isolation, Comprehensive data protection, End-to-end access control, Monitoring and auditing, Quick look at CSA, NIST and ENISA guidelines for cloud security, Common attack vectors and threats. Secure isolation of physical & logical infrastructure; Data protection for cloud infrastructure and service, Network and storage, Verified and measured boot, Firewalls, IDS, IPS and honeypots. |
| 9 | **Contents for lab (If applicable)** | No lab is associated with the course |

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|---|---|---|
| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | IT 614 |
| 4 | **Title of the subject** | IoT Protocols and Security |
| 5 | **Any prerequisite** | Fundamentals of Internet of Things |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning objectives of the subject (in about 50 words)** | To understand the architectural overview of IoT and analyse basic protocols in wireless sensor network.<br><br>Design IoT applications in different domain and be able to analyse their performance.<br><br>Implement basic IoT applications on embedded platform. |
| 8 | **Brief contents** | Overview of IoT, IoT-an architectural overview– Building an architecture, Main design principles and needed capabilities, Reference architecture IoT architecture-State of the art – introduction. Functional view, Information view, Deployment and operational view. Network & communication aspects Wireless medium access issues. Challenges in IoT design, Development challenges, Security challenges. Domain specific applications of IoT home automation, Industry applications, Surveillance applications, Other IoT applications. Developing IoTs introduction to python, Introduction to different IoT tools, Developing applications through IoT tools, Developing sensor based application through embedded system platform, Implementing IoT concepts with python. IoT data link layer & network layer protocols. Transport & session layer protocols. Service layer protocols & security service layer. |
| 9 | **Contents for lab (If applicable)** | No lab is associated with the course |

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|---|---|---|
| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | IT 615 |
| 4 | **Title of the subject** | High Speed Network |
| 5 | **Any prerequisite** | Digital Circuits and Network Technology |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning objectives of the subject (in about 50 words)** | After successful completion of this course, students will able to learn high speed networks, traffic and congestion management system. Study of wireless network operations, resource allocation, service management. |

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| 8 | **Brief contents** | Introduction to high-speed networks (HSNs), Congestion and traffic management, QOS in IP networks, Wireless network and its operations, Network management, configuration selection method-MIB-SNMP-XMLCORBA-COPS-VPNS-mobile IP-voice over IP. |
| 9 | **Contents for lab (If applicable)** | No lab is associated with the course |

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|---|---|---|
| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | IT 616 |
| 4 | **Title of the subject** | Machine Vision |
| 5 | **Any prerequisite** | Machine Learning |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning objectives of the subject (in about 50 words)** | In this course, students will gain a broad understanding of the algorithms used for image segmentation, feature extraction and object detection. They will also understand the challenges involved in end-to-end machine vision system along with image acquisition, model deployment and actuation. Students will be able to develop convolution neural network for object recognition and deploy them on the edge for manufacturing industry. |
| 8 | **Brief contents** | Introduction to image processing system- Thresholding, Image enhancement, Contrast stretching, Image histograms, Filters, Image sharpening, Gradient based edge detection, Finding corners, Using scale and orientation to build neighborhood, SIFT, SURF, HOG feature detection, Computing local features, and segmentation, Convolutional neural networks, Padding, Strided convolution, Convolution over volume, One layer convolution, Pooling, Object localization, Object detection, Classic networks, Transfer learning, ImageNet challenge, Feature extraction from videos and parallelization, Image acquisition. |

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| 9 | **Contents for lab (If applicable)** | |

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|---|---|---|
| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | IT 617 |
| 4 | **Title of the subject** | Nature Inspired Computing |
| 5 | **Any prerequisite** | Basic Mathematics, Data Structures, and Algorithms |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning objectives of the subject (in about 50 words)** | It introduces a new paradigm of computing and solving problems. It has great applications in artificial intelligence, Data mining, Machine learning, and real-world design and optimization problems. |
| 8 | **Brief contents** | Introduction to evolutionary computation: Representation, Initial population, Fitness function, Selection, Reproduction operators, Stopping conditions, Evolutionary versus classical computation; Genetic algorithm: Canonical genetic algorithm, Crossover, Mutation, Control parameters, Genetic algorithm Variants, Applications; Differential evolution, Particle swarm optimization, Artificial bee colony algorithm. ANN introduction, Evolution, McCulloh-Pitts neuron, Linear separability, Hebb network; Perceptron networks, Adaptive linear neuron, Multiple Adaptive linear neuron, Back-propagation Network, Radial basis function network; Associative memory network, Heteroassociative memory network, Bidirectional associative memory, Hopfield network, Iterative autoassociative memory network, Temporal associative, Self-organizing maps, Linear vector quantization, Counter propagation network. |
| 9 | **Contents for lab (If applicable)** | |

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|---|---|---|
| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | IT 618 |
| 4 | **Title of the subject** | Computer Graphics and Multimedia |
| 5 | **Any prerequisite** | |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning objectives of the subject (in about 50 words)** | Computer graphics is the illustration field of computer science. Its use today spans virtually all scientific fields and is utilized for design, presentation, education and training. Computer graphics and its derivative, visualization, have become the primary tools by which the flood of information from computational science is analysed. |
| 8 | **Brief contents** | Introduction of computer graphics, Graphic displays, Mid-point circle generating algorithm, and parallel version of these algorithms.<br>Three Dimensional: 3-D geometric primitives, 3-D object representation, 3-D transformation, 3-D viewing, Projections, 3-D clipping. Transformations: Basic transformation, Matrix representations and homogenous coordinates, Composite transformations, Windowing and clipping: Viewing pipeline, Viewing transformations, 2-D clipping algorithms- Cohen Sutherland line clipping algorithm, Liang Barsky algorithm, Line clipping against non-rectangular clip windows; Weiler and Atherton polygon clipping, Curve clipping, Text clipping; Hidden lines and surfaces: Back face detection algorithm, Depth buffer method. Multimedia basics – Multimedia applications – Multimedia system architecture – Evolving technologies for multimedia – Defining objects for multimedia systems – Multimedia data interface standards – Multimedia databases. Compression and decompression – Data and file format standards – Multimedia I/O technologies – Digital voice and audio – Video image and animation – Full motion video – Storage and retrieval technologies. |
| 9 | **Contents for lab (If applicable)** | Graphic displays, Viewing, Projections, 3-D clipping. Basic transformation, Matrix representations and homogenous coordinates, Composite transformations, 2-D clipping algorithms- Cohen Sutherland line clipping algorithm |

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| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | IT 619 |
| 4 | **Title of the subject** | Advance Machine Learning |
| 5 | **Any prerequisite** | Linear algebra, Statistics and machine learning |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning objectives of the subject (in about 50 words)** | |
| 8 | **Brief contents** | Convolutional neural networks, Recurrent neural networks, Timeseries processing, Transformer networks, Semantic segmentation, Generative models, Generative adversarial networks model interpretation: Introduction, Sample complexity bound for learning axis parallel rectangles. Definition of PAC learning. A Theory of the learnable – valiant PAC learnability of finite hypothesis classes, Empirical risk minimization, Agnostic PAC learnability of finite hypothesis class, Uniform convergence, No free lunch theorem, VC dimension, Sauer lemma, Growth function, Fundamental theorem of statistical learning theory, Nonuniform learnability, Structural risk minimization. |
| 9 | **Contents for lab (If applicable)** | |

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|---|---|---|
| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | IT 620 |
| 4 | **Title of the subject** | Special Topics in AI |

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| 5 | **Any prerequisite** | Machine Learning. |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning objectives of the subject (in about 50 words)** | The chief objective is to teach modern methods of probabilistic reasoning that are commonly used in many parts of computer science, including but not limited to artificial intelligence. Such methods have become extremely important and transforming the approach to a great variety of computational problems, in the field of computer science itself, and broadly across many application fields. |
| 8 | **Brief contents** | Overview of probability theory, Bayes networks, Independence, I-maps, Undirected graphical models, Bayes networks and Markov networks, Local models, Template based representations, Exact inference: Variable elimination; Clique trees, Belief propagation, Tree construction, Approximate inference: Sampling Markov chains, MAP inference, Inference in temporal models, Learning graphical models, Parameter estimation, Bayesian networks and shared parameters, Structure learning, Structure search, Partially observed data, Gradient descent, EM, Hidden variables, Undirected models, Undirected structure learning causality, Utility functions, Decision problems, Expected utility, Value of information |
| 9 | **Contents for lab (If applicable)** | |

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|---|---|---|
| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | IT 621 |
| 4 | **Title of the subject** | Information Theory and Coding |
| 5 | **Any prerequisite** | Students should have brief idea about linear algebra. |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning objectives of the subject (in about 50 words)** | This course gives brief knowledge about the basic algebraic relationships of entropy, relative entropy, and mutual information.<br>In this course students are going to learn how to compress the data using source coding and how to make data transmission reliable using channel coding. It introduces the basic principles of encoding, decoding, error detecting and error correcting techniques. |
| 8 | **Brief contents** | Information theory: Introduction, Discrete memory less source, Binary source.<br>Entropy, Relative entropy, and Mutual information, Channel capacity, Data compression<br>Examples of codes, Kraft inequality, Optimal codes, Bounds on the optimal code length, Kraft inequality for uniquely decodable codes, Huffman codes, Shannon–Fano coding, etc.<br>Error detecting and error correcting code, Block codes, Cyclic codes, Convolution codes. |
| 9 | **Contents for lab (If applicable)** | Nil |

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|---|---|---|
| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | IT 622 |
| 4 | **Title of the subject** | Detection and Estimation Theory |
| 5 | **Any prerequisite** | Student must have basic knowledge about linear algebra, probability and random process. |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning objectives of the subject (in about 50 words)** | Detection theory involves detecting one hypothesis from two or more than two hypotheses. This may be done based on Bayes detection, Minmax detection, NP test. Estimation theory is a branch of statistics that deals with estimating the values of parameters based on measured empirical data that has a random component using various estimators.<br><br>In general, the information that one wishes to extract from such observation is unknown to the observer, it is useful to cast |

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| | | detection and estimation problems in a probabilistic framework in which unknown behaviour is assumed to be random. Applications of the theory of signal detection and estimation are in many areas, such as communications, automatic control, telecommunication, radar etc. |
| 8 | **Brief contents** | Review of Gaussian variables and processes, Statistical Decision Theory: Bayesian, Minimax, and Neyman-Pearson decision rules, Likelihood ratio, Composite hypothesis testing,<br>Detection of Deterministic Signals: Matched filter detector and its performance.<br>Detection of random signals: Estimator-correlator, Linear model, General Gaussian detection.<br>Nonparametric detection: Detection in the absence of complete statistical description of observations.<br>Estimation of signal parameters: Minimum variance unbiased estimation, Fisher information matrix, Cramer-Rao bound, Sufficient statistics.<br>Signal estimation in discrete-time: Linear Bayesian estimation, Weiner filtering, Dynamical signal model, Discrete Kalman filtering. |
| 9 | **Contents for lab (If applicable)** | |

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| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | IT 623 |
| 4 | **Title of the subject** | Adaptive Signal Processing |
| 5 | **Any prerequisite** | Digital Signal Processing |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning objectives of the subject (in about 50 words)** | Development of various adaptation algorithms and assessing them in terms of convergence rate, computational complexity, robustness against noisy data, hardware complexity, numerical stability.<br><br>The course will present several examples of adaptive filter applications like channel equalization, echo cancellation, noise cancellation, interference suppression. |
| 8 | **Brief contents** | Introduction to adaptive systems: Definitions, Characteristics, Applications, Example of an adaptive system. The adaptive linear combiner – Description, Weight vectors, Desired response performance function – Gradient & mean square error. Development of adaptive filter theory & searching the performance surface: Introduction to filtering – Smoothing and prediction – Linear optimum filtering, Problem statement, Principle of orthogonally – Minimum mean square error, Wiener-Hopf equations, Error performance – Minimum mean square error, Steepest descent algorithms: LMS algorithm & applications: Stability & performance analysis of LMS algorithms – LMS gradient & stochastic algorithms – Convergence of LMS algorithm, RLS algorithm. Statement of Kalman filtering problem, Innovation process, Estimation of state using the innovation process- Expression of Kalman gain, Filtering example estimation of state from observations of noisy observed narrow band signals. Target tracking using only DOA. |
| 9 | **Contents for lab (If applicable)** | No lab is associated with the course |

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|---|---|---|
| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | IT 624 |
| 4 | **Title of the subject** | Queuing Theory |
| 5 | **Any prerequisite** | Basic knowledge of engineering mathematics and statistics |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning objectives of the subject (in about 50 words)** | To teach the applications of queuing theory related to computer networks. |
| 8 | **Brief contents** | Basics of probability and statistics, Random processes-introduction, Classification, Stationary process – Wide sense stationary, Strict sense stationary, Markov process, Markov chain, Problems based on Markov process.<br>Transition probabilities, Limiting distributions, Poisson process - Properties, Poisson process - Problems<br>Queuing system – Introduction, Markovian models, Birth and death Process, Little's formula, M/M/1, Infinite capacity, M/M/1, Finite capacity, M/M/c, Infinite capacity, M//M/c, Finite capacity and finite population, M/M/ queue.<br>Non Markovian queues- M/G/1 queue, GI/M/1 queue, GI/M/m queue, GI/G/1 queue, M/G/m queue, GI/G/m queue, Pollaczek-Khinchine formula.<br>Priority queues- Queues with preemption, Queues with time dependent priorities.<br>Series queues, Open networks, Closed networks, Batch service, Batch arrival. |
| 9 | **Contents for lab (If applicable)** | No |

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|---|---|---|
| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | IT 625 |
| 4 | **Title of the subject** | Digital Signal Processing |
| 5 | **Any prerequisite** | Signals & Systems |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning objectives of the subject (in about 50 words)** | In this course, we will mainly study the following topics: signal representation in time domain, Fourier transform, sampling theorem, linear time-invariant system, discrete convolution, z-transform, discrete Fourier transform, and discrete filter design. After this course, the students should be able to understand how |

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| | | to analyse a given signal or system using tools such as Fourier transform and z-transform; how to process signals to make them more useful. |
| 8 | **Brief contents** | Review of signals and systems: Discrete time complex exponentials and other basic signals-scaling of the independent axis and differences from its continuous-time counterpart-system properties (Linearity, Time-invariance, Memory, Causality, BIBO stability)-LTI systems, Convolution, Correlation, Continuous-time Fourier series and Fourier transform. Sampling discrete-time Fourier transform (DTFT) Z-transform. Frequency domain analysis of LTI systems. Discrete Fourier Transform (DFT), FIR, IIR, Filter Design. |
| 9 | **Contents for lab (If applicable)** | NA |

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| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | IT 626 |
| 4 | **Title of the subject** | Modern Cryptography |
| 5 | **Any prerequisite** | |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning objectives of the subject (in about 50 words)** | To make the students understand the process of deciphering coded messages without being told the key.<br>To study of codes and the art of writing and solving them.<br>To give motivation towards recent research development in the field of cryptography, cryptanalysis, and steganography.<br>Overall this course explores modern cryptographic (code making) and cryptanalytic (code breaking) techniques in detail. |
| 8 | **Brief contents** | Number theory basics, Modular arithmetic fields, Binary fields, Primes, GCD and Chinese reminder theorems, Pseudorandom bits and sequences, Extended Euclidean algorithm and application Fermat‘s Little theorem and application, Euler phi |

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| | | function, Block ciphers in mathematical way, DES historical ciphers, Public key cryptography, RSA, Two fish, Digital signatures, Key management techniques, Identification and entity authentication, Hash function and data integrity. |
| 9 | **Contents for lab (If applicable)** | |

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|---|---|---|
| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | IT 627 |
| 4 | **Title of the subject** | Cognitive Radio |
| 5 | **Any prerequisite** | Digital Communication |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | The students will be enabled to understand and acquire knowledge in cognitive networks.<br>To emphasis on knowledge-building to understand architectures for various networks.<br>To provide a complete understanding on concepts, to identify the pros and cons of designing a cognitive network and SDR. |
| 8 | **Brief Contents** | Introduction of various generation of wireless communication, Spectrum scarcity, Cognitive radio (CR) architecture, Functions of cognitive radio, Fundamental challenges and issues in designing cognitive radio.<br>Spectrum access models, Dynamic spectrum access (DSA), Underlay, Overlay, and hybrid cognitive radio, Potential applications of cognitive radio.<br>Interference temperature/channel estimation, Detection of spectrum holes, Practical spectrum sensing approaches, Collaborative sensing, External sensing.<br>Framework of trust in CRN; Trusted association and routing; Trust with learning; Security in CRN. Introduction to SDR. Evolution of SDR baseband requirements. SDR architectures - ideal SDR architectures, Realistic SDR architecture. SDR and cognitive radio relationship. |
| 9 | **Contents for lab (If applicable)** | No lab is associated with the course. |

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|---|---|---|
| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | IT 628 |
| 4 | **Title of the subject** | Digital Watermarking and Steganalysis |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | The objective of the course makes students familiar about digital watermarking and steganography. |
| 8 | **Brief Contents** | Information hiding, Steganography, and watermarking, Importance of digital watermarking, Applications and properties. Models of watermarking: Communication-based models of watermarking, Geometric models of watermarking, Modelling watermark detection by correlation; Basic message coding: Mapping messages into message vectors, Error correction coding, Detecting multi-symbol watermarks; Watermarking with side information: Informed embedding, Watermarking using side information, Dirty-paper codes; Robust watermarking: Approaches, Robustness to volumetric distortions, Robustness to temporal and geometric distortions; Watermark security: Security requirements, Watermark security and cryptography, Some significant known attacks; Content authentication: Exact authentication, Selective authentication, Localization, Restoration; Notation and terminology, Information-theoretic foundations of steganography, Practical steganographic methods, Minimizing the embedding impact;<br><br>Steganalysis: Steganalysis scenarios, Some significant steganalysis algorithms. |
| 9 | **Contents for lab (If applicable)** | No lab is associated with the course. |

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|---|---|---|
| 1 | **Semester** | |
| 2 | **Type of course** | Elective |

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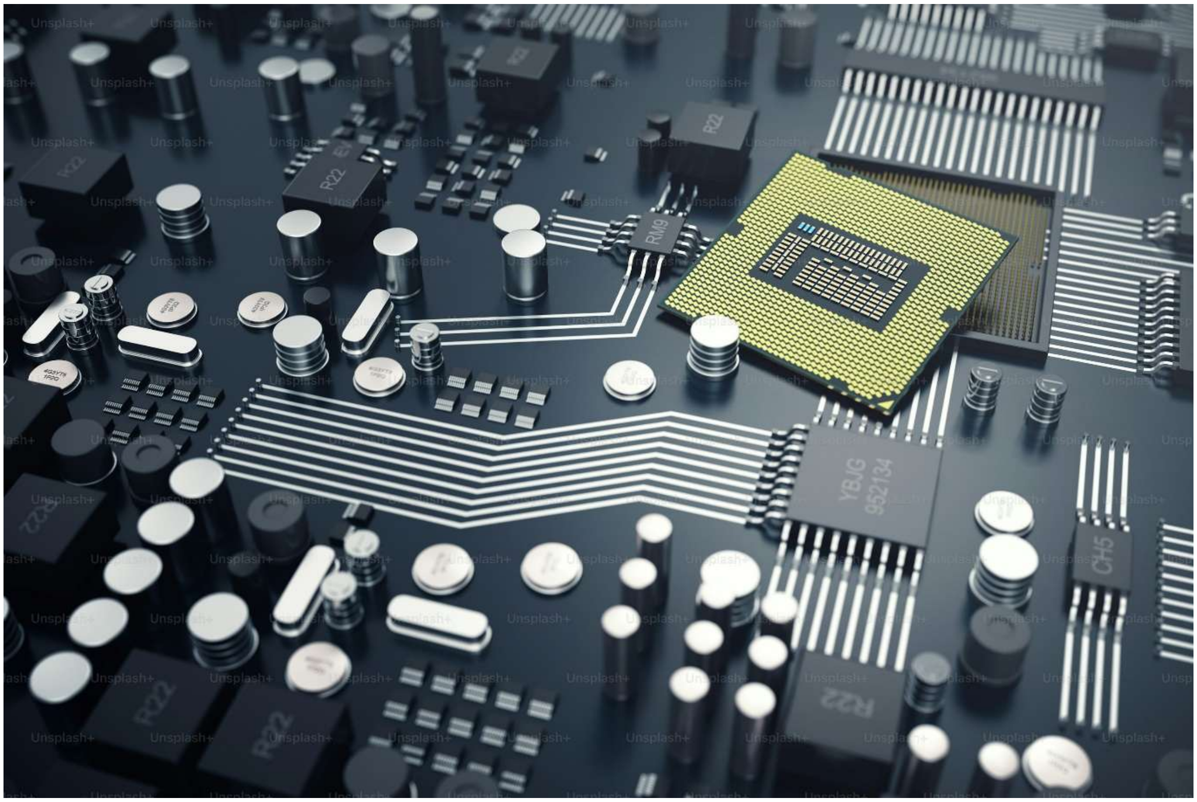
|---|---|---|
| 3 | **Code of the subject** | IT 629 |
| 4 | **Title of the subject** | Game Theory and its Application |
| 5 | **Any prerequisite** | Basic knowledge of engineering mathematics and statistics |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning objectives of the subject (in about 50 words)** | To teach the applications of game theory, auction and equilibrium. |
| 8 | **Brief contents** | Introduction to game theory, Dominant strategies and Nash equilibrium, Alternate strategies: Maximin, Maximax, and Minimax regret solvability, N-player games, Mixed strategy, Subgame perfection in discrete choice games, Continuous games and imperfect competition, Infinitely repeated games, Tacit collusion, Simultaneous-play, Bayesian games, Applications of Bayesian games: Auctions and voting, Cournot's duopoly with imperfect information, Radio spectrum, With arbitrary distribution of valuations, Extensive form game with perfect information, Stackelberg model of duopoly, Buying votes, Committee decision-making, Repeated games, The Prisoner's dilemma, General result, Supermodular game and potential game, Wireless networks: Resource allocations, Admission control, Routing in sensor and ad-hoc networks, Modeling network traffic and strategic network formation, Rubinstein bargaining model with alternating offers, Nash bargaining solution, Multi armed bandit problem. |
| 9 | **Contents for lab (If applicable)** | |

Curriculum & Contents

# M. Tech.

# (IC Design and Technology)




**Electrical and Electronics Engineering Department (EEE)**

ABV-Indian Institute of Information Technology & Management, Gwalior

# SCHEMA

**Name of the program: M. Tech. (IC Design and Technology)**

**(Credits: 73)**

**Name of the Department: Electrical and Electronics Engineering**

| **SEMESTER-I** | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject Code** | **Title of the course** | **L-T-P** | **Credits** |
| **1.** | EE-601 | Digital IC Design | 3-0-0 | 3 |
| **2.** | EE-602 | System Design using HDL | 3-0-0 | 3 |
| **3.** | EE-603 | Machine Learning Techniques | 3-0-2 | 4 |
| **4.** | EE-604 | IC Technology | 3-0-0 | 3 |
| **5.** | EE-605 | Device Modelling and Simulation | 3-0-0 | 3 |
| **6.** | EE-606 | Advanced IC Design and Technology Lab-1 | 0-1-4 | 3 |
| **7.** | EE-XXX | Elective 1 | 3-0-0 | 3 |
| | | | **Total credits** | **22** |

| **SEMESTER-II** | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject code** | **Title of the course** | **L-T-P** | **Credits** |
| **1.** | EE-607 | Analog IC Design | 3-0-0 | 3 |

| | | | | |
|---|---|---|---|---|
| **2.** | EE-608 | Design Verification and Testing | 3-0-0 | 3 |
| **3.** | EE-609 | Engineering Research Methodology | 2-1-0 | 3 |
| **4.** | EE-610 | CAD for VLSI | 3-0-0 | 3 |
| **5.** | EE-611 | Advanced IC Design and Technology Lab-II | 0-1-4 | 3 |
| **6.** | EE-XXX | Elective- II | 3-0-0 | 3 |
| **7.** | EE-XXX | Elective-III | 3-0-0 | 3 |
| | | | **Total credits** | **21** |

EXIT AFTER YEAR-1: Post Graduate Diploma in IC Design and Technology

| **SEMESTER-III** | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject code** | **Title of the course** | **L-T-P** | **Credits** |
| 1 | XXX | Elective-IV/MOOC course | 3-0-0 | 3 |
| 2 | EE-698 | Major Project Part I/Internship | - | 12 |
| | | | **Total credits** | **15** |

| SEMESTER-IV | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject Code** | **Title of the course** | **L-T-P** | **Credits** |
| **1** | EE-699 | Major Project Part II/Internship | - | 15 |
| | | | **Total credits** | **15** |

| SEMESTER-I | SEMESTER-II | SEMESTER-III | SEMESTER-IV | TOTAL CREDITS |
|---|---|---|---|---|
| 22 | 21 | 15 | 15 | **73** |

# Electives Courses

| S.N. | Code | Electives I,II,III, and IV Category: IC Design and Technology |
|---|---|---|
| 1 | EE-051 | Device and Interconnect Modelling |
| 2 | EE-052 | VLSI Signal Processing |
| 3 | EE-053 | Low Power VLSI |
| 4 | EE-054 | Microcontroller and Embedded Systems |
| 5 | EE-055 | Memory Devices and Circuits |
| 6 | EE-056 | VLSI Architecture |
| 7 | EE-057 | Hardware Security |
| 8 | EE-058 | FPGA-Based System Design |
| 9 | EE-059 | Quantum Electronics |
| 10 | EE-060 | RF Circuit Design |
| 11 | EE-061 | Mixed Signal SoC Design |
| 12 | EE-062 | AI-Accelerator Design |
| 13 | EE-063 | System-on-Chip Design |
| 14 | EE-064 | Embedded Software |
| 15 | EE-066 | Special Topics in IC Design and Technology |
| 16 | EE-068 | Network on Chip |
| 17 | EE-069 | Digital Image Computation |
| 18 | EE-070 | Audio Signal Processing |
| 19 | EE-071 | Advanced Digital Signal Processing |
| 20 | EE-072 | Biomedical Signal Processing |
| 21 | EE-074 | Computer Vision |
| 22 | EE-076 | Internet of Bio-Nano Things |
| 23 | EE-079 | Cyber Security |

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|---|---|---|
| 24 | EE-081 | Optimization Techniques |
| 25 | EE-083 | Internet of Things |
| 26 | EE-085 | Software Defined Radio |
| 27 | EE-086 | Quantum Communication |
| 28 | EE-087 | 5G and 6G standards |
| 29 | EE-088 | Smart Antennas |
| 30 | EE-089 | Advanced Optical Communication |
| 31 | EE-092 | Data Communication Protocol |
| 32 | EE-613 | Next-Generation Communication Systems |
| 33 | EE-065 | High-Performance Computing Systems |
| 34 | EE-067 | Sensors for Autonomous System |
| 35 | EE-073 | Data Analytics |
| 36 | EE-075 | Reinforcement Learning |
| 37 | EE-078 | Quantum Computing |
| 38 | EE-080 | Deep Learning for Autonomous Systems |
| 39 | EE-082 | Advanced Control System |
| 40 | EE-093 | Drone Technology and Robotics |
| 41 | EE-612 | Sensors and Actuators |
| 42 | EE-615 | Autonomous Systems |

# Course Contents

| | | |
|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | EE-601 |
| 4 | **Title of the subject** | Digital IC Design |
| 5 | **Any prerequisite** | NIL |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To introduce the physics of MOSFETs, design rules of CMOS layout, basic theory of static and dynamic characteristics of CMOS logic circuits, power dissipation in CMOS logic circuits. On completion of this course, the students will be able to:<br>1. Synthesize and analyze the MOSFET based circuits.<br>2. Draw the layout/stick diagram of CMOS logic circuits.<br>3. Analyse the performance of CMOS logic circuits.<br>4. Design CMOS combinational and dynamic logic circuits. |
| 8 | **Brief Contents** | Basic MOSFET Characteristics – Threshold Voltage, Body Bias concept, Current-Voltage Characteristics – Square-Law Model, MOSFET Modeling – Drain-Source Resistance, MOSFET Capacitances, Geometric Scaling Theory – Full-Voltage Scaling, Constant-Voltage Scaling, Challenges of MOSFET Scaling. CMOS fabrication processing steps, Design Rules, Stick diagram, Layout of logic circuits, latch-up, CMOS Inverter, Power Dissipation in CMOS Digital Circuits, Dynamic Logic Circuit Concepts and CMOS Dynamic Logic Families |
| 9 | **Text/ Reference Books** | 1. Kang, S. and Leblebici, Y., CMOS Digital Integrated Circuits – Analysis and Design, Tata McGraw Hill (2008) 3rd ed.<br>2. J P Uyemura, CMOS Circuit Design, Springer<br>3. Weste, N.H.E., Harris, D., CMOS VLSI Design: A Circuits and Systems Perspective, Pearson; 4th edition (2010).<br>4. Rabaey, J.M., Chandrakasen, A.P. and Nikolic, B., Digital Integrated Circuits – A Design perspective, Pearson Education (2007) 2nd ed.<br>5. Baker, R.J., Lee, H. W. and Boyce, D. E., CMOS Circuit Design, Layout and Simulation, Wiley - IEEE Press (2004) 2nd ed.<br>6. Weste, N.H.E. and Eshraghian, K., CMOS VLSI Design: A Circuits and Systems Perspective, eddision Wesley (1998) 2nd ed. |

| | | |
|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | EE-602 |
| 4 | **Title of the subject** | System Design using HDL |
| 5 | **Any prerequisite** | Digital Electronics in UG |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Correctly describe the detailed behavior of the given standard and a few special application-based digital logic circuits as defined by Verilog HDL, state diagrams, or other means, including those circuits related to modern computer architecture.<br><br>Translate system requirements into a practical digital design using Verilog HDL, Xilinx Vivado, and FPGA prototyping boards. Model the digital designs including FSMs to Processor architectures using the knowledge of HDL Language. Apply the knowledge of Reconfigurable architectures like FPGAs in designing and implementing digital ICs. |
| 8 | **Brief Contents** | Basic concepts of hardware description languages (VHDL, Verilog HDL), Logic and delay modeling, Structural, Data- flow and Behavioral styles of hardware description, Architecture of event driven simulators, Operators, Operands, Operator types, Blocking and non-blocking statements, Delay control, Generate statement, Event control, Sequential Logic Design, FSM, Configuration Specifications, Sub-Programs, Test Benches.<br><br>Types of Reconfiguration, Details study of FPGA, Design tradeoffs, Bidirectional wires and switches, FPGA Placement: Placement Algorithms, FPGA Routing, Timing Analysis, Network Virtualization with FPGAs, On-chip Monitoring Infrastructures, Multi-FPGA System Software, Logic Emulation, Applications, High Level Compilation |
| 9 | **Text/ Reference Books** | 1. Charles H. Roth, Digital System Design Using VHDL, Jr., Thomson, (2008)2nd Ed.<br>2. Bhaskar, J., A VHDL Primer, Pearson Education/ Prentice Hall (2006)3rd Ed.<br>3. Samir Palnitkar, Verilog HDL: A Guide to Digital Design and Synthesis, Prentice Hall PTR (2003) 2nd Ed.<br>4. Ashenden, P., The Designer's Guide To VHDL, Elsevier (2008) 3rd Ed.<br>5. David C. Black and Jack Donovan, SystemC: From the Ground Up, Springer, (2014) 2nd Ed.<br>6. Rushton, A., VHDL for Logic Synthesis, Wiley (1998) 2ed. |

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|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | EE-603 |
| 4 | **Title of the subject** | Machine Learning Techniques |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning Objectives of the subject** | • Understand key machine learning concepts and algorithms, including supervised and unsupervised learning.<br>• Gain practical experience in implementing machine learning models.<br>• Learn data preprocessing techniques and model evaluation methods for accurate performance assessment.<br>• Explore neural networks and deep learning basics, focusing on real-world applications. |
| 8 | **Brief Contents** | Supervised, unsupervised, and reinforcement learning, along with their real-world applications. It explores key algorithms like linear regression for model fitting and evaluation, and classification techniques such as Logistic Regression, K-Nearest Neighbors, and Support Vector Machines. The course also delves into decision trees and random forests, examining their use in both classification and regression tasks. Unsupervised learning methods like K-means clustering, Hierarchical Clustering, and DBSCAN are discussed. Basics of neural networks, including their architecture, backpropagation, and activation functions. Students will learn how to evaluate models using techniques like cross-validation, confusion matrices, precision, recall, and F1 scores. Dimensionality reduction techniques, including PCA etc. |
| 9 | **Lab Content** | Implementation of various machine learning algorithms, starting with supervised learning techniques like linear regression, logistic regression, K-Nearest Neighbors, and Support Vector Machines for both classification and regression tasks. They will explore unsupervised learning methods such as K-means clustering, Hierarchical Clustering, and DBSCAN to uncover patterns in data. The lab will also cover decision trees and random forests, and introduce students to the basics of neural networks, including their architecture, backpropagation, and activation functions. Additionally, students will practice model evaluation using techniques like cross-validation, confusion matrices, precision, recall, and F1 scores. The lab will conclude with experiments on dimensionality reduction using methods like PCA to simplify complex datasets. |
| 10 | **Text/ Reference Books** | 1. "Pattern Recognition and Machine Learning" by Christopher M. Bishop<br>2. "Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow" by Aurélien Géron<br>3. "Machine Learning: A Probabilistic Perspective" by Kevin P. Murphy<br>4. "Introduction to Machine Learning with Python" by Andreas C. Müller and Sarah Guido<br>5. "MATLAB for Machine Learning" by Giuseppe Ciaburro |

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|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | EE-604 |
| 4 | **Title of the subject** | IC Technology |
| 5 | **Any prerequisite** | Nil |
| 6 | **L.T.P.** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Students will be able to learn the flow of IC Design, which includes the fundamentals of the fabrication of chips, input-output packaging, and interconnection networks. To demonstrate a clear understanding of CMOS fabrication flow, input/output circuits, and chip packaging. Get an idea of data flow in interconnection network, routing, and topology basics. |
| 8 | **Brief Contents** | Introduction to semiconductor manufacturing, wafer production, wafer Identification, wafer handling, and wafer cleaning. Introduction to the cleanroom, Cleanroom protocols, safety, and precautions. Introduction/Recap to various instruments. photolithography: photoresist, spin-coating, masking, annealing - hands-on/demonstration for the same inside the cleanroom. Cleanroom processes such as patterning, oxygen-plasma etching, dry-etching, lift-off, structural characterization of the pattern/actuator: optical characterization, surface profilometer. Metallization of devices using negative photoresist, pattern formation. Device characterization (I-V curve in dark and with illumination), statistical analysis of the devices. Introduction to the packaging of the devices. |
| 9 | **Text/ Reference Books** | 1. Ghandhi S K, VLSI Fabrication Principles: Silicon and Gallium Arsenide 2nd Edition, Wiley Blackwell (1994)<br>2. Plummer J D, Deal M D and Griffin P B, Silicon VLSI Technology: Fundamentals, Practice, and Modeling,1st<br>3. Edition, Pearson Education (2009)<br>4. Sze S M, VLSI Technology, 2nd Edition, McGraw Hill Education (2017)<br>5. Stanley A. Wolf and Richard N. Tauber, Silicon Processing for the VLSI Era Volume 1-Process Technology Lattice Press, 1999<br>Peter Van Zant, Microchip Fabrication. McGrawHill, 2004 |

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|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | EE-605 |
| 4 | **Title of the subject** | Device Modeling and Simulation |
| 5 | **Any prerequisite** | Electronics Devices and Circuits |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning Objectives of the subject** | The objective of the course is to provide the fundamental knowledge for understanding the basic concepts of semiconductor devices. Upon successful completion of the course, students will be able to grasp fundamental knowledge of semiconductor devices for integrated circuit design and be able to model the devices and circuits using SPICE. |
| 8 | **Brief Contents** | Device Level Modelling: PN junction, MOSFET, limitations of long-channel analysis, short-channel effects, technology nodes and ITRS, physical and technological challenges to scaling, nonconventional MOSFETs (FDSOI, SOI, Multi-gate MOSFETs), compact modeling, Verilog-A model.<br><br>Interconnect Modelling: Introduction to VLSI interconnects, distributed RC interconnect model, Elmore delay, equivalent Elmore model for RLC interconnects (distributed model), two-pole model of RLC interconnects from ABCD parameters.<br><br>Circuit Modelling: Circuit simulation using available device models, netlist, and System Modelling |
| 9 | **Text/ Reference Books** | 1. G. Massobrio, P. Antognetti, Semiconductor Device Modeling with SPICE 2nd edition, McGraw-Hill, New York,1993.<br>2. M Rudolph, Introduction to Modeling HBTs, Artech House, Boston, 2006<br>3. S M Sze, K K Ng, Physics of Semiconductor Devices 3rd edition, John Wiley, New Jersey, 2007<br>4. G. A. Armstrong, C.K.Maiti, Technology Computer Aided Design for Si, SiGe and GaAs Integrated Circuits IET Series, London, 2007<br>5. Nandita Das Gupta, Amitava Das Gupta, “Semiconductor devices, modeling and Technology”, Prentice Hall of India, 2004.<br>6. Philip.E.Allen Douglas, R. Hoberg, “CMOS Analog circuit Design” Second edition, Oxford Press, 2002. |

| | | |
|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | EE-606 |
| 4 | **Title of the subject** | Advanced IC Design and Technology Lab-I |
| 5 | **Any prerequisite** | NIL |
| 6 | **L-T-P** | 0-1-4 |
| 7 | **Learning Objectives of the subject** | The lab experiments of this course will provide exposure to how the fundamental and advanced theories, design concepts, and principles of the core courses studied in the 1st semester can be applied in practice. The objective of the course is to provide the fundamental knowledge for understanding the flow of IC design using EDA tools and better approaches/solutions for more effective design.<br><br>The course will cover the fundamentals of HDL language, concepts to design systems using HDL, and the implementation of the design on FPGA boards. |

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| 8 | **Brief Contents** | The complete IC layout design and its implementation using EDA tool. Provide the in-depth concept and flow for implementation of IC Design, CMOS logic, Circuit analysis with change in the device parameters, Impact of parasitic on circuit performance.<br><br>Fundamentals of Verilog HDL, different levels of abstraction, tasks and directives, Concept to design the FSM and microarchitecture, Timing and delay simulations, Fundamentals of Physical Design during RTL to |
| 9 | **Contents for lab** | Schematic and Layout analysis of inverter, AND gate, OR gate, NAND gate, NOR gate, XOR gate and XNOR gate (pre layout simulation and post layout simulation), IC fabrication process.<br><br>Implementation of all the basic and universal gates using HDL, combinational circuits, sequential circuits, FSM implementation, memory design, Micro-architecture implementation. Automation of FPGAs. Physical Design, Partitioning, Floor plan, Placement and Routing, Timing analysis |
| 10 | **Text/ Reference Books** | 1. S. M. Kang and Y. Leblebici, `CMOS Digital Integrated Circuits' Tata McGraw-Hill |

| | | |
|---|---|---|
| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | EE-607 |
| 4 | **Title of the subject** | Analog IC Design |
| 5 | **Any prerequisite** | Digital IC Design |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | This course builds the basic concepts and the design of advanced CMOS analog Integrated Circuit. This course focuses on the concepts of MOSFETs and design of amplifiers including non-linear effects. The course will give the practical aspects of CMOS analog IC design. The course aims to teach basic concepts along with advanced design techniques for CMOS amplifiers. The objective of the course is to design and implement the product-level opamps and buffers for VLSI applications. |

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| 8 | **Brief Contents** | Small signal Models, Amplifiers and Current sources: Large Signal and Small-Signal analysis of common source stage, Source Follower, Common Gate Stage, Cascode, Folded Cascode, Differential amplifier, current Sources, Basic Current Mirrors, Cascode Current Mirrors and current mirror based differential amplifier, Frequency Response of Amplifiers, Feedback, Operational Amplifier, Noise, Determination of dominants poles; Compensation and relocation of poles and zeros, Basic concepts to design PLL and ADC |
| 9 | **Text/ Reference Books** | 1. Behzad Razavi, Design of Analog CMOS Integrated Circuits, McGraw-Hill Education, Second Edition (2017).<br>2. Tony Chan Carusone David A. Johns Kenneth W. Martin, Analog Integrated Circuit Design, Wiley, Second Edition (2011)<br>3. CMOS Analog Circuit Design" by Phillip Allen and Douglas R. Holberg, OUP USA; Third Edition edition (1 September 2011)<br>4. Operation and Modeling of the MOS Transistor" by Yannis Tsividis, Oxford University, Press; 2 edition, June 26, 2003<br>5. "Microelectronic Circuits-Theory & Applications" by A.S. Sedra and K.C. Smith, Adapted by A.N. Chandorkar, 6th Edition, Oxford, 2013. |

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|---|---|---|
| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | EE-608 |
| 4 | **Title of the subject** | Design Verification and Testing |
| 5 | **Any prerequisite** | CAD for VLSI |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The main objective of this course is to provide in-depth understanding of the problems encountered in testing large circuits, approaches to detect and diagnose the faults and methods to improve the design to make it testable. The students will be able to develop algorithms and tools for VLSI testing, designing of testable and trustworthy circuits. The scope of this course is to particularly address the challenges in the VLSI testing domain and get motivated towards research in this field. |

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| 8 | **Brief Contents** | Introduction and Fault Modeling, Testing Techniques, Time frame expansion methods, Boolean Satisfiability, Transitive-closure based and Neural Network based approaches, Fault Simulation, Design for Testability and Built-in-self-test, Controllability and observability measures, TEMEAS, SCOAP, Ad-hoc design built-in-logic-block- observer (BILBO), Linear feedback shift register (LFSR), Theory of LFSRs, Design for Trust Techniques: Different Types of Attacks, Counter Measures for different types of attacks, Prevention based Approaches, Importance of verification, Verification plan, Verification flow, Levels of verification, Verification methods and languages, Introduction to Hardware Verification methodologies, Verifications based on simulation, Analytical and formal approaches. Functional verification, Timing verification, Formal verification. Basics of equivalence checking and model checking |
| 9 | **Text/ Reference Books** | 1. M.L. Bushnell and V.D. Agrawal, "Essentials of Electronic Testing", Kluwer Academic Publishers, 2000<br>2. N.K. Jha and S. Gupta, "Testing of Digital Systems", Cambridge University Press 2004<br>3. M. Abramovici, M.A. Breuer and A.D. Friedman, "Digital Systems Testing and Testable Design", Wiley-IEEE Press,1993<br>4. P.H. Bardell, W.H. McAnney and J. Savir, "Built-in Test for VLSI: Pseudorandom Techniques", Wiley Interscience, 1987<br>5. L-T. Wang, C-W. Wu and X. Wen, "VLSI Test Principles and Architectures", Morgan Kaufman Publishers, 2006<br>6. P.K. Lala, "Fault Tolerant and Fault Testable Hardware Design", Prentice-Hall Intl 1985 |

| | | |
|---|---|---|
| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | EE-609 |
| 4 | **Title of the subject** | Engineering Research Methodology |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 2-1-0 |
| 7 | **Learning Objectives of the subject** | • Equip students with the ability to formulate research problems, design experiments, and employ appropriate research methodologies in engineering.<br>• Teach students to collect, analyse, and interpret data using various statistical and computational tools.<br>• Install a strong understanding of ethical considerations in research, including data integrity, plagiarism, and responsible reporting.<br>• Develop students' skills in technical writing and presentation, enabling them to effectively communicate research findings. |

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| | | • Foster critical thinking and problem-solving abilities, preparing students to tackle complex engineering challenges through rigorous research. |
| 8 | **Brief Contents** | This course provides an in-depth understanding of research techniques and methodologies essential for engineering research. Topics include the formulation of research problems, literature review, research design, and experimental methods. Students will learn quantitative and qualitative research methods, data collection and analysis techniques, and the use of statistical tools. The course covers ethical considerations, technical writing, and presentation skills, emphasizing the importance of reproducibility and peer review. Practical sessions will involve developing research proposals, designing experiments, and analysing real-world data, equipping students with the skills to conduct rigorous and impactful engineering research. |
| 9 | **Text/ Reference Books** | 1. "Research Methodology: A Step-by-Step Guide for Beginners" by Ranjit Kumar<br>2. "Research Methods for Engineers" by David V. Thiel<br>3. "Engineering Research: Design, Methods, and Analysis" by Herman Tang<br>4. "The Craft of Research" by Wayne C. Booth, Gregory G. Colomb, and Joseph M. Williams |

| | | |
|---|---|---|
| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | EE-610 |
| 4 | **Title of the subject** | CAD for VLSI |
| 5 | **Any prerequisite** | Digital Design |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectivesof the subject** | 1. Understand the general design process of modern VLSI chips.<br>2. Be able to identify and formulate design problems within a sound methodology.<br>3. Build capability to analysis a problem, and design efficient algorithms to solve it.<br>4. Become familiar with most algorithms and methods used in VLSI CAD.<br>5. Be able to implement algorithms in CAD tools. |
| 8 | **Brief Contents** | Introduction to VLSI-CAD, module generation, PLAs and FPGAs, digital hardware modelling, benchmark circuits (ISCAS’85, ISCAS’89, etc.), simulation algorithms, design verification, graph data structure and algorithms for VLSI-CAD, high-level synthesis, algorithms for physical design automation, slicing and non-slicing floorplans, polar graphs and adjacency graphs for floorplans, Placement: objective functions; partitioning based placement. Global routing: geometric spanning trees; Steiner trees; net |

| | | |
|---|---|---|
| | | ordering. Detailed Routing: shortest paths and maze search, Channel routing, introducing NoC as a future SoC paradigm, timing analysis, SDC, set-up and hold time concepts, timing exceptions, set-up and hold calculations, and noise analysis. |
| 9 | **Text/ Reference Books** | 1. Sherwani, N., Algorithms for VLSI Physicsl Design Automation, Springer (2005) 3rd ed.<br>2. Gerez S.H., Algorithms for VLSI Design Automation, John Wiley (1998)<br>3. Sarrafzadeh, M. and Wong, C. K., An Introduction to VLSI Physical Design, McGraw Hill (1996).<br>4. Trimberger, S. M., An Introduction to CAD for VLSI, Kluwer (1987).<br>5. Sait, S. M. and Youssef, Habib, VLSI Physical Design Automation – Theory and Practice, World Scientific, 2004. |

| | | |
|---|---|---|
| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | EE-611 |
| 4 | **Title of the subject** | Advanced IC Design and Technology Lab-II |
| 5 | **Any prerequisite** | NILL |
| 6 | **L-T-P** | 0-1-4 |
| 7 | **Learning Objectives of the subject** | • The lab experiments of this course will provide exposure to how the fundamental and advanced theories, design concepts, and principles of the core/elective courses studied in the 2nd semester can be applied in practice.<br>• The objective of the course is to provide the fundamental knowledge for understanding the flow of IC design using EDA tools and better approaches/solutions for more effective design.<br>• The objective of the course is to provide the fundamental knowledge of analog IC design using the Cadence EDA tool. In-depth introduction to System Verilog and efficient verification using System Verilog. |
| 8 | **Brief Contents** | Design steps to implement the Analog circuits using EDA tools, Provide the in-depth concept and flow for implementation of IC Design, Circuit analysis with change in the device parameters, Impact of parasitic on circuit performance. Improvements for RTL design and synthesis; Verification enhancements such as object-oriented design; Assertions and randomization. |

| | | |
|---|---|---|
| 9 | **Contents for lab** | Introduction to digital circuit simulators– NGSPICE and Cadence tools for circuit and layout simulations; SPICE models of CMOS devices; Static and dynamic characterization of CMOS inverters, gate delay and interconnect delay in CMOS; Analog Circuits Simulations, Combinational and sequential static CMOS circuits including pass transistors; Dynamic CMOS logic circuits; Introduction to hardware description languages (VHDL/Verilog)-<br>- analysis, elaboration, and synthesis of HDLs and implementation on FPGAs. |
| 10 | **Text/ Reference Books** | 1. S. M. Kang and Y. Leblebici, `CMOS Digital Integrated Circuits' Tata McGraw-Hill |

| | | |
|---|---|---|
| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-051 |
| 4 | **Title of the subject** | Device and Interconnect Modelling |
| 5 | **Any prerequisite** | NIL |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | By studying this course, students will gain a comprehensive understanding of technology trends and scaling in the semiconductor industry. They will learn about Moore's Law, technology nodes, and the physical and technological limitations that impact semiconductor miniaturization. The course will provide in-depth knowledge of interconnect modeling and analysis, covering RC, RLC, and transmission line models while exploring the effects of capacitive and inductive coupling on signal integrity. Students will also understand key factors such as power dissipation, reliability concerns, and performance trade-offs in interconnects. |

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| 8 | **Brief Contents** | Technology trends, Device and interconnect scaling, Interconnect Models: RC model and RLC model, Effect of capacitive coupling, Effect of inductive coupling, Transmission line model, Power dissipation, Interconnect reliability, Driver and Load Device Models, Interconnect Analysis, Time domain analysis, RLC network analysis, RC network analysis and responses in time domain, S domain analysis, Circuit reduction via matrix approximation, Analysis using moment matching, Crosstalk Analysis, Advanced Interconnect Materials. Moore law, Technology nodes and ITRS, Physical & Technological Challenges to scaling, Two terminal MOS Device threshold voltage modelling, C-V Characteristics, Four terminal MOSFET threshold voltage I-V modelling, short channel effect (SCE), High-K gate dielectric, Nonconventional MOSFET – (FDSOI, SOI, Multi-gate MOSFETs). Nonconventional MOSFET – (FDSOI, SOI, Multi-gate MOSFETs) and advanced VLSI devices and interconnects |
| **9** | **Lab Content** | NA |
| **10** | **Text/ Reference Books** | **1.** Nano Interconnects: Device Physics, Modeling and Simulation by Afreen Khursheed and, Kavita Khare (CRC Press, 2024)<br>**2.** Fundamentals of Device and Systems Packaging: Technologies and Applications, Second Edition by Rao Tummala |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-052 |
| 4 | **Title of the subject** | VLSI Signal Processing |
| 5 | **Any prerequisite** | Digital Circuit, and Signals & Systems |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Provides comprehensive coverage of techniques for designing efficient VLSI architectures specifically for Digital Signal Processing (DSP) systems.<br>• Addresses real-world challenges in implementing DSP systems, such as high throughput data processing, real-time operation, and resource constraints.<br>• Focuses on optimizing power consumption and minimizing chip area while maintaining performance in DSP applications.<br>• Equips students with the skills to design VLSI architectures that meet the demands of modern DSP systems in terms of efficiency and scalability. |
| 8 | **Brief Contents** | Discusses Signal Flow Graph (SFG), Data Flow Graph (DFG), and Dependence Graph (DG) for DSP algorithms. Critical path minimization, retiming of DFG, loop retiming, and iteration bounds. Pipelined DSP architectures and parallel realization of DSP algorithms for optimization. Explores parallel realizations of FIR filters, including 2-parallel and 3-parallel architectures, and hardware minimization. Introduces unfolding theorem and polyphase decomposition for efficient DSP realization. |
| 9 | **Reference Book** | 1. VLSI Digital Signal Processing Systems: Design and Implementation, Keshab K. Parhi,: Wiley-Interscience.<br>2. VLSI for Signal Processing, Umesh H. Patil, Prentice Hall<br>3. Digital Signal Processing: A VLSI Implementation Perspective, Keshab K. Parhi, Wiley-Interscience. |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-053 |
| 4 | **Title of the subject** | Low Power VLSI |
| 5 | **Any prerequisite** | Digital Electronics |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning Objectives of the subject** | • Understand the Need for Low Power VLSI Design.<br>• Analyze Power Dissipation Mechanisms in CMOS Circuits.<br>• Apply Low Power Design Techniques at device, circuit, and architecture level.<br>• Perform Power Estimation and Analysis.<br>• Understand clock gating and low-power clocking strategies.<br>• Reduce power consumption in clock distribution networks. |
| 8 | **Brief Contents** | Need for low-power VLSI chips, Sources of Power Dissipation on Digital Integrated Circuits, Dynamic Dissipation, Static Dissipation, Technology & Device Innovation, Emerging Low power Approaches, Low Power Design Techniques at Architecture and System Levels, Power Consumption of Dedicated Hardware vs. Software Implementations of Systems, Low Power Architecture, RTL design Techniques for Low Power, Low Power Random Access Memory Circuits, Power Analysis and Design at System level and state-of-the-art Low Power Applications. |
| 9 | **Lab Content** | NA |
| 10 | **Text/ Reference Books** | 1. "Low-Power CMOS VLSI Circuit Design" by Kaushik Roy and Sharat C. Prasad<br>2. "Low-Power Digital VLSI Design: Circuits and Systems" by Abdellatif Bellaouar and Mohamed I. Elmasry<br>2. "Low Power Digital CMOS Design" by Anantha P. Chandrakasan and Robert W. Brodersen |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-054 |
| 4 | **Title of the subject** | Microcontroller and Embedded System |
| 5 | **Any prerequisite** | Nil |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | This course aims to convey knowledge of basic concepts of embedded system design required for every state-of-the-art electrical/electronic system in the form of autonomous and real– time computing machine embodied within them. Emphasis is on the features and characteristics of embedded system, design metrics, embedded system design flow, processor, memory and input output interfacing and input output devices, assembly language, hardware description language, I/O interface design and programming, real-time operating system, hardware-software co- design and co-simulation. Special attention will be devoted to the most important challenges facing embedded system designers today and in the coming decade. |

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| 8 | **Brief Contents** | Introduction to Embedded System, Major components, Design issues, Microprocessor, DSP, Microcontroller architecture, Memory, FPGA, ASIC, ARM architecture fundamentals, Interfacing and Communication Protocols |
| 9 | **Text/ Reference Books** | 1. "The Art of Designing Embedded Systems" by Jack Ganssle<br>2. "Embedded Systems: Real-Time Interfacing to ARM Cortex-M Microcontrollers" by Jonathan W. Valvano<br>**3.** "Architecting High-Performance Embedded Systems", Jim Ledin |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-055 |
| 4 | **Title of the subject** | Memory Devices and Circuits |
| 5 | **Any prerequisite** | Microelectronic Devices/Digital Electronics |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Understand the Fundamentals of Memory Systems.<br>• Analyze SRAM and DRAM Architectures.<br>• Evaluate Non-Volatile Memory Technologies.<br>• Design and Optimize Memory Peripheral Circuits.<br>• Explore Advanced and Emerging Memory Technologies. |
| 8 | **Brief Contents** | Introduction to Memory Systems, Memory Arrays, Memory Market, 6T/8T SRAM Design, 3T/1T-1C DRAM Design, Charge Pump Circuits, Open and Folded Bit Line Architecture, Arrays organizations, Sense Amplifiers & Peripheral Circuits, Introduction to Flash memory, NAND/NOR Flash memory, Organization of NAND Flash Memory, Advance 3D NAND Flash Configuration, Next Generation Memory (PCM, MRAM, RRAM), Emerging Memory Devices for Neuromorphic Applications. |
| 9 | **Lab Content** | NA |
| 10 | **Text/ Reference Books** | 1. "Digital Integrated Circuits: A Design Perspective" by Jan M. Rabaey, Anantha Chandrakasan, and Borivoje Nikolić.<br>2. "CMOS Digital Integrated Circuits: Analysis and Design" by Sung-Mo Kang and Yusuf Leblebici.<br>3. "Advanced Memory Technology" by Ye Zhou and Guoxing Wang. |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-056 |
| 4 | **Title of the subject** | VLSI Architecture |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • The course objective is to cover the architecture design of VLSI systems and subsystems with the notion of optimization for area, speed, dissipation, cost and reliability.<br>• Different aspects of VLSI system design and its applications in various fields.<br>• The course also discusses traditional, and state of the art analog and digital VLSI architectures optimized techniques. |
| 8 | **Brief Contents** | **Module 1:** ISA, Datapath and Control Path Design, Single Cycle MIPS, 5-Stage Pipeline MIPS, CISC Architecture.<br>**Module 2:** RISC Architecture, Arithmetic Unit Design, Fixed Point and Floating Point, Memory Units, Optimization.<br>**Module 3:** Instruction Level Parallelism, Superscalar Processor, Multi-Core and Multi-Thread Architecture.<br>**Module 4:** Network on Chip, Dynamically Reconfigurable Gate Array, Static vs. Dynamic Reconfiguration.<br>**Module 5:** Single Context vs. Multi-Context Dynamic Reconfiguration, Full Spatial Run-Time Reconfiguration. |
| 9 | **Text/ Reference Books** | 1. "VLSI Architecture" Prentice Hall publisher by B. Randell and P.C. Treleaven<br>2. "Physical Architecture of VLSI Systems" Wiley publisher by Robert J. Hannemann, Allan D. Kraus, and Michael Pecht<br>3. "Advanced VLSI Architectures: From Concept to Silicon" I I P Iterative International Publishers by Mr. Somnath Maity and Mr. Rakesh Kumar |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-057 |
| 4 | **Title of the subject** | Hardware Security |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning Objectives of the subject** | • Learning the state-of-the-art security methods and devices.<br>• Better understanding of attacks and providing counter measures against them<br>• CMOS implementation of hardware security primitives, Attacks oncyber-physical systems |
| 8 | **Brief Contents** | **Module 1:** Fundamentals of Hardware Security and Trust for Integrated Circuits, Physical and Invasive Attacks, Side-Channel Attacks and Countermeasures.<br>**Module 2:** Physically Unclonable Functions (PUFs), Hardware-Based True Random Number Generators, CMOS PUF Implementations.<br>**Module 3:** Hardware Trojan, Hardware Security Primitives, Hardware Trojan Detection and Isolation in IP Cores.<br>**Module 4:** Watermarking of Intellectual Property (IP) Blocks, FPGA Security, Passive and Active Metering for Prevention of Piracy.<br>**Module 5:** Access Control, Counterfeit IC Detection, Security Measures for Integrated Circuits. |
| 9 | **Text/ Reference Books** | 1. "Introduction to Hardware Security and Trust" Springer publisher by Mohammad Tehranipoor and Cliff Wang<br>2. "Hardware Security: Design, Threats, and Safeguards" CRC Press publisher by Debdeep Mukhopadhyay and Rajat Subhra Chakraborty<br>3. "Hardware Security: A Hands-on Learning Approach" Morgan Kaufmann publisher by Swarup Bhunia and Mark Tehranipoor |

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| 1 | **Semester** | I/II/III/IV |
| **2** | **Type of course** | Elective |
| **3** | **Code of the subject** | EE-058 |
| **4** | **Title of the subject** | FPGA-Based System Design |
| **5** | **Any prerequisite** | Nil |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The goal of the course is to study the basic principles and methods of FPGA prototyping.<br>Understanding of principles of IC prototyping; hardware and software; design strategies and methods |

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| 8 | **Brief Contents** | ROM, SPLD, CPLD Architecture and Features of FPGA and designing techniques. Architecture of ROM – ROM Programming – Architecture of SPLDs – SPLDs programming – Architecture of CPLDs, Basics of FPGAs– Structure of FPGAs Implementation of Digital circuits in FPGA processor, Education FPGA kit – FPGA pin assignment – Interfacing Input/Output devices with FPGA, SPI, I2C, I3C, UART protocol RTL design System Design Examples using Xilinx FPGAs – Traffic light Controller, Real Time Clock, VGA, Keyboard, LCD, Embedded Processor Hardware Design. |
| 9 | **Text/ Reference Books** | 1. M.J.S. Smith, "Application Specific Integrated Circuits", Pearson, 2000.<br>2. Peter Ashenden, "Digital Design using Verilog", Elsevier, 2007.<br>3. W. Wolf, "FPGA based system design", Pearson, 2004.<br>4. Clive Maxfield, "The Design Warriors's Guide to FPGAs", Elsevier, 2004<br>5. S. Ramachandran, "Digital VLSI System Design: A Design Manual for implementation of Projects on FPGAs and ASICs Using Verilog" Springer Publication, 2007.<br>6. Wayne Wolf, "FPGA Based System Design", Prentices Hall Modern Semiconductor Design Series. |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-059 |
| 4 | **Title of the subject** | Quantum Electronics |
| 5 | **Any prerequisite** | Microelectronic Devices and Circuits |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Gain insight into the fundamental structure of solids and how their atomic arrangement influences electronic properties.<br>• Grasp the basic principles of quantum mechanics, including wave-particle duality, uncertainty principle, and quantization.<br>• Learn how to solve Schrödinger's wave equation for different potential systems and understand its significance in electronic properties.<br>• Understand the concept of DOS and its importance in determining the electronic properties of materials.<br>• Carrier Transport Phenomenon in Semiconductors. |
| 8 | **Brief Contents** | The Crystal Structure of Solids, Introduction to Quantum Mechanics: Principles of Quantum mechanics, Application of Schrodinger's Wave Equations, Introduction to Quantum Theory of Solids: The kronig-Penney Model, Electrical conduction in Solids, DOS, Statistical |

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| | | Mechanics, The semiconductor in Equilibrium Carrier transport Phenomenon, Non-equilibrium Excess Carriers in Semiconductor, PN-Junction, MOSCAP, Thin film Transistors, Quantum Cellular Automata |
| 9 | **Lab Content** | NA |
| 10 | **Text/ Reference Books** | 1. "Quantum Mechanics: Concepts and Applications" by Nouredine Zettili<br>2. "Semiconductor Physics and Devices" by Donald A. Neamen<br>3. "Quantum Theory of Solids" by Charles Kittel<br>4. "Quantum Cellular Automata and Quantum Computing" by S. I. Zernov |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-060 |
| 4 | **Title of the subject** | RF Circuit Design |
| 5 | **Any prerequisite** | Analog IC Design |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Get the idea of various parameters of interest in RF systems.<br>• To understand issues involved in design for GHz frequencies.<br>• To understand theoretical background relevant for design of active and passive circuits for RF front end in wireless digital communication systems. |
| 8 | **Brief Contents** | Characteristics of passive components for RF circuits. Passive RLC networks. Transmission lines. Two-port network modeling. S-parameter model. The Smith Chart and its applications, Active devices for RF circuits: SiGe MOSFET, GaAs pHEMT, HBT and MESFET. RF Amplifier design: single and multi-stage amplifiers. Review of analog filter design. Voltage references and biasing.<br>Low Noise Amplifier design: noise types and their characterization, LNA topologies, Power match vs Noise match. Linearity and large- signal performance, RF Power amplifiers: General properties. Class A, AB and C Power amplifiers. Class D, E and F amplifiers. Modulation of power amplifiers, Analog communication circuits, Phase-locked loops, Oscillators and synthesizers. |
| 9 | **Lab Content** | None |
| 10 | **Text/ Reference Books** | 1. D. M. Pozar, "*Microwave Engineering*," 4th Edition, Wiley, 2012.<br>2. C. Bowick, "*RF circuit design*," 2nd Edition, Newnes, 2007. |

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| | | 3. R. C. Li, "*RF Circuit Design*," 2nd Edition, John Wiley & Sons, 2012.<br>4. G. Gonzalez, "*Microwave Transistor Amplifiers: Analysis and Design,*" 2nd Edition, Prentice Hall, 1996.<br>5. T. H. Lee, "*Planar Microwave Engineering: A Practical Guide to Theory, Measurement, and Circuits*," Cambridge University Press, 2004.<br>6. D. M. Pozar, "*Microwave and RF Design of Wireless Systems*," John Wiley & Sons, 2001. |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-061 |
| 4 | **Title of the subject** | Mixed Signal SoC Design |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Understand the significance of different biasing styles and apply it for different circuits.<br>• Design basic building blocks like sources, sinks, mirrors, up to layout level.<br>• Comprehend the stability issues of the systems and design Op- amp fully compensated against process, supply and temperature variations.<br>• Identify suitable topologies of the constituent subsystems and corresponding circuits as per the specifications of the system Design.<br>• Analog integrated system including parasitic effects up to tape-out. |
| 8 | **Brief Contents** | **Module 1:** Process and Temperature Independent Compensation, Resistor Equivalence of a Switched Capacitor, Parasitic-Sensitive and Parasitic-Insensitive Integrators.<br>**Module 2:** Signal-Flow-Graph Analysis, Noise in Switched-Capacitor Circuits, Performance of Sample-and-Hold Circuits.<br>**Module 3:** Ideal D/A Converter, Ideal A/D Converter, Quantization Noise, Charge-Redistribution A/D, Resistor-Capacitor Hybrid.<br>**Module 4:** Basic Phase-Locked Loop (PLL) Architecture, Voltage-Controlled Oscillator (VCO), Divider, Phase Detector, Loop Filter, PLL in Lock.<br>**Module 5:** Linearized Small-Signal Analysis, Second-Order PLL Model, Jitter and Phase Noise, Period Jitter, Probability Density Function of Jitter, Ring and LC Oscillators. |
| 9 | **Text/ Reference Books** | 1. "Design of Analog CMOS Integrated Circuits" Mc Graw Hill publisher by Behzad Razavi<br>2. "Analog Integrated Circuit Design" Wiley publisher by Tony Chan Carusone, David Johns, and Kenneth Martin<br>3. "Analog Design for CMOS VLSI Systems" Kluwer Academic publishers by Franco Maloberti |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-062 |
| 4 | **Title of the subject** | AI-Accelerator Design |
| 5 | **Any prerequisite** | NIL |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • This course provides in-depth coverage of the architectural techniques used to design accelerators for training and inference in machine learning.<br>• Get exposure of implementation of CNN network in FPGA board.<br>• Get an idea about the data system bus used in communication between different system blocks.<br>• To design energy-efficient accelerators, develop the intuition to make trade-offs between ML model parameters and hardware implementation techniques. |
| 8 | **Brief Contents** | **Module 1:** Deep Understanding of Neural Networks, Linear Algebra Fundamentals, Accelerating Linear Algebra.<br>**Module 2:** Implementation of Deep Learning Kernels, Zynq Series FPGA Architecture, Interface Knowledge.<br>**Module 3:** High-Speed Protocols (Ethernet 100/10 Gbps), SPI, I2C, I3C, UART Protocol RTL Design.<br>**Module 4:** C/C++ Coding for Vivado SDK, Activation Function Verilog Implementation.<br>**Module 5:** Classification Layer HDL Implementation, Optimization for FPGA-based Deep Learning.. |
| 9 | **Text/ Reference Books** | 1. “Efficient Processing of Deep Neural Networks” Morgan & Claypool Publisher by Vivienne Sze, Yu-Hsin Chen, Tien-Ju Yang, and Joel Emer<br>2. “Artificial Intelligence Hardware Design: Challenges and Solutions” Wiley-IEEE Press publisher by Albert Chun Chen Liu and Oscar Ming Kin Law<br>3. “From CNN to DNN hardware Accelerators: A Survey on Design, Exploration, Simulation, and Frameworks” Now publisher by Leonardo Rezende Juracy, Rafael Garibotti and Fernando Gehm Moraes |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-063 |
| 4 | **Title of the subject** | System-on-Chip Design |
| 5 | **Any prerequisite** | NIL |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | This course provides in-depth coverage of System-on-Performance Chip Design. Design, optimize, and program a modern System-on- a-Chip to analyze and characterize its computational requirements computational task, and identify performance bottlenecks. Characterize and develop real-time solutions. Implement both hardware and software solutions, formulate hardware/software tradeoffs, and perform hardware/software codesign. |
| 8 | **Brief Contents** | Hardware/software co-design: partitioning, real-time scheduling, hardware acceleration; Virtual prototyping: electronic system-level languages and hardware/software co-simulation; High-level synthesis: allocation, scheduling and binding algorithms for C-to-RTL synthesis; SoC integration: SoC communication architectures, IP interfacing, verification and test; FPGA prototyping of hardware/software systems. |
| 9 | **Text/ Reference Books** | 1. P. Marwedel, Embedded System Design: Embedded Systems Foundations of Cyber-Physical Systems, Third Edition, Springer, 2018. (author's website)<br>2. D. C. Black, J. Donovan, B. Bunton, A. Keist, SystemC: From the Ground Up, Second Edition, Springer, 2010.<br>3. G. De Micheli, Synthesis and Optimization of Digital Circuits, McGraw-Hill, 1994. |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-064 |
| 4 | **Title of the subject** | Embedded Software |
| 5 | **Any prerequisite** | Nil |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning Objectives of the subject** | • Convert software programs into equivalent cycle-based hardware and vice versa.<br>• Partition software into hardware and software components with proper interfaces.<br>• Identify and optimize performance bottlenecks in hardware-software architectures |
| 8 | **Brief Contents** | Design of embedded systems, architectures and platforms for embedded systems, general purpose vs. application-specific architectures, reconfigurable systems, optimization techniques for design space exploration, software synthesis and code generation, system-level power/energy optimization, Security in embedded systems, embedded software for AI and IoT Applications, embedded system Testing & Validation |
| 9 | **Text/ Reference Books** | 1. David E. Simon, "An Embedded Software Primer"<br>2. Daniele Lacamera, "Embedded Systems Architecture"<br>3. Mohamed Rafiquzzaman, "Microprocessors and microcomputer Based System Design" |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-066 |
| 4 | **Title of the subject** | Special Topics in IC Design and Technology |
| 5 | **Any prerequisite** | NIL |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of thesubject** | This will focus on special topics of contemporary relevance and interest toboth VLSI industry and state-of-the-art research. |
| 8 | **Brief Contents** | It will cover current research and development topics and in line with VLSI industry and may cover all aspects from Device Technology to chip design flow through ASIC and FPGA, Topics from state-of-the-art design methodologies. Architecture, circuit and layout level issues, Timing and Design closure. Deep sub-micron circuit design-logic and layout issues, FinFET and other novel devices. |

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| **9** | **Text/ Reference Books** | 1. Neil Weste and David Harris, "CMOS VLSI Design: A circuits and Systems perspective", 3rd Ed., Addison Wesley, 2004<br>2. RF microelectronics, Behzad Razavi, Prentice Hall, 1998.<br>3. William J. Dally, John W. Poulton, "Digital Systems Engineering, "Cambridge University Press 1999<br>4. Yaun Taur and Tak H.Ning, "Fundamentals of modern VLSI devices", Cambridge University Press 1999<br>5. Recent publications from IEEE, IEICE and ACM Journals |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-068 |
| 4 | **Title of the subject** | Network on Chip |
| 5 | **Any prerequisite** | NIL |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | 1. To learn the basic concepts of NoC design by studying the topologies, router design and MPSoC styles,<br>2. To learn sample routing algorithms on a NoC with deadlock and livelock avoidance,<br>3. To understand the role of system-level design and performance metrics in choosing a NoC design |
| 8 | **Brief Contents** | Introduction to NoC, OSI layer rules in NoC, Interconnection Networks in Network-on-Chip Network Topologies, Switching Techniques, Routing Strategies, Architecture Design, Switching Techniques and Packet Format, Asynchronous FIFO Design, Wormhole Router Architecture Design - VC Router Architecture Design - Adaptive Router Architecture Design, Routing Algorithms, Test and Fault Tolerance of NOC, 3-D integration of NOC. |
| **9** | **Text/ Reference Books** | 1. N. Enright Jerger and L-S. Peh, On-Chip Networks, Synthesis Lectures on Computer Architecture, Morgan & Claypool, 2009,<br>2. A Jantsch and H. Tenhunen, Networks on Chip, Kluwer Academic Publishers, 2003.<br>3. W. J. Dally, Principles and Practices of Interconnection Networks, Morgan Kaufmann, 2004. |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-069 |
| 4 | **Title of the subject** | Digital Image Computation |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Understand the fundamentals of digital image representation, storage, and color models in image processing.<br>• Learn techniques for image transformation, enhancement, filtering, and noise reduction.<br>• Gain skills in image segmentation, feature extraction, and morphological processing for object analysis.<br>• Apply image compression and machine learning techniques for recognition, classification, and practical applications. |
| 8 | **Brief Contents** | This course covers essential techniques and methods in digital image processing, beginning with an introduction to digital images, their representation, and storage, including color models and resolution. It explores image transformations such as Fourier Transform and Discrete Fourier Transform (DFT) for image analysis and filtering, followed by image enhancement techniques like histogram equalization and noise reduction. Students will learn about linear and nonlinear image filtering, segmentation, and feature extraction methods such as SIFT and SURF for object detection and recognition. The course also covers morphological image processing, including dilation, erosion, and shape analysis, as well as image compression methods like JPEG and PNG. Finally, the course applies machine learning techniques for image recognition and classification, with real-world applications in medical imaging, remote sensing, computer vision, and digital photography. |
| 9 | **Lab Content** | Not Applicable |
| 10 | **Text/ Reference Books** | 1. "Digital Image Processing" by Rafael C. Gonzalez and Richard E. Woods<br>2. "Computer Vision: Algorithms and Applications" by Richard Szeliski<br>3. ""Pattern Recognition and Machine Learning" by Christopher M. Bishop<br>4. "Digital Image Processing Using MATLAB" by Rafael C. Gonzalez, Richard E. Woods, and Steven L. Eddins<br>5. "Practical Python and OpenCV + Case Studies" by Adrian Rosebrock |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-070 |
| 4 | **Title of the subject** | Audio Signal Processing |
| 5 | **Any prerequisite** | Signals and Systems |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Focuses on algorithms for acoustic and audio signal processing, including applications in audio algorithm design and signal analysis.<br>• Emphasizes critical areas such as monophonic and stereophonic echo cancellation, active noise control, and feedback reduction in communication systems.<br>• Addresses real-world challenges in both wired and wireless communication, with an emphasis on audio signal processing technologies used globally in various industries. |
| 8 | **Brief Contents** | Audio signal recording, analysis and representation techniques, audio measurement, sound intensity, noise signal analysis and characterization, stationary and nonstationary signals, probabilistic signal processing techniques with applications for acoustic & audio signal analysis, digital filters for audio enhancement. Characteristics of widely interfaced acoustic signals, multiple sub-filters different error, common error and combined error algorithms, monophonic and stereophonic acoustic echo-cancellation, active noise suppression, feedback cancellation. |
| 9 | **Text/ Reference Books** | 1. D. Manolakis, M. Ingle, S. Kogon, Statistical and Adaptive Signal Processing, McGraw-Hill, Revised Edition 2014.<br>2. Jacob Benesty, Israel Cohen, Jingdong Chen, Fundamentals of Signal Enhancement and Array Signal Processing, Wiley & Sons, 2018.<br>3. Udo Zolzer, Digital Audio Signal Processing, Wiley & Sons, 2008.<br>4. Steven L. Gay, Jacob Benesty, Acoustic Signal Processing for Telecommunication, Springer, 2001. |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-071 |
| 4 | **Title of the subject** | Advance Digital Signal Processing |
| 5 | **Any prerequisite** | Signals and Systems, Digital Signal Processing |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Understand the advanced principles of digital signal processing (DSP) and its applications in real-time systems.<br>• Develop proficiency in advanced DSP techniques such as adaptive filtering, multirate signal processing, and spectral analysis.<br>• Gain expertise in the design and implementation of efficient DSP algorithms for applications like speech, audio, and image processing. |
| 8 | **Brief Contents** | Overview of advanced topics in DSP including sampling, quantization, and the z-transform. Emphasis on discrete-time signals and systems, and their mathematical representations. Study of adaptive filter algorithms such as LMS (Least Mean Squares), RLS (Recursive Least Squares), and their applications in noise cancellation, echo cancellation, and channel equalization. Techniques for downsampling and upsampling, interpolation, decimation, and polyphase filters. Applications in data compression and speech signal processing. Advanced methods for spectral estimation, including the periodogram, Bartlett's method, and the Welch method. Wavelet bases. Balian-Low theorem. Multiresolution analysis. (MRA). Focus on real-time and non-stationary signal analysis. Implementation of DSP techniques in communication systems, including OFDM (Orthogonal Frequency Division Multiplexing), channel coding, and modulation schemes. |
| 9 | **Text/ Reference Books** | 1. "Understanding Digital Signal Processing" by Richard G. Lyons,: Pearson Education.<br>2. "Digital Signal Processing: Principles, Algorithms, and Applications" by John G. Proakis and Dimitris G. Manolakis<br>3. "Advanced Digital Signal Processing: Theory and Applications" by Saeed V. Vaseghi Publisher: Wiley-Interscience<br>4. "Discrete-Time Signal Processing" by Alan V. Oppenheim and Ronald W. Schafer, Publisher: Pearson Education |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-072 |
| 4 | **Title of the subject** | Biomedical Signal Processing |
| 5 | **Any prerequisite** | Understanding of Digital and Analog Signals |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Understand the principles of acquiring and preprocessing physiological signals.<br>• Learn techniques for noise reduction, filtering, and signal enhancement.<br>• Apply time-domain and frequency-domain analysis methods to biomedical signals.<br>• Develop and implement algorithms for feature extraction and pattern recognition in diagnostics. |
| 8 | **Brief Contents** | The "Biomedical Signal Processing" course covers the fundamentals and advanced techniques for analysing physiological signals. Topics include signal acquisition and preprocessing, noise reduction, and filtering. Students will explore time-domain and frequency-domain analysis, feature extraction, and pattern recognition methods. The course also delves into advanced topics such as wavelet transforms, machine learning for biomedical signal analysis, and applications in diagnostics and monitoring. Practical sessions involve MATLAB/Python programming for real-world signal processing tasks. By the end of the course, students will be equipped with the skills to develop and implement algorithms for interpreting complex biomedical signals. |
| 9 | **Text/ Reference Books** | 1. "Biomedical Signal Processing and Signal Modelling" by Eugene N. Bruce<br>2. "Biomedical Signal Processing: Principles and Techniques" by D. C. Reddy<br>3. "Advanced Methods of Biomedical Signal Processing" edited by Sergio Cerutti and Carlo Marchesi<br>4. "Biomedical Signal Analysis: A Case-Study Approach" by Rangaraj M. Rangayyan |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-074 |
| 4 | **Title of the subject** | Computer Vision |
| 5 | **Any prerequisite** | Understanding of Signals |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning Objectives of the subject** | • Understand the principles of image formation and feature detection in computer vision.<br>• Learn techniques for object recognition, classification, and scene reconstruction.<br>• Apply motion analysis and 3D vision methods to interpret visual information.<br>• Develop and implement deep learning algorithms for computer vision using Python and OpenCV. |
| 8 | **Brief Contents** | The "Computer Vision" course explores the fundamentals and advanced techniques for enabling machines to interpret and understand visual information from the world. Topics include image formation, feature detection, and matching, as well as object recognition and classification. Students will study motion analysis, 3D vision, and scene reconstruction. Advanced topics such as deep learning for computer vision, including convolutional neural networks (CNNs), are also covered. Practical sessions involve implementing algorithms and applications using Python and OpenCV. By the end of the course, students will be proficient in developing computer vision systems for real-world applications. |
| 9 | **Text/ Reference Books** | 1. "Computer Vision: Algorithms and Applications" by Richard Szeliski<br>2. "Multiple View Geometry in Computer Vision" by Richard Hartley and Andrew Zisserman<br>3. "Deep Learning for Computer Vision" by Rajalingappaa Shanmugamani<br>4. "Learning OpenCV 4: Computer Vision with Python" by Adrian Kaehler and Gary Bradski |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of Subject** | EE-076 |
| 4 | **Title of the Subject** | Internet of Bio-Nano Things |
| 5 | **Prerequisite** | Linear Algebra, Signals and Systems, Digital Communication, Probability and Statistics, Computational Theory |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives** | This course will cover communication techniques and technologies to conceive networks on the nanoscale. Instead of the standard use of electromagnetic waves, we will perform the emission and detection of molecules according to the paradigm of Molecular Communications. We will follow a network architecture approach from a computer network perspective, see the picture on the right. In the physical layer, we will introduce models for the communication channels through molecular means, as well as for emitters and receivers. In the link layer, we will address mechanisms for the information flow and error control mechanisms. In this course, we will not only study theoretical concepts but will conduct many hands-on activities in the MATLAB simulator to model the physical and link layers. |

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| 8 | **Brief Contents** | Introduction to Molecular communication: Why, what, and how? Applications areas: Biological engineering, Medical and healthcare applications, Industrial applications, Environmental applications, Information and communication technology applications, Nature-made biological nanomachines, Basic physical concepts, Chemical reactions and the master equation, Chemical reactions and the master equation (part 2), Basics of biochemistry, Brownian motion, First arrival time distribution, Concentration and counting, Modulation techniques, Transportation Mechanisms, Timing channels, Concentration channels, Noise and intersymbol interference, Molecular MIMO, Signal transduction, Information theory of molecular communication, Experimental approaches, Jamming bacterial communications: new strategies to combat bacterial infections and the development of biofilms, Quorum sensing and cell-to-cell communication in the dental biofilm. |
| 9 | **Text and Reference Books** | 1. R. G. Gallager, "Stochastic Processes: Theory for Applications," 1st edition, Cambridge University Press, 2013.<br>2. T. Nakano, A. Eckford, "Molecular Communication", 1st edition, Cambridge University Press, 2013.<br>3. P. Peebles, "Probability, Random Variables, and Random Signals", 4th edition, New York, NY: McGraw-Hill, 2017.<br>4. D. R. Demuth, R. J. Lamont, "Bacterial Cell-to-Cell Communication", 1st Edition, Cambridge University Press, 2006.<br>5. S.M. Ross, "Stochastic Processes", 2nd Edition, Wiley, 1996.<br>6. S. Karlin, and H. M. Taylor, "A First Course in Stochastic Processes", 2nd edition, Academic Press, 1975.<br>7. Research Papers |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-079 |
| 4 | **Title of the subject** | Cyber Security |
| 5 | **Any prerequisite** | NA |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Develop a understanding of cybersecurity principles and techniques<br>• Explore foundational concepts, and emerging technologies<br>• Gain skills in cryptography, threat detection, network security<br>• Understand policies, compliance, and cyber risk management |
| 8 | **Brief Contents** | Introduction to Cybersecurity: Importance, Threat Landscape, Security Goals, Symmetric and Asymmetric Cryptography, Hash Functions, Digital Signatures, Network Security Essentials: Firewalls, Intrusion Detection Systems. Viruses, Worms, Ransomware, SQL Injection, Cloud and IoT Security Challenges, IoT Threats, and Countermeasures, Artificial Intelligence in Security, AI-based Threat Detection, Machine Learning Models for Security, Zero Trust Architecture: Concepts, Zero Trust Network Access, Implementation Strategies, Security Policies and Compliance, Cyber Risk Management and Governance: Risk Assessment, Business Continuity, |

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| | | Disaster Recovery, Future of Cyber Security |
| 9 | **Lab Content** | NA |
| 10 | **Text/ Reference Books** | 1. Introduction to Modern Cryptography by Jonathan Katz, Yehuda Lindell, 2025, Chapman & Hall/CRC<br>2. Cryptography and Network Security: Principles and Practice by William Stallings, 2021, Pearson<br>3. Zero Trust Networks: Building Secure Systems in Untrusted Networks by Evan Gilman, Doug Barth, 2017, O'Reilly Media<br>4. Computer Security: Principles and Practice by William Stallings, Lawrie Brown, 2017, Pearson<br>5. The Web Application Hacker's Handbook: Finding and Exploiting Security Flaws by Dafydd Stuttard, Marcus Pinto, 2011, Wiley |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-081 |
| 4 | **Title of the subject** | Optimization Techniques |
| 5 | **Any prerequisite** | NA |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | This course introduces optimization techniques, covering both linear and non-linear programming. While the primary focus is on convex optimization, the course also explores techniques for optimizing non-convex functions. Following a foundational overview of linear algebra and probability theory, students will learn to formulate engineering problems involving minima and maxima within the framework of optimization. |
| 8 | **Brief Contents** | The content covers various optimization and computational techniques, including network flow models and algorithms such as shortest path methods (Dijkstra, label-correcting, and auction algorithms), max-flow and min-cost flow problems (Ford-Fulkerson, simplex methods), and transformations in optimization. It delves into solving linear and nonlinear programming problems using iterative methods, line search techniques, Hessian-based approaches (Newton, conjugate directions, quasi-Newton), and constrained optimization (Lagrange variables, KKT conditions, quadratic programming, convex problems, mixed integer models, and interior point methods). Additionally, it introduces OR models, linear programming techniques (simplex, artificial variables, two-phase, big-M), transportation and assignment problems, sequencing, replacement, game theory, inventory management, and dynamic programming with engineering applications. The final module explores quantum information theory, |

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| | | including density operators, entanglement, teleportation, Shannon entropy, quantum channels, cryptography, and quantum key distribution. |
| 9 | **Text/ Reference Books** | 1. Boyd, Stephen, Stephen P. Boyd, and Lieven Vandenberghe. Convex optimization. Cambridge university press, 2004.<br>2. D. Bertsekas Nonlinear programming, 2nd Edition, Athena Scientific, 1999, Nashua.<br>3. V. Chvatal Linear programming, W. H. Freeman, 1983, New York.<br>4. E. K. P. Chong and S. Zak, An introduction to optimization, 2nd Edition, 2004, John Wiley and Sons (Asia) Pvt. Ltd., Singapore<br>5. R. Fletcher, Practical methods of optimization, 2nd Edition, Wiley, 2000, New York<br>6. D. Luenberger, Linear and nonlinear programming, 2nd Edition, 1984, Kluwer Academic Publisher, New York<br>7. O. L. Mangasarian, Nonlinear programming, SIAM, 1987, Philadelphia |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-083 |
| 4 | **Title of the subject** | Internet of Things |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • To introduce the concept of Internet of Things (IoT), reference layer and various protocols and software.<br>• To make the students capable of building IoT systems using sensors, single board computers and open source IoT platforms. |
| 8 | **Brief Contents** | Evolution of IoT, IoT architecture reference layer, IoT protocols, software and gateway protocols, IoT point to point communication technologies IoT Communication Pattern, Introduction to Cloud computation and Big data analytics, IoT security, Sensors: Working Principles: Different types Interface Electronic Circuit for Smart Sensors and Challenges for Interfacing the Smart Sensor, Usefulness of Silicon Technology in Smart Sensor And Future scope of research in smart sensor |
| 9 | **Lab Content** | None |
| 10 | **Text/ Reference Books** | **Text Books:**<br>1. IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things, David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, Cisco Press, 2017<br>2. Internet of Things – A hands-on approach, Arshdeep Bahga, Vijay Madisetti, Universities Press, 2015<br>3. Internet of Things: Architecture, Design Principles and Applications, Rajkamal, McGraw Hill Higher Education |

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| | | **Reference Books:**<br>1. The Internet of Things – Key applications and Protocols, Olivier Hersent, David Boswarthick, Omar Elloumi and Wiley, 2012<br>2. “From Machine-to-Machine to the Internet of Things – Introduction to a New Age of Intelligence”, Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis, Karnouskos, Stefan Avesand. David Boyle and Elsevier, 2014.<br>4. Architecting the Internet of Things, Dieter Uckelmann, Mark Harrison, Michahelles and Florian (Eds), Springer,2011.<br>5. Jacob Fraden, “Handbook of Modern Sensors: physics, Designs and Applications”, 2015, 3rd edition, Springer, New York.<br>6. Jon. S. Wilson, “Sensor Technology Handbook”, 2011, 1st edition, Elsevier, Netherland. |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-085 |
| 4 | **Title of the subject** | Software Defined Radio |
| 5 | **Any prerequisite** | Understanding of basic concepts of communication systems and signals |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Understand different models for Software Defined Radio in detail, like Software Defined Radio Architecture for performance optimization. Program and test software-defined radio transceivers; Implement different physical layer communication protocol/algorithm using Software Defined Radio. |
| 8 | **Brief Contents** | Introduction: The requirement for software defined radio, Software defined radio architectures; Ideal Software defined radio architectures, required hardware specifications, Digital aspects of a Software Defined radio, Current technology limitations<br><br>Introduction to USRP radios and GNU Radio software platform and Coding; implementation on SDR: Digital modulation and demodulation; AM transceiver, Time and frame synchronization, channel estimation and equalization; Machine learning with SDR |
| 9 | **Lab Content** | NA. |
| 10 | **Text/ Reference Books** | 1. Travis F. Collins, Robin Getz, Di Pu, and Alexander M. Wyglinski, “Software-Defined Radio for Engineers,” Artech House, 2018<br>2. F. Xiong,. Digital Modulation Techniques, Artech House, 2006. ProQuest eBook Central. ISBN: 9781580538640<br>3. J. G. Proakis and M. Salehi, Digital Communications, McGraw-Hill, 5th ed., 2008. (ISBN 978-0-07-295716-7)<br>4. J. Vanakka, “Digital Synthesizers and Transmitter for Software Radio”, Springer, 2005 |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-086 |
| 4 | **Title of the subject** | Quantum Communication |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Introduce key concepts and theories of Quantum Communication.<br>• Explain the working principles of quantum communication systems.<br>• Explore fundamental limits of quantum communication over classical and quantum channels.<br>• Discuss practical implementation and challenges in quantum communication systems. |
| 8 | **Brief Contents** | Vector Spaces, Inner-Product Spaces, Linear Independence and Basis, Finite-Dimensional Hilbert Spaces, Linear Operators and Projectors, Eigenvalue Decomposition, Tensor Products, Analysis and Probability, Limits, Infimum, Supremum, and Continuity, Compact Sets and Convexity, Qubits and Axioms of Quantum Systems, Positive Operator-Valued Measure (POVM), Helstrom Decision Theory and Quantum Communication Systems, Quantum Modulation Schemes, Density Operators and Quantum Entanglement, Quantum Teleportation and Cryptography, Shannon Entropy and Classical Information Theory, Quantum Channels and Noisy Transmission, Quantum Key Distribution |
| 9 | **Lab Content** | NA |
| 10 | **Text/ Reference Books** | 1. "Quantum Communications", Gianfranco Cariolaro, Springer, 2015.<br>2. "Quantum Communication, Quantum Networks, and Quantum Sensing", Ivan B. Djordjevic, Academic Press, 2022.<br>3. Principles of Quantum Communication Theory: A Modern Approach", Sumeet Khatri, and Mark M. Wilde, 2021<br>4. Quantum Computation and Quantum Information", Michael Nielsen and Isaac Chuang, Cambridge University Press, 2010. |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-087 |
| 4 | **Title of the subject** | 5G and 6G Standards |
| 5 | **Any prerequisite** | Advanced Communication Systems |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning Objectives of the subject** | • Trace the evolution from 1G to 6G, highlighting key concepts, performance metrics, and advancements.<br>• Study 5G standards, architecture, technologies, use cases, and the role of 3GPP and ITU.<br>• Discover 6G vision, emerging standards, features, enabling technologies, and use cases.<br>• Analyze regulatory, security, spectrum management, and deployment challenges for 5G and 6G. |
| 8 | **Brief Contents** | Evolution of Mobile Networks, 1G to 6G Advancements, Performance Metrics and Spectrum Utilization, Energy Efficiency and Sustainability in Wireless Networks, 5G Architecture and Core Technologies, Network Slicing and Virtualization, mmWave Communications and Massive MIMO, 5G NR Interface and Channel Modulation, 5G Use Cases and Applications, Standardization Bodies: 3GPP, ITU, GSMA, 6G Vision and Roadmap, Key Enabling Technologies for 6G, Security and Privacy in 5G/6G Networks, Spectrum Allocation and Regulatory Challenges, Future Trends and Research in 5G/6G Deployment. |
| 9 | **Lab Content** | NA |
| 10 | **Text/ Reference Books** | 1. Wireless Communications: Principles and Practice by Theodore S. Rappaport, 2nd Edition, Pearson Education.<br>2. Xingqin Lin and Namyoon Lee, 5G and Beyond: Fundamentals and Standards, Springer, Edition Number1<br>3. Abdulrahman Yarali, From 5G to 6G: Technologies, Architecture, AI, and Security, Wiley-IEEE Press |

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| 1 | **Semester** | I |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-088 |
| 4 | **Title of the subject** | Smart Antenna System |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Understand the fundamental parameters of antenna and use of cellular concepts and basic architecture, features and benefits of smart antennas.<br>• Able to integrate smart antenna technology with overall communication system design, principle and its performance.<br>• Understand the beamforming techniques and adaptive array techniques.<br>• Understand the implementation of smart antennas for Direct sequence CDMA systems and examine some of the challenges involved in applying smart antennas to CDMA.<br>. |
| 8 | **Brief Contents** | Fundamental Parameters of Antenna and cellular concepts, Mobile antennas and mobile Radio Propagation and Modelling. Antennas for Mobile Communication. Different Types of Antennas, Introduction to |

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| | | Smart Antenna systems, need of smart antenna, Fixed Beam forming networks, Switched Beam Systems, Adaptive Antenna Systems, Smart Antennas Techniques for CDMA, Analysis Using Smart Antennas – A Vector Based Approach |
| 9 | **Lab Content** | None |
| 10 | **Text/ Reference Books** | **1.** Antennas for all applications, 3rd edition, by J.D. Krauss, TMH.<br>**2.** Antenna & Wave Propagation, K.D. Prasad, Satyaprakash publications.<br>4. Wireless Communications: Principles and practice, 2nd edition, Theodore S. Rappaport, PHI.<br>5. Joseph C. Liberti and Theodore S. Rappaport, Smart Antennas for Wireless Communications IS 95 and Third Generation CDMA Applications, Prentice Hall PTR<br>6. Balanis C A, Antenna Theory: design and applications, Wiley<br>7. Frank Gross, Smart Antennas for Wireless Communications-McGraw Hill<br>8. Ahmed El-Zooghby, Smart Antenna Engineering, Artech House Publishers<br>9. Constantine Balanis, Introduction to Smart Antennas, Morgan and Claypool Publisher.<br>10. F.B. Gross - Smart Antennas for Wireless Communications, McGraw-Hill., 2005. |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-089 |
| 4 | **Title of the subject** | Advanced Optical Communication |
| 5 | **Any prerequisite** | Advanced Communication Systems |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Learn the fundamentals of optical communication, including fiber properties, light propagation, dispersion, and nonlinearity.<br>• Explore optical sources, detectors, modulation techniques, and design aspects for transmitters and receivers with a focus on SNR and BER.<br>• Understand WDM principles, components, optical amplifiers, and noise management in system performance.<br>• Analyze high-speed modulation techniques, optical networks, emerging technologies, and scalability challenges. |
| 8 | **Brief Contents** | Overview of Optical Communication Systems, Optical Fiber Types and Light Propagation, Dispersion and Nonlinear Effects in Fibers, Optical Fiber Waveguides and Specialty Fibers, Optical Sources: LEDs and Laser Diodes, Photodetectors and Receiver Sensitivity, Optical Receivers and Coherent Detection, Point-to-Point Optical Links and Power Budget, Wavelength Division Multiplexing (WDM) Principles |

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| | | and System Design Considerations, Optical Amplifiers: EDFAs and Raman Amplifiers, Optical Network Architectures and Topologies, Optical Cross-Connects and ROADMs, Elastic Optical Networks and Space-Division Multiplexing, Quantum Optical Communication and Future Trends. |
| 9 | **Lab Content** | NA |
| 10 | **Text/ Reference Books** | 1. Fiber Optic Communications by Gerd Keiser, 5th Edition, McGraw Hill Education.<br>2. Optical Fiber Communications: Principles and Practice by John Senior, 3rd Edition, Pearson Education.<br>3. Optical Networks: Design and Implementation by Rajiv Ramaswami and Kumar Sivarajan, Third Edition. |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-092 |
| 4 | **Title of the subject** | Data Communication Protocol |
| 5 | **Any prerequisite** | Knowledge of fundamentals of data structures and associated algorithms |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Define and understand the meaning and role of protocol, the concept of layering, appreciate the role of TCP/IP layer model<br>• Demonstrate the basic concepts of error detection, checking and correction at data link layer and application to flow control protocols.<br>• Apply formulae to practical communication systems and analyse their performances in transmitting data signals. |
| 8 | **Brief Contents** | The course will focus on the design and implementation techniques essential for engineering robust networks. Topics include networking principles, Transmission Control, Protocol/Internet Protocol, naming and addressing (Domain Name System), data encoding/decoding techniques, link layer protocols, routing protocols, transport layer services, congestion control, quality of service, network services, Software Defined Networks (SDNs), programmable routers and overlay networks, wireless and mobile networking, security in computer networks, multimedia networking, and network management. |
| 9 | **Lab Content** | NA. |
| 10 | **Text/ Reference Books** | 1. Data and Computer Communications by William Stallings<br>2. Data communication & Networking by Bahrouz Forouzan.<br>3. Computer Networks by Andrew S. Tanenbaum |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-613 |
| 4 | **Title of the subject** | Next-Generation Communication Systems |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Understand the communication requirements and challenges in autonomous systems.<br>• Explore various wireless communication technologies and network protocols.<br>• Learn sensor network integration and data fusion techniques for autonomous system functionality. |
| 8 | **Brief Contents** | This course focuses on communication technologies for autonomous system. It covers communication requirements and challenges in autonomous environments. Topics include signal representation, transmission, and reception. The course also explores multipath fading, path-loss, and noise in communication systems, and how they affect signal quality. Additionally, it covers various next generation wireless communication technologies, network protocols (TCP/IP, UDP, real-time protocols), and machine-to-machine (M2M) communication. The course also explores sensor networks, data fusion techniques etc. |
| 9 | **Lab Content** | NA |
| 10 | **Text/ Reference Books** | 1. "Communication Systems" by Simon Haykin<br>2. "Wireless Communications: Principles and Practice" by Theodore S. Rappaport<br>3. "Autonomous Vehicles: Opportunities, Strategies, and Disruptions" by Daniel P. K. Riewoldt<br>4. "Introduction to Autonomous Robots: Mechanisms, Sensors, Actuators, and Algorithms" by Nikolaus Correll et al.<br>5. "Principles of Modern Wireless Communication Systems, Theory and Practice," A. Jagannatham, McGraw Hill Education (India) Private Limited, 2016. |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-065 |
| 4 | **Title of the subject** | High Performance Computing Systems |
| 5 | **Any prerequisite** | VLSI Architecture |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • To get in-depth analysis of issues in High Performance Computing systems including Parallel Computing, New Processor Architectures, Power-Aware Computing and Communication, Advanced Topics on Peta scale Computing and Optical Systems.<br>• To understand parallel models of computation such as dataflow, and demand-driven computation. |
| 8 | **Brief Contents** | Parallel Processing Concepts; Levels and model of parallelism: Instruction, Transaction, Task, Thread, Memory, Function, Data Flow models, Demand-driven computation; Parallel architectures: Superscalar architectures, Multi-core, Multi- threaded, Server and cloud; Fundamental design issues in HPC: Load balancing, scheduling, Synchronization and resource management; Operating systems for scalable HPC; Parallel languages and programming environments; Fundamental limitations in HPC, Benchmarking HPC, Scalable storage systems, Accelerated HPC, Power-aware HPC Design. |
| **9** | **Text/ Reference Books** | 1. "High Performance Computing: Modern Systems and Practices" by Thomas Sterling, Matthew Anderson, Maciej Brodowicz, Morgan Kaufmann, 2017.<br>2. "Introduction to High Performance Computing for Scientists and Engineers" by Georg Hager and Gerhard Wellein, CRC Press, 2010.<br>3. "Parallel Computer Architecture: A Hardware/Software Approach" by David Culler and Jaswinder Pal Singh, Morgan Kaufmann 1998.<br>4. "Dataflow Supercomputing" by Patrick K. O'Neil, Springer International Publishing AG, 2017.<br>5. "Power-Aware Computing" by Andrea Biedenkapp, Rainer Hartenstein, et al.<br>6. "Introduction to High Performance Computing for Scientists and Engineers" by Georg Hager and Gerhard Wellein |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-067 |
| 4 | **Title of the subject** | Sensors for Autonomous System |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Understanding the fundamentals and functionality of micro sensors.<br>• Exploring sensor usage in autonomous systems.<br>• Examining sensor integration for real-time applications.<br>• Learning mathematical modeling and estimation techniques for real-world systems.<br>• Studying various approaches, including optimization techniques, to achieve desired system outcomes. |
| 8 | **Brief Contents** | Introduction and Historical Background, Microsensors, Sensor Principles/Classification-Physical Sensors, Methods for Data Acquisition, Modelling Dynamic Systems using Transfer Functions, Multiple-input-Multiple-output Systems, Feedback control methods, Rule based and Optimization Approaches, Hardware Development, System Dependability, Fault Detection, Diagnosis and Prognosis. |
| 9 | **Lab Content** | NA |
| 10 | **Text/ Reference Books** | 1. "Introduction to Sensors and Actuators" by John R. Gardner.<br>2. "Sensor Fusion Approaches for Positioning, Navigation, and Mapping: How Autonomous Vehicles and Robots Navigate in the Real World: With MATLAB Examples" by Mohamed M. Atia<br>3. "Robotics and Smart Autonomous Systems" by Rashmi Priyadarshini, Ram Mohan Mehra, Amit Sehgal, and Prabhu Jyot Singh |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-073 |
| 4 | **Title of the subject** | Data Analytics |
| 5 | **Any prerequisite** | Should have knowledge of one Programming Language (Java preferably), Practice of SQL (queries and sub queries), exposure to Linux Environment. |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning Objectives of the subject** | • Understand the Big Data Platform and its Use cases<br>• Provide an overview of Apache Hadoop<br>• Understand Map Reduce Jobs<br>• Provide hands on Hadoop Eco System<br>• Apply analytics on Structured, Unstructured Data<br>• Exposure to Data Analytics with R |
| 8 | **Brief Contents** | Types of Digital Data, Introduction to Big Data, Big Data Analytics, History of Hadoop, Apache Hadoop, Analyzing Data with Unix and Hadoop, Hadoop Streaming, Hadoop Echo System, IBM Big Data Strategy, HDFS Concepts, Command Line Interface, Hadoop file system interfaces, Data flow, Data Ingest with Flume and Scoop and Hadoop archives, Map Reduce Anatomy of a Map Reduce Job Run, Failures, Job Scheduling, Shuffle and Sort, Task Execution, Map Reduce Types and Formats, Map Reduce Features, Introduction to PIG, Execution Modes of Pig, User Defined Functions, Data Processing operators, Data Analytics with R Machine Learning, Big Data Analytics with BigR. |
| 9 | **Lab Content** | NA |
| 10 | **Text/ Reference Books** | 1. "Data Analytics Made Accessible" by Anil Maheshwari (2023 Edition)<br>2. "Advancing Into Analytics: From Excel to Python and R" by George Mount (2021)<br>3. "Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython" by Wes McKinney (2017)<br>4. "The Data Warehouse Toolkit: The Definitive Guide to Dimensional Modeling" by Ralph Kimball and Margy Ross (2013)<br>5. "Data Mining: Concepts and Techniques" by Jiawei Han, Micheline Kamber, and Jian Pei (2011) |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-075 |
| 4 | **Title of the subject** | Reinforcement Learning |
| 5 | **Any prerequisite** | Understanding of Signals |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Understand the fundamentals of reinforcement learning and Markov decision processes (MDPs).<br>• Learn key algorithms such as Q-learning, Monte Carlo methods, and temporal-difference learning.<br>• Explore advanced techniques in deep reinforcement learning using neural networks.<br>• Implement reinforcement learning algorithms and apply them to real-world problems using Python. |

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| 8 | **Brief Contents** | The "Reinforcement Learning" course delves into the core concepts and methodologies of reinforcement learning (RL), where agents learn to make decisions by interacting with their environment. Topics include Markov decision processes (MDPs), dynamic programming, Monte Carlo methods, and temporal-difference learning. Students will explore advanced RL techniques such as Q-learning, policy gradients, and deep reinforcement learning using neural networks. The course also covers applications in robotics, game playing, and autonomous systems. Practical sessions involve implementing RL algorithms using Python and frameworks like TensorFlow or PyTorch. By the end of the course, students will be capable of designing and deploying RL solutions for complex problems. |
| 9 | **Text/ Reference Books** | 1. "Reinforcement Learning: An Introduction" by Richard S. Sutton and Andrew G. Barto<br>2. "Deep Reinforcement Learning Hands-On" by Maxim Lapan<br>3. "Reinforcement Learning: State-of-the-Art" edited by Marco Wiering and Martijn van Otterlo<br>4. "Python Reinforcement Learning" by Sudharsan Ravichandran |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-078 |
| 4 | **Title of the subject** | Quantum Computing |
| 5 | **Any prerequisite** | NA |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | This course serves as an introduction to the quantum computational model, focusing on understanding and analysing fundamental quantum algorithms. It also explores the limitations of quantum algorithms and provides the essential tools and techniques to demonstrate these constraints. |
| 8 | **Brief Contents** | Introduction: Elementary quantum mechanics: linear algebra for quantum mechanics, Quantum states in Hilbert space, The Bloch sphere, Density operators, generalized measurements, no-cloning theorem. Quantum correlations: Bell inequalities and entanglement, Schmidt decomposition, superdense coding, teleportation. Quantum cryptography: quantum key distribution. Quantum gates and algorithms: Universal set of gates, quantum circuits, Solovay-Kitaev theorem, Deutsch-Jozsa algorithm, factoring. Programming a quantum computer: The IBMQ, coding a quantum computer using a simulator to carry out basic quantum measurement and state analysis. |

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| 9 | **Text/ Reference Books** | 1. Phillip Kaye, Raymond Laflamme et. al., An introduction to Quantum Computing, Oxford University press, 2007.<br>2. Chris Bernhardt, Quantum Computing for Everyone, The MIT Press, Cambridge, 2020<br>3. David McMahon-Quantum Computing Explained-Wiley-Interscience, IEEE Computer Society (2008).<br>4. Quantum Computation and Quantum Information, M. A. Nielsen &I. Chuang, Cambridge University Press (2013).<br>5. (5) Quantum Computing, A Gentle Introduction, Eleanor G. Rieffel and Wolfgang H. Polak MIT press (2014) |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-080 |
| 4 | **Title of the subject** | Deep Learning for Autonomous Systems |
| 5 | **Any prerequisite** | Machine Learning |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Provide an in-depth understanding of deep learning techniques and their applications in autonomous systems.<br>• Enable students to design and implement neural networks for perception, decision-making, and control in autonomous systems.<br>• Introduce state-of-the-art deep learning frameworks and tools for real-world deployment.<br>• Foster the ability to address challenges like dynamic environments, uncertainty, and real-time processing in autonomous systems. |
| 8 | **Brief Contents** | Introduction: Defining Autonomous Systems, Artificial Intelligence, Machine Learning, and Deep learning. Overview of the 3 pillars of Autonomous Vehicles: Perception, Prediction, Planning and Quick overview of sensing modalities. Deep learning for Perception, Introduction to deep learning, Neural Network, CNN, regularization techniques. State-of-the-art techniques: Self supervised learning, Vision Transformer, and Deep learning for Prediction. Introduction to Recurrent Neural Networks, Graph Neural Network, Transformer, Diffusion. Generative Models: Variational Autoencoders (VAEs) and Generative Adversarial Networks (GANs) for simulation and environment modeling. Case Studies and Applications: Real-world examples in autonomous vehicles, drones, and robotic systems, addressing challenges in dynamic and uncertain environments. |
| 9 | **Text/ Reference Books** | 1. Deep Learning From Scratch: Building with Python from First Principles by Seth Weidman.<br>2. Deep Learning for Computer Vision with Python |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-082 |
| 4 | **Title of the subject** | Advanced Control System |
| 5 | **Any prerequisite** | Understanding of Systems |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Understand state-space representation and concepts of controllability and observability.<br>• Learn advanced control methods such as optimal, robust, and adaptive control.<br>• Apply modern control design techniques like pole placement and LQR.<br>• Develop and simulate advanced control systems using MATLAB/Simulink for real-world applications. |
| 8 | **Brief Contents** | Control theory for designing and analysing complex control systems. State-space representation, controllability, observability, and state feedback control. Students will explore advanced methods like optimal control, robust control, and adaptive control systems. Modern control design techniques such as pole placement, linear quadratic regulator (LQR), and H-infinity control. Students will study the application of these techniques in systems with uncertainty and nonlinearity. Practical sessions involve MATLAB/Simulink to model and simulate advanced control systems, preparing students to tackle real-world control engineering challenges. |
| 9 | **Text/ Reference Books** | 1. "Modern Control Engineering" by Ogata Katsuhiko<br>2. "Feedback Control of Dynamic Systems" by Gene F. Franklin, J. Da Powell, and Abbas Emami-Naeini<br>3. "Advanced Control Engineering" by Roland S. Burns<br>4. "Robust Control: The Parameter Space Approach" by Kemin Zhou and John C. Doyle |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-093 |
| 4 | **Title of the subject** | Drone Technology and Robotics |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning Objectives of the subject** | • Design, construct, and program basic autonomous robots.<br>• Apply standard signal processing and control algorithms effectively.<br>• Develop and implement UAV drone systems.<br>• Gain an understanding of various engine types and their applications.<br>• Comprehend static and dynamic stability, dynamic instability, and associated control principles. |
| 8 | **Brief Contents** | Robotics: Robotics and AI, Embedded Systems, Agent-Task-Environment model. AI and the Internet of Things: Real World Use-Cases: Automated vacuum cleaners, Smart thermostat solutions. Introduction to Drones: Introduction to Unmanned Aircraft Systems, History of UAV drones, classification of drones, System Composition, applications. Design of UAV Drone Systems: Introduction to Design and Selection of the System, Design for Stealth. Avionics Hardware of Drones: Autopilot, AGL-pressure sensors servos-accelerometer, gyros-actuators, power supply-processor, integration, installation, configuration. |
| 9 | **Lab Content** | None |
| 10 | **Text/ Reference Books** | 1. Reg Austin "Unmanned Aircraft Systems UAV design, development and deployment", Wiley, 2010.<br>2. Robert C. Nelson, Flight Stability and Automatic Control, McGraw-Hill, Inc, 1998.<br>3. The Art of Robotics: An introduction to engineering, F Martin, Addison-Wesley. |

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|---|---|---|
| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-612 |
| 4 | **Title of the subject** | Sensors and Actuators |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning Objectives of the subject** | • Understand the principles and working mechanisms of various types of sensors and actuators.<br>• Explore calibration techniques and the characteristics of different sensors in real-world environments.<br>• Gain hands-on experience in controlling actuators such as motors and solenoids for the development of autonomous systems. |

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| 8 | **Brief Contents** | This course covers the principles, design, and applications of sensors and actuators in modern systems. Topics include the working principles of various types of sensors such as temperature, pressure, humidity, proximity, and motion sensors. Students will explore the characteristics and calibration. The course also focuses on actuators, including motors, solenoids, and piezoelectric devices, discussing their control use for the development for autonomous systems. Practical sessions will involve designing and implementing systems that use sensors and actuators for real-time monitoring and actuation applications. |
| 9 | **Lab Content** | The lab covers experiments on different types of sensors, including temperature sensors (thermocouples, RTDs, thermistors), light and proximity sensors (LDR, IR, ultrasonic), pressure and force sensors (strain gauges, load cells), motion and acceleration sensors (accelerometers, gyroscopes), gas and humidity sensors (MQ-series, DHT11/DHT22), and magnetic sensors (Hall-effect). Additionally, students work with actuators such as DC motors, stepper motors, servo motors, and pneumatic/hydraulic actuators. The lab also focuses on interfacing sensors with microcontrollers like Arduino or Raspberry Pi, enabling real-time data acquisition and control. Advanced topics include smart sensors, IoT applications, and wireless sensor networks. |
| 10 | **Text/ Reference Books** | 1. Introduction to Sensors and Actuators by John R. Gardner<br>2. Sensors and Actuators: Engineering System Instrumentation by D. Patranabis<br>3. Sensors and Transducers by D. Patranabis<br>4. The Art of Electronics by Paul Horowitz and Winfield Hill |

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|---|---|---|
| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-615 |
| 4 | **Title of the subject** | Autonomous Systems |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Understand the principles and applications of autonomous systems in robotics, drones, and self-driving vehicles.<br>• Learn the integration and role of sensors like LIDAR, radar, cameras, and IMUs in perception and data collection.<br>• Implement computer vision and deep learning techniques for object detection, tracking, and decision-making in autonomous systems.<br>• Apply path planning, SLAM-based localization, reinforcement learning, and control algorithms for autonomous navigation and decision-making. |

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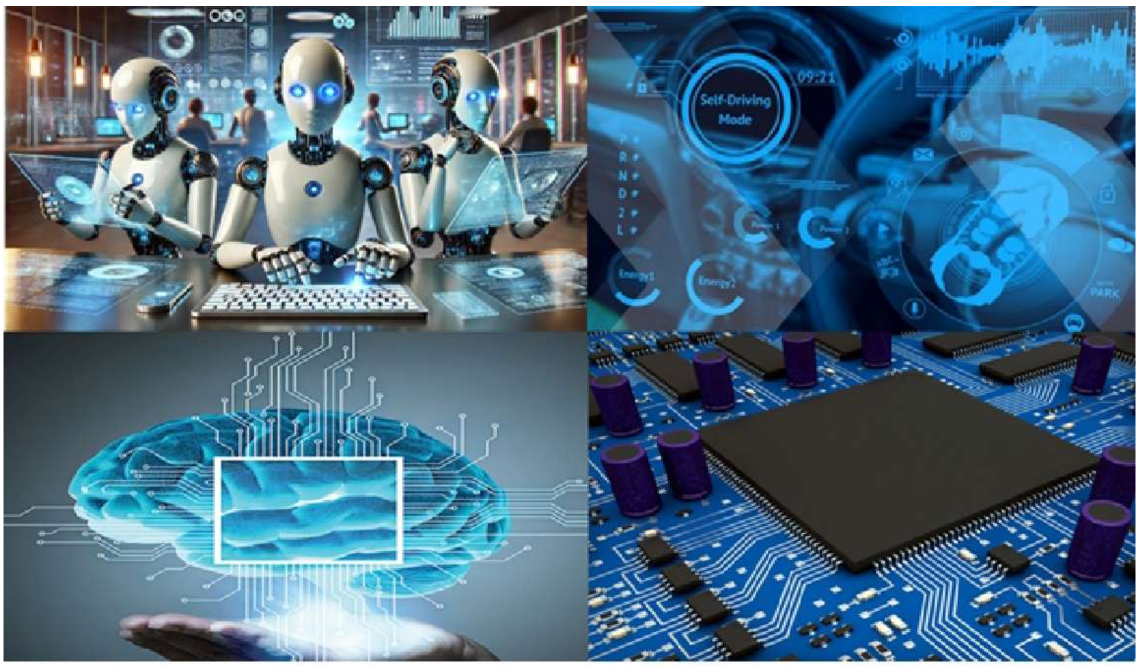
| 8 | **Brief Contents** | Introduction to autonomous systems and their applications in robotics, drones, and self-driving vehicles, followed by an exploration of key sensors like LIDAR, radar, cameras, and IMUs (Inertial Measurement Units) and their role in perception and data collection. The course covers computer vision techniques for image processing, feature extraction, object detection, and tracking, along with deep learning architectures such as CNNs and RNNs for decision-making and navigation. Students will also study sensor fusion methods, including Kalman filtering and deep sensor fusion, to combine data from multiple sensors for enhanced accuracy. The syllabus includes path planning, real-time navigation, localization using SLAM, and reinforcement learning for decision-making in dynamic environments. Control systems for vehicle dynamics and the ethical, safety, and security aspects of autonomous systems are also discussed. Finally, the course delves into real-world applications through case studies and hands-on projects. |
| 9 | **Lab Content** | NA |
| 10 | **Text/ Reference Books** | 1. "Autonomous Systems: A Comprehensive Approach" by Michael A. Hsieh<br>2. "Autonomous Robots: From Biological Inspiration to Implementation and Control" by George A. Bekey<br>3. "Computer Vision: Algorithms and Applications" by Richard Szeliski<br>4. "Autonomous Vehicles: Opportunities, Strategies, and Disruptions" by Chris Gerdes, Wade H. H.<br>5. "Deep Learning" by Ian Goodfellow, Yoshua Bengio, and Aaron Courville<br>6. "Robotics: Modelling, Planning and Control" by Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, and Giuseppe Oriolo |

# Curriculum & Contents

## M. Tech.

### Autonomous Systems and Machine Intelligence (ASMI)




**Electrical and Electronics Engineering Department (EEE)**

विश्वजीवनामृतं ज्ञानम्

# ABV-Indian Institute of Information Technology & Management, Gwalior

# SCHEMA

**Name of the program: M. Tech. (Autonomous Systems and Machine Intelligence)**

**(Credits: 72)**

**Name of the Department: Electrical and Electronics Engineering**

| SEMESTER-I | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject Code** | **Title of the course** | **L-T-P** | **Credits** |
| **1.** | EE-603 | Machine Learning Techniques | 3-0-2 | 4 |
| **2.** | EE-612 | Sensors and Actuators | 3-0-2 | 4 |
| **3.** | EE-613 | Next-Generation Communication Systems | 3-0-2 | 4 |
| **4.** | EE-614 | Human-Machine Interaction | 3-0-0 | 3 |
| **5.** | EE-XXX | Elective-1 | 3-0-0 | 3 |
| **6.** | EE-XXX | Elective-2 | 3-0-0 | 3 |
| | | | **Total credits** | **21** |

| SEMESTER-II | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject code** | **Title of the course** | **L-T-P** | **Credits** |
| **1.** | EE-615 | Autonomous Systems | 3-0-2 | 4 |
| **2.** | EE-616 | Artificial Intelligence | 3-0-2 | 4 |
| **3.** | EE-617 | Advanced Embedded Systems | 3-0-2 | 4 |
| **4.** | EE-609 | Engineering Research Methodology | 2-1-0 | 3 |
| **5.** | EE-XXX | Elective-3 | 3-0-0 | 3 |

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|---|---|---|---|---|
| **6.** | EE-XXX | Elective-4 | 3-0-0 | 3 |
| | | | **Total credits** | **21** |

EXIT AFTER YEAR-1: Post Graduate Diploma in Autonomous Systems and Machine Intelligence

| **SEMESTER-III** | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject code** | **Title of the course** | **L-T-P** | **Credits** |
| **1** | EE-XXX | MOOC-1/ Elective-5 | 3-0-0 | 3 |
| **2** | EE-698 | M. Tech Dissertation-I / Internship | NA | 12 |
| | | | **Total credits** | **15** |

| **SEMESTER-IV** | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject Code** | **Title of the course** | **L-T-P** | **Credits** |
| **1** | EE-699 | M. Tech Dissertation-II / Internship | NA | 15 |
| | | | **Total credits** | **15** |

| **SEMESTER-I** | **SEMESTER-II** | **SEMESTER-III** | **SEMESTER-IV** | **TOTAL CREDITS** |
|---|---|---|---|---|
| 21 | 21 | 15 | 15 | **72** |

## Electives Courses

| S.N. | Code | Electives I,II,III, IV, and V Category: Autonomous & Intelligent Transportation, Communication & Signal Processing, VLSI & Embedded Systems |
|---|---|---|
| 1 | EE-065 | High-Performance Computing Systems |
| 2 | EE-067 | Sensors for Autonomous System |
| 3 | EE-073 | Data Analytics |
| 4 | EE-075 | Reinforcement Learning |
| 5 | EE-078 | Quantum Computing |
| 6 | EE-080 | Deep Learning for Autonomous Systems |
| 7 | EE-082 | Advanced Control System |
| 8 | EE-069 | Digital Image Computation |
| 9 | EE-070 | Audio Signal Processing |
| 10 | EE-071 | Advanced Digital Signal Processing |
| 11 | EE-072 | Biomedical Signal Processing |
| 12 | EE-074 | Computer Vision |
| 13 | EE-076 | Internet of Bio-Nano Things |
| 14 | EE-079 | Cyber Security |
| 15 | EE-081 | Optimization Techniques |
| 16 | EE-083 | Internet of Things |
| 17 | EE-085 | Software Defined Radio |
| 18 | EE-086 | Quantum Communication |
| 19 | EE-087 | 5G and 6G standards |
| 20 | EE-088 | Smart Antennas |

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|---|---|---|
| 21 | EE-089 | Advanced Optical Communication |
| 22 | EE-092 | Data Communication Protocol |
| 23 | EE-051 | Device and Interconnect Modelling |
| 24 | EE-052 | VLSI Signal Processing |
| 25 | EE-053 | Low Power VLSI |
| 26 | EE-054 | Microcontroller and Embedded Systems |
| 27 | EE-055 | Memory Devices and Circuits |
| 28 | EE-056 | VLSI Architecture |
| 29 | EE-057 | Hardware Security |
| 30 | EE-058 | FPGA-Based System Design |
| 31 | EE-059 | Quantum Electronics |
| 32 | EE-060 | RF Circuit Design |
| 33 | EE-061 | Mixed Signal SoC Design |
| 34 | EE-062 | AI-Accelerator Design |
| 35 | EE-063 | System-on-Chip Design |
| 36 | EE-064 | Embedded Software |
| 37 | EE-066 | Special Topics in IC Design and Technology |
| 38 | EE-068 | Network on Chip |
| 39 | EE-602 | System Design using HDL |
| 40 | EE-608 | Design Verification and Testing |
| 41 | EE-610 | CAD for VLSI |

# Course Contents

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|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | EE-603 |
| 4 | **Title of the subject** | Machine Learning Techniques |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning Objectives of the subject** | • Understand key machine learning concepts and algorithms, including supervised and unsupervised learning.<br>• Gain practical experience in implementing machine learning models.<br>• Learn data preprocessing techniques and model evaluation methods for accurate performance assessment.<br>• Explore neural networks and deep learning basics, focusing on real-world applications. |
| 8 | **Brief Contents** | Supervised, unsupervised, and reinforcement learning, along with their real-world applications. It explores key algorithms like linear regression for model fitting and evaluation, and classification techniques such as Logistic Regression, K-Nearest Neighbors, and Support Vector Machines. The course also delves into decision trees and random forests, examining their use in both classification and regression tasks. Unsupervised learning methods like K-means clustering, Hierarchical Clustering, and DBSCAN are discussed. Basics of neural networks, including their architecture, backpropagation, and activation functions. Students will learn how to evaluate models using techniques like cross-validation, confusion matrices, precision, recall, and F1 scores. Dimensionality reduction techniques, including PCA etc. |
| 9 | **Lab Content** | Implementation of various machine learning algorithms, starting with supervised learning techniques like linear regression, logistic regression, K-Nearest Neighbors, and Support Vector Machines for both classification and regression tasks. They will explore unsupervised learning methods such as K-means clustering, Hierarchical Clustering, and DBSCAN to uncover patterns in data. The lab will also cover decision trees and random forests, and introduce students to the basics of neural networks, including their architecture, backpropagation, and activation functions. Additionally, students will practice model evaluation using techniques like cross-validation, confusion matrices, precision, recall, and F1 scores. The lab will conclude with experiments on dimensionality reduction using methods like PCA to simplify complex datasets. |
| 10 | **Text/ Reference Books** | 6. "Pattern Recognition and Machine Learning" by Christopher M. Bishop<br>7. "Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow" by Aurélien Géron<br>8. "Machine Learning: A Probabilistic Perspective" by Kevin P. Murphy |

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| | | 9. "Introduction to Machine Learning with Python" by Andreas C. Müller and Sarah Guido<br>10. "MATLAB for Machine Learning" by Giuseppe Ciaburro |

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|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | EE-612 |
| 4 | **Title of the subject** | Sensors and Actuators |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning Objectives of the subject** | • Understand the principles and working mechanisms of various types of sensors and actuators.<br>• Explore calibration techniques and the characteristics of different sensors in real-world environments.<br>• Gain hands-on experience in controlling actuators such as motors and solenoids for the development of autonomous systems. |
| 8 | **Brief Contents** | This course covers the principles, design, and applications of sensors and actuators in modern systems. Topics include the working principles of various types of sensors such as temperature, pressure, humidity, proximity, and motion sensors. Students will explore the characteristics and calibration. The course also focuses on actuators, including motors, solenoids, and piezoelectric devices, discussing their control use for the development for autonomous systems. Practical sessions will involve designing and implementing systems that use sensors and actuators for real-time monitoring and actuation applications. |
| 9 | **Lab Content** | The lab covers experiments on different types of sensors, including temperature sensors (thermocouples, RTDs, thermistors), light and proximity sensors (LDR, IR, ultrasonic), pressure and force sensors (strain gauges, load cells), motion and acceleration sensors (accelerometers, gyroscopes), gas and humidity sensors (MQ-series, DHT11/DHT22), and magnetic sensors (Hall-effect). Additionally, students work with actuators such as DC motors, stepper motors, servo motors, and pneumatic/hydraulic actuators. The lab also focuses on interfacing sensors with microcontrollers like Arduino or Raspberry Pi, enabling real-time data acquisition and control. Advanced topics include smart sensors, IoT applications, and wireless sensor networks. |
| 10 | **Text/ Reference Books** | 5. Introduction to Sensors and Actuators by John R. Gardner<br>6. Sensors and Actuators: Engineering System Instrumentation by D. Patranabis<br>7. Sensors and Transducers by D. Patranabis<br>8. The Art of Electronics by Paul Horowitz and Winfield Hill |

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|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | EE-613 |
| 4 | **Title of the subject** | Next-Generation Communication Systems |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning Objectives of the subject** | • Understand the communication requirements and challenges in autonomous systems.<br>• Explore various wireless communication technologies and network protocols.<br>• Learn sensor network integration and data fusion techniques for autonomous system functionality. |
| 8 | **Brief Contents** | This course focuses on communication technologies for autonomous system. It covers communication requirements and challenges in autonomous environments. Topics include signal representation, transmission, and reception. The course also explores multipath fading, path-loss, and noise in communication systems, and how they affect signal quality. Additionally, it covers various next generation wireless communication technologies, network protocols (TCP/IP, UDP, real-time protocols), and machine-to-machine (M2M) communication. The course also explores sensor networks, data fusion techniques etc. |
| 9 | **Lab Content** | Network simulation tools such as NS-3 or MATLAB Simulink help in modeling wireless communication environments, analyzing multipath fading, path loss, and network performance. Microcontrollers and embedded systems, including Raspberry Pi and Arduino, are employed for sensor network implementation and machine-to-machine (M2M) communication. Various network analysis tools like Wireshark are used to inspect and evaluate TCP/IP, UDP, and real-time communication protocols. Additionally, data fusion techniques are implemented using Python and MATLAB to process and integrate sensor data from multiple sources. Security and encryption mechanisms are explored using cryptographic libraries and network security tools. |
| 10 | **Text/ Reference Books** | 6. “Communication Systems" by Simon Haykin<br>7. “Wireless Communications: Principles and Practice" by Theodore S. Rappaport<br>8. “Autonomous Vehicles: Opportunities, Strategies, and Disruptions" by Daniel P. K. Riewoldt<br>9. “Introduction to Autonomous Robots: Mechanisms, Sensors, Actuators, and Algorithms" by Nikolaus Correll et al.<br>10. “Principles of Modern Wireless Communication Systems, Theory and Practice,” A. Jagannatham, McGraw Hill Education (India) Private Limited, 2016. |

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|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | EE-614 |
| 4 | **Title of the subject** | Human-Machine Interaction |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Understand the fundamental principles and technologies of human-machine interaction.<br>• Develop skills in designing and evaluating user interfaces with a focus on usability.<br>• Gain proficiency in audio-based interaction techniques, including speech recognition and synthesis.<br>• Learn to implement signal and image-based interaction methods, such as gesture recognition and computer vision. |
| 8 | **Brief Contents** | Explores technologies and principles for human-machine interaction (HMI), with a focus on audio, signal, and image-based communication. Fundamental UI design concepts and usability principles to enhance user experience. Speech recognition and synthesis techniques for audio-based communication with machines. Methods to interpret human inputs such as gestures and physiological signals. Computer vision techniques used for face and emotion recognition, gesture detection, and object detection. Relevant tools and frameworks for developing HMI systems based on audio, signal, and image data. |
| 9 | **Text/ Reference Books** | 1. "Human-Machine Interaction: Control, Communication, and Cognition" by Ian R. McAndrew and Alan M. Wing<br>2. "Introduction to Mechatronics and Measurement Systems" by David G. Alciatore and Michael B. Histand<br>3. "Designing the User Interface: Strategies for Effective Human-Computer Interaction" by Ben Shneiderman, Catherine Plaisant, Maxine Cohen, and Steven Jacobs<br>4. "Human-Computer Interaction" by Alan Dix, Janet Finlay, Gregory D. Abowd, and Russell Beale<br>5. "Speech and Language Processing" by Daniel Jurafsky and James H. Martin<br>6. "Computer Vision: Algorithms and Applications" by Richard Szeliski<br>7. "Designing the User Interface: Strategies for Effective Human-Computer Interaction" by Ben Shneiderman et al. |

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|---|---|---|
| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | EE-615 |
| 4 | **Title of the** | Autonomous Systems |

| | | |
|---|---|---|
| | **subject** | |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning Objectives of the subject** | • Understand the principles and applications of autonomous systems in robotics, drones, and self-driving vehicles.<br>• Learn the integration and role of sensors like LIDAR, radar, cameras, and IMUs in perception and data collection.<br>• Implement computer vision and deep learning techniques for object detection, tracking, and decision-making in autonomous systems.<br>• Apply path planning, SLAM-based localization, reinforcement learning, and control algorithms for autonomous navigation and decision-making. |
| 8 | **Brief Contents** | Introduction to autonomous systems and their applications in robotics, drones, and self-driving vehicles, followed by an exploration of key sensors like LIDAR, radar, cameras, and IMUs (Inertial Measurement Units) and their role in perception and data collection. The course covers computer vision techniques for image processing, feature extraction, object detection, and tracking, along with deep learning architectures such as CNNs and RNNs for decision-making and navigation. Students will also study sensor fusion methods, including Kalman filtering and deep sensor fusion, to combine data from multiple sensors for enhanced accuracy. The syllabus includes path planning, real-time navigation, localization using SLAM, and reinforcement learning for decision-making in dynamic environments. Control systems for vehicle dynamics and the ethical, safety, and security aspects of autonomous systems are also discussed. Finally, the course delves into real-world applications through case studies and hands-on projects. |
| 9 | **Lab Content** | In the lab sessions, students will implement and test various autonomous system algorithms using sensors like LIDAR, cameras, and IMUs for perception and navigation. They will work on computer vision tasks, including image processing, object detection, and tracking, using deep learning models such as CNNs. Sensor fusion techniques, including Kalman filtering, will be applied to combine data from multiple sensors for enhanced accuracy. Students will also develop and evaluate path planning and localization algorithms like SLAM for real-time navigation. The lab will include hands-on projects focused on autonomous decision-making and control in dynamic environments. |
| 10 | **Text/ Reference Books** | 7. "Autonomous Systems: A Comprehensive Approach" by Michael A. Hsieh<br>8. "Autonomous Robots: From Biological Inspiration to Implementation and Control" by George A. Bekey<br>9. "Computer Vision: Algorithms and Applications" by Richard Szeliski<br>10. "Autonomous Vehicles: Opportunities, Strategies, and Disruptions" by Chris Gerdes, Wade H. H.<br>11. "Deep Learning" by Ian Goodfellow, Yoshua Bengio, and Aaron Courville<br>12. "Robotics: Modelling, Planning and Control" by Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, and Giuseppe Oriolo |

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| 1 | **Semester** | II |
| 2 | **Type of course** | Core |

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| 3 | **Code of the subject** | EE-616 |
| 4 | **Title of the subject** | Artificial Intelligence |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning Objectives of the subject** | • Understand the fundamental concepts and techniques in artificial intelligence, including search algorithms and knowledge representation.<br>• Learn probabilistic reasoning and Bayesian networks for handling uncertainty in AI systems.<br>• Gain expertise in reinforcement learning and its applications in decision-making and autonomous systems.<br>• Explore deep learning models and their use in solving complex problems like image recognition. |
| 8 | **Brief Content s** | Artificial Intelligence explores core concepts of AI, adversarial each, Bayesian rule, probabilistic learning, reinforcement learning, and deep learning techniques. The course begins with an introduction to the history and applications of AI, followed by a deep dive into search algorithms, including adversarial search used in game-playing AI. Students will learn about the Bayesian rule for probabilistic reasoning and its applications in AI. The course covers probabilistic learning methods, emphasizing the understanding and implementation of models that handle uncertainty. Reinforcement learning is explored in detail, focusing on algorithms that enable agents to learn optimal behaviors through interaction with their environment. Deep learning techniques are introduced, highlighting neural networks, convolutional neural networks (CNNs), and recurrent neural networks (RNNs) for tasks such as image recognition. Practical sessions involve hands-on experience with AI tools like Python, TensorFlow, and PyTorch. By the end of the course, students will be proficient in applying AI methods to solve complex problems. |
| 9 | **Lab Content** | Python basics (NumPy, Pandas, Matplotlib, Sklearn), search algorithms (BFS, DFS, A*), constraint satisfaction problems (Sudoku, N-Queens),<br><br>supervised learning (linear & logistic regression, decision trees, random forest), unsupervised learning (K-means clustering, PCA), neural networks (MLP, CNN using TensorFlow/Keras), NLP (sentiment analysis, named entity recognition), reinforcement learning (Q-learning, OpenAI Gym), computer vision (face detection, object recognition with YOLO), AI ethics (bias analysis, explainability techniques). |
| 9 | **Text/ Reference Books** | 1. "Artificial Intelligence: A Modern Approach" by Stuart Russell and Peter Norvig<br>2. "Deep Learning" by Ian Goodfellow, Yoshua Bengio, and Aaron Courville<br>3. "Reinforcement Learning: An Introduction" by Richard S. Sutton and Andrew G. Barto<br>4. "Pattern Recognition and Machine Learning" by Christopher M. Bishop |

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| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | EE-617 |
| 4 | **Title of the subject** | Advanced Embedded Systems |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning Objectives of the subject** | • Understand the architecture and design principles of embedded systems and microcontrollers.<br>• Develop proficiency in programming microcontrollers and implementing real-time applications using C/C++.<br>• Gain hands-on experience in interfacing peripherals, integrating sensors, and using communication protocols in embedded systems. |
| 8 | **Brief Contents** | This course introduces the fundamentals of embedded systems, focusing on microcontroller architecture, real-time operating systems (RTOS), and interfacing techniques. Topics include embedded system design, hardware and software integration, and the use of development tools. Students will explore programming microcontrollers, using languages such as C/C++, and implementing real-time applications. The course covers peripheral interfacing, sensor integration, and communication protocols (I2C, SPI, UART). Practical lab sessions provide hands-on experience in designing, coding, and debugging embedded systems. Applications in various fields, such as automotive, healthcare, and consumer electronics, will be examined, highlighting the role of embedded systems in modern technology. |
| 9 | **Lab Content** | The lab component of this course provides hands-on experience in designing, programming, and debugging embedded systems, focusing on microcontroller architecture, real-time operating systems (RTOS), and hardware-software integration. Students will work with microcontrollers such as Arduino, ESP32, and STM32 to develop real-time applications using C and C++. Experiments include peripheral interfacing, where students integrate sensors, actuators, and communication modules using I2C, SPI, and UART protocols. The lab also covers RTOS implementation, allowing students to manage real-time tasks and scheduling efficiently. Development tools such as Keil, MPLAB, and Platform IO are used for coding, compiling, and debugging embedded applications. |
| 10 | **Text/ Reference Books** | 1. "Embedded Systems: Design and Applications" by Jean-Claude Baron, Didier El Baz, and Michael A. Pecht<br>2. "The Art of Designing Embedded Systems" by Jack Ganssle<br>3. "Embedded Systems: Real-Time Interfacing to ARM Cortex-M Microcontrollers" by Jonathan W. Valvano<br>4. "Programming Embedded Systems: With C and GNU Development Tools" by Michael Barr and Anthony Massa |

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| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | EE-609 |
| 4 | **Title of the subject** | Engineering Research Methodology |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 2-1-0 |
| 7 | **Learning Objectives of the subject** | • Equip students with the ability to formulate research problems, design experiments, and employ appropriate research methodologies in engineering.<br>• Teach students to collect, analyse, and interpret data using various statistical and computational tools.<br>• Instil a strong understanding of ethical considerations in research, including data integrity, plagiarism, and responsible reporting.<br>• Develop students' skills in technical writing and presentation, enabling them to effectively communicate research findings.<br>• Foster critical thinking and problem-solving abilities, preparing students to tackle complex engineering challenges through rigorous research. |
| 8 | **Brief Contents** | This course provides an in-depth understanding of research techniques and methodologies essential for engineering research. Topics include the formulation of research problems, literature review, research design, and experimental methods. Students will learn quantitative and qualitative research methods, data collection and analysis techniques, and the use of statistical tools. The course covers ethical considerations, technical writing, and presentation skills, emphasizing the importance of reproducibility and peer review. Practical sessions will involve developing research proposals, designing experiments, and analysing real-world data, equipping students with the skills to conduct rigorous and impactful engineering research. |
| 9 | **Text/ Reference Books** | 5. "Research Methodology: A Step-by-Step Guide for Beginners" by Ranjit Kumar<br>6. "Research Methods for Engineers" by David V. Thiel<br>7. "Engineering Research: Design, Methods, and Analysis" by Herman Tang<br>8. "The Craft of Research" by Wayne C. Booth, Gregory G. Colomb, and Joseph M. Williams |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-065 |
| 4 | **Title of the subject** | High Performance Computing Systems |
| 5 | **Any prerequisite** | VLSI Architecture |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives ofthe subject** | • To get in-depth analysis of issues in High Performance Computing systems including Parallel Computing, New Processor Architectures, Power-Aware Computing and Communication, Advanced Topics on Peta scale Computing and Optical Systems.<br>• To understand parallel models of computation such as dataflow, and demand-driven computation. |
| 8 | **Brief Contents** | Parallel Processing Concepts; Levels and model of parallelism: Instruction, Transaction, Task, Thread, Memory, Function, Data Flow models, Demand-driven computation; Parallel architectures: Superscalar architectures, Multi-core, Multi- threaded, Server and cloud; Fundamental design issues in HPC: Load balancing, scheduling, Synchronization and resource management; Operating systems for scalable HPC; Parallel languages and programming environments; Fundamental limitations in HPC, Benchmarking HPC, Scalable storage systems, Accelerated HPC, Power-aware HPC Design. |
| **9** | **Text/ Reference Books** | 7. “High Performance Computing: Modern Systems and Practices" by Thomas Sterling, Matthew Anderson, Maciej Brodowicz, Morgan Kaufmann, 2017.<br>8. “Introduction to High Performance Computing for Scientists and Engineers" by Georg Hager and Gerhard Wellein, CRC Press, 2010.<br>9. “Parallel Computer Architecture: A Hardware/Software Approach" by David Culler and Jaswinder Pal Singh, Morgan Kaufmann 1998.<br>10. “Dataflow Supercomputing" by Patrick K. O'Neil, Springer International Publishing AG, 2017.<br>11. “Power-Aware Computing" by Andrea Biedenkapp, Rainer Hartenstein, et al.<br>12. “Introduction to High Performance Computing for Scientists and Engineers" by Georg Hager and Gerhard Wellein |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-067 |
| 4 | **Title of the subject** | Sensors for Autonomous System |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Understanding the fundamentals and functionality of micro sensors.<br>• Exploring sensor usage in autonomous systems.<br>• Examining sensor integration for real-time applications.<br>• Learning mathematical modeling and estimation techniques for real-world systems.<br>• Studying various approaches, including optimization techniques, to achieve desired system outcomes. |
| 8 | **Brief Contents** | Introduction and Historical Background, Microsensors, Sensor Principles/Classification-Physical Sensors, Methods for Data Acquisition, Modelling Dynamic Systems using Transfer Functions, Multiple-input-Multiple-output Systems, Feedback control methods, Rule based and Optimization Approaches, Hardware Development, System Dependability, Fault Detection, Diagnosis and Prognosis. |
| 9 | **Lab Content** | NA |
| 10 | **Text/ Reference Books** | 1. "Introduction to Sensors and Actuators" by John R. Gardner.<br>2. "Sensor Fusion Approaches for Positioning, Navigation, and Mapping: How Autonomous Vehicles and Robots Navigate in the Real World: With MATLAB Examples" by Mohamed M. Atia<br>3. "Robotics and Smart Autonomous Systems" by Rashmi Priyadarshini, Ram Mohan Mehra, Amit Sehgal, and Prabhu Jyot Singh |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-073 |
| 4 | **Title of the subject** | Data Analytics |
| 5 | **Any prerequisite** | Should have knowledge of one Programming Language (Java preferably), Practice of SQL (queries and sub queries), exposure to Linux Environment. |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning Objectives of the subject** | • Understand the Big Data Platform and its Use cases<br>• Provide an overview of Apache Hadoop<br>• Understand Map Reduce Jobs<br>• Provide hands on Hadoop Eco System<br>• Apply analytics on Structured, Unstructured Data<br>• Exposure to Data Analytics with R |
| 8 | **Brief Contents** | Types of Digital Data, Introduction to Big Data, Big Data Analytics, History of Hadoop, Apache Hadoop, Analyzing Data with Unix and Hadoop, Hadoop Streaming, Hadoop Echo System, IBM Big Data Strategy, HDFS Concepts, Command Line Interface, Hadoop file system interfaces, Data flow, Data Ingest with Flume and Scoop and Hadoop archives, Map Reduce Anatomy of a Map Reduce Job Run, Failures, Job Scheduling, Shuffle and Sort, Task Execution, Map Reduce Types and Formats, Map Reduce Features, Introduction to PIG, Execution Modes of Pig, User Defined Functions, Data Processing operators, Data Analytics with R Machine Learning, Big Data Analytics with BigR. |
| 9 | **Lab Content** | NA |
| 10 | **Text/ Reference Books** | 6. "Data Analytics Made Accessible" by Anil Maheshwari (2023 Edition)<br>7. "Advancing Into Analytics: From Excel to Python and R" by George Mount (2021)<br>8. "Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython" by Wes McKinney (2017)<br>9. "The Data Warehouse Toolkit: The Definitive Guide to Dimensional Modeling" by Ralph Kimball and Margy Ross (2013)<br>10. "Data Mining: Concepts and Techniques" by Jiawei Han, Micheline Kamber, and Jian Pei (2011) |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-075 |
| 4 | **Title of the subject** | Reinforcement Learning |
| 5 | **Any prerequisite** | Understanding of Signals |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Understand the fundamentals of reinforcement learning and Markov decision processes (MDPs).<br>• Learn key algorithms such as Q-learning, Monte Carlo methods, and temporal-difference learning.<br>• Explore advanced techniques in deep reinforcement learning using neural networks.<br>• Implement reinforcement learning algorithms and apply them to real-world problems using Python. |
| 8 | **Brief Contents** | The "Reinforcement Learning" course delves into the core concepts and methodologies of reinforcement learning (RL), where agents learn to make decisions by interacting with their environment. Topics include Markov decision processes (MDPs), dynamic programming, Monte Carlo methods, and temporal- |

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| | | difference learning. Students will explore advanced RL techniques such as Q-learning, policy gradients, and deep reinforcement learning using neural networks. The course also covers applications in robotics, game playing, and autonomous systems. Practical sessions involve implementing RL algorithms using Python and frameworks like TensorFlow or PyTorch. By the end of the course, students will be capable of designing and deploying RL solutions for complex problems. |
| 9 | **Text/ Reference Books** | 5. "Reinforcement Learning: An Introduction" by Richard S. Sutton and Andrew G. Barto<br>6. "Deep Reinforcement Learning Hands-On" by Maxim Lapan<br>7. "Reinforcement Learning: State-of-the-Art" edited by Marco Wiering and Martijn van Otterlo<br>8. "Python Reinforcement Learning" by Sudharsan Ravichandran |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-078 |
| 4 | **Title of the subject** | Quantum Computing |
| 5 | **Any prerequisite** | NA |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | This course serves as an introduction to the quantum computational model, focusing on understanding and analysing fundamental quantum algorithms. It also explores the limitations of quantum algorithms and provides the essential tools and techniques to demonstrate these constraints. |
| 8 | **Brief Content s** | Introduction: Elementary quantum mechanics: linear algebra for quantum mechanics, Quantum states in Hilbert space, The Bloch sphere, Density operators, generalized measurements, no-cloning theorem. Quantum correlations: Bell inequalities and entanglement, Schmidt decomposition, superdense coding, teleportation. Quantum cryptography: quantum key distribution. Quantum gates and algorithms: Universal set of gates, quantum circuits, Solovay-Kitaev theorem, Deutsch-Jozsa algorithm, factoring. Programming a quantum computer: The IBMQ, coding a quantum computer using a simulator to carry out basic quantum measurement and state analysis. |
| 9 | **Text/ Reference Books** | 6. Phillip Kaye, Raymond Laflamme et. al., An introduction to Quantum Computing, Oxford University press, 2007.<br>7. Chris Bernhardt, Quantum Computing for Everyone, The MIT Press, Cambridge, 2020<br>8. David McMahon-Quantum Computing Explained-Wiley-Interscience, IEEE Computer Society (2008).<br>9. Quantum Computation and Quantum Information, M. A. Nielsen &I. Chuang, Cambridge University Press (2013).<br>10. (5) Quantum Computing, A Gentle Introduction, Eleanor G. Rieffel and Wolfgang H. Polak MIT press (2014) |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-080 |
| 4 | **Title of the subject** | Deep Learning for Autonomous Systems |
| 5 | **Any prerequisite** | Machine Learning |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Provide an in-depth understanding of deep learning techniques and their applications in autonomous systems.<br>• Enable students to design and implement neural networks for perception, decision-making, and control in autonomous systems.<br>• Introduce state-of-the-art deep learning frameworks and tools for real-world deployment.<br>• Foster the ability to address challenges like dynamic environments, uncertainty, and real-time processing in autonomous systems. |
| 8 | **Brief Contents** | Introduction: Defining Autonomous Systems, Artificial Intelligence, Machine Learning, and Deep learning. Overview of the 3 pillars of Autonomous Vehicles: Perception, Prediction, Planning and Quick overview of sensing modalities. Deep learning for Perception, Introduction to deep learning, Neural Network, CNN, regularization techniques. State-of-the-art techniques: Self supervised learning, Vision Transformer, and Deep learning for Prediction. Introduction to Recurrent Neural Networks, Graph Neural Network, Transformer, Diffusion. Generative Models: Variational Autoencoders (VAEs) and Generative Adversarial Networks (GANs) for simulation and environment modeling. Case Studies and Applications: Real-world examples in autonomous vehicles, drones, and robotic systems, addressing challenges in dynamic and uncertain environments. |
| 9 | **Text/ Reference Books** | 1. Deep Learning From Scratch: Building with Python from First Principles by Seth Weidman.<br><br>2. Deep Learning for Computer Vision with Python |

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| | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-082 |
| 4 | **Title of the subject** | Advanced Control System |
| 5 | **Any prerequisite** | Understanding of Systems |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Understand state-space representation and concepts of controllability and observability.<br>• Learn advanced control methods such as optimal, robust, and adaptive control.<br>• Apply modern control design techniques like pole placement and LQR.<br>• Develop and simulate advanced control systems using MATLAB/Simulink for real-world applications. |
| 8 | **Brief Contents** | Control theory for designing and analysing complex control systems. State-space representation, controllability, observability, and state feedback control. Students will explore advanced methods like optimal control, robust control, and adaptive control systems. Modern control design techniques such as pole placement, linear quadratic regulator (LQR), and H-infinity control. Students will study the application of these techniques in systems with uncertainty and nonlinearity. Practical sessions involve MATLAB/Simulink to model and simulate advanced control systems, preparing students to tackle real-world control engineering challenges. |
| 9 | **Text/ Reference Books** | 5. "Modern Control Engineering" by Ogata Katsuhiko<br>6. "Feedback Control of Dynamic Systems" by Gene F. Franklin, J. Da Powell, and Abbas Emami-Naeini<br>7. "Advanced Control Engineering" by Roland S. Burns<br>8. "Robust Control: The Parameter Space Approach" by Kemin Zhou and John C. Doyle |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-069 |
| 4 | **Title of the subject** | Digital Image Computation |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning Objectives of the subject** | • Understand the fundamentals of digital image representation, storage, and color models in image processing.<br>• Learn techniques for image transformation, enhancement, filtering, and noise reduction.<br>• Gain skills in image segmentation, feature extraction, and morphological processing for object analysis.<br>• Apply image compression and machine learning techniques for recognition, classification, and practical applications. |
| 8 | **Brief Contents** | This course covers essential techniques and methods in digital image processing, beginning with an introduction to digital images, their representation, and storage, including color models and resolution. It explores image transformations such as Fourier Transform and Discrete Fourier Transform (DFT) for image analysis and filtering, followed by image enhancement techniques like histogram equalization and noise reduction. Students will learn about linear and nonlinear image filtering, segmentation, and feature extraction methods such as SIFT and SURF for object detection and recognition. The course also covers morphological image processing, including dilation, erosion, and shape analysis, as well as image compression methods like JPEG and PNG. Finally, the course applies machine learning techniques for image recognition and classification, with real-world applications in medical imaging, remote sensing, computer vision, and digital photography. |
| 9 | **Lab Content** | Not Applicable |
| 10 | **Text/ Reference Books** | 6. "Digital Image Processing" by Rafael C. Gonzalez and Richard E. Woods<br>7. "Computer Vision: Algorithms and Applications" by Richard Szeliski<br>8. ""Pattern Recognition and Machine Learning" by Christopher M. Bishop<br>9. "Digital Image Processing Using MATLAB" by Rafael C. Gonzalez, Richard E. Woods, and Steven L. Eddins<br>10. "Practical Python and OpenCV + Case Studies" by Adrian Rosebrock |

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| | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-070 |
| 4 | **Title of the subject** | Audio Signal Processing |
| 5 | **Any prerequisite** | Signals and Systems |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Focuses on algorithms for acoustic and audio signal processing, including applications in audio algorithm design and signal analysis.<br>• Emphasizes critical areas such as monophonic and stereophonic echo cancellation, active noise control, and feedback reduction in communication systems.<br>• Addresses real-world challenges in both wired and wireless communication, with an emphasis on audio signal processing technologies used globally in various industries. |
| 8 | **Brief Content s** | Audio signal recording, analysis and representation techniques, audio measurement, sound intensity, noise signal analysis and characterization, stationary and nonstationary signals, probabilistic signal processing techniques with applications for acoustic & audio signal analysis, digital filters for audio enhancement. Characteristics of widely interfaced acoustic signals, multiple sub-filters different error, common error and combined error algorithms, monophonic and stereophonic acoustic echo-cancellation, active noise suppression, feedback cancellation. |
| 9 | **Text/ Reference Books** | 5. D. Manolakis, M. Ingle, S. Kogon, Statistical and Adaptive Signal Processing, McGraw-Hill, Revised Edition 2014.<br>6. Jacob Benesty, Israel Cohen, Jingdong Chen, Fundamentals of Signal Enhancement and Array Signal Processing, Wiley & Sons, 2018.<br>7. Udo Zolzer, Digital Audio Signal Processing, Wiley & Sons, 2008.<br>8. Steven L. Gay, Jacob Benesty, Acoustic Signal Processing for Telecommunication, Springer, 2001. |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-071 |
| 4 | **Title of the subject** | Advance Digital Signal Processing |
| 5 | **Any prerequisite** | Signals and Systems, Digital Signal Processing |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Understand the advanced principles of digital signal processing (DSP) and its applications in real-time systems.<br>• Develop proficiency in advanced DSP techniques such as adaptive filtering, multirate signal processing, and spectral analysis.<br>• Gain expertise in the design and implementation of efficient DSP algorithms for applications like speech, audio, and image processing. |
| 8 | **Brief Content s** | Overview of advanced topics in DSP including sampling, quantization, and the z-transform. Emphasis on discrete-time signals and systems, and their mathematical representations.Study of adaptive filter algorithms such as LMS (Least Mean Squares), RLS (Recursive Least Squares), and their applications in noise cancellation, echo cancellation, and channel equalization. Techniques for downsampling and upsampling, interpolation, decimation, and polyphase filters. Applications in data compression and speech signal processing. Advanced methods for spectral estimation, including the periodogram, Bartlett's method, and the Welch method. Wavelet bases. Balian-Low theorem. Multiresolution analysis. (MRA). Focus on real-time and non-stationary signal analysis. Implementation of DSP techniques in communication systems, including OFDM (Orthogonal Frequency Division Multiplexing), channel coding, and modulation schemes. |
| 9 | **Text/ Reference Books** | 1. “Understanding Digital Signal Processing" by Richard G. Lyons,: Pearson Education.<br>2. "Digital Signal Processing: Principles, Algorithms, and Applications" by John G. Proakis and Dimitris G. Manolakis<br>3. "Advanced Digital Signal Processing: Theory and Applications" by Saeed V. Vaseghi Publisher: Wiley-Interscience<br>4. "Discrete-Time Signal Processing" by Alan V. Oppenheim and Ronald W. Schafer, Publisher: Pearson Education |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-072 |

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| 4 | **Title of the subject** | Biomedical Signal Processing |
| 5 | **Any prerequisite** | Understanding of Digital and Analog Signals |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Understand the principles of acquiring and preprocessing physiological signals.<br>• Learn techniques for noise reduction, filtering, and signal enhancement.<br>• Apply time-domain and frequency-domain analysis methods to biomedical signals.<br>• Develop and implement algorithms for feature extraction and pattern recognition in diagnostics. |
| 8 | **Brief Contents** | The "Biomedical Signal Processing" course covers the fundamentals and advanced techniques for analysing physiological signals. Topics include signal acquisition and preprocessing, noise reduction, and filtering. Students will explore time-domain and frequency-domain analysis, feature extraction, and pattern recognition methods. The course also delves into advanced topics such as wavelet transforms, machine learning for biomedical signal analysis, and applications in diagnostics and monitoring. Practical sessions involve MATLAB/Python programming for real-world signal processing tasks. By the end of the course, students will be equipped with the skills to develop and implement algorithms for interpreting complex biomedical signals. |
| 9 | **Text/ Reference Books** | 5. "Biomedical Signal Processing and Signal Modelling" by Eugene N. Bruce<br>6. "Biomedical Signal Processing: Principles and Techniques" by D. C. Reddy<br>7. "Advanced Methods of Biomedical Signal Processing" edited by Sergio Cerutti and Carlo Marchesi<br>8. "Biomedical Signal Analysis: A Case-Study Approach" by Rangaraj M. Rangayyan |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-074 |
| 4 | **Title of the subject** | Computer Vision |
| 5 | **Any prerequisite** | Understanding of Signals |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Understand the principles of image formation and feature detection in computer vision.<br>• Learn techniques for object recognition, classification, and scene reconstruction.<br>• Apply motion analysis and 3D vision methods to interpret visual information.<br>• Develop and implement deep learning algorithms for computer vision using Python and OpenCV. |

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| 8 | **Brief Contents** | The "Computer Vision" course explores the fundamentals and advanced techniques for enabling machines to interpret and understand visual information from the world. Topics include image formation, feature detection, and matching, as well as object recognition and classification. Students will study motion analysis, 3D vision, and scene reconstruction. Advanced topics such as deep learning for computer vision, including convolutional neural networks (CNNs), are also covered. Practical sessions involve implementing algorithms and applications using Python and OpenCV. By the end of the course, students will be proficient in developing computer vision systems for real-world applications. |
| 9 | **Text/ Reference Books** | 5. "Computer Vision: Algorithms and Applications" by Richard Szeliski<br>6. "Multiple View Geometry in Computer Vision" by Richard Hartley and Andrew Zisserman<br>7. "Deep Learning for Computer Vision" by Rajalingappaa Shanmugamani<br>8. "Learning OpenCV 4: Computer Vision with Python" by Adrian Kaehler and Gary Bradski |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of Subject** | EE-076 |
| 4 | **Title of the Subject** | Internet of Bio-Nano Things |
| 5 | **Prerequisite** | Linear Algebra, Signals and Systems, Digital Communication, Probability and Statistics, Computational Theory |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives** | This course will cover communication techniques and technologies to conceive networks on the nanoscale. Instead of the standard use of electromagnetic waves, we will perform the emission and detection of molecules according to the paradigm of Molecular Communications. We will follow a network architecture approach from a computer network perspective, see the picture on the right. In the physical layer, we will introduce models for the communication channels through molecular means, as well as for emitters and receivers. In the link layer, we will address mechanisms for the information flow and error control mechanisms. In this course, we will not only study theoretical concepts but will conduct many hands-on activities in the MATLAB simulator to model the physical and link layers. |

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| 8 | **Brief Contents** | Introduction to Molecular communication: Why, what, and how? Applications areas: Biological engineering, Medical and healthcare applications, Industrial applications, Environmental applications, Information and communication technology applications, Nature-made biological nanomachines, Basic physical concepts, Chemical reactions and the master equation, Chemical reactions and the master equation (part 2), Basics of biochemistry, Brownian motion, First arrival time distribution, Concentration and counting, Modulation techniques, Transportation Mechanisms, Timing channels, Concentration channels, Noise and intersymbol interference, Molecular MIMO, Signal transduction, Information theory of molecular communication, Experimental approaches, Jamming bacterial communications: new strategies to combat bacterial infections and the development of biofilms, Quorum sensing and cell-to-cell communication in the dental biofilm. |
| 9 | **Text and Reference Books** | 8. R. G. Gallager, "Stochastic Processes: Theory for Applications," 1st edition, Cambridge University Press, 2013.<br>9. T. Nakano, A. Eckford, "Molecular Communication", 1st edition, Cambridge University Press, 2013.<br>10. P. Peebles, "Probability, Random Variables, and Random Signals", 4th edition, New York, NY: McGraw-Hill, 2017.<br>11. D. R. Demuth, R. J. Lamont, "Bacterial Cell-to-Cell Communication", 1st Edition, Cambridge University Press, 2006.<br>12. S.M. Ross, "Stochastic Processes", 2nd Edition, Wiley, 1996.<br>13. S. Karlin, and H. M. Taylor, "A First Course in Stochastic Processes", 2nd edition, Academic Press, 1975.<br>14. Research Papers |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-079 |
| 4 | **Title of the subject** | Cybersecurity |
| 5 | **Any prerequisite** | NA |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Develop a understanding of cybersecurity principles and techniques<br>• Explore foundational concepts, and emerging technologies<br>• Gain skills in cryptography, threat detection, network security<br>• Understand policies, compliance, and cyber risk management |
| 8 | **Brief Contents** | Introduction to Cybersecurity: Importance, Threat Landscape, Security Goals, Symmetric and Asymmetric Cryptography, Hash Functions, Digital Signatures, Network Security Essentials: Firewalls, Intrusion Detection Systems. Viruses, Worms, Ransomware, SQL Injection, Cloud and IoT Security Challenges, IoT Threats, and Countermeasures, Artificial Intelligence in Security, AI-based Threat Detection, Machine Learning Models for Security, Zero Trust Architecture: Concepts, Zero Trust Network Access, Implementation Strategies, Security Policies and |

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| | | Compliance, Cyber Risk Management and Governance: Risk Assessment, Business Continuity, Disaster Recovery, Future of Cybersecurity |
| 9 | **Lab Content** | NA |
| 10 | **Text/ Reference Books** | 6. Introduction to Modern Cryptography by Jonathan Katz, Yehuda Lindell, 2025, Chapman & Hall/CRC<br>7. Cryptography and Network Security: Principles and Practice by William Stallings, 2021, Pearson<br>8. Zero Trust Networks: Building Secure Systems in Untrusted Networks by Evan Gilman, Doug Barth, 2017, O'Reilly Media<br>9. Computer Security: Principles and Practice by William Stallings, Lawrie Brown, 2017, Pearson<br>10. The Web Application Hacker's Handbook: Finding and Exploiting Security Flaws by Dafydd Stuttard, Marcus Pinto, 2011, Wiley |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-081 |
| 4 | **Title of the subject** | Optimization Techniques |
| 5 | **Any prerequisite** | NA |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | This course introduces optimization techniques, covering both linear and non-linear programming. While the primary focus is on convex optimization, the course also explores techniques for optimizing non-convex functions. Following a foundational overview of linear algebra and probability theory, students will learn to formulate engineering problems involving minima and maxima within the framework of optimization. |
| 8 | **Brief Contents** | The content covers various optimization and computational techniques, including network flow models and algorithms such as shortest path methods (Dijkstra, label-correcting, and auction algorithms), max-flow and min-cost flow problems (Ford-Fulkerson, simplex methods), and transformations in optimization. It delves into solving linear and nonlinear programming problems using iterative methods, line search techniques, Hessian-based approaches (Newton, conjugate directions, quasi-Newton), and constrained optimization (Lagrange variables, KKT conditions, quadratic programming, convex problems, mixed integer models, and interior point methods). Additionally, it introduces OR models, linear programming techniques (simplex, artificial variables, two-phase, big-M), transportation and assignment problems, sequencing, replacement, game theory, inventory management, and dynamic programming with engineering applications. The final module explores quantum information |

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| | | theory, including density operators, entanglement, teleportation, Shannon entropy, quantum channels, cryptography, and quantum key distribution. |
| 9 | **Text/ Reference Books** | 8. Boyd, Stephen, Stephen P. Boyd, and Lieven Vandenberghe. Convex optimization. Cambridge university press, 2004.<br>9. D. Bertsekas Nonlinear programming, 2nd Edition, Athena Scientific, 1999, Nashua.<br>10. V. Chvatal Linear programming, W. H. Freeman, 1983, New York.<br>11. E. K. P. Chong and S. Zak, An introduction to optimization, 2nd Edition, 2004, John Wiley and Sons (Asia) Pvt. Ltd., Singapore<br>12. R. Fletcher, Practical methods of optimization, 2nd Edition, Wiley, 2000, New York<br>13. D. Luenberger, Linear and nonlinear programming, 2nd Edition, 1984, Kluwer Academic Publisher, New York<br>14. O. L. Mangasarian, Nonlinear programming, SIAM, 1987, Philadelphia |

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| 1 | **Semester** | I |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-083 |
| 4 | **Title of the subject** | Internet of Things |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • To introduce the concept of Internet of Things (IoT), reference layer and various protocols and software.<br>• To make the students capable of building IoT systems using sensors, single board computers and open source IoT platforms. |
| 8 | **Brief Contents** | Evolution of IoT, IoT architecture reference layer, IoT protocols, software and gateway protocols, IoT point to point communication technologies IoT Communication Pattern, Introduction to Cloud computation and Big data analytics, IoT security, Sensors: Working Principles: Different types Interface Electronic Circuit for Smart Sensors and Challenges for Interfacing the Smart Sensor, Usefulness of Silicon Technology in Smart Sensor And Future scope of research in smart sensor |
| 9 | **Lab Content** | None |
| 10 | **Text/ Reference Books** | **Text Books:**<br>1. IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things, David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, Cisco Press, 2017<br>2. Internet of Things – A hands-on approach, Arshdeep Bahga, Vijay Madisetti, Universities Press, 2015<br>3. Internet of Things: Architecture, Design Principles and Applications, Rajkamal, McGraw Hill Higher Education<br>**Reference Books:** |

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| | | 1. The Internet of Things – Key applications and Protocols, Olivier Hersent, David Boswarthick, Omar Elloumi and Wiley, 2012<br>2. "From Machine-to-Machine to the Internet of Things – Introduction to a New Age of Intelligence", Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis, Karnouskos, Stefan Avesand. David Boyle and Elsevier, 2014.<br>4. Architecting the Internet of Things, Dieter Uckelmann, Mark Harrison, Michahelles and Florian (Eds), Springer,2011.<br>5. Jacob Fraden, "Handbook of Modern Sensors: physics, Designs and Applications", 2015, 3rd edition, Springer, New York.<br>6. Jon. S. Wilson, "Sensor Technology Handbook", 2011, 1st edition, Elsevier, Netherland. |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-085 |
| 4 | **Title of the subject** | Software Defined Radio |
| 5 | **Any prerequisite** | Understanding of basic concepts of communication systems and signals |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Understand different models for Software Defined Radio in detail, like Software Defined Radio Architecture for performance optimization. Program and test software-defined radio transceivers; Implement different physical layer communication protocol/algorithm using Software Defined Radio. |
| 8 | **Brief Contents** | Introduction: The requirement for software defined radio, Software defined radio architectures; Ideal Software defined radio architectures, required hardware specifications, Digital aspects of a Software Defined radio, Current technology limitations<br><br>Introduction to USRP radios and GNU Radio software platform and Coding; implementation on SDR: Digital modulation and demodulation; AM transceiver, Time and frame synchronization, channel estimation and equalization; Machine learning with SDR |
| 9 | **Lab Content** | NA. |
| 10 | **Text/ Reference Books** | 5. Travis F. Collins, Robin Getz, Di Pu, and Alexander M. Wyglinski, "Software-Defined Radio for Engineers," Artech House, 2018<br>6. F. Xiong,. Digital Modulation Techniques, Artech House, 2006. ProQuest eBook Central. ISBN: 9781580538640<br>7. J. G. Proakis and M. Salehi, Digital Communications, McGraw-Hill, 5th ed., 2008. (ISBN 978-0-07-295716-7)<br>8. J. Vanakka, "Digital Synthesizers and Transmitter for Software Radio", Springer, 2005 |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-086 |
| 4 | **Title of the subject** | Quantum Communication |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Introduce key concepts and theories of Quantum Communication.<br>• Explain the working principles of quantum communication systems.<br>• Explore fundamental limits of quantum communication over classical and quantum channels.<br>• Discuss practical implementation and challenges in quantum communication systems. |
| 8 | **Brief Contents** | Vector Spaces, Inner-Product Spaces, Linear Independence and Basis, Finite-Dimensional Hilbert Spaces, Linear Operators and Projectors, Eigenvalue Decomposition, Tensor Products, Analysis and Probability, Limits, Infimum, Supremum, and Continuity, Compact Sets and Convexity, Qubits and Axioms of Quantum Systems, Positive Operator-Valued Measure (POVM), Helstrom Decision Theory and Quantum Communication Systems, Quantum Modulation Schemes, Density Operators and Quantum Entanglement, Quantum Teleportation and Cryptography, Shannon Entropy and Classical Information Theory, Quantum Channels and Noisy Transmission, Quantum Key Distribution |
| 9 | **Lab Content** | NA |
| 10 | **Text/ Reference Books** | 5. "Quantum Communications", Gianfranco Cariolaro, Springer, 2015.<br>6. "Quantum Communication, Quantum Networks, and Quantum Sensing", Ivan B. Djordjevic, Academic Press, 2022.<br>7. Principles of Quantum Communication Theory: A Modern Approach", Sumeet Khatri, and Mark M. Wilde, 2021<br>8. Quantum Computation and Quantum Information", Michael Nielsen and Isaac Chuang, Cambridge University Press, 2010. |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-087 |
| 4 | **Title of the subject** | 5G and 6G Standards |
| 5 | **Any prerequisite** | Advanced Communication Systems |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning Objectives of the subject** | • Trace the evolution from 1G to 6G, highlighting key concepts, performance metrics, and advancements.<br>• Study 5G standards, architecture, technologies, use cases, and the role of 3GPP and ITU.<br>• Discover 6G vision, emerging standards, features, enabling technologies, and use cases.<br>• Analyze regulatory, security, spectrum management, and deployment challenges for 5G and 6G. |
| 8 | **Brief Contents** | Evolution of Mobile Networks, 1G to 6G Advancements, Performance Metrics and Spectrum Utilization, Energy Efficiency and Sustainability in Wireless Networks, 5G Architecture and Core Technologies, Network Slicing and Virtualization, mmWave Communications and Massive MIMO, 5G NR Interface and Channel Modulation, 5G Use Cases and Applications, Standardization Bodies: 3GPP, ITU, GSMA, 6G Vision and Roadmap, Key Enabling Technologies for 6G, Security and Privacy in 5G/6G Networks, Spectrum Allocation and Regulatory Challenges, Future Trends and Research in 5G/6G Deployment. |
| 9 | **Lab Content** | NA |
| 10 | **Text/ Reference Books** | 2. Wireless Communications: Principles and Practice by Theodore S. Rappaport, 2$^{nd}$ Edition, Pearson Education.<br>3. Xingqin Lin and Namyoon Lee, 5G and Beyond: Fundamentals and Standards, Springer, Edition Number1<br>4. Abdulrahman Yarali, From 5G to 6G: Technologies, Architecture, AI, and Security, Wiley-IEEE Press |

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| 1 | **Semester** | I |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-088 |
| 4 | **Title of the subject** | Smart Antenna |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Understand the fundamental parameters of antenna and use of cellular concepts and basic architecture, features and benefits of smart antennas.<br>• Able to integrate smart antenna technology with overall communication system design, principle and its performance.<br>• Understand the beamforming techniques and adaptive array techniques.<br>• Understand the implementation of smart antennas for Direct sequence CDMA systems and examine some of the challenges involved in applying smart antennas to CDMA.<br>. |
| 8 | **Brief Contents** | Fundamental Parameters of Antenna and cellular concepts, Mobile antennas and mobile Radio Propagation and Modelling. Antennas for |

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| | | Mobile Communication. Different Types of Antennas, Introduction to Smart Antenna systems, need of smart antenna, Fixed Beam forming networks, Switched Beam Systems, Adaptive Antenna Systems, Smart Antennas Techniques for CDMA, Analysis Using Smart Antennas – A Vector Based Approach |
| 9 | **Lab Content** | None |
| 10 | **Text/ Reference Books** | **1.** Antennas for all applications, 3rd edition, by J.D. Krauss, TMH.<br>**2.** Antenna & Wave Propagation, K.D. Prasad, Satyaprakash publications.<br>5. Wireless Communications: Principles and practice, 2nd edition, Theodore S. Rappaport, PHI.<br>6. Joseph C. Liberti and Theodore S. Rappaport, Smart Antennas for Wireless Communications IS 95 and Third Generation CDMA Applications, Prentice Hall PTR<br>7. Balanis C A, Antenna Theory: design and applications, Wiley<br>8. Frank Gross, Smart Antennas for Wireless Communications- McGraw Hill<br>9. Ahmed El-Zooghby, Smart Antenna Engineering, Artech House Publishers<br>10. Constantine Balanis, Introduction to Smart Antennas, Morgan and Claypool Publisher.<br>11. F.B. Gross - Smart Antennas for Wireless Communications, McGraw-Hill., 2005. |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-089 |
| 4 | **Title of the subject** | Advanced Optical Communication |
| 5 | **Any prerequisite** | Advanced Communication Systems |
| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning Objectives of the subject** | • Learn the fundamentals of optical communication, including fiber properties, light propagation, dispersion, and nonlinearity.<br>• Explore optical sources, detectors, modulation techniques, and design aspects for transmitters and receivers with a focus on SNR and BER.<br>• Understand WDM principles, components, optical amplifiers, and noise management in system performance.<br>• Analyze high-speed modulation techniques, optical networks, emerging technologies, and scalability challenges. |
| 8 | **Brief Contents** | Overview of Optical Communication Systems, Optical Fiber Types and Light Propagation, Dispersion and Nonlinear Effects in Fibers, Optical Fiber Waveguides and Specialty Fibers, Optical Sources: LEDs and Laser Diodes, Photodetectors and Receiver Sensitivity, Optical Receivers and Coherent Detection, Point-to-Point Optical Links and Power Budget, Wavelength Division Multiplexing (WDM) Principles |

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| | | and System Design Considerations, Optical Amplifiers: EDFAs and Raman Amplifiers, Optical Network Architectures and Topologies, Optical Cross-Connects and ROADMs, Elastic Optical Networks and Space-Division Multiplexing, Quantum Optical Communication and Future Trends. |
| 9 | **Lab Content** | NA |
| 10 | **Text/ Reference Books** | 4. Fiber Optic Communications by Gerd Keiser, 5th Edition, McGraw Hill Education.<br>5. Optical Fiber Communications: Principles and Practice by John Senior, 3rd Edition, Pearson Education.<br>6. Optical Networks: Design and Implementation by Rajiv Ramaswami and Kumar Sivarajan, Third Edition. |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-092 |
| 4 | **Title of the subject** | Data Communication Protocol |
| 5 | **Any prerequisite** | Knowledge of fundamentals of data structures and associated algorithms |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Define and understand the meaning and role of protocol, the concept of layering, appreciate the role of TCP/IP layer model<br>• Demonstrate the basic concepts of error detection, checking and correction at data link layer and application to flow control protocols.<br>• Apply formulae to practical communication systems and analyse their performances in transmitting data signals. |
| 8 | **Brief Contents** | The course will focus on the design and implementation techniques essential for engineering robust networks. Topics include networking principles, Transmission Control, Protocol/Internet Protocol, naming and addressing (Domain Name System), data encoding/decoding techniques, link layer protocols, routing protocols, transport layer services, congestion control, quality of service, network services, Software Defined Networks (SDNs), programmable routers and overlay networks, wireless and mobile networking, security in computer networks, multimedia networking, and network management. |
| 9 | **Lab Content** | NA. |
| 10 | **Text/ Reference Books** | 4. Data and Computer Communications by William Stallings<br>5. Data communication & Networking by Bahrouz Forouzan.<br>6. Computer Networks by Andrew S. Tanenbaum |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-051 |
| 4 | **Title of the subject** | Device and Interconnect Modelling |
| 5 | **Any prerequisite** | NIL |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | By studying this course, students will gain a comprehensive understanding of technology trends and scaling in the semiconductor industry. They will learn about Moore's Law, technology nodes, and the physical and technological limitations that impact semiconductor miniaturization. The course will provide in-depth knowledge of interconnect modeling and analysis, covering RC, RLC, and transmission line models while exploring the effects of capacitive and inductive coupling on signal integrity. Students will also understand key factors such as power dissipation, reliability concerns, and performance trade-offs in interconnects. |
| 8 | **Brief Contents** | Technology trends, Device and interconnect scaling, Interconnect Models: RC model and RLC model, Effect of capacitive coupling, Effect of inductive coupling, Transmission line model, Power dissipation, Interconnect reliability, Driver and Load Device Models, Interconnect Analysis, Time domain analysis, RLC network analysis, RC network analysis and responses in time domain, S domain analysis, Circuit reduction via matrix approximation, Analysis using moment matching, Crosstalk Analysis, Advanced Interconnect Materials. Moore law, Technology nodes and ITRS, Physical & Technological Challenges to scaling, Two terminal MOS Device threshold voltage modelling, C-V Characteristics, Four terminal MOSFET threshold voltage I-V modelling, short channel effect (SCE), High-K gate dielectric, Nonconventional MOSFET – (FDSOI, SOI, Multi-gate MOSFETs). Nonconventional MOSFET – (FDSOI, SOI, Multi-gate MOSFETs) and advanced VLSI devices and interconnects |
| **9** | **Lab Content** | NA |
| **10** | **Text/ Reference Books** | **1.** Nano Interconnects: Device Physics, Modeling and Simulation by Afreen Khursheed and, Kavita Khare (CRC Press, 2024)<br>**2.** Fundamentals of Device and Systems Packaging: Technologies and Applications, Second Edition by Rao Tummala |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-052 |
| 4 | **Title of the subject** | VLSI Signal Processing |
| 5 | **Any prerequisite** | Digital Circuit, and Signals & Systems |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Provides comprehensive coverage of techniques for designing efficient VLSI architectures specifically for Digital Signal Processing (DSP) systems.<br>• Addresses real-world challenges in implementing DSP systems, such as high throughput data processing, real-time operation, and resource constraints.<br>• Focuses on optimizing power consumption and minimizing chip area while maintaining performance in DSP applications.<br>• Equips students with the skills to design VLSI architectures that meet the demands of modern DSP systems in terms of efficiency and scalability. |
| 8 | **Brief Contents** | Discusses Signal Flow Graph (SFG), Data Flow Graph (DFG), and Dependence Graph (DG) for DSP algorithms. Critical path minimization, retiming of DFG, loop retiming, and iteration bounds. Pipelined DSP architectures and parallel realization of DSP algorithms for optimization. Explores parallel realizations of FIR filters, including 2-parallel and 3-parallel architectures, and hardware minimization. Introduces unfolding theorem and polyphase decomposition for efficient DSP realization. |
| 9 | **Reference Book** | 4. VLSI Digital Signal Processing Systems: Design and Implementation, Keshab K. Parhi,: Wiley-Interscience.<br>5. VLSI for Signal Processing, Umesh H. Patil, Prentice Hall<br>6. Digital Signal Processing: A VLSI Implementation Perspective, Keshab K. Parhi, Wiley-Interscience. |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-053 |
| 4 | **Title of the subject** | Low Power VLSI |
| 5 | **Any prerequisite** | Digital Electronics |

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| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Understand the Need for Low Power VLSI Design.<br>• Analyze Power Dissipation Mechanisms in CMOS Circuits.<br>• Apply Low Power Design Techniques at device, circuit, and architecture level.<br>• Perform Power Estimation and Analysis.<br>• Understand clock gating and low-power clocking strategies.<br>• Reduce power consumption in clock distribution networks. |
| 8 | **Brief Contents** | Need for low-power VLSI chips, Sources of Power Dissipation on Digital Integrated Circuits, Dynamic Dissipation, Static Dissipation, Technology & Device Innovation, Emerging Low power Approaches, Low Power Design Techniques at Architecture and System Levels, Power Consumption of Dedicated Hardware vs. Software Implementations of Systems, Low Power Architecture, RTL design Techniques for Low Power, Low Power Random Access Memory Circuits, Power Analysis and Design at System level and state-of-the-art Low Power Applications. |
| 9 | **Lab Content** | NA |
| 10 | **Text/ Reference Books** | 1. "Low-Power CMOS VLSI Circuit Design" by Kaushik Roy and Sharat C. Prasad<br>2. "Low-Power Digital VLSI Design: Circuits and Systems" by Abdellatif Bellaouar and Mohamed I. Elmasry<br>3. "Low Power Digital CMOS Design" by Anantha P. Chandrakasan and Robert W. Brodersen |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-054 |
| 4 | **Title of the subject** | Microcontroller and Embedded System |
| 5 | **Any prerequisite** | Nil |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning Objectives of the subject** | This course aims to convey knowledge of basic concepts of embedded system design required for every state-of-the-art electrical/electronic system in the form of autonomous and real–time computing machine embodied within them. Emphasis is on the features and characteristics of embedded system, design metrics, embedded system design flow, processor, memory and input output interfacing and input output devices, assembly language, hardware description language, I/O interface design and programming, real-time operating system, hardware-software co- design and co-simulation. Special attention will be devoted to the most important challenges facing embedded system designers today and in the coming decade. |
| 8 | **Brief Contents** | Introduction to Embedded System, Major components, Design issues, Microprocessor, DSP, Microcontroller architecture, Memory, FPGA, ASIC, ARM architecture fundamentals, Interfacing and Communication Protocols |
| 9 | **Text/ Reference Books** | 4. "The Art of Designing Embedded Systems" by Jack Ganssle<br>5. "Embedded Systems: Real-Time Interfacing to ARM Cortex-M Microcontrollers" by Jonathan W. Valvano<br>**6.** “Architecting High-Performance Embedded Systems”, Jim Ledin |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-055 |
| 4 | **Title of the subject** | Memory Devices and Circuits |
| 5 | **Any prerequisite** | Microelectronic Devices/Digital Electronics |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Understand the Fundamentals of Memory Systems.<br>• Analyze SRAM and DRAM Architectures.<br>• Evaluate Non-Volatile Memory Technologies.<br>• Design and Optimize Memory Peripheral Circuits.<br>• Explore Advanced and Emerging Memory Technologies. |

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| 8 | **Brief Contents** | Introduction to Memory Systems, Memory Arrays, Memory Market, 6T/8T SRAM Design, 3T/1T-1C DRAM Design, Charge Pump Circuits, Open and Folded Bit Line Architecture, Arrays organizations, Sense Amplifiers & Peripheral Circuits, Introduction to Flash memory, NAND/NOR Flash memory, Organization of NAND Flash Memory, Advance 3D NAND Flash Configuration, Next Generation Memory (PCM, MRAM, RRAM), Emerging Memory Devices for Neuromorphic Applications. |
| 9 | **Lab Content** | NA |
| 10 | **Text/ Reference Books** | 1. "Digital Integrated Circuits: A Design Perspective" by Jan M. Rabaey, Anantha Chandrakasan, and Borivoje Nikolić.<br>2. "CMOS Digital Integrated Circuits: Analysis and Design" by Sung-Mo Kang and Yusuf Leblebici.<br>3. "Advanced Memory Technology" by Ye Zhou and Guoxing Wang. |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-056 |
| 4 | **Title of the subject** | VLSI Architecture |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • The course objective is to cover the architecture design of VLSI systems and subsystems with the notion of optimization for area, speed, dissipation, cost and reliability.<br>• Different aspects of VLSI system design and its applications in various fields.<br>• The course also discusses traditional, and state of the art analog and digital VLSI architectures optimized techniques. |
| 8 | **Brief Contents** | **Module 1:** ISA, Datapath and Control Path Design, Single Cycle MIPS, 5-Stage Pipeline MIPS, CISC Architecture.<br>**Module 2:** RISC Architecture, Arithmetic Unit Design, Fixed Point and Floating Point, Memory Units, Optimization.<br>**Module 3:** Instruction Level Parallelism, Superscalar Processor, Multi-Core and Multi-Thread Architecture.<br>**Module 4:** Network on Chip, Dynamically Reconfigurable Gate Array, Static vs. Dynamic Reconfiguration. |

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| | | **Module 5:** Single Context vs. Multi-Context Dynamic Reconfiguration, Full Spatial Run-Time Reconfiguration. |
| 9 | **Text/ Reference Books** | 4. "VLSI Architecture" Prentice Hall publisher by B. Randell and P.C. Treleaven<br>5. "Physical Architecture of VLSI Systems" Wiley publisher by Robert J. Hannemann, Allan D. Kraus, and Michael Pecht<br>6. "Advanced VLSI Architectures: From Concept to Silicon" I I P Iterative International Publishers by Mr. Somnath Maity and Mr. Rakesh Kumar |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-057 |
| 4 | **Title of the subject** | Hardware Security |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Learning the state-of-the-art security methods and devices.<br>• Better understanding of attacks and providing counter measures against them<br>• CMOS implementation of hardware security primitives, Attacks oncyber-physical systems |
| 8 | **Brief Contents** | **Module 1:** Fundamentals of Hardware Security and Trust for Integrated Circuits, Physical and Invasive Attacks, Side-Channel Attacks and Countermeasures.<br>**Module 2:** Physically Unclonable Functions (PUFs), Hardware-Based True Random Number Generators, CMOS PUF Implementations.<br>**Module 3:** Hardware Trojan, Hardware Security Primitives, Hardware Trojan Detection and Isolation in IP Cores.<br>**Module 4:** Watermarking of Intellectual Property (IP) Blocks, FPGA Security, Passive and Active Metering for Prevention of Piracy.<br>**Module 5:** Access Control, Counterfeit IC Detection, Security Measures for Integrated Circuits. |
| 9 | **Text/ Reference Books** | 4. "Introduction to Hardware Security and Trust" Springer publisher by Mohammad Tehranipoor and Cliff Wang<br>5. "Hardware Security: Design, Threats, and Safeguards" CRC Press publisher by Debdeep Mukhopadhyay and Rajat Subhra Chakraborty<br>6. "Hardware Security: A Hands-on Learning Approach" Morgan Kaufmann publisher by Swarup Bhunia and Mark Tehranipoor |

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|---|---|---|
| 1 | **Semester** | I/II/III/IV |
| **2** | **Type of course** | Elective |
| **3** | **Code of the subject** | EE-058 |
| **4** | **Title of the subject** | FPGA-Based System Design |
| **5** | **Any prerequisite** | Nil |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The goal of the course is to study the basic principles and methods of FPGA prototyping.<br>Understanding of principles of IC prototyping; hardware and software; design strategies and methods |
| 8 | **Brief Contents** | ROM, SPLD, CPLD Architecture and Features of FPGA and designing techniques. Architecture of ROM – ROM Programming – Architecture of SPLDs – SPLDs programming – Architecture of CPLDs, Basics of FPGAs– Structure of FPGAs Implementation of Digital circuits in FPGA processor, Education FPGA kit – FPGA pin assignment – Interfacing Input/Output devices with FPGA, SPI, I2C, I3C, UART protocol RTL design System Design Examples using Xilinx FPGAs – Traffic light Controller, Real Time Clock, VGA, Keyboard, LCD, Embedded Processor Hardware Design. |
| 9 | **Text/ Reference Books** | 1. M.J.S. Smith, “Application Specific Integrated Circuits”, Pearson, 2000.<br>2. Peter Ashenden, “Digital Design using Verilog”, Elsevier, 2007.<br>3. W. Wolf, “FPGA based system design”, Pearson, 2004.<br>4. Clive Maxfield, “The Design Warriors’s Guide to FPGAs”, Elsevier, 2004<br>5. S. Ramachandran, “Digital VLSI System Design: A Design Manual for implementation of Projects on FPGAs and ASICs Using Verilog” Springer Publication, 2007.<br>6. Wayne Wolf, “FPGA Based System Design”, Prentices Hall Modern Semiconductor Design Series. |

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|---|---|---|
| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-059 |
| 4 | **Title of the subject** | Quantum Electronics |
| 5 | **Any prerequisite** | Microelectronic Devices and Circuits |

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|---|---|---|
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Gain insight into the fundamental structure of solids and how their atomic arrangement influences electronic properties.<br>• Grasp the basic principles of quantum mechanics, including wave-particle duality, uncertainty principle, and quantization.<br>• Learn how to solve Schrödinger's wave equation for different potential systems and understand its significance in electronic properties.<br>• Understand the concept of DOS and its importance in determining the electronic properties of materials.<br>• Carrier Transport Phenomenon in Semiconductors. |
| 8 | **Brief Contents** | The Crystal Structure of Solids, Introduction to Quantum Mechanics: Principles of Quantum mechanics, Application of Schrodinger's Wave Equations, Introduction to Quantum Theory of Solids: The kronig-Penney Model, Electrical conduction in Solids, DOS, Statistical Mechanics, The semiconductor in Equilibrium Carrier transport Phenomenon, Non-equilibrium Excess Carriers in Semiconductor, PN-Junction, MOSCAP, Thin film Transistors, Quantum Cellular Automata |
| 9 | **Lab Content** | NA |
| 10 | **Text/ Reference Books** | 1. "Quantum Mechanics: Concepts and Applications" by Nouredine Zettili<br>2. "Semiconductor Physics and Devices" by Donald A. Neamen<br>3. "Quantum Theory of Solids" by Charles Kittel<br>4. "Quantum Cellular Automata and Quantum Computing" by S. I. Zernov |

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|---|---|---|
| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-060 |
| 4 | **Title of the subject** | RF Circuit Design |
| 5 | **Any prerequisite** | Analog IC Design |
| 6 | **L-T-P** | 3-0-0 |

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|---|---|---|
| 7 | **Learning Objectives of the subject** | • Get the idea of various parameters of interest in RF systems.<br>• To understand issues involved in design for GHz frequencies.<br>• To understand theoretical background relevant for design ofactive and passive circuits for RF front end in wireless digital communication systems. |
| 8 | **Brief Contents** | Characteristics of passive components for RF circuits. Passive RLC networks. Transmission lines. Two-port network modeling. S-parameter model. The Smith Chart and its applications, Active devices for RF circuits: SiGe MOSFET, GaAs pHEMT, HBT and MESFET. RF Amplifier design: single and multi-stage amplifiers. Review of analog filter design. Voltage references and biasing.<br><br>Low Noise Amplifier design: noise types and their characterization, LNA topologies, Power match vs Noise match. Linearity and large- signal performance, RF Power amplifiers: General properties.Class A, AB and C Power amplifiers. Class D, E and F amplifiers. Modulation of power amplifiers, Analog communication circuits, Phase-locked loops, Oscillators and synthesizers. |
| 9 | **Lab Content** | None |
| 10 | **Text/ Reference Books** | 7. D. M. Pozar, "*Microwave Engineering*," 4th Edition, Wiley, 2012.<br>8. C. Bowick, "*RF circuit design*," 2nd Edition, Newnes, 2007.<br>9. R. C. Li, "*RF Circuit Design*," 2nd Edition, John Wiley & Sons, 2012.<br>10. G. Gonzalez, "*Microwave Transistor Amplifiers: Analysis and Design,*" 2nd Edition, Prentice Hall, 1996.<br>11. T. H. Lee, "*Planar Microwave Engineering: A Practical Guide to Theory, Measurement, and Circuits*," Cambridge University Press, 2004.<br>12. D. M. Pozar, "*Microwave and RF Design of Wireless Systems*," John Wiley & Sons, 2001. |

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|---|---|---|
| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-061 |
| 4 | **Title of the subject** | Mixed Signal SoC Design |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning Objectives of the subject** | • Understand the significance of different biasing styles and apply it for different circuits.<br>• Design basic building blocks like sources, sinks, mirrors, up to layout level.<br>• Comprehend the stability issues of the systems and design Op-amp fully compensated against process, supply and temperature variations.<br>• Identify suitable topologies of the constituent subsystems and corresponding circuits as per the specifications of the system Design.<br>• Analog integrated system including parasitic effects up to tape-out. |
| 8 | **Brief Contents** | **Module 1:** Process and Temperature Independent Compensation, Resistor Equivalence of a Switched Capacitor, Parasitic-Sensitive and Parasitic-Insensitive Integrators.<br>**Module 2:** Signal-Flow-Graph Analysis, Noise in Switched-Capacitor Circuits, Performance of Sample-and-Hold Circuits.<br>**Module 3:** Ideal D/A Converter, Ideal A/D Converter, Quantization Noise, Charge-Redistribution A/D, Resistor-Capacitor Hybrid.<br>**Module 4:** Basic Phase-Locked Loop (PLL) Architecture, Voltage-Controlled Oscillator (VCO), Divider, Phase Detector, Loop Filter, PLL in Lock.<br>**Module 5:** Linearized Small-Signal Analysis, Second-Order PLL Model, Jitter and Phase Noise, Period Jitter, Probability Density Function of Jitter, Ring and LC Oscillators. |
| 9 | **Text/ Reference Books** | 4. "Design of Analog CMOS Integrated Circuits" Mc Graw Hill publisher by Behzad Razavi<br>5. "Analog Integrated Circuit Design" Wiley publisher by Tony Chan Carusone, David Johns, and Kenneth Martin<br>6. "Analog Design for CMOS VLSI Systems" Kluwer Academic publishers by Franco Maloberti |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-062 |
| 4 | **Title of the subject** | AI-Accelerator Design |
| 5 | **Any prerequisite** | NIL |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning Objectives of the subject** | • This course provides in-depth coverage of the architectural techniques used to design accelerators for training and inference in machine learning.<br>• Get exposure of implementation of CNN network in FPGA board.<br>• Get an idea about the data system bus used in communication between different system blocks.<br>• To design energy-efficient accelerators, develop the intuition to make trade-offs between ML model parameters and hardware implementation techniques. |
| 8 | **Brief Contents** | **Module 1:** Deep Understanding of Neural Networks, Linear Algebra Fundamentals, Accelerating Linear Algebra.<br>**Module 2:** Implementation of Deep Learning Kernels, Zynq Series FPGA Architecture, Interface Knowledge.<br>**Module 3:** High-Speed Protocols (Ethernet 100/10 Gbps), SPI, I2C, I3C, UART Protocol RTL Design.<br>**Module 4:** C/C++ Coding for Vivado SDK, Activation Function Verilog Implementation.<br>**Module 5:** Classification Layer HDL Implementation, Optimization for FPGA-based Deep Learning.. |
| 9 | **Text/ Reference Books** | 4. "Efficient Processing of Deep Neural Networks" Morgan & Claypool Publisher by Vivienne Sze, Yu-Hsin Chen, Tien-Ju Yang, and Joel Emer<br>5. "Artificial Intelligence Hardware Design: Challenges and Solutions" Wiley-IEEE Press publisher by Albert Chun Chen Liu and Oscar Ming Kin Law<br>6. "From CNN to DNN hardware Accelerators: A Survey on Design, Exploration, Simulation, and Frameworks" Now publisher by Leonardo Rezende Juracy, Rafael Garibotti and Fernando Gehm Moraes |

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|---|---|---|
| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-063 |
| 4 | **Title of the subject** | System-on-Chip Design |
| 5 | **Any prerequisite** | NIL |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning Objectives of the subject** | This course provides in-depth coverage of System-on-Performance Chip Design. Design, optimize, and program a modern System-on-a-Chip to analyze and characterize its computational requirements computational task, and identify performance bottlenecks. Characterize and develop real-time solutions. Implement both hardware and software solutions, formulate hardware/software tradeoffs, and perform hardware/software codesign. |
| 8 | **Brief Contents** | Hardware/software co-design: partitioning, real-time scheduling, hardware acceleration; Virtual prototyping: electronic system-level languages and hardware/software co-simulation; High-level synthesis: allocation, scheduling and binding algorithms for C-to-RTL synthesis; SoC integration: SoC communication architectures, IP interfacing, verification and test; FPGA prototyping of hardware/software systems. |
| 9 | **Text/ Reference Books** | 4. P. Marwedel, Embedded System Design: Embedded Systems Foundations of Cyber-Physical Systems, Third Edition, Springer, 2018. (author's website)<br>5. D. C. Black, J. Donovan, B. Bunton, A. Keist, SystemC: From the Ground Up, Second Edition, Springer, 2010.<br>6. G. De Micheli, Synthesis and Optimization of Digital Circuits, McGraw-Hill, 1994. |

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|---|---|---|
| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-064 |
| 4 | **Title of the subject** | Embedded Software |
| 5 | **Any prerequisite** | Nil |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Convert software programs into equivalent cycle-based hardware and vice versa.<br>• Partition software into hardware and software components with proper interfaces.<br>• Identify and optimize performance bottlenecks in hardware-software architectures |

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| 8 | **Brief Contents** | Design of embedded systems, architectures and platforms for embedded systems, general purpose vs. application-specific architectures, reconfigurable systems, optimization techniques for design space exploration, software synthesis and code generation, system-level power/energy optimization, Security in embedded systems, embedded software for AI and IoT Applications, embedded system Testing & Validation |
| 9 | **Text/ Reference Books** | 4. David E. Simon, "An Embedded Software Primer"<br>5. Daniele Lacamera, "Embedded Systems Architecture"<br>6. Mohamed Rafiquzzaman, "Microprocessors and microcomputer Based System Design" |

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|---|---|---|
| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-066 |
| 4 | **Title of the subject** | Special Topics in IC Design and Technology |
| 5 | **Any prerequisite** | NIL |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of thesubject** | This will focus on special topics of contemporary relevance and interest toboth VLSI industry and state-of-the-art research. |
| 8 | **Brief Contents** | It will cover current research and development topics and in line with VLSI industry and may cover all aspects from Device Technology to chip design flow through ASIC and FPGA, Topics from state-of-the-art design methodologies. Architecture, circuit and layout level issues, Timing and Design closure. Deep sub-micron circuit design-logic and layout issues, FinFET and other novel devices. |
| **9** | **Text/ Reference Books** | 6. Neil Weste and David Harris, "CMOS VLSI Design: A circuits and Systems perspective", 3rd Ed., Addison Wesley, 2004<br>7. RF microelectronics, Behzad Razavi, Prentice Hall, 1998.<br>8. William J. Dally, John W. Poulton, "Digital Systems Engineering, "Cambridge University Press 1999<br>9. Yaun Taur and Tak H.Ning, "Fundamentals of modern VLSI devices", Cambridge University Press 1999<br>10. Recent publications from IEEE, IEICE and ACM Journals |
| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |

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|---|---|---|
| 3 | **Code of the subject** | EE-068 |
| 4 | **Title of the subject** | Network on Chip |
| 5 | **Any prerequisite** | NIL |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives ofthe subject** | 4. To learn the basic concepts of NoC design by studying the topologies, router design and MPSoC styles,<br>5. To learn sample routing algorithms on a NoC with deadlock and livelock avoidance,<br>6. To understand the role of system-level design and performance metrics in choosing a NoC design |
| 8 | **Brief Contents** | Introduction to NoC, OSI layer rules in NoC, Interconnection Networks in Network-on-Chip Network Topologies, Switching Techniques, Routing Strategies, Architecture Design, Switching Techniques and Packet Format, Asynchronous FIFO Design, Wormhole Router Architecture Design - VC Router Architecture Design - Adaptive Router Architecture Design, Routing Algorithms, Test and Fault Tolerance of NOC, 3-D integration of NOC. |
| **9** | **Text/ Reference Books** | 4. N. Enright Jerger and L-S. Peh, On-Chip Networks, Synthesis Lectures on Computer Architecture, Morgan & Claypool, 2009,<br>5. A Jantsch and H. Tenhunen, Networks on Chip, Kluwer Academic Publishers, 2003.<br>6. W. J. Dally, Principles and Practices of Interconnection Networks, Morgan Kaufmann, 2004. |

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|---|---|---|
| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-602 |
| 4 | **Title of the subject** | System Design using HDL |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | • Understand the fundamentals of Hardware Description Languages (HDL)<br>• Learn to design combinational and sequential logic circuits<br>• Develop skills in both structural and behavioral modeling techniques and gain hands-on experience in writing testbenches and running simulations.<br>• Apply synthesis tools and optimization techniques for efficient HDL code, focusing on area, speed, power |
| 8 | **Brief Contents** | Introduction to Hardware Description Languages (HDL), including VHDL and Verilog, and compares them to other programming languages. It explores HDL syntax, semantics, data types, operators, |

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| | | and constructs, with a focus on designing combinational and sequential logic circuits such as logic gates, multiplexers, flip-flops, counters, and state machines. Students will learn both structural and behavioral modeling techniques and gain experience in writing testbenches and running simulations using tools like ModelSim, Vivado etc. The course also introduces synthesis tools and optimization techniques for efficient HDL code in terms of area, speed, and power. Topics like finite state machine design, FPGA design, and timing constraints are covered, with real-world case studies and applications, including communication systems and embedded systems design using HDL. |
| 9 | **Lab Content** | Not Applicable |
| 10 | **Text/ Reference Books** | 1. "Digital Design with Verilog" by Michael D. Ciletti<br>2. "Verilog HDL: A Guide to Digital Design and Synthesis" by Samir Palnitkar<br>3. "Verilog by Example: A Concise Introduction for FPGA Design" by Blaine C. Readler<br>4. VHDL: Programming by Example" by Douglas L. Perry<br>5. "FPGA Prototyping by Verilog Examples" by Pong P. Chu<br>6. "Verilog: Frequently Asked Questions" by Mike H. Godfrey |

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| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-608 |
| 4 | **Title of the subject** | Design Verification and Testing |
| 5 | **Any prerequisite** | CAD for VLSI |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | 1. Acquire knowledge about fault modelling and collapsing.<br>2. Learn about various combinational automatic test pattern generation techniques.<br>4. Learn about various sequential automatic test pattern generation techniques.<br>5. Analyze different memory faults and its testing methods.<br>6. Develop the verification plan for the small to complex VLSI designs.<br>7. Develop testbench using HVL for testing and verification of VLSI designs |

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| 8 | **Brief Contents** | Introduction and Fault Modeling, Testing Techniques, Time frame expansion methods, Boolean Satisfiability, Transitive-closure based and Neural Network based approaches, Fault Simulation, Design for Testability and Built-in-self-test, Controllability and observability measures, TEMEAS, SCOAP, Ad-hoc design built-in-logic-block- observer (BILBO), Linear feedback shift register (LFSR), Theory of LFSRs, Design for Trust Techniques: Different Types of Attacks, Counter Measures for different types of attacks, Prevention based Approaches, Importance of verification, Verification plan, Verification flow, Levels of verification, Verification methods and languages, Introduction to Hardware Verification methodologies, Verifications based on simulation, Analytical and formal approaches. Functional verification, Timing verification, Formal verification. Basics of equivalence checking and model checking. |
| 9 | **Text/ Reference Books** | 2. M. Bushnell and Vishwani Agrawal, Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits, Springer, ISBN 978-0792379911.<br>3. Chris Spear, System Verilog for Verification, Springer, ISBN 978-1-4614-0714-0<br>4. M. Abramovici, M. Breuer, and A. Friedman, Digital System Testing and Testable Design, IEEE Press, 1994<br>5. Diraj K. Pradhan, “Fault Tolerant Computer System Design”, Prentice Hall.<br>6. L. T. Wang, C. W. Wu, and X. Wen, VLSI Test Principles and Architectures, Morgan Kaufmann, 2006, ISBN-13: 978-0-12-370597-6, ISBN-10: 0-12-370597-5.<br>7. System-on-a-Chip Verification-Methodology and Techniques, P. Rashinkar, Paterson and L. Singh, Kluwer Academic Publishers, 2001 |

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|---|---|---|
| 1 | **Semester** | I/II/III/IV |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | EE-610 |
| 4 | **Title of the subject** | CAD for VLSI |
| 5 | **Any prerequisite** | Digital Design |
| 6 | **L-T-P** | 3-0-0 |

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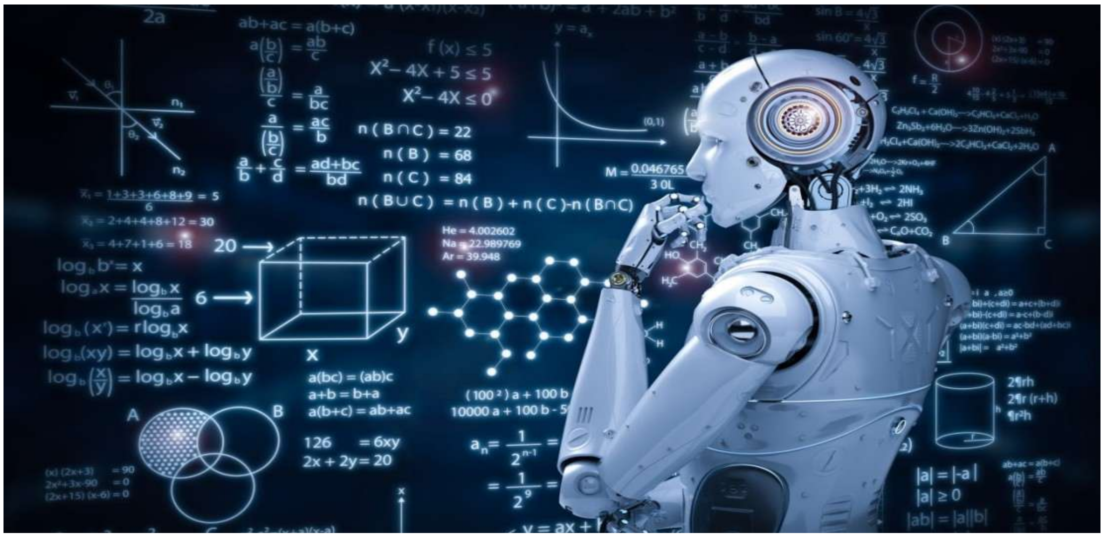
| 7 | **Learning Objectives of the subject** | 6. Understand the general design process of modern VLSI chips.<br>7. Be able to identify and formulate design problems within a sound methodology.<br>8. Build capability to analysis a problem, and design efficient algorithms to solve it.<br>9. Become familiar with most algorithms and methods used in VLSI CAD.<br>10. Be able to implement algorithms in CAD tools. |
| 8 | **Brief Contents** | Introduction to VLSI-CAD, module generation, PLAs and FPGAs, digital hardware modelling, benchmark circuits (ISCAS'85, ISCAS'89, etc.), simulation algorithms, design verification, graph data structure and algorithms for VLSI-CAD, high-level synthesis, algorithms for physical design automation, slicing and non-slicing floorplans, polar graphs and adjacency graphs for floorplans, Placement: objective functions; partitioning based placement. Global routing: geometric spanning trees; Steiner trees; net ordering. Detailed Routing: shortest paths and maze search, Channel routing, introducing NoC as a future SoC paradigm, timing analysis, SDC, set-up and hold time concepts, timing exceptions, set-up and hold calculations, and noise analysis. |
| **9** | **Text/ Reference Books** | 6. Sherwani, N., Algorithms for VLSI Physicsl Design Automation, Springer (2005) 3rd ed.<br>7. Gerez S.H., Algorithms for VLSI Design Automation, John Wiley (1998)<br>8. Sarrafzadeh, M. and Wong, C. K., An Introduction to VLSI Physical Design, McGraw Hill (1996).<br>9. Trimberger, S. M., An Introduction to CAD for VLSI, Kluwer (1987).<br>10. Sait, S. M. and Youssef, Habib, VLSI Physical Design Automation – Theory and Practice, World Scientific, 2004. |

Curriculum & Contents

# M.S.

# (Artificial Intelligence and Data Science)




**Department of Engineering Sciences**

विश्वजीवनामृतं ज्ञानम्

ABV-Indian Institute of Information Technology & Management Gwalior

# SCHEMA

**Name of the program: MS (Artificial Intelligence and Data Science)**

**(Credits: 76)**

**Name of the Department: Engineering Sciences**

| SEMESTER-I | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject Code** | **Title of the course** | **L-T-P** | **Credits** |
| **1.** | ES511 | Fundamentals of Statistics | 3-1-0 | 4 |
| **2.** | ES512 | Computational Linear Algebra | 3-1-0 | 4 |
| **3.** | ES513 | Foundations of Data Science | 3-0-0 | 3 |
| **4.** | ES514 | Machine Learning Techniques | 3-0-2 | 4 |
| **5.** | ES515 | Data Structures and Algorithms | 3-0-0 | 3 |
| **6.** | ES516 | Programming for Data Science | 3-0-2 | 4 |
| | | | **Total credits** | **22** |

| SEMESTER-II | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject code** | **Title of the course** | **L-T-P** | **Credits** |
| **1.** | ES521 | Statistical Inference | 3-0-0 | 3 |
| **2.** | ES522 | Artificial Intelligence | 3-0-2 | 4 |
| **3.** | ES523 | System Analysis and Design | 3-0-2 | 4 |
| **4.** | ES524 | Data Mining and Data Warehousing | 3-0-0 | 3 |
| **5.** | ES525 | Engineering Research Methodology | 2-1-0 | 3 |
| **6.** | ES5XX | Elective-I/ MOOC | 3-0-0 | 3 |
| | | | **Total credits** | **20** |

**Summer Project/Internship (Tentative credits: 4)*

EXIT AFTER YEAR-1: Post Graduate Diploma in Artificial Intelligence and Data Science

| SEMESTER-III | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject code** | **Title of the course** | **L-T-P** | **Credits** |
| **1** | ES531 | Decision Support and Expert Systems | 2-0-2 | 3 |
| **2** | ES532 | Deep Learning | 2-0-2 | 3 |
| **3** | ES533 | Natural Language Processing | 3-0-0 | 3 |
| **4** | ES534 | Big Data Analytics and Visualization | 3-0-2 | 4 |
| **5** | ES5XX | Elective-II/ MOOC | 3-0-0 | 3 |
| **6** | ES5XX | Elective-III/ MOOC | 3-0-0 | 3 |
| | | | **Total credits** | **19** |

| SEMESTER-IV | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject Code** | **Title of the course** | **L-T-P** | **Credits** |
| **1** | ES541 | Internship / Major Project | - | 12 |
| **2** | ES5XX | Elective- IV/ MOOC | 3-0-0 | 3 |
| | | | **Total credits** | **15** |

| SEMESTER-I | SEMESTER-II | SEMESTER-III | SEMESTER-IV | TOTAL CREDITS |
|---|---|---|---|---|
| 22 | 20 | 19 | 15 | **76** |

# <u>Electives Courses</u>

| S. No. | Electives I,II,III, and IV Category: Artificial Intelligence and Data Science |
|---|---|
| 1 | Fuzzy Sets and Applications |
| 2 | Numerical Methods for Data Science |
| 3 | Optimization Methods for Computational Intelligence |
| 4 | Modelling and Simulation |
| 5 | Cyber Security and Cyber Law |
| 6 | Bayesian Data Analysis |
| 7 | Business Data Analysis |
| 8 | Introduction to Game Theory |
| 9 | Data Science for Biology and Medicine |
| 10 | Data Visualization and Interpretation |
| 11 | Advanced Graph Theory |
| 12 | Quantum Computing |
| 13 | Time Series and Forecasting Methods |
| 14 | Data Analytics for Material Science |
| 15 | Information Retrieval and Extraction |
| 16 | Innovation and Entrepreneurship |
| 17 | Database Management System |
| 18 | Software Reliability |
| 19 | Digital Forensics |

# Course Contents

| | | |
|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | ES511 |
| 4 | **Title of the subject** | Fundamentals of Statistics |
| 5 | **Any prerequisite** | |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | The use of statistical reasoning and methodology is indispensable in the modern world. It is applicable to every discipline, be it physical sciences, engineering and technology, economics or social sciences. Much of the advanced research in electronics, electrical, computer science, industrial engineering, biology, genetics, and information science relies increasingly on use of statistical tools. It is essential for the students to get acquainted with the subject of probability and statistics at an early stage. The present course has been designed to introduce the subject to undergraduate/postgraduate students in science and engineering. The course contains a good introduction to each topic and an advanced treatment of theory at an understandable level to the students at this stage. Each concept has been explained through examples and application-oriented problems. |
| 8 | **Brief Contents**<br><br>**(Module wise)** | Sets, Classes, Collections, Sequence of Sets, Ring, Field (Algebra), Sigma-Ring, Sigma-Field, Monotone Class, Random Experiment, Events, Definitions of Probability, Properties of Probability Function. Conditional Probability, Independence of Events, Random Variables, Probability Distribution of a Random Variable-I, Moments, Characteristics of Distributions-I, Characteristics of Distributions-II, Special Discrete Distributions<br><br>Poisson Process, Special Continuous Distributions, Normal Distribution, Function of a Random Variable, Joint Distributions, Independence, Product Moments, Linearity Property of Correlation and Examples<br><br>Bivariate Normal Distribution, Transformation of Random Variables, Chi-Square Distribution, t-Distribution, F-Distribution, Descriptive Statistics, Introduction to Estimation, Unbiased and Consistent Estimators, Confidence Intervals, Basic Definitions, Two Types of Errors.<br><br>Testing for Normal Mean, Testing for Normal Variance, Large Sample Test for Variance and Two Sample Problem, Paired t-Test, Examples, Testing Equality of Proportions |
| 9 | **Contents for lab (If applicable)** | |
| 10 | **Evaluation pattern** | Midsem, Major, Assignment/ Quiz/ Presentation. |
| 11 | **List of textbooks/ references** | 1. An Introduction to Probability and Statistics by V.K. Rohatgi & A.K. Md. E. Saleh<br><br>2. Probability and Statistical Inference by Hogg, R. V., Tanis, E. A. & Zimmerman D. L. |

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| | | 3. Probability and Statistics in Engineering by W.W. Hines, D.C. Montgomery, D.M. Goldsman, C.M. Borror<br><br>4. Introduction to Probability and Statistics for Engineers and Scientists by S.M. Ross<br><br>5. Introduction to Probability and Statistics by J.S. Milton & J.C. Arnold.<br><br>6. Introduction to Probability Theory and Statistical Inference by H.J. Larson<br><br>7. Probability and Statistics for Engineers and Scientists by R.E. Walpole, R.H. Myers, S.L. Myers, Keying Ye<br><br>8. Modern Mathematical Statistics by E.J. Dudewicz & S.N. Mishra<br><br>9. Introduction to the Theory of Statistics by A.M. Mood, F.A. Graybill and D.C. Boes |

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| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | ES512 |
| 4 | **Title of the subject** | Computational Linear Algebra |
| 5 | **Any prerequisite** | Engineering Mathematics-I |
| 6 | **L-T-P** | 3-1-0 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | By the end of this course, students will be able to apply computational linear algebra techniques to solve complex machine learning problems, understand and implement matrix decompositions, perform dimensionality reduction using PCA, and utilize orthogonality and least-squares methods in data analysis, ensuring a strong mathematical foundation for advanced machine learning applications. |
| 8 | **Brief Contents**<br><br>**(module wise)** | **Vector Spaces**: Vector spaces and subspaces, Linear dependent and independent vectors, Coordinate system, Basis and dimension, vector transformations, Change of basis.<br><br>**Orthogonality and least-squares**: Inner products, length and orthogonality, orthogonal sets, orthogonal projections, The Gram-Schmidt process, least-square problems, machine learning and linear models, Inner product spaces and it's applications.<br><br>**Symmetric Matrices and Quadratic Forms**: Diagonalization of symmetric matrices, spectral theorem, principal axes theorem and quadratic and canonical forms, Positive Definite Matrices, constrained optimization.<br><br>**Principal Component Analysis**: Eigenvalues and Eigenvectors, Singular Value Decomposition and it's applications, Condition number, Principal components, principal component analysis (PCA), Reduction of multivariate data. Factor analysis for data science and machine learning. |
| 9 | **Contents for lab (If applicable)** | NA |

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| 10 | **Evaluation pattern** | Mid-sem, Major, Assignment/ Quiz/ Presentation. |
| 11 | **List of text books/references** | 1. David C. Lay, Steven R. Lay, Judi J. McDonald. Linear Algebra and It's Applications. 6th Edition, Pearson Education Limited<br>2. Strang, G. (2022). *Introduction to linear algebra*. Wellesley-Cambridge Press.<br>3. Holfman K and Kunze R. Linear Algebra, Pearson India. |

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| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | ES513 |
| 4 | **Title of the subject** | Foundations of Data Science |
| 5 | **Any prerequisite** | No. |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | |
| 8 | **Brief Contents**<br>**(module wise )** | **INTRODUCTION**<br>Data Science: Benefits and uses, facets of data, Data Science Process: Overview, defining research goals, retrieving data, Data preparation, Exploratory Data analysis, build the model, presenting findings and building applications, Data Mining, Data Warehousing, Basic Statistical descriptions of Data<br>**DESCRIBING DATA**<br>Types of Data, Types of Variables, Describing Data with Tables and Graphs, Describing Data with Averages, Describing Variability, Normal Distributions and Standard (z) Scores<br>**DESCRIBING RELATIONSHIPS**<br>Correlation, Scatter plots, correlation coefficient for quantitative data, computational formula for correlation coefficient, Regression, regression line, least squares regression line, Standard error of estimate, interpretation of r2, multiple regression equations, regression towards the mean<br>**PYTHON LIBRARIES FOR DATA WRANGLING**<br>Basics of NumPy arrays, aggregations, computations on arrays, comparisons, masks, Boolean logic, fancy indexing, structured arrays, Data manipulation with Pandas, data indexing and selection, operating on data, missing data, Hierarchical indexing, combining datasets, aggregation and grouping, pivot tables<br>**DATA VISUALIZATION** |

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| | | Importing Matplotlib, Line plots, Scatter plots, visualizing errors, density and contour plots, Histograms, legends, colours, subplots, text and annotation, customization, three-dimensional plotting, Geographic Data with Basemap, Visualization with Seaborn. |
| 9 | **Contents for lab (If applicable)** | |
| 10 | **Evaluation pattern** | Midsem, Major, Assignment/ Quiz/ Presentation. |
| 11 | **List of text books/references** | 1. Foundations of Data Science, Avrim Blum, Toyota Technological Institute at Chicago, John Hopcroft, Cornell University, New York, Ravindran Kannan, Microsoft Research, India<br>2. Martin Osborne, An Introduction to Game Theory, Oxford University Press.<br>3. The visual display of quantitative information, Edward Tufte, Graphics Press LLC |

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| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | **ES514** |
| 4 | **Title of the subject** | **Machine Learning Techniques** |
| 5 | **Any prerequisite** | |
| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | The syllabus for a machine learning course typically covers fundamental concepts, algorithms, techniques, and applications that are essential for understanding and applying machine learning in various domains. |
| 8 | **Brief Contents**<br>**(module wise)** | Introduction to ML, Fundamentals of ML - PCA and Dimensionality reduction, Nearest neighbours and KNN, Linear regression, Decision tree classifiers, Notion of generalization and concern of overfitting, Notion of training, Validation, and testing; Connect to generalization and overfitting. Selected algorithms - ensembling and RF, Linear SVM, K means, Logistic regression, Naive bayes, Neural network learning - Role of loss functions and optimization, Gradient descent and Perceptron/Delta learning, MLP, Backpropagation, MLP for classification and regression, Regularization, Early Stopping, Kernels (with SVM), Bayesian methods, Generative methods, HMM, EM, PAC learning, Introduction to Deep Learning, CNNs, Popular CNN architectures, RNNs, GANS and Generative models, Advances in backpropagation and optimization for neural networks adversarial learning. |
| 9 | **Contents for lab (If applicable)** | |
| 10 | **Evaluation pattern** | Midsem, Major, Assignment/ Quiz/ Presentation. |

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| 11 | **List of text books/references** | 1. "Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow" by Aurélien Géron.<br>2. "Machine Learning: A Probabilistic Perspective" by Kevin P. Murphy.<br>3. "Introduction to Machine Learning with Python" by Andreas C. Müller and Sarah Guido |

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| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | ES515 |
| 4 | **Title of the subject** | Data Structures and Algorithms |
| 5 | **Any prerequisite** | Discrete mathematics, Engineering mathematics, any programming language |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | This course provides a comprehensive understanding of data structures and algorithms essential for solving complex problems in AI and Data sciences. Students will learn fundamental concepts and advanced techniques, focusing on their application. |
| 8 | **Brief Contents**<br><br>**(module wise)** | **Introduction to data structures and algorithms:** Important in AI and data sciences, complexity analysis: Big: O, Big-theta, Big-Omega<br><br>**Linear Data Structures: Array and linked lists**: implementation and applications, Stacks and ques<br><br>**Advanced Data Structure:** Nonlinear data structure, trees, Binary, binary search, AVL trees. Graphs (representation, adjacency matrix and list), DFS, BFS; heaps and priority queues, heap sort **algorithm,**<br><br>**Algorithm design and optimization:** Sorting and searching (quick sort, merge sort and radix sort), greedy algorithms: Huffman Encoding, Minimum Spanning Trees (Prim's and Kruskal's Algorithms), dynamic programming<br><br>**Algorithms for Big Data and AI Applications:** Graph Algorithms, PageRank Algorithm, Graph Partitioning, and Community Detection. String Matching (KMP, Boyer-Moore), Tries. |
| 9 | **Contents for lab (If applicable)** | |
| 10 | **Evaluation pattern** | |
| 11 | **List of text books/references** | 1. "Introduction to Algorithms" by Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein (CLRS)<br>2. "Problem Solving with Algorithms and Data Structures Using Python" by Bradley N. Miller and David L. Ranum<br>3. "Data Structures and Algorithms for Big Data" by Saket S.R. Mengle and Anand H. Kulkarni<br>4. "Algorithms for Data Science" by Brian Steele, John Chandler, and Swarna Reddy |

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| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | ES516 |
| 4 | **Title of the subject** | Programming for Data Science |
| 5 | **Any prerequisite** | NIL |
| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | • To gain knowledge on the main principles of programming in the Data science<br>• To develop ability to handle and visualize data<br>• To apply computational thinking in various applications domains<br>• To pprovide training in state-of-the-art tools, e.g. SQL, Python, R and Git<br>• To communicate the data analysis results to stakeholders and share work with people in the Data Science industry |
| 8 | **Brief Contents (module wise )** | Python 3.5, The NumPy package for scientific computing<br>The pandas data analysis library, including reading and writing of CSV files<br>The Jupyter and PyDev development environments<br>The Matplotlib 2D plotting library, Understanding the shell<br>Using Git and GitHub, a Best-practice software engineering techniques |
| 9 | **Contents for lab (If applicable)** | Yes (Python Programming) |
| 10 | **Evaluation pattern** | Midsem, Major, Assignment/ Quiz/ Presentation. |
| 11 | **List of text books/references** | 1. Gutagg J.V. Introduction to Computation and Programming using Python, MIT Press, 2nd edition (2017)<br>2. Jake Vanderplas, Python Data Science Handbook, O′Reilly, 2016<br>3. Göktürk Üçoluk, Sinan Kalkan, Introduction to Programming Concepts with Case Studies in Python, Springer Verlag, 2012 |

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| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | ES521 |
| 4 | **Title of the subject** | Statistical Inference |
| 5 | **Any prerequisite** | |

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| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | This course aims at giving the foundation knowledge of Probability and Statistical Inference. It gives details of the theory of Estimation and testing of hypotheses. Both theoretical aspects will be discussed, and practical problems will be dealt with in detail. This course will help students and practitioners of statistics at both UG and PG level. This course will also serve as a foundation course for students working on Machine Learning. |
| 8 | **Brief Contents**<br><br>**(Module wise)** | Revision of Probability, Different Discrete and Continuous Distributions, Functions of Random Variables and their distributions, T, Chi-sq, F distributions and their Moments<br><br>Introduction of statistics and the distinction between Data and its properties, and probabilistic models, Estimator and methods of estimation, Properties of an estimator: Consistency, Unbiasedness, Efficiency and Sufficiency<br><br>Neyman Factorization, Cramer-Rao Bound, Confidence Intervals, Concepts of hypothesis testing, Characteristics of Good Hypothesis, null and Alternative Hypotheses, Types of Errors<br><br>Inference on Population mean, comparing two population means, Inference on Variance, Comparing two population variances.<br><br>Module V: Neyman Pearson Lemma |
| 9 | **Contents for lab (If applicable)** | |
| 10 | **Evaluation pattern** | Midsem, Major, Assignment/ Quiz/ Presentation. |
| 11 | **List of text books/references** | 1) Probability and Statistics for engineers and scientists, Ed 4, Anthony J Hayter, Brroks/Cole, Cengage Learning.<br>2) Statistical Methods, R.J.Freund, W.J. Wilson and D.L Mohr, (Ed 3) Elsevier.<br>3) Mathematical Statistics: A Textbook, S. Biswas and G.L.Sriwastav, Narosa |

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| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | ES525 |
| 4 | **Title of the subject** | Engineering Research Methodology |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 2-1-0 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | Research tools and techniques, skill and ethics in research |

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| 8 | **Brief Contents**<br>**(module wise )** | Introduction to research, Analytical vs. Empirical methods, surveys, Controlled experiments, Ethnography and action research, Quantitative, Qualitative, and mixed methods, Choosing research methods, Validity threats. An empirical research framework, Research problems, Literature reviews, Introduction to quantitative research, Study designs, Controlled experiments, Elements and methods, Example experiments, Data collection techniques, Analysis and interpretation of quantitative data, Descriptive statistics, sampling, Sampling distribution, Parameter estimation, statistical inference, Confidence interval and hypothesis testing, Tests of significance, Test of difference of mean and proportions, T-tests, ANOVA, Chi-square tests, Correlation, and regression, Review process, Review guidelines, Validity threats, Review decisions, Qualitative methods, Study designs, Elements, and methods, Data collection methods - primary and secondary sources, Types of data analysis methods, Survey research, Sampling methods, Survey study designs, Case studies, Introduction to mixed methods research, Study designs and method, Writing research papers, Purpose, nature and evaluation, Content and format, Research presentations, The art of scientific and technical writing. |
| 9 | **Contents for lab (If applicable)** | NA |
| 10 | **Evaluation pattern** | Mid Sem-20%<br>Assignment/project/Qizzes- 10%<br>Major- 50%<br>Lab work-20% |
| 11 | **List of text books/references** | 1. Research Methodology: A step by step guide for beginners- Ranjit Kumar<br>2. Guide to Research & Documentation- Kirk G. Rasmussen<br>3. Research Methodology for Engineers- R Ganesan<br>4. Research Methodology- C R Kothari<br>5. Research Methods- R. Panneerselvam |

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| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | ES522 |
| 4 | **Title of the subject** | Artificial Intelligence |
| 5 | **Any prerequisite** | Basic knowledge of Probability and linear algebra |
| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | ● The objective of this course is to give an overview of the principles and practices of AI to address such complex real-world problems.<br>● The course is designed to develop a basic understanding of problem solving, knowledge representation, reasoning and learning methods of AI. |

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| 8 | **Brief Contents**<br><br>**(module wise )** | Introduction, Problem Solving by Search , Knowledge Representation and Reasoning, Planning and Decision Making, Machine Learning |
| 9 | **Contents for lab (If applicable)** | Yes, will be declared later |
| 10 | **Evaluation pattern** | Midsem, Major, Assignment/ Quiz/ Presentation. |
| 11 | **List of text books/references** | 1. Nils J Nilsson, Principles of Artificial Intelligence, Illustrated Reprint Edition, Springer Heidelberg, 2014.<br>2. Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, 3rd Edition, PHI 2009.<br>3. Patrick Henry Winston, Artificial Intelligence, Third Edition, Addison-Wesley Publishing Company, 2004. |

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| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | ES523 |
| 4 | **Title of the subject** | System Analysis and Design |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | The students will be able to analyze and design complex systems using modeling techniques, develop project management skills, create user-centered designs, implement and test systems using modern methodologies, and evaluate system performance. They will gain practical experience through real-world case studies and projects. |
| 8 | **Brief Contents**<br><br>**(module wise)** | Software Design Fundamentals: General design concepts, Context of software design, Software design process, Software design principles. Key Issues in Software Design: Concurrency, Control and handling of events, Data persistence, Distribution of components, Error exception handling and fault tolerance, Interaction and presentation, Security.<br><br>Software Structure and Architecture: Architectural structures and viewpoints, Architectural styles, Design patterns, Architecture design decisions, Families of programs and frameworks<br><br>User Interface Design: General user interface design principles, User interface design issues, Design of user interaction modalities, Design of information presentation, User interface design process, Localization and internationalization, Metaphors and conceptual models<br><br>Software Design Quality Analysis and Evaluation: Quality attributes, Quality analysis and evaluation techniques, Measures. 6. Software |

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| | | Design Notations: Structural descriptions (static view), Behavioral descriptions (dynamic view).<br><br>Software Design Strategies and Methods: General strategies, Function-oriented (structured) design, Objectoriented design, Data structure-oriented design, Component-based design, other methods |
| 9 | **Contents for lab (If applicable)** | Creating use case diagrams, activity diagrams, and sequence diagrams based on a sample project scenario. Data models that reflect the system's data requirements, Create Entity-Relationship (ER) diagrams for data modelling. etc. |
| 10 | **Evaluation pattern** | Mid-sem, Major, Assignment/ Quiz/ Presentation. |
| 11 | **List of text books/references** | 1. Systems Analysis and Design (MindTap Course List) 12th Edition by Scott Tilley, 2019.<br>2. System analysis and design, Dennis A, Wixom BH, Roth RM. Fifth edition. John Wiley and Sons.<br>3. Head First Design Patterns: Building Extensible and Maintainable Object-Oriented Software 2nd Edition 2nd Edition by Eric Freema.<br>4. Designing Data-Intensive Applications: The Big Ideas Behind Reliable, Scalable, and Maintainable Systems Kindle Edition by Martin Kleppmann |

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| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | ES524 |
| 4 | **Title of the subject** | Data Mining and Data Warehousing |
| 5 | **Any prerequisite** | Basic Statistics |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | ● Extract knowledge using data mining techniques<br>● Design a data mart or data warehouse for any organization<br>● Explore recent trends in data mining such as web mining, spatial-temporal mining |
| 8 | **Brief Contents**<br><br>**(module wise )** | Module I: Introduction to knowledge discovery from data, Data Warehousing, Data pre-processing, Dimensionality reduction<br><br>Module II: Association mining algorithms<br><br>Module III: Clustering algorithms<br><br>Module IV: Classification Algorithms<br><br>Module V: Application of data mining tools |

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| 9 | **Contents for lab (If applicable)** | Programming of association mining, classification and clustering algorithms |
| 10 | **Evaluation pattern** | Midsem, Major, Assignment/ Quiz/ Presentation. |
| 11 | **List of text books/references** | 1. J. Han and M. Kamber, Data Mining Concepts and Techniques, Morgan Kaufmann Publishers.<br>2. Ian H. Witten and Eibe Frank, ―Data Mining: Practical Machine Learning Tools and Techniques with Java implementations‖, Morgan Kaufmann Publishers, San Fransisco, CA (2000).<br>3. D. Pyle, ―Data Preparation for Data Mining‖, Morgan Kaufmann, (1999) |

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| 1 | **Semester** | III |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | ES531 |
| 4 | **Title of the subject** | Decision Support and Expert System |
| 5 | **Any prerequisite** | Basics of Software Engineering |
| 6 | **L-T-P** | 2-0-2 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | The course has been designed with a multifold objective, where various techniques will be discussed to understand the systems, decision making processes, data collection, analysis and modern IT tools to analyse the existing system and proposed/develop an expert system if required. |
| 8 | **Brief Contents**<br><br>**(module wise )** | **Understanding Systems and Related Environment**: System definition, characteristics of a system, organization, interaction, interdependence, integration, elements of a system, outputs and inputs, processors, control, feedback, boundaries and interface, types of system.<br><br>**Process Models and Role of System analyst**: SDLC models, Role of the Systems Analyst, Organizational Style and its Impact on Information Systems, Feasibility and Managing Analysis and Design Activities.<br><br>**Information Requirements Analysis**: Sampling and Investigating Hard Data, Interviewing using Questionnaires, Decision Making and Decision Support System : Decision Types, Characteristics.<br><br>**Knowledge Engineering and Expert Systems:** Knowledge management, Expert Systems, Types of Expert Systems, Development of Expert Systems, Role of AI and ANN in expert system development, Examples with Case studies |
| 9 | **Contents for lab (If applicable)** | No |
| 10 | **Evaluation pattern** | Midsem, Major, Assignment/ Quiz/ Presentation/Project |

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|---|---|---|
| 11 | **List of text books/references** | 1. Decision Options: The Art and Science of Making Decision: by Gill Eapen, CRC Press<br>2. Systems Analysis and Design (6th Edition) by Kenneth E. Kendall and Julie E. Kendall (Hardcover - Mar 1, 2004)<br>3. Decision and The Information Systems: by Maryse Salles, ISTE, Wiley<br>4. Knowledge Engineering: the Uses of Artificial Intelligence in Business by Thomas B Cross |

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| 1 | **Semester** | III |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | ES532 |
| 4 | **Title of the subject** | Deep Learning |
| 5 | **Any prerequisite** | |
| 6 | **L-T-P** | 2 0 0 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | |
| 8 | **Brief Contents**<br>**(Module wise)** | History of Deep Learning, Deep Learning Success Stories, McCulloch Pitts Neuron, Thresholding Logic, Perceptron, Perceptron Learning Algorithm. Multilayer Perceptron (MLPs), Representation Power of MLPs, Sigmoid Neurons, Feedforward Neural Networks, Representation Power of Feedforward Neural Networks. Gradient Descent (GD), Momentum Based GD, Nesterov Accelerated GD, Stochastic GD, AdaGrad, RMSProp, Adam, Eigenvalues and eigenvectors, Eigenvalue Decomposition, Basis. History, GPU Architecture, Clock speeds, CPU / GPU comparisons, Heterogeneity, Accelerators, Parallel Programming, CUDA OpenCL / OpenACC, Kernels Launch parameters, Thread hierarchy, Warps/Wavefronts, Threadblocks/Workgroups, Streaming multiprocessors, 1D/2D/3D thread mapping, Device properties, Simple Programs. Memory hierarchy, DRAM / global, local / shared, private / local, textures, Constant Memory, Pointers, Parameter Passing, Arrays and dynamic Memory, Multi-dimensional Arrays, Memory Allocation, Memory copying across devices, Programs with matrices, Performance evaluation with different memories. |
| 9 | **Contents for lab (If applicable)** | |
| 10 | **Evaluation pattern** | Midsem, Major, Assignment/ Quiz/ Presentation. |
| 11 | **List of text books/references** | 1. Richard O. Duda, Peter E. Hart, David G. Stork, "Pattern Classification", John Wiley & Sons Inc.<br>2. Shane Cook, CUDA Programming: A Developer's Guide to Parallel Computing with GPUs, Morgan Kaufman; 2012 (ISBN: 978-0124159334) |

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| 1 | **Semester** | III |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | ES533 |
| 4 | **Title of the subject** | Natural Language Processing |
| 5 | **Any prerequisite** | |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | A syllabus for a Natural Language Processing (NLP) course typically covers foundational concepts, techniques, algorithms, and applications related to processing and understanding human language using computational methods. |
| 8 | **Brief Contents**<br><br>**(module wise)** | Introduction to Natural Language Processing<br><br>Text Preprocessing<br><br>Statistical Language Models<br><br>Part-of-Speech Tagging (POS)<br><br>Syntax and Parsing<br><br>Semantic Analysis<br><br>Sentiment Analysis and Opinion Mining<br><br>Machine Translation and Language Generation<br><br>Information Retrieval and Question Answering<br><br>Advanced Topics in NLP<br><br>Ethical and Social Considerations in NLP<br><br>Hands-on Projects and Assignments |
| 9 | **Contents for lab (If applicable)** | |
| 10 | **Evaluation pattern** | Midsem, Major, Assignment/ Quiz/ Presentation. |
| 11 | **List of text books/references** | 1. "Speech and Language Processing" by Daniel Jurafsky and James H. Martin.<br>2. "Natural Language Processing with Python: Analyzing Text with the Natural Language Toolkit" by Steven Bird, Ewan Klein, and Edward Loper.<br>3. "Foundations of Statistical Natural Language Processing" by Christopher D. Manning and Hinrich Schütze. |

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| 1 | **Semester** | III |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | ES534 |
| 4 | **Title of the subject** | Big Data Analytics and Visualization |
| 5 | **Any prerequisite** | |
| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | A course on Big Data Analytics and Visualization in an MSc Data Science program focuses on the techniques, tools, and methodologies required to handle, analyze, and visualize large-scale data sets. |
| 8 | **Brief Contents**<br><br>**(module wise)** | 1. Introduction to Big Data Definition and Characteristics<br>2. Data Acquisition and Preprocessing Data Sources<br>3. Big Data Storage and Management<br>4. Big Data Processing Frameworks<br>5. Big Data Analytics Techniques<br>6. Machine Learning and AI in Big Data<br>7. Data Visualization Techniques Principles of Data Visualization<br>8. Big Data Security and Privacy Data Security<br>9. Case Studies and Applications Industry-specific Case Studies<br>10. Evaluation and Assessment Assignments |
| 9 | **Contents for lab (If applicable)** | |
| 10 | **Evaluation pattern** | Midsem, Major, Assignment/ Quiz/ Presentation. |
| 11 | **List of text books/references** | 1. Big Data: Principles and Best Practices of Scalable Real-Time Data Systems by Nathan Marz.<br>2. Hadoop: The Definitive Guide by Tom White.<br>3. Online Courses: Coursera, edX, and Udacity offer specialized courses on big data analytics and visualization.<br><br>Tools and Software: Familiarity with Hadoop, Spark, Python (with libraries like Pandas, Matplotlib, Seaborn), R, Tableau, and Power BI. |

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| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | ES5XX |
| 4 | **Title of the subject** | Numerical Methods For Data Science |
| 5 | **Any prerequisite** | |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | |
| 8 | **Brief Contents**<br>**(Module wise)** | Numerical Linear Algebra,<br>Numerical Optimization,<br>Machine Learning and Statistics |
| 9 | **Contents for lab (If applicable)** | |
| 10 | **Evaluation pattern** | Midsem, Major, Assignment/ Quiz/ Presentation. |
| 11 | **List of text books/references** | 1. Lloyd N. Trefethen and David Bau, III: *Numerical linear algebra,* SIAM (1997).<br>2. Boyd and Vandenberghe, *Convex Optimization*, Cambridge University Press 2008,<br>3. T. Hastie, R. Tibshirani, and J. Friedman., The Elements of Statistical Learning, Springer Series in Statistics |

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| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | ES5XX |
| 4 | **Title of the subject** | Optimization Methods for Computational Intelligence |
| 5 | **Any prerequisite** | - |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | ➢ To give the overall idea about the optimization for computational intelligence<br>➢ To explore various optimization techniques available for modelling real-life problems<br>➢ To study the applications of such methods in some specific problems |
| 8 | **Brief Contents**<br><br>**(module wise )** | Linear Programming: All the basic mathematical concepts related to LPP, Simplex Method, Big-M method, Two-Phase method, Revised Simplex Method, Dual Simplex Method<br><br>Integer Linear Programming: Branch and Bound method, Gomary's cutting plane method.<br><br>Mathematical concepts of Assignment Problem (2 methods), Transportation Problems. Cargo-Loading Problem, Nearest Neighbourhood Method.<br><br>Dynamic Programming: MAthematical concepts related to DP. Forward Dynamic Programming, Backward Dynamic Programming, Applications of Dynamic Programming Problems. Bio-Inspired Algorithms. |
| 9 | **Contents for lab (If applicable)** | NA |
| 10 | **Evaluation pattern** | Midsem, Major, Assignment/ Quiz/ Presentation. |
| 11 | **List of text books/references** | 1. Operations Research, fifth edition by H.A. Taha. Publisher: Prentice Hall Publication.<br>2. Computational Intelligence-based Optimization Algorithms From Theory to Practice, Babak Zolghadr-Asli. Publisher: CRC Press |

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| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | ES525 |
| 4 | **Title of the subject** | Database Management System |
| 5 | **Any prerequisite** | - |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning Objectives of the subject (in about 50 words)** | ➢ Understand fundamentals of database management systems – with emphasis on relational data modeling, querying using SQL, and internals of RDBMS.<br>➢ Introduction to relational algebra/calculus, query optimization techniques, and transaction processing will be given. With this course the students will be equipped to develop database-backed applications and have a good understanding of the internal workings of a database management system. |
| 8 | **Brief Contents**<br>**(module wise )** | Review of relational model-Brief introduction to new features in relational databases<br>Storage devices and file organizations<br>Query processing and Query optimization<br>Transaction Management (Concurrency, Recovery)<br>Concurrency and recovery in parallel and distributed databases |
| 9 | **Contents for lab (If applicable)** | SQL (Creation and Basic Query Structure, Basic Operations, Aggregate and Grouping, Nested Subqueries and Sets, Updates and Joins, Views and Triggers), Database Normalization, Database Transactions, Recovery Systems, Transaction Schedules, Query Processing, etc. |
| 10 | **Evaluation pattern** | Midsem, Major, Seminar/Assignment/ Quiz/ Presentation. |
| 11 | **List of text books/references** | 1. Database System Concepts (7 ed.) by Silberschatz, Korth and Sudarshan, McGraw-Hill. (resource website)<br>2. Database Systems: The Complete Book by Garcia-Molina, Ullman, Widom, Prentice Hall. |

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| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | ES526 |
| 4 | **Title of the subject** | Information Retrieval and Extraction |
| 5 | **Any prerequisite** | Basic Statistics and Vectors |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | ➢ To understand the theoretical basis behind the standard models of IR (Boolean, Vector-space, Probabilistic and Logical models),<br>➢ To understand the difficulty of representing and retrieving documents, images, speech, etc.,<br>➢ To be able to implement, run and test a standard IR system,<br>➢ To be familiar with various IR algorithms and IR systems. |

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| 8 | **Brief Contents**<br><br>**(module wise )** | Introduction to IRE, Text mining, Vector Space Models<br><br>Probabilistic Retrieval Strategies, Language Models, Inference Networks, Extended Boolean Retrieval<br><br>Latent Semantic Indexing, Neural Networks, Genetic Algorithms, Fuzzy Set retrieval, Fuzzy Information Retrieval System in Detail Relevance feedback, Clustering Fuzzy Clustering Passage based Retrieval N-grams Cross-Language Information Retrieval Efficiency |
| 9 | **Contents for lab (If applicable)** | No |
| 10 | **Evaluation pattern** | Midsem, Major, Assignment/ Quiz/ Presentation. |
| 11 | **List of text books/references** | 1. Information Retrieval- Algorithms and Heuristics‖, second edition by David A. Grossman and OphirFrieder. Publisher: Springer.<br>2. “Modern Information Retrieval”by R. Baeza-Yates and B. Ribeiro-Neto.<br>3. Information Retrieval: Implementing and Evaluating Search Engines‖ by S. Büttcher, C. Clarke, and G. Cormack. |

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| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | ES5XX |
| 4 | **Title of the subject** | Data Mining and Data Warehousing |
| 5 | **Any prerequisite** | Basic Statistics |
| 6 | **L-T-P** | 3-0-2 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | ● Extract knowledge using data mining techniques<br>● Design a data mart or data warehouse for any organization<br>● Explore recent trends in data mining such as web mining, spatial-temporal mining |
| 8 | **Brief Contents**<br><br>**(module wise )** | Introduction to knowledge discovery from data, Data Warehousing, Data pre-processing, Dimensionality reduction, Association mining algorithms, Clustering algorithms, Classification Algorithms, Application of data mining tools |
| 9 | **Contents for lab (If applicable)** | Programming of association mining, classification and clustering algorithms |
| 10 | **Evaluation pattern** | Midsem, Major, Assignment/ Quiz/ Presentation. |
| 11 | **List of text books/references** | 1. J. Han and M. Kamber, Data Mining Concepts and Techniques, Morgan Kaufmann Publishers.<br>2. Ian H. Witten and Eibe Frank, ―Data Mining: Practical Machine Learning Tools and Techniques with Java implementations‖, Morgan Kaufmann Publishers, San Fransisco, CA (2000). |

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| | | 3. D. Pyle, ―Data Preparation for Data Mining‖, Morgan Kaufmann, (1999) |

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| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | ES5XX |
| 4 | **Title of the subject** | Advanced Graph Theory |
| 5 | **Any prerequisite** | |
| 6 | **L-T-P** | 3 0 0 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | The primary goal of Advanced Graph Theory is to solve problems by utilizing the key ideas of graph theory, together with a thorough understanding of its applications to the engineering sciences. An in-depth grasp of graphs, as well as the basic ideas and models that underpin the theory, algorithms, and methods of proof used in the discipline of graph theory, are provided by this course. The substantial influence of emerging applications of graph theory in the field of data science will be discussed. Students will have a thorough understanding of how graph theory is used to tackle technology-driven and research-oriented challenges after finishing this course. |
| 8 | **Brief Contents**<br><br>**(Module wise)** | Introduction to Graphs & its Applications, Basics of Paths, Cycles, and Trails, Connection, Bipartite Graphs, Eulerian Circuits, Vertex Degrees and Counting, Degree-sum formula, The Chinese Postman Problem and Graphic Sequences. Trees and Distance, Properties of Trees, Spanning Trees and Enumeration, Matrix-tree computation, Cayley's Formula, Prufer code. Matchings and Covers, Hall's Condition, Min-Max Theorem, Independent Sets, Covers and Maximum Bipartite Matching, Augmenting Path Algorithm, Weighted Bipartite Matching, Hungarian Algorithm.<br><br>Connectivity and Paths: Cuts and Connectivity, k-Connected Graphs, Network Flow Ford-Fulkerson Labeling Algorithm, Max-Flow Min-cut Theorem, Menger's Proof using Max-Flow Min-Cut Theorem.<br><br>Vertex Coloring and Upper Bounds, Brooks Theorem and Color-Critical Graphs, Counting Proper Colorings**.**<br><br>Planar Graphs, Characterization of Planar Graphs, Kuratowski's Theorem, Wagner's Theorem.<br><br>Line Graphs and Edge-coloring, Hamiltonian Graph, Traveling Salesman Problem and NP-Completeness, Dominating Sets. |
| 9 | **Contents for lab (If applicable)** | |
| 10 | **Evaluation pattern** | Midsem, Major, Assignment/ Quiz/ Presentation. |

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| 11 | **List of text books/references** | 1. D.B. West, Introduction to Graph Theory, Prentice Hall, 2001<br>2. Jon Kleinberg and Eva Tardos, Algorithm Design, Addison-Wesley, 2005<br>3. J.A.Bondy and U.S.R.Murty: Graph Theory, Springer, 2008. |

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| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | ES5XX |
| 4 | **Title of the subject** | Time Series and Forecasting Methods |
| 5 | **Any prerequisite** | NIL |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | • 1. To learn Master techniques for analyzing time series data to identify patterns, trends, and seasonal effects.<br>• 2. To Develop skills in applying forecasting methods to predict future values based on historical data.<br>• 3. To Gain proficiency in using statistical software and programming languages to implement time series models. |
| 8 | **Brief Contents (module wise )** | Stationary Processes: Forecasting Stationary Time Series, ARMA Models: ARMA(p, q) Processes, The ACF and PACF of an ARMA(p, q) Process<br>Spectral Analysis: The Periodogram, Time-Invariant Linear Filters<br>Modeling and Forecasting with ARMA Processes: Yule-Walker Estimation, Maximum Likelihood Estimation, Order Selection<br>Nonstationary and Seasonal Time Series Models: ARIMA Models for Nonstationary Time Series,Unit Roots in Time Series Models, Forecasting ARIMA Models<br>Multivariate Time Series: Estimation of the Mean and Covariance Function,Multivariate ARMA Processes<br>State-Space Models: The Kalman Recursions, Estimation For State-Space Models, The EM Algorithm<br>Forecasting Techniques: ARAR Algorithm, The Holt–Winters Algorithm |
| 9 | **Contents for lab (If applicable)** | May be (Time Series analysis by using R) |
| 10 | **Evaluation pattern** | Midsem, Major, Assignment/ Quiz/ Presentation. |
| 11 | **List of text books/references** | 1. Peter J. Brockwell Richard A. Davis, Introduction to Time Series and Forecasting, Third Edition, Springer-Verlag New York, Inc., 2016<br>2. Douglas C. Montgomery, Cheryl L. Jennings, and Murat Kulahci , Introduction to Time Series Analysis and Forecasting, 2nd edition, Wiley-Interscience, 2019<br>3. Chris Chatfield and Haipeng Xing, The Analysis of Time-series: An Introduction with R, 7th edition, CRC Press, 2019 |

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| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | ES5XX |
| 4 | **Title of the subject** | Fuzzy Sets and Applications |
| 5 | **Any prerequisite** | - |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | ➢ To give an introduction to the theory of fuzzy sets<br>➢ To explore various techniques available for modelling real-life problems involving uncertainty<br>➢ To study the applications of fuzzy sets in Decision Science |
| 8 | **Brief Contents (module wise )** | UNIT-I<br>Fuzzy sets – introduction, Basic types and Basic concepts, Additional properties of -cuts, Representation of fuzzy sets, Extension principles.<br>UNIT-II<br>Type of operators on fuzzy sets and fuzzy complements, Fuzzy intersection and fuzzy unions, Combination of operations.<br><br>UNIT-III<br>Fuzzy numbers and arithmetic operations on intervals, Arithmetic operations on fuzzy numbers, Fuzzy equations and fuzzy relations, Binary fuzzy relations and binary relation on a single set, Fuzzy equivalence relations. Fuzzy Arithmetics - Fuzzy number, Addition of fuzzy numbers, Subtraction of fuzzy numbers, Multiplication of fuzzy numbers, Division of Fuzzy numbers, Fuzzy Max and Fuzzy Min, L-R Fuzzy number, Triangular(or Trapezoidal ) Fuzzy Number.<br>UNIT-IV<br>Classification by equivalence relations-Crisp relations, Fuzzy relations, Cluster Analysis, Cluster Validity, c-means Clustering- Hard c-means(HCM), Fuzzy c-Means(FCM).<br><br>UNIT-V<br>Fuzzy Decision making – introduction, Conversion of linguistic variables to fuzzy numbers, Multicriteria decision Making, Fuzzy ranking methods, Decision-Making Methods (at least 3). This unit will have more weightage. |
| 9 | **Contents for lab (If applicable)** | NA |
| 10 | **Evaluation pattern** | Midsem, Major, Assignment/ Quiz/ Presentation. |
| 11 | **List of text books/references** | 1. George J.Klir, Bo Yuan, Fuzzy Sets and Fuzzy logic – Theory and Applications, Prentice Hall India, New Delhi, 1997.<br>2. H.J Zimmermann, Fuzzy sets, Decision making and expert systems, Kluwer, Bosten, 1987.<br>3. Relevant research articles |

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| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | ES5XX |
| 4 | **Title of the subject** | Digital Forensics |
| 5 | **Any prerequisite** | NIL |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | ● To understand the basic digital forensics and techniques for conducting the forensic examination on different digital devices.<br>● To understand how to examine digital evidence such as the data acquisition, identification analysis. |
| 8 | **Brief Contents**<br>**(module wise )** | Computer forensics fundamentals, Benefits of forensics, computer crimes, computer forensics evidence and courts, legal concerns and private issues.<br>Understanding Computing Investigations – Procedure for corporate High-Tech investigations, understanding data recovery workstation and software<br>Data acquisition- understanding storage formats and digital evidence, determining the best acquisition method, acquisition tools, validating data acquisitions, performing RAID data acquisitions, remote network acquisition tools<br>Processing crimes and incident scenes, securing a computer incident or crime, seizing digital evidence at scene, storing digital evidence, obtaining digital hash<br>Current computer forensics tools- software, hardware tools, validating and testing forensic software, addressing data-hiding techniques, performing remote acquisitions, E-Mail investigations- investigating email crime and violations, understanding E-Mail servers, specialized E-Mail forensics tool. |
| 9 | **Contents for lab (If applicable)** | NIL |
| 10 | **Evaluation pattern** | Midsem, Major, Assignment/ Quiz/ Presentation. |
| 11 | **List of text books/references** | **1.** Warren G. Kruse II and Jay G. Heiser, Computer Forensics: Incident Response Essentials, Addison Wesley, 2002.<br>2. Nelson, B, Phillips, A, Enfinger, F, Stuart, C., Guide to Computer Forensics and Investigations, 2nd ed., Thomson Course Technology, 2006, ISBN: 0-619-21706-5.<br>3. Vacca, J, Computer Forensics, Computer Crime Scene Investigation, $2^{nd}$ Ed, Charles River Media, 2005, ISBN: 1-58450-389. |

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| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | ES5XX |
| 4 | **Title of the subject** | Introduction to Game Theory |
| 5 | **Any prerequisite** | |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | ➢ |
| 8 | | Elements of Game theory, examples, Strategic Games, 2 Player Strategy Games, payoffs, Minimax, Weak and Strong Domination, Saddle Points, Nash Equilibrium, Prisoner's Dilemma, Stag Hunt.<br><br>Matching pennies, BOS, Multi NE, Cooperative and Competitive Games, Strict and Non Strict NE, Best response functions for NE, Combinatorial games, Winning and losing positions.<br><br>Subtraction Game, 3-Pile and K-Pile Games, Proof of Correctness, Variations of K-Pile Games, Graph Games, Construction, Proof of finiteness, SG theorem for sum of games.<br><br>Cournot's Oligopoly, Bertrand's Oligopoly, Electoral Competition, Median Voter Theorem, Auctions, role of knowledge, Decision making and Utility Theory, Mixed Strategy Equilibrium, Extensive Games with Perfect Information.<br><br>Stackelberg's model of Duopoly, Buying Votes, Committee Decision making, Repeated Games, Prisoner's Dilemma, Super modular Game and Potential games. |
| 9 | **Contents for lab (If applicable)** | |
| 10 | **Evaluation pattern** | Midsem, Major, Assignment/ Quiz/ Presentation. |
| 11 | **List of text books/references** | 1. Martin Osborne, An Introduction to Game Theory, Oxford University Press.<br>2. Games of Strategy, A. Dixit, S. Skeath, and D. Reiley, 3rd edition (NY: W.W. Norton & Company, 2009). |

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| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | ES5XX |
| 4 | **Title of the subject** | Data Visualization and Interpretation |
| 5 | **Any prerequisite** | |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | |
| 8 | **Brief Contents**<br><br>**(module wise )** | Introduction: Introduction to Data Science, Exploratory Data Analysis and Data Science Process. Motivation for using Python for Data Analysis, Introduction of Python shell iPython and Jupyter Notebook. Essential Python Libraries: NumPy, pandas, matplotlib, SciPy, scikit-learn, stats models<br><br>Getting Started with Pandas: Arrays and vectorized computation, Introduction to pandas Data Structures, Essential Functionality, Summarizing and Computing Descriptive Statistics. Data Loading, Storage and File Formats. Reading and Writing Data in Text Format, Web Scraping, Binary Data Formats, Interacting with Web APIs, Interacting with Databases Data Cleaning and Preparation. Handling Missing Data, Data Transformation, String Manipulation<br><br>Data Wrangling: Hierarchical Indexing, Combining and Merging Data Sets Reshaping and Pivoting. Data Visualization matplotlib: Basics of matplotlib, plotting with pandas and seaborn, other python visualization tools<br><br>Data Aggregation and Group operations: Group by Mechanics, Data aggregation, General split-apply-combine, Pivot tables and cross tabulation Time Series Data Analysis: Date and Time Data Types and Tools, Time series Basics, date Ranges, Frequencies and Shifting, Time Zone Handling, Periods and Periods Arithmetic, Resampling and Frequency conversion, Moving Window Functions.<br><br>Module V: Advanced Pandas: Categorical Data, Advanced Group By Use, Techniques for Method Chaining |
| 9 | **Contents for lab (If applicable)** | |
| 10 | **Evaluation pattern** | Midsem, Major, Assignment/ Quiz/ Presentation. |
| 11 | **List of text books/references** | 1.<br><br>2.<br><br>3. |

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| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | ES5XX |
| 4 | **Title of the subject** | Software Reliability |
| 5 | **Any prerequisite** | |
| 6 | **L-T-P** | |
| 7 | **Learning Objectives of the subject (in about 50 words)** | The syllabus for a course on Software Reliability typically encompasses theoretical foundations, practical methodologies, and tools used to ensure and measure the reliability of software systems. |
| 8 | **Brief Contents**<br>**(module wise)** | 1. Introduction to Software Reliability<br>2. Software Failure and Fault Models<br>3. Reliability Metrics and Measures<br>4. Software Reliability Models<br>5. Statistical Methods in Software Reliability<br>6. Fault Tolerance and Redundancy Techniques<br>7. Software Testing for Reliability<br>8. Fault Injection and Simulation<br>9. Software Maintenance and Reliability Improvement<br>10. Case Studies and Applications |
| 9 | **Contents for lab (If applicable)** | |
| 10 | **Evaluation pattern** | Midsem, Major, Assignment/ Quiz/ Presentation. |
| 11 | **List of text books/references** | 1. "Software Reliability Engineering: More Reliable Software Faster and Cheaper" by John D. Musa, Anthony Iannino, and Khaled El Emam.<br>2. "Software Fault Tolerance Techniques and Implementation" by Laura L. Pullum.<br>3. "Software Quality Engineering: Testing, Quality Assurance, and Quantifiable Improvement" by Jeff Tian. |

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| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | ESXXX |
| 4 | **Title of the subject** | Bayesian Data Analysis |
| 5 | **Any prerequisite** | |
| 6 | **L-T-P** | 3 0 0 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | |

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| 8 | **Brief Contents**<br><br>**(Module wise)** | Objective vs Subjective Definition of Probability, Axiomatic Definition of Probability, Bayes Theorem, Applications of Bayes Theorem, Decision Theoretic framework and major concepts of Bayesian Analysis, Likelihood, Prior and posterior, Loss function, Bayes Rule, Conjugate priors and other priors, Sensitivity Analysis, Posterior Convergence<br><br>One-parameter Bayesian models, Poisson Model for Count data, Binomial Model for Count data, Multi-parameter Bayesian models, Univariate Gaussian Model, Multivariate Gaussian Model, Covariance Matrix with Wishart Distribution, Bayesian solution for high-dimensional problem in Covariance matrix for Portfolio Risk Analysis, Multinomial-Dirichlet Allocation Models for Topic Model<br><br>Bayesian Machine Learning, Hierarchical Bayesian Model, Regression with Ridge prior, LASSO prior, Classification with Bayesian Logistic Regression, Discriminant Analysis<br><br>Bayesian Computation with stan, Estimation of Posterior Mode with Optimization, Estimation of Posterior Mean and other summary with Monte Carlo Simulation, Accept-Rejection Sampling, Importance Sampling, Markov Chain and Monte Carlo, Metropolis-Hastings, Hamiltonial Monte Carlo<br><br>Gaussian Process Regression, Introduction, Gaussian Process Regression for Big Data, Bayesian Optimization |
| 9 | **Contents for lab (If applicable)** | |
| 10 | **Evaluation pattern** | Midsem, Major, Assignment/ Quiz/ Presentation. |
| 11 | **List of text books/references** | 1. John Kruschke: *Doing Bayesian Data Analysis: A Tutorial with R, JAGS, and Stan* (2014), Academic Press<br>2. Carl Edward Rasmussen and Christopher K. I. Williams: *Gaussian Processes for Machine Learning*, MIT Press (2006) |

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| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | ES5XX |
| 4 | **Title of the subject** | Modeling and Simulation |
| 5 | **Any prerequisite** | Engineering Mathematics-I, Probability and Statistics, Differential Equations |
| 6 | **L-T-P** | 3-0-1 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | By the end of this course, students will be able to construct and analyze mathematical models, distinguish between deterministic and stochastic models, apply simulation techniques, and utilize probability concepts. They will also gain practical insights through case studies in engineering, healthcare, environment, and economics, enhancing their interdisciplinary modeling skills. |

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| 8 | **Brief Contents**<br><br>**(module wise)** | Introduction to Mathematical Modelling, compartmental models, population growth models etc. Deterministic and stochastic models, data-driven dynamical systems. Case studies and Applications in: Engineering, Physical, medicine and healthcare, environmental, social and economics.<br><br>Module IV: System Simulation, Monte Carlo methods, Continuous and Discrete time Simulation, Probability Concepts in Simulation, Queuing theory. |
| 9 | **Contents for lab (If applicable)** | o Simulation of Deterministic models (Using MATLAB/Python/R/Mathematica and Euler & Runge–Kutta methods).<br>a) Phase portraits b) Time series c) Nullcline plots<br>o Monte Carlo simulations<br>a) Finding value of pi b) Area under the curve c) Double integration d) Multiple integration e) Area of irregular shaped body<br>o Discrete Event simulation<br>a) Tossing a coin/dice simulation b) Singer server queue c) Multiple server queues d) Inventory problems |
| 10 | **Evaluation pattern** | Mid-sem, Major, Assignment/ Quiz/ Presentation. |
| 11 | **List of text books/references** | 1. Banks, J., Carson, I. I., Nelson, B. L., &Nicol, D. M. (2005). Discrete-event system simulation. Pearson.<br>2. Kishor S Trivedi, Probability & Statistics With Reliability, Queuing And Computer Science Applications, 2nd Ed, Wiley.<br>3. Geoffrey Gordon, System Simulation, Prentice-Hall. |

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| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | ES5XXX |
| 4 | **Title of the subject** | Data Science for Biology and Medicine |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | This is a course for the application of data science in biology and medicine. The course will introduce the fundamental principles on data science, the technologies and implementations of data mining, as well as the modeling of several practical questions in biomedicine. The topics include introduction to biomedical data, data visualization, regression methods and classification methods. |

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| 8 | **Brief Contents (module wise)** | Introduction to data science: overview of data science, type of biological and medical data, data collection and processing techniques, Ethics and privacy. Statistical Methods for Biological and Medical Data: Descriptive statistics, central tendency, variability, data visualization. Inferential statistics; Hypothesis testing, confidence intervals, p-values, various kinds of tests (t-test, chi-square etc.). Machine learning methods Supervised (regression, decision tree, support vector, neural networks) Unsupervised (Clustering, dimensionality reduction). Deep learning: Basics of deep learning, convolution neural network, recurrent neural networks (RNNs) for genomic data. Computational biology: system dynamics, Pathway and Network Analysis: Biological pathways, network models, applications in systems biology. |
| 9 | **Contents for lab (If applicable)** | NA |
| 10 | **Evaluation pattern** | Mid-sem, Major, Assignment/ Quiz/ Presentation. |
| 11 | **List of text books/references** | 1. Ivo D. Dinov. Data Science and Predictive Analytics, Biomedical and health applications using R. Springer<br>2. Malley JD, Malley KG, Pajevic S. **Statistical Learning for Biomedical** Data. Cambridge University press.<br>3. Costa J. Peter Applied Mathematics for the Analysis of Biomedical Data: Models, Methods, and MATLAB. Wiley.<br>4. White P. Data handling in Biomedical sciences. Cambridge University press. |

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| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | ES5XX |
| 4 | **Title of the subject** | Cyber Security and Cyber Law |
| 5 | **Any prerequisite** | NIL |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | ● To understand the fundamental concepts in cyber security and distinguish among the threats, attacks and vulnerabilities<br>● To differentiate, identify and explain different cyber crimes and frauds.<br>● To adopt and appreciate the best practices in cyber security and network security |

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| 8 | **Brief Contents** **(module wise )** | Introduction to Cyber Security, Implementing Hardware Based Security, Software Based Firewalls, Security Standards**.** Assessing Threat Levels, Forming an Incident Response Team, Reporting Cyber crime. Operating System Attacks, Application Attacks, Reverse Engineering & Cracking Techniques and Financial Frauds. Introduction to IT laws & Cyber Crimes – Internet, Hacking, Cracking, Viruses, Virus Attacks, Software Piracy. Intellectual property, Legal System of Information Technology, Social Engineering, Mail Bombs, Bug Exploits |
| 9 | **Contents for lab (If applicable)** | NIL |
| 10 | **Evaluation pattern** | Midsem, Major, Assignment/ Quiz/ Presentation. |
| 11 | **List of text books/references** | 1. Alfred Basta, Cyber Security and Cyber Laws, Cengage Publishers,<br>2. Elma Sibonghanoy Groenewald, Coenrad Adolph Groenewald, Cyber Law and Cyber Security, PIP, ISBN: 9789360100872<br>3. William Stallings, Cryptography and Network Security, , Pearson Education |

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| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | ES5XX |
| 4 | **Title of the subject** | Quantum Computing |
| 5 | **Any prerequisite** | Knowledge of Elementary Quantum Mechanics |
| 6 | **L-T-P** | 3-0-1 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | Fundamentals of Quantum Computation, Quantum mechanics vis-à-vis quantum computing, Quantum entanglement, Quantum gates and circuits, Quantum Algorithms, Teleportation and Superdense coding, Quantum Noise & Error correction, Quantum Computers-Physical realization, Topological quantum computing |
| 8 | **Brief Contents** **(module wise )** | **Qubits and quantum states: C**lassical & quantum information, qubits, quantum computing and laws of physics, quantum information, quantum computers, vector spaces, postulates of quantum mechanics, linear combinations, basis & dimensions, inner products, Cauchy-schwartz and triangle inequalities.<br><br>M**atrices & Operators -** Pauli operators, outer products & matrix representation, Hermitian, unitary & normal operators, eigenvalues and eigenvectors, characteristic equation, trace of an operator, expectation value of an operator, projection operators**.**<br><br>**Entanglement & Quantum Gates:** Entanglement, exchange of information using entangled particles, Bell's theorem, Bipartite systems and the Bell basis. |

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| | | classical logic gates and circuits, one qubit quantum gates, the Hadamard gate, two qubit quantum gates- the CNOT gate, three qubit quantum gates- The Fredkin gate, The Toffoli gate, quantum circuits, universal quantum gates.<br><br>**Quantum Algorithms & Cryptography:** classical to quantum Turing machines, computational complexity, quantum algorithms, quantum interference, Deutsch's algorithm, The Deutsch-Josza Algorithm, Shor's Algorithm, Grover's Algorithm, quantum cryptography, BB84-emergence of quantum cryptography, quantum noise and error correction. |
| 9 | **Contents for lab (If applicable)** | Hands on – QISKIT software |
| 10 | **Evaluation pattern** | Mid Sem-20%<br><br>Assignment/project/Qizzes- 10%<br><br>Major- 50%<br><br>Lab work-20% |
| 11 | **List of text books/references** | 1. Quantum Computing Explained- David McMahon, Wiley Interscience<br>2. Quantum computing- Mika Hirvensalo<br>3. Quantum Computation and Quantum Information-Michael Nielsen & Chuang<br>4. An introduction to quantum computing- Phillip Kaye<br>5. Lectures on Quantum Information- Dagmar Brub, Gerd Leuchs<br>6. Quantum Computing- J. Stolze, Dieter Suter |

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| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | ES5XX |
| 4 | **Title of the subject** | Data Analytics for Materials Science |
| 5 | **Any prerequisite** | Basic knowledge of Probability and linear algebra |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | The objective of the Data Analytics for Materials Science course is to provide students with the skills and knowledge necessary to effectively analyze and interpret data related to materials science. The course will cover key concepts in data analytics, including data collection, preprocessing, visualization, and modeling, with a specific focus on applications in materials research and development. By the end of the course, students will be able to:<br><br>- Understand the fundamentals of data analytics and its importance in materials science research<br>- Collect, clean, and preprocess data from various sources relevant to materials characterization and development<br>- Apply appropriate data visualization techniques to explore and communicate insights from materials science data<br>- Build and evaluate predictive models using machine learning algorithms to forecast materials properties and performance |

| | | |
|---|---|---|
| | | - Interpret model outputs and make data-driven decisions in materials research and development<br>- Effectively communicate data-driven insights to stakeholders in the materials science domain |
| 8 | **Brief Contents**<br><br>**(module wise )** | Introduction to Materials Science and Informatics<br><br>Exploratory Data Analysis and Visualization for Materials<br><br>Machine Learning for Materials Science<br><br>Deep Learning for Materials Science. Applications, Communication, and Ethics in Materials Data Analytics |
| 9 | **Contents for lab (If applicable)** | |
| 10 | **Evaluation pattern** | Midsem, Major, Assignment/ Quiz/ Presentation. |
| 10 | **List of text books/references** | 1. Stefan Sandfeld, Introduction to Data Mining, Machine Learning, and Data-Driven Predictions for Materials Science and Engineering, Springer Cham, 2024.<br>2. Jeffrey P. Simmons, Lawrence F. Drummy, Charles A. Bouman, Marc De Graef, Statistical Methods for Materials Science (The Data Science of Microstructure Characterization), CRS Press (Taylor & Francs Group), 2019<br>3. Hierarchical Materials Informatics: Novel Analytics for Materials Data, by Dr. Surya R. Kalidindi<br>4. Materials Informatics: Methods, Tools, and Applications by by Olexandr Isayev (Editor), Alexander Tropsha (Editor), Stefano Curtarolo (Editor)<br>5. Informatics for Materials Science and Engineering: Data-driven Discovery for Accelerated Experimentation and Application 1st Edition by Krishna Rajan |

| | | |
|---|---|---|
| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | ES5XX |
| 4 | **Title of the subject** | Business Data Analytics |
| 5 | **Any prerequisite** | Basic knowledge of Probability and Statistics |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | By the end of this course, students will:<br><br>- Understand core statistical concepts relevant to business.<br>- Learn data visualization, descriptive statistics, and inferential techniques.<br>- Apply regression, forecasting, and decision-making tools.<br>- Use Excel, R, or Python for data analysis |
| 8 | **Brief Contents**<br><br>**(module wise)** | Introduction to Business Analytics and Data-Driven Decision Making, Types of Business Data: Qualitative vs Quantitative, Cross-sectional vs Time-series, Data Sources, Sampling Techniques, and Data Cleaning Basics,<br><br>Business Data Visualization: Charts, Histograms, Boxplots, Introduction to Pivot Tables and Summary Statistics in Excel/Python/R. |

| | | |
|---|---|---|
| | | Business Forecasting using Time Series, Unit 5: Business Prediction Using Generalised Linear Model, machine learning models for Businesses, data blending, Decision Analytics and Calculations |
| 9 | **Contents for lab (If applicable)** | No |
| 10 | **Evaluation pattern** | Midsem, Major, Assignment/ Quiz/ Presentation. |
| 10 | **List of text books/references** | W. Winston, S. Albright Business Analytics: Data Analysis and Decision Making – Albright, Winston. South-Western College Publishing<br><br>Paul Newbold, William Carlson, Betty Thorne. Statistics for Business and Economics –<br><br>John W. Foreman (Wiley) Data Smart: Using Data Science to Transform Information into Insight –<br><br>Andrew Siegel Practical Business Statistics<br><br>Wes McKinney. Python for Data Analysis |

| | | |
|---|---|---|
| 1 | **Semester** | |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | ES5XX |
| 4 | **Title of the subject** | Innovation and Entrepreneurship |
| 5 | **Any prerequisite** | |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject (in about 50 words)** | Course is designed for preparing students to take of Entrepreneurial journey on the basis of innovative ideas. The content is highly focused to start venture to making business mature up-to international level.. |
| 8 | **Brief Contents**<br><br>**(module wise)** | Entrepreneurship, Creativity and innovation, Business planning<br><br>process, Institutions supporting entrepreneurs, Family<br><br>businesses, International entrepreneurship opportunities,<br><br>Informal risk capital and venture capital, Managing growth |
| 9 | **Contents for lab (If applicable)** | |
| 10 | **Evaluation pattern** | Midsem, Major, Assignment/ Quiz/ Presentation. |
| 11 | **List of text books/references** | |

Curriculum & Contents

# Master of Business Administration (MBA)

**Department of Management Studies**

विश्वजीवनामृतं ज्ञानम्

ABV-Indian Institute of Information Technology & Management, Gwalior

# SCHEMA

**Name of the program: Master of Business Administration**

**(Credits: 111)**

**Name of the Department: Management Studies**

**Focus of MBA-I Year:** The First Year of the programme intends to impart the general management principles and practices along with the analytical ability required for modern businesses.

**Focus of MBA-II Year:** The second year of the programme is intended to provide specialized and sectorial management ability through a blend of technology-embedded analytics. The students can flexibly choose their area of specialization in the six baskets of electives. The four massive open online courses complement the chosen basket of electives openly to meet the business needs of students.

**Credit Requirement:** First Year (Semester I+II+ Summer Term): 26+27+4=57

Second Year (Semester III+IV): 30+24=54

**Total Credits: 111**

| **SEMESTER-I** | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject Code** | **Title of the course** | **L-T-P** | **Credits** |
| **1** | MS600 | Foundation of Mathematics and Computer Programming | 1-0-2 | 2 |
| **2** | MS601 | Principles and Practices of Management | 3-0-0 | 3 |
| **3** | MS602 | Business Statistics | 3-0-0 | 3 |
| **4** | MS603 | Business Economics | 3-0-0 | 3 |
| **5** | MS604 | Business and Legal Environment | 3-0-0 | 3 |
| **6** | MS605 | Financial Reporting and Control | 3-0-0 | 3 |
| **7** | MS606 | Organizational Behavior | 3-0-0 | 3 |
| **8** | MS607 | IoT and Big Data Management | 3-0-0 | 3 |
| **9** | MS608 | International Business | 3-0-0 | 3 |
| | | Computational laboratory (based on semester courses) | Part of course MS607 | |
| | | | **Total credits** | **26** |

| SEMESTER-II | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject code** | **Title of the course** | **L-T-P** | **Credits** |
| **1** | MS609 | Human Resource Management | 3-0-0 | 3 |
| **2** | MS610 | Operations Management | 3-0-0 | 3 |
| **3** | MS611 | Marketing Management | 3-0-0 | 3 |
| **4** | MS612 | Financial Engineering and Management | 3-0-0 | 3 |
| **5** | MS613 | Business Research Method | 3-0-0 | 3 |
| **6** | MS614 | Decision Modelling and Optimization | 3-0-0 | 3 |
| **7** | MS615 | Artificial Intelligence and Machine Learning | 3-0-0 | 3 |
| **8** | MS616 | Project Management | 3-0-0 | 3 |
| **9** | MSA03 | Seminar on Contemporary Business* | 0-0-2 | 0 |
| **10** | | Massive Open Online Course (MOOC-1) | 0-0-6 | 3 |
| | | Computational laboratory (based on semester courses) | Part of the course MS615 | |
| | | | **Total credits** | **27** |

***Compulsory Audit course for MBA batch**

**Summer Term**

| | | | | |
|---|---|---|---|---|
| 1 | MS697 | Summer term of 6-8 weeks (Industry project. R&D Project etc.) | 0-0-8 | 4 |

**Remark:** If some student quits the MBA programme after successful completion of the first year, the student may be awarded a "Post Graduate Diploma in Management."

EXIT AFTER YEAR-1: Post Graduate Diploma in Management

| SEMESTER-III | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject code** | **Title of the course** | **L-T-P** | **Credits** |
| **1** | MS618 | Strategic Management | 3-0-0 | 3 |
| **2** | MS619 | Entrepreneurship and Innovation | 3-0-0 | 3 |
| **3** | MS620 | Business Process Management | 3-0-0 | 3 |
| **4** | MS621 | Business Ethics and Sustainability | 3-0-0 | 3 |
| **5** | | Elective-I | 3-0-0 | 3 |
| **6** | | Elective-II | 3-0-0 | 3 |
| **7** | | Elective-III | 3-0-0 | 3 |
| **8** | | Massive Open Online Course (MOOC-2) | 3-0-0 | 3 |
| **9** | MS698 | Major Project Part-I | 0-0-12 | 6 |
| | | | **Total credits** | **30** |

| SEMESTER-IV | | | | |
|---|---|---|---|---|
| **S. No.** | **Subject Code** | **Title of the course** | **L-T-P** | **Credits** |
| **1** | | Elective-IV/ Massive Open Online Course (MOOC-3) | 3-0-0 | 3 |
| **2** | | Elective-V/ Massive Open Online Course (MOOC-4) | 3-0-0 | 3 |
| **3** | MS699 | Major Project Part-II | 0-0-36 | 18 |
| | | | **Total credits** | **24** |

| SEMESTER-I | SEMESTER-II | SUMMER TERM | SEMESTER-III | SEMESTER-IV | TOTAL CREDITS |
|---|---|---|---|---|---|
| 26 | 27 | 04 | 30 | 24 | **111** |

**Composition of Electives:** A student has to choose 07 electives from the basket of 04 MOOC courses and 05 Departmental Electives. The composition of electives shall be a minimum of 03 from the departmental electives and a minimum of 02 from MOOC electives, and the remaining two electives may be flexibly chosen either from the department or from MOOC electives.

**List of suggested courses for MOOC:** MOOC courses should be relevant to the area of management programs catering to the need for specialization and relevant to the frontier areas of technology, information technology, or management fulfilling modern business needs and are not being offered as in-house courses of ABV-IIITM Gwalior.

***Specialization in the MBA degree:*** A student will be able to earn specialization in a particular area(s) by earning a minimum of ***15 credits (ordinarily equal to 05 courses)***. MOOC courses for the IV Semester will be given as per institute norms.

**Exit Option from MBA Program:** A student can exercise the option of program exit after completing the First Year of the DoMS MBA. In such a scenario, the student may be awarded the **certificate of *Post Graduate Diploma in Management.***

# Electives Courses

| S. No. | **Electives I, II, III, IV and V Category from the basket of Information Technology and Systems** |
|---|---|
| MS001 | Digital Production System |
| MS002 | IT Products and Intellectual Property Rights |
| MS003 | Management of Digital Technologies |
| MS004 | Knowledge Management |
| MS005 | Service-Oriented Computing |
| MS006 | Social Networks Analytics |
| MS007 | Software Project Management |
| MS008 | Software Quality Management |
| MS009 | Programming for Business Intelligence |
| MS010 | Strategic Planning of Information Systems |

| S. No. | **Electives I, II, III, IV and V Category from the basket of Technology and Operations Management** |
|---|---|
| MS011 | Business Systems Simulation |
| MS012 | Service Operations Management |
| MS013 | Sustainable Supply Chain Management |
| MS014 | Technology Management |
| MS015 | Technology and Operations Strategy |
| MS016 | Total Quality Management |
| MS017 | World Class Production Systems |
| MS018 | Emerging Areas in Technology and Operations Management |
| MS019 | New Products and Services Development |
| MS020 | Operational Intelligence |

| S. No. | Electives I, II, III, IV and V Category from the basket of Human Resource Management |
|---|---|
| MS021 | Compensation Management |
| MS022 | Change Management |
| MS023 | Corporate Social Responsibility |
| MS024 | Competency Management |
| MS025 | Human Resource Information System |
| MS026 | Emerging Areas in Human Resource |
| MS027 | Organization Theory and Development |
| MS028 | Leadership and Talent Management |
| MS029 | Training and Development |
| MS030 | Management of Employee Relations |

| S. No. | Electives I, II, III, IV and V Category from the basket of Finance |
|---|---|
| MS031 | Corporate Restructuring |
| MS032 | Corporate Tax Planning |
| MS033 | Economic and Financial Modeling |
| MS034 | Entrepreneurial Finance |
| MS035 | Management of Financial Services |
| MS036 | Financial Risk management |
| MS037 | Personal Wealth Management |
| MS038 | International Finance |
| MS039 | Project Appraisal and Finance |
| MS040 | Security Analysis and Portfolio Management |

| S. No. | Electives I, II, III, IV and V Category from the basket of Marketing Management |
|---|---|
| MS041 | Consumer Behavior |
| MS042 | Advertisement and Sales Promotion Management |
| MS043 | Product and Brand Management |
| MS044 | E-marketing |
| MS045 | Retail Management |
| MS046 | International Marketing |
| MS047 | Sales and Distribution |
| MS048 | Marketing Research |
| MS049 | Service Marketing |
| MS050 | Strategic Marketing |

| S. No. | Electives I, II, III, IV and V Category from the basket of Management of Social Sector |
|---|---|
| MS051 | Public Policy and Processes |
| MS052 | Public Private Partnerships |
| MS053 | Sustainable Development |
| MS054 | Management of Rural and Social Sector |
| MS055 | Information Technology Enabled Services |
| MS056 | Management of Non-Formal Organization |
| MS057 | Healthcare System Management |
| MS058 | Emerging Areas in Management of Social Sector |
| MS059 | Infrastructure Management |

# Course Contents

| | | |
|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | MS600 |
| 4 | **Title of the subject** | Foundations of Mathematics and Computer Programming |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 1-0-2 |
| 7 | **Learning Objectives of the subject** | This course aims to provide basic concepts of mathematics, statistics and computer systems for the purpose of setting foundation for subsequent development of quantitative skill sets in the broad areas of operations, economics, finance and marketing. |
| 8 | **Brief Contents** | Fundamental concepts of linear algebra, statistical representation of data, calculus, probability and distributions,<br><br>Fundamental concepts of computer organisation and architecture, memory and storage systems, computer codes, operating systems, Boolean algebra, communications and networks, computer programming and application packages |
| 9 | **Contents for lab** | Yes |

| | | |
|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | MS601 |
| 4 | **Title of the subject** | Principles and Practices of Management |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Element of Management is concerned with the way in which organizations manage their resources. The aim is to explore the concepts of management, managers, and organizations in today's dynamic environment. This course outline illustrates the varied backgrounds, skills, and characteristics required for successful managers. It continues with an examination of the functions of management, managerial roles and diverse nature of modern business organizations, and rewards and challenges offered by a career in management. |
| 8 | **Brief Contents** | Explain what is meant by the term management, Classify the three levels of managers and identify the primary responsibility of each group, Describe the difference between managers and operative employees, Explain the skills and roles manager, Describe the value of studying management, Identify the relevance of popular humanities and social science courses to management practices, Define planning. |

| | | |
|---|---|---|
| | | Explain the potential benefits of planning, Distinguish between strategic and tactical plans, Define management by objectives and identify its common elements, Outline the steps in the strategic management process, Explain SWOT analysis, Describe the steps in the decision-making process, Identify the assumptions of the rational decision-making model, Define certainty, risk, and uncertainty as they relate to decision making, Identify the two types of decision problems and the two types of decisions that are used to solve them, Describe the advantages and disadvantages of group decisions, Identify and define the six elements of organization structure, Contrast mechanistic and organic organizations, Summarize the effect of strategy, size, technology, and environment on organization structures, Contrast the divisional and functional structures, Define leader and explain the difference between managers and leaders, Describe the skills that visionary leader exhibit, Explain the styles and theories of leadership, Define Motivation at work, Techniques of motivation, Theories of motivation, Explain what is meant by the term learning organization, Define control, Describe three approaches to control, Explain why control is important, Describe the control process, Distinguish among the three types of control, Describe the qualities of an effective control system, Explain how controls can become dysfunctional |
| 9 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | MS602 |
| 4 | **Title of the subject** | Business Statistics |
| 5 | **Any prerequisite** | Basic knowledge of mathematics and statistics |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To understand the role of statistics in the field of business management. To understand the process associated with statistical decisions, defining and formulating problems, analysing the data, and using the results in decision making. |
| 8 | **Brief Contents** | Introduction to Statistics, Charts and Graphs, Measures of central tendency, Measures of dispersion, Probability, Discrete probability distribution, Continuous probability distribution Sampling and sampling distributions, Statistical inference: Estimation for single populations, Statistical inference: Hypothesis testing for single population, Statistical inference: Hypothesis testing for two populations, Analysis of variance and Experimental designs, Hypothesis testing for categorical data (chi-square test), Simple linear regression analysis , Multiple regression analysis, Time series and Index numbers, Statistical quality control, Non-parametric statistics, Statistical decision theory |
| 9 | **Contents for lab** | Application of appropriate statistical software |

| | | |
|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | MS603 |
| 4 | **Title of the subject** | Business Economics |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Managerial Economics is the use of economic theory and mathematical and statistical techniques in order to examine how a firm can make optimal managerial decisions given the constraints it faces. The main objective of this course is to equip students with the necessary theory and techniques and the ability to apply them in order to inform and enhance managerial decision making. Topics covered include: goals of the firm, optimization techniques, demand theory and estimation, forecasting and measurement, theory of production and estimation, cost theory and estimation, pricing and output determination under different market structures, game theory, and pricing in practice. |
| 8 | **Brief Contents** | Introduction to Economics; Nature and Scope of Management Economics, Significance in decision-making and fundamental concepts, Consumer behaviour and typical characteristics of Indian consumer, Consumer decision making process, Indian market: characteristics, Objectives of a firm, Demand Analysis, Law of Demand, Exceptions to the law of Demand, Determinants of Demand. Elasticity of Demand- Price, Income, Cross and Advertising Elasticity, Uses of Elasticity of Demand for managerial decision making, Measurement of Elasticity of Demand, Demand forecasting meaning, significance and methods, Supply Analysis, Law of Supply, Supply Elasticity, Analysis and its uses for managerial decision making, Production concepts & analysis, Production function, single variable-law of variable proportion, two variable-Law of returns to scale, Cost concept and analysis, short-run and long-run cost curves and its managerial use, Market Equilibrium and Average Revenue Concept, Market Structure: Perfect Competition, features, determination of price under perfect competition, Monopoly: Feature, pricing under monopoly, Price discrimination, Monopolistic: Features, pricing under monopolistic competition, product differentiation, Oligopoly: Features, kinked demand curve, cartels, price leadership, Pricing strategies Price determination, Full cost pricing, Product line pricing, Price skimming, Penetration pricing, National Income; Concepts and various methods of its measurement, Inflation, types and causes, Business cycle, Profit concept and major theories of profits; Dynamic Surplus theory, Risk & Uncertainty bearing theory and Innovation theory |
| 9 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | MS604 |
| 4 | **Title of the subject** | Business and Legal Environment |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | This course will give orientation to the students about different forms of organizations, functions in organizations, business environment and strategies, along with an exposure to basic elements of company laws, economics laws, industrial and labour laws, foreign exchange management act in business perspective. |
| 8 | **Brief Contents** | Concepts of Vision and Mission statements, Types of Environments, Business Environment with reference to Global integration, Forms of business organisation: Scales of business; Emerging trends in business, Company Laws: The Companies Act 2013, Limited Liability Partnership Act, 2008, The insolvency and bankruptcy code 2016, Economic Laws: FDI Policy-Foreign Direct Investment in India and abroad, External Commercial Borrowing (ECB), Formalities-Establishment of Branch Office of a foreign entity in India, Foreign Trade Policy- Opportunities of commerce/finance professional in foreign trade-Procedure of import and export-Export promotion schemes and initiatives, Competition Commission of India-Compliance of competition law, Industrial and Labour laws: Overview of Industrial Policy of Govt. of India, Regulatory Mechanism under IDRA, MSME Development Act, Advantages of MSMEs and their role and significance in economic development, Central and State Schemes for MSME Promotion-Udyog Aadhar, Foreign Exchange Management Act: Features and Application-Opportunities for Indian Business Challenges, Foreign Contribution (Regulation) Act 2010 |
| 9 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | MS605 |
| 4 | **Title of the subject** | Financial Reporting and Control |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | After the completion of this course, students will be able to understand the role and relevance of financial accounting in management and its implications for a business entity, and utility of cost and management accounting information as a vital input for management and decision-making process. |

| | | |
|---|---|---|
| 8 | **Brief Contents** | Introduction, nature and scope of financial and management accounting, GAAP and accounting environment, Principles, concepts and conventions of accounting, Accounting process, Construction of profit and loss statement, Balance sheet and cash flow statement, Concept of financial statements analysis, Horizontal and vertical Analysis, Trend analysis, Ratio analysis, Cash flow statement analysis, Cost accounting and information, Types of cost, Preparation of cost sheet, Activity-based costing, Concepts of budget and budgetary control, Static and flexible budgets, Preparation of sales budget, Production budget, Material budget, Cash budget, Master budget, Concept of standard costing and variance analysis, Setting of standards, Analysis of material variances, Labour variances and overhead variances, Marginal costing and absorption costing, Marginal costing, and its applications, Cost-volume-profit analysis, Concept of contribution and break-even analysis and its uses, Margin of safety and angle of incidence. |
| 9 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | MS606 |
| 4 | **Title of the subject** | Organizational Behavior |
| 5 | **Any prerequisite** | General Understanding of Management Functioning |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To provide a comprehensive analysis of individual and group behaviour in the organizations. To provide an understanding of how organizations can be managed more effectively and at the same time enhancing the quality of employees work life. |
| 8 | **Brief Contents** | What is organizational behaviour? OB as an interdisciplinary subject, The Individual: Diversity in the organizations, attitudes and job satisfaction, emotions and moods, personality and values, perception and individual decision making, motivation concepts, motivation: from concepts to applications The Group: Foundations of group behaviour, understanding work teams, communication, leadership, power and politics, conflict and negotiations, foundations of organization structure, The Organization system Organizational culture, human resource policies and practices, organizational change and stress management |
| 9 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | MS607 |
| 4 | **Title of the subject** | IoT and Big Data Management |
| 5 | **Any prerequisite** | Fundamentals of Computer/ Computer organization and any programming language |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Upon course completion, students will be able to: Understand deploying smart applications on different IoT platforms. Develop Interface of various sensors, I/O devices and I/O peripherals with N/W Protocols. Understand the impact of big data for business decisions and strategy. Gain hands-on experience on large-scale analytics tools to solve some open big data problems. Understand the concept and challenge of big data and why existing technology is inadequate to analyze the big data |
| 8 | **Brief Contents** | Design principles and needed capabilities, AI applications in IoT Applications, Sensing, Actuation, Basics of networking, M2M and IoT technology fundamentals- devices and gateways, Data management, Business processes in IoT, Everything as a Service (XaaS), Role of Cloud in IoT, Security aspects in IoT, Components selection criterion for implementing IoT application, Hardware components computing (Node MCU, Raspberry Pi), Communication, Sensing, Actuation, I/O interfaces, Software components- programming API's (using Python/Node.js/Arduino), Sensors interfacing: Interfacing of temperature, Humidity, Light, Accelerometer, Ultrasonic, IR/PIR, Camera etc, Communication and I/O components, Interfacing: bluetooth, WiFi, GSM, Displays and touch sensor etc., Types of Digital Data, Introduction to Big Data, Big Data Analytics, Relational Databases & SQL, Data Cleansing and Preparation, History of Hadoop, Apache Hadoop, Analysing Data with Unix tools, analyzing data with Hadoop, Hadoop Streaming, IBM Big Data Strategy, Infosphere Big Insights and Big Sheets, HDFS (Hadoop Distributed File System): The Design of HDFS, HDFS concepts, Command Line Interface, Hadoop file system interfaces, Data flow, Data ingest with Flume and Scoop and Hadoop archives, NoSQL, Types of NoSQL database, Advantages, New SQL, Comparison of SQL, NoSQL and NewSQL., Supervised learning with regression and classification techniques, Bias-Variance trade-off, Model validation approaches, Logistic regression, Linear discriminant analysis, Quadratic discriminant analysis, Ensemble methods: random forest neural networks, Deep learning unsupervised learning and challenges for big data analytics, Clustering, associative rule mining, Challenges for big data analytics prescriptive analytics, Creating data for analytics through designed experiments, Creating data for analytics through active learning, Creating data for analytics through reinforcement learning. |
| 9 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | MS608 |
| 4 | **Title of the subject** | International Business |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The goal of this course is to introduce participants to the field of international business. This course will make participants familiar with three basic areas: underlying theories of international business, environmental factors affecting international activities, and the management of business functional operations in an international context. In addition, participants will learn how to analyse international situations and evaluate contemporary issues in international business. |
| 8 | **Brief Contents** | Background for International Business: Globalization and International Business, Comparative Environmental Frameworks: The Cultural environments facing business, The Political and Legal environments facing business, The Economic environments facing business, Globalization and Society, Theories and Institutions: Trade and Investment:<br>International trade and Factor mobility theory, Governmental Influence on trade, Cross-National cooperation and agreements World Financial Environment Global Foreign: Exchange markets, The Determination of Exchange rates, Global capital markets, Global Strategy, Structure, and Implementation: The Strategy of international business, Country evaluation and selection, Export and Import, Direct investment and Collaborative strategies, The Organization of international business, Managing International Operations: Marketing globally, Global operations and supply-chain management, International accounting and finance issues, International human resource management |
| 9 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Audit |
| 3 | **Code of the subject** | MSA01 |
| 4 | **Title of the subject** | Mathematical Foundation For Management |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 1-0-0 |
| 7 | **Learning Objectives of the subject** | An introduction to the mathematical skills and techniques used in business or in preparation for M.B.A. coursework. Designed to provide a solid foundation in Mathematics and Statistics as well as explore basic math principles in the context of business, economics, budgeting, statistics, and probability. Emphasis will be on applying these |

| | | |
|---|---|---|
| | | principles to the study of economics, finance, mathematical analysis of investments, decision making, and other business applications. |
| 8 | **Brief Contents** | 1. Essentials of set theory<br>2. Elements of Number theory<br>3. Simple algebraic tools<br>4. Analysis of real functions of one variable<br>5. Differentiation<br>6. Partial Differentiation<br>7. Simple Integration<br>8. Single-variable optimization<br>9. Determinant<br>10. Matrices<br>11. Probability and Distribution |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | I |
| 2 | **Type of course** | Audit |
| 3 | **Code of the subject** | MSA02 |
| 4 | **Title of the subject** | Introduction to Computer System |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 1-0-0 |
| 7 | **Learning Objectives of the subject** | After the completion of this course students will be able to understand the organization and the environment in which it functions and competes. The student should be able to integrate acquired knowledge of other functional areas with the body of the knowledge of strategic management and be able to deploy all as a unified tool to analyse and formulate the actions that shall deliver the intended results. |
| 8 | **Brief Contents** | **1. Knowing computer:** What is Computer, Basic Applications of Computer; Components of Computer System, Central Processing Unit (CPU), VDU, Keyboard and Mouse, Other input/output Devices, Computer Memory, Concepts of Hardware and Software; Concept of Computing, Data and Information; Applications of IECT; Connecting keyboard, mouse, monitor and printer to CPU and checking power supply.<br><br>2. **Operating Computer using GUI Based Operating System**: What is an Operating System; Basics of Popular Operating Systems; The User Interface, Using Mouse; Using right Button of the Mouse and Moving Icons on the screen, Use of Common Icons, Status Bar, Using Menu and Menu-selection, Running an Application, Viewing of File, Folders and Directories, Creating and Renaming of files and folders, |

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| | | Opening and closing of different Windows; Using help; Creating Short cuts, Basics of O.S Setup; Common utilities.<br><br>3. **Understanding Word Processing**: Word Processing Basics; Opening and Closing of documents; Text creation and Manipulation; Formatting of text; Table handling; Spell check, language setting and thesaurus; Printing of word document.<br><br>**4. Using Spread Sheet**: Basics of Spreadsheet; Manipulation of cells; Formulas and Functions; Editing of Spread Sheet, printing of Spread Sheet.<br><br>5. **Introduction to Internet, WWW and Web Browsers**: Basic of Computer networks; LAN, WAN; Concept of Internet; Applications of Internet; connecting to internet; What is ISP; Knowing the Internet; Basics of internet connectivity related troubleshooting, World Wide Web; Web Browsing softwares, Search Engines; Understanding URL; Domain name; IP Address; Using e-governance website |
| 9 | **Contents for lab** | Yes |

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|---|---|---|
| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | MS609 |
| 4 | **Title of the subject** | Human Resource Management |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Human Resource Management (HRM) is concerned with the way in which organizations manage their people. The aim is to chart some of the broad terrain of a rapidly developing field of study in order to prepare the students for the more finely grained treatment of specific HRM topics. This course outline examines the recent rise of HRM, the effects of the changing context of work on HRM, what it involves, and the strategic nature of HRM practice, its impact on organizational performance and the changing role of HRM function. |
| 8 | **Brief Contents** | Define HRM, Describe the Nature, Feature and Scope of HRM, Describe the major activities of HRM, Explain the skills and roles of Human Resource manager, Why HRM is important to all managers, List the challenges and opportunities of HR manager, Define Job Analysis, Explain types of Job analysis, Understand Job Analysis Process, Describe the basic methods of collecting the Job analysis information, Define HR planning, Describe the need and objectives of HR planning, Understand the HR planning model, Explain the factors affecting HR planning, Define Recruitment, Explain essential steps for Recruitment Planning, Understand Recruitment model, Describe sources of Recruitment, Explain the Pros and Cons of recruitment, |

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| | | Define selection , Steps / process of selection, Define Employee training, Explain need and objectives of training, Differentiate between training and development, Describe the principles, areas and benefits of training, Understand the Training Methods, Describe Training system model, Understand levels of training evaluation, Define Career and its related terms, Understand stages of growth and career, Describe Career-planning process and its responsibility, Understand the benefits of Career development system, Know the career program for special target groups, Explain the Model or Designing organizational career development, Define Performance appraisal, Explain why it is important to effectively appraise performance, Understand features, purposes and objectives of performance appraisal. Describe the methods of performance appraisal. List the criticism of performance appraisal. |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | MS610 |
| 4 | **Title of the subject** | Operations Management |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Upon successful completion of the course, student should be able to: Understand the role of operations in both manufacturing and service organizations. Describe the importance of facilities location decision in the end-to-end supply chain. Develop understanding of a range of inventory models available their contextual suitability. Employ different quality prescriptive and the tools of statistical process control. |
| 8 | **Brief Contents** | Operations and strategy: nature, evolution and scope of production and operations management, Emerging trends in operations management, Operations strategy: linkage with competitive strategy and formulation of operations strategy, Facility Planning: facilities location: globalization of operations, Factors affecting location decisions, Location planning methods, Linkage with supply chain network design decisions, Process Management: Design of production process and facility layout, Process design and analysis, Design of products and services: process of product and service design, Tools, Critical chain, Just-in-time, Lean operations and Toyota production system, Inventory Management: deterministic models, Probabilistic models: multi-period and single period (news vendor) models, Selective inventory models, Aggregate production planning (APP), Master production schedule (MPS), Materials requirements planning (MRP), Quality management, Statistical process control (SPC), Process capability and Six Sigma. |
| 9 | **Contents for lab** | Simulation exercises on Arena |

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|---|---|---|
| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | MS611 |
| 4 | **Title of the subject** | Marketing Management |
| 5 | **Any prerequisite** | Basic understanding of microeconomics |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To understand the fundamental marketing concepts and the processes that influences the market orientation of a firm. To understand the role of marketing within the organization. To recognize the importance of marketing in the competitive world. To analyze critically the marketing process and its relationship with the environment within which it operates. To broadly look at the role of Marketing as a key element within an organization's strategy. |
| 8 | **Brief Contents** | Introduction to Marketing- Definition of marketing, Marketing environment, Business models and value chain, Segmentation and targeting- Concept of segmentation, Bases of segmentation (B2C & B2B), Targeting, Application in real life scenario, Positioning and differentiation- Differentiation parameters, POP& POD, Competition, Consumer Behavior- Consumer decision making process, factors influencing consumer behavior, B2B Marketing- Organizational decision making process, buying roles, Marketing strategy (product, service and pricing decisions)- Product strategy, branding, service, pricing strategy, Marketing strategy (place decisions)- Channels of distribution, Distribution strategy, Marketing strategy (promotion decisions)- Integrated marketing communication, Advance topics in marketing- Predictive, contextual, augmented and agile marketing. |
| 9 | **Contents for lab** | Simulation on marketing environment<br>Case study exercises<br>Class projects and exercises<br>Field projects and company visits |

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|---|---|---|
| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | MS612 |
| 4 | **Title of the subject** | Financial Engineering and Management |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The course aims at providing an understanding of financial engineering and management concepts. This will enable to understand how corporations make investment & financing decisions with dynamic risk exposures. It will help develop the financial engineering fundamentals for proper risk mitigation. |
| 8 | **Brief Contents** | Changing Financial arena and associated risks, Financial engineering as a response to increased risks, Types of Risks and Risk management, |

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|---|---|---|
| | | Financial markets, Financial institutions, Financial services, Financial instruments,. Financial Management: Nature, Scope, and Objectives of financial management, Time value of money, Risk and return, Capital Structure and Cost of Capital: Capital structure theories and leverage, Optimum capital structure, Measurement of specific costs, Computation of overall cost of capital. Financing Decision: Long-term financing, Short-term financing, Term financing, Venture capital. Capital Budgeting: Principles, Techniques, Measurement, evaluation, and involved risk analysis, Working Capital Management: Planning of working capital, Working capital financing, Cash management, Receivable management and Inventory management. Dividend Policy Decision: Dividend and valuation, Determinants of dividend policy, The Futures Markets, Static and dynamic hedging, Devising a Hedging Strategy Using Futures, Stock Index Futures, Value at Risk (VaR), Short Term and Long Term Interest Rate Futures, Foreign Currency Futures and Commodity Futures, Options Markets; Properties of Stock Option Prices; Option Pricing Models – Binomial Model, Black-Scholes; Model, Single Period Options –Calls and Puts, Option Strategies, Multi-Period Options – Caps, Floors, Collars, Captions, Swaptions and Compound options, Cross-currency Futures and Options, Structure of a Swap, Interest Rate Swaps, Currency of Swaps, Commodity Swaps, Other Swaps, Credit Risk and Credit Derivatives, Credit default swaps, Role of a Swap Dealer. Basics of FRAs, Emerging Innovations and recent trends |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | MS613 |
| 4 | **Title of the subject** | Business Research Methods |
| 5 | **Any prerequisite** | Basic knowledge of business statistics |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To design and execute a basic survey research project. To understand the research tools and techniques for executing a business project and decision making. |
| 8 | **Brief Contents** | Introduction to business research: Business research methods: An introduction, business research process design, Research design formulation: Measurement and scaling, questionnaire design, sampling and sampling distributions, Sources and collection of data: Secondary data sources, data collection: survey and observations, experimentation, fieldwork and data preparation, Data analysis and presentation: Statistical inference: hypothesis testing for single population, hypothesis testing for two populations, analysis of variance and experimental designs, hypothesis testing for categorical data (chi-square test), non-parametric statistics, Correlation and simple linear regression analysis, Multivariate analyses (Multiple regression analysis, discriminant analysis, conjoint analysis, factor analysis, cluster analysis, multidimensional |

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| | | scaling, correspondence analysis), Result presentation: Presentation of results, report writing |
| 9 | **Contents for lab** | Data analysis and presentation: Statistical inference: hypothesis testing for single population, hypothesis testing for two populations, analysis of variance and experimental designs, hypothesis testing for categorical data (chi-square test), non-parametric statistics, Correlation and simple linear regression analysis, Multivariate analyses (Multiple regression analysis, discriminant analysis, conjoint analysis, factor analysis, cluster analysis, multidimensional scaling, correspondence analysis) |

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| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | MS614 |
| 4 | **Title of the subject** | Decision Modelling and Optimization |
| 5 | **Any prerequisite** | Basic Knowledge of Mathematics, Probability distributions and Statistics. |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The objectives of the course is to acquaint the student with the applications of Operations Research to business and industry and help them to grasp the significance of analytical techniques in decision making |
| 8 | **Brief Contents** | Introduction to Operation Research, Overview of how Operations Research and Analytics professionals analyse problems, Introduction to Linear Programming<br><br>Solving Linear Programming problems: The Simplex method, The Theory of the Simplex Method, Duality theory, Linear Programming under Uncertainty, Other Algorithms for Linear Programming, The Transportation and Assignment problems Network Optimization models<br>Dynamic Programming, Integer Programming, Nonlinear Programming, Metaheuristics, Game Theory, Decision Analysis, Queueing Theory, Inventory Theory, Markov Decision Processes, Simulation |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | MS615 |
| 4 | **Title of the subject** | Artificial Intelligence and Machine Learning |
| 5 | **Any prerequisite** | Statistics, linear algebra, matrix, probability, programming languages and data modelling. |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Upon course completion, students will be able to: Identify problems that are amenable to solution by AI methods, and which AI methods may be suited to solving a given problem. Formalize a given problem in the language/framework of different AI methods. Implement basic algorithms using basic machine learning libraries mostly in python. Gain hands-on experience in applying ML to problems encountered in various domains. Obtain exposure to high-level ML libraries or frameworks such as TensorFlow, PyTorch. |
| 8 | **Brief Contents** | Introduction to AI: Definitions, Historical foundations, Basic elements of AI, Characteristics of intelligent algorithm, AI application areas, Neural network representation, Neural networks as a paradigm for parallel processing, Linear discrimination, Gradient descent, Logistic discrimination, Perceptron, Training a perceptron, Multilayer perceptron, Back propagation algorithm, Recurrent networks, Dynamically modifying network structure, Basic concepts, Hypothesis space search, Genetic programming, Models of evolution and learning, Parallelizing genetic algorithms, State space search, Production systems, Search space control: depth-first, breadth-first search, Heuristic search - hill climbing, Best-first search, Branch and Bound, Problem reduction, Constraint satisfaction end, Means-end analysis, Need of machine learning, Types of machine learning, Supervised learning: k-nearest neighbours, Linear regression, Logistic regression, Classification, Support vector machines, Neural networks, Unsupervised learning: clustering (k-means, hierarchical, EM), Auto-encoders, Dimensionality reduction, Learning by agents, Intelligent agent, Online learning, Batch learning, Markov Decision Processes, Temporal difference learning, Dynamic programming, Hyperparameters, Deep learning, Optimization techniques. |
| 9 | **Contents for lab** | Use Python/Jupyter notebooks/ google Colab for programming and hand out assignments<br>Machine learning platforms: TensorFlow, Scikit-Learn etc.<br>It may be good to have both theory and programming components in the assignment/homework component, to allow students to appreciate and learn both aspects of AI and machine learning |

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| 1 | **Semester** | II |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | MS616 |
| 4 | **Title of the subject** | Project Management |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Students will be able to understand to manage the scope, cost, timing, and quality of the project, as defined by project stakeholders. Align the project to the organization's strategic plans and business justification throughout its lifecycle. Identify project goals, constraints, deliverables, performance criteria, control needs, and resource requirements in consultation with stakeholders. Implement project management knowledge, processes, lifecycle and the embodied concepts, tools and techniques in order to achieve project success. Apply project management practices to the launch of new programs, products, and services |
| 8 | **Brief Contents** | Introduction to Project Management: Concept of a project; categories of project, project development cycle, tools & techniques of project management, forms of project organizations, project management theory, various stages of planning, designing and managing projects, Development of Project Matrices, Critical Success factors and key performance indicators, Project Organization, Scheduling & Planning: Project Elements, Work Breakdown Structure (WBS), Types of WBS, Functions, Activities and Tasks, Project Life Cycle and Product Life Cycle, Project schedule, Scheduling Objectives, Building the project schedule, Scheduling terminology and techniques, Network Diagrams: PERT, CPM; Bar Charts, Milestone Charts, Gantt Charts, Estimating Project Costs and Project Selection: Estimation of activity and project costs, means of financing, financial projections, Qualitative and Quantitative Methods of Project identification and selection, Developing the Project Schedule: Activity Sequencing, Precedence Network Diagram, Project Resource levelling and allocation in projects, network techniques and timelines, crashing of projects: time vs. cost trade-off, Program Evaluation and Review Technique, Critical Path Method, Project Scheduling, Basics of Scheduling, project management tools, Project Execution and Control: Assessing and managing costs and gains, crashing of projects: time vs. cost trade-off, earned value method, Managing Project Risks: Probabilistic aspects of projects; risk management; Principles & Concepts of project Risks Management, Risk Assessment, Risk control; critical chain project management. |
| 9 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | III |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | MS618 |
| 4 | **Title of the subject** | Strategic Management |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | After the completion of this course students will be able to understand the organization and the environment in which it functions and competes. The student should be able to integrate acquired knowledge of other functional areas with the body of the knowledge of strategic management and be able to deploy all as a unified tool to analyse and formulate the actions that shall deliver the intended results. |
| 8 | **Brief Contents** | Concept of strategy and strategic management, Difference between corporate planning and strategic planning, Strategic management model, Different levels of strategies, Relevance of strategic management in 21st century, Strategic intent-vision and mission statement, Organisational objectives, Setting objectives, Organisational values and its impact, External and internal Environment and analytical tools- evaluating the company's strategic environment, SWOT analysis, PESTEL analysis, Competitive analysis, Porter's five force model, Internal Assessment- strategic capability: fit and stretch concept, Porter's value chain analysis, Core competencies, Organisational capabilities, Resource analysis and synergy, Strategies in action- Functional level- Achieving superior efficiency- Economics of scale, Experience curve, Just-in-Time, Six-sigma, Business level-cost leadership, Differentiation & focus strategies, Growth strategies, Corporate level- integration, Diversification, Acquisition, Mergers & joint venture, Short term corporate strategies-stability, Retrenchment, and turnaround, Portfolio and other analytical models- BCG matrix, GE/McKinsy matrix, Corporate parenting, Evaluation of strategy- suitability, Acceptability, and feasibility, Implementing strategies-resource allocation, Structure and strategy, Organisation culture, Balance score card. |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | III |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | MS619 |
| 4 | **Title of the subject** | Entrepreneurship and Innovation |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning Objectives of the subject** | Course is designed for preparing students to take of Entrepreneurial journey on the basis of innovative ideas. The content is highly focused to start venture to making business mature up-to international level. |
| 8 | **Brief Contents** | Entrepreneurship, Creativity and innovation, Business planning process, Institutions supporting entrepreneurs, Family businesses, International entrepreneurship opportunities, Informal risk capital and venture capital, Managing growth. |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | III |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | MS620 |
| 4 | **Title of the subject** | Business Process Management |
| 5 | **Any prerequisite** | Courses on functional areas of management |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Upon successful completion of the course, student should be able to: Describe and evaluate the development of process management and tasks of process holders in organizations. Assess the importance of the strategic perspective of business process management. Analyse and model strategic and operational business processes. Employ process performance indicators and measures. |
| 8 | **Brief Contents** | Orientation: Process perspective, Components of processes, Evolution of processes, Process life-cycle, Process identification, Process architecture, Process selection, Process modeling: Introduction to BPMN, Business objects, Process decomposition, Process Discovery: Process discovery, Methods, Process modeling, Process model quality assurance, Process Analysis: qualitative process analysis, Value-added analysis, Waste analysis, Stakeholder analysis, Root-cause analysis, Quantitative process analysis: flow analysis, Queues, Simulation, Process redesign, Transactional methods, Transformational methods, Process aware information systems: Types of process aware information systems, Process implementation with executable models, Process monitoring, Process as enterprise capability |
| 9 | **Contents for lab** | BPMN modeling software (open source) for modeling of processes |

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| 1 | **Semester** | III |
| 2 | **Type of course** | Core |
| 3 | **Code of the subject** | MS621 |
| 4 | **Title of the subject** | Business Ethics and Sustainability |

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| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Upon course completion, students will be able to: Develop skills in recognizing and analysing ethical issues. Define cross cultural variations and similarities in organizational practices in corporate social responsibility and business ethics. Understand sources of organizational ethical culture and to design ethical programs designed to accomplish specific objectives in organizations. Develop ethical leadership skills and practices |
| 8 | **Brief Contents** | Business ethics- an overview, Concepts and theories of business ethics, Emerging business ethics issues, Ethical decision making in business, Creating an ethical organization globalization and business ethics, Stakeholders and business ethics, Social responsibility and ethics, Issues in social responsibility, Implementing stakeholders' perspective, Stakeholder and issue management approaches, Managing corporate responsibility with external stakeholders, Corporate governance and ethical leadership, Kohlberg's six stages of moral development, Levels of ethical analysis, Concept of corporate integrity, Issues in corporate governance, good corporate governance - obligations towards society and stake holders, Ethics in consumer protection, Role of government agencies, SEBI, judiciary in ensuring ethical practices, Ethics and Indian business, Marketing ethics, Ethics in human resource management, financial management, banking and insurance. |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | Odd |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS001 |
| 4 | **Title of the subject** | Digital Production System |
| 5 | **Any prerequisite** | Operations Management |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Upon successful completion of the course, student should be able to: Appreciate role of digital manufacturing. Analyse various computing models. Employ information and communication technologies for design of digital production systems. |
| 8 | **Brief Contents** | Science of digital manufacturing: operation mode and architecture of digital manufacturing system, Modeling theory and method of digital manufacturing science, Theory system of digital manufacturing science, Computing manufacturing in digital manufacturing science: computing manufacturing methodology, Manufacturing computational model, Theoretical units in manufacturing computing, Manufacturing informatics in digital manufacturing science: Principal properties of manufacturing information, Measurement, Synthesis and materialization of manufacturing information, Integration, sharing and security of manufacturing information, Intelligent manufacturing in |

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|---|---|---|
| | | digital manufacturing science: Intelligent multi-information sensing and fusion in the manufacturing process, Knowledge engineering in the whole life cycle of manufacturing product, Autonomy, Self-learning, Adapting of manufacturing system, Intelligent manufacturing system |
| 9 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | Even |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS002 |
| 4 | **Title of the subject** | IT Products and Intellectual Property Rights |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The course is designed to impart the value driven IT products development including software, and firmware/hardware of different industrial requirements. Through understanding of the Intellectual property rights, the learner acquaint with the protection of new IT product from business threat. |
| 8 | **Brief Contents** | Industry Need analysis for IT product development, The Design thinking for new IT product development, Tools and Techniques of IT product development, Software design analysis, Firmware design, Product prototyping, Value analysis, Intellectual property rights for Software and Firmware, Industry-Market fit performance, Evaluation of product |
| 9 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | Odd |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS003 |
| 4 | **Title of the subject** | Management of Digital Technologies |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The course has been designed to provide comprehensive and in-depth coverage of all important aspects of modern digital technologies on the principle of industrial applications to maximize the efficiency, effectiveness and business performance. It is primarily intended for students who wish to pursue a career in mapping industrial design on the digital system. |
| 8 | **Brief Contents** | Introduction of Industry 4.0. Business System engineering and Management through Digital Technologies, Digital Transformation |

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| | | and Business Transition to industrial revolution 5.0. Concepts of Industry 5.0-sustainability, human centricity and system resilience through digital technologies, Understanding Blockchain principles, technology and its applications, Introduction of sensory inputs, data acquisition and applications, Introduction of Business data cloud and management, Human-system interface concept, principles, and design, Introduction of Cyber Physical System and understanding design cases |
| 9 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | Even |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS004 |
| 4 | **Title of the subject** | Knowledge Management |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Develop an integrated and comprehensive perspective of knowledge management as a strategic function.<br>Identify the strategic contexts of knowledge management and the role of organisational structure and processes.<br>Discuss the frameworks, techniques, and the nature of IT support for managing knowledge.<br>Delineate the role of innovations in knowledge creation.<br>Raise and resolve issues in knowledge protection for sustaining competitive advantage.<br>Provide a platform for sharing experiences in knowledge management. |
| 8 | **Brief Contents** | The Nature of knowledge: Introduction to knowledge management, the nature of knowing, leveraging knowledge, Intellectual capital, Strategic management perspectives, creating knowledge, Organisational learning, the learning organisation, Knowledge management tools and systems, Knowledge management tools: component technologies, Knowledge management systems, mobilising knowledge, enabling knowledge contexts and networks, Implementing knowledge management. |
| 9 | **Contents for lab** | Case study exercises |

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| 1 | **Semester** | Odd |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS005 |
| 4 | **Title of the subject** | Service-Oriented Computing |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Service delivery lifecycle and associated phases. Analysis and conceptualization of services and micro-services. Service design through web. Modern service APIs and contract versioning techniques for web services |
| 8 | **Brief Contents** | Introduction of Service Oriented Architecture design and development, Case examples and case descriptions, Understanding Service-Orientation- Business Automation, Design paradigm, Design principles, Silo-based application architecture, Effects of service-orientation on the enterprise, Service-orientation and the concept of application and integration, The Service composition, Goals and benefits of Service-Oriented computing, Four pillars of Service-orientation, Understanding SOA- The Four characteristics of SOA: Business-driven, Vendor-neutral, Enterprise-centric, Composition-centric, Design priorities; The Four common types of SOA, The End result of Service-orientation and SOA, SOA Project delivery strategies, SOA project stages, SOA adoption planning, Service inventory analysis, SOA modelling, Contract, Logic design, Service development, Testing, Deployment and maintenance, Usage and monitoring, Understanding layers with services and micro services, Analysis and modelling with Web services and Micro services, Analysis and modelling with REST services and Micro services |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | Even |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS006 |
| 4 | **Title of the subject** | Social Networks Analytics |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The main learning objective with this course is to enable students to put Social Network Analysis projects into action in a planned, informed and efficient manner. This overarching goal involves the following subtasks: Formalize different types of entities and relationships as nodes and edges and represent this information as relational data. Plan and execute network analytical computations. Use advanced network analysis software to generate visualizations and perform empirical investigations of network data. Interpret and |

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| | | synthesize the meaning of the results with respect to a question, goal, or task. Collect network data in different ways and from different sources while adhering to legal standards and ethics standards. |
| 8 | **Brief Contents** | Overview on network analysis, The Network analysis process and methodology, Network visualization, When images do not suffice: Network analytical measures, Models and simulation of network evolution, Models and simulation of diffusion in networks, Subgroups and cliques clustering, Block models, Ego networks, Reciprocity, Social capital, structural holes, equivalence; Network Data: Ethics, Privacy, Legality, Introduction: Using text data for network analysis, natural Language Processing and Relation Extraction from Texts Construct: A model of meta-network dynamics, Usage of network analysis for investigating crime, Relational methods for analysing covert networks |
| 9 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | Odd |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS007 |
| 4 | **Title of the subject** | Software Project Management |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The students will be able to understand the principles of project management. Comprehend the fundamental principles of project management, including project planning, scheduling, resource allocation, and risk management. Develop a project plan that includes a work breakdown structure, critical path analysis, resource allocation, budgeting and time management. |
| 8 | **Brief Contents** | Introduction and Software Project Planning: Fundamentals of software project management (SPM), Need identification, Vision and scope document, project management cycle, SPM objectives, Management spectrum, SPM framework, Software project planning, Planning objectives, Project plan, Types of project plan, Structure of a software project management plan, Software project estimation, Estimation methods, Estimation models, Decision process, Project Organization and Scheduling: Project Elements, Work Breakdown Structure (WBS), Types of WBS, Functions, Activities and Tasks, Project Life Cycle and Product Life Cycle, Ways to Organize Personnel, Project schedule, Scheduling objectives; Building the project schedule, Scheduling terminology and techniques, Network Diagrams: PERT, CPM, Bar Charts: Milestone Charts, Gantt Charts, Project Monitoring and Control: Dimensions of Project Monitoring & Control, Earned Value Analysis, Earned Value indicators: Budgeted Cost for Work Scheduled (BCWS); Cost Variance (CV), Schedule Variance (SV), Cost Performance Index (CPI), Schedule Performance Index (SPI), Interpretation of Earned Value Indicators, Error Tracking; Software Reviews, Types of Review: Inspections, Deskchecks, Walkthroughs, |

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| | | Code Reviews, Pair Programming, Software Quality Assurance and Testing: Testing Objectives, Testing Principles, Test Plans, Test Cases, Types of Testing, Levels of Testing, Test strategies, Program correctness, Program verification & validation, Testing automation & Testing tools, Concept of Software quality; Software quality attributes; Software Quality Metrics and indicators; The SEI Capability Maturity Model CMM), SQA activities, Formal SQA Approaches: Proof of correctness, Statistical quality assurance, Cleanroom process, Project Management and Project Management Tools: Software Configuration Management: Software Configuration items and tasks; Baselines; Plan for Change, Change control, Change Requests management, Version Control; Risk management: Risks and risk types, Risk Breakdown Structure (RBS); Risk Management process: Risk identification, Risk analysis, Risk planning, Risk monitoring; Cost Benefit analysis; Software Project management tools: CASE tools, Planning and Scheduling tools, MS-Project. |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | Even |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS008 |
| 4 | **Title of the subject** | Software Quality Management |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Students will be able to develop a comprehensive understanding of the concepts and practices related to software quality management.<br><br>Gaining knowledge of software quality standards, testing techniques, and software metrics. Evaluate the effectiveness of quality management strategies, such as continuous improvement, risk management, and quality assurance. |
| 8 | **Brief Contents** | Introduction to Software Quality: Defining Software Quality, Software quality, Attributes and specification, Cost of quality defects, faults, failures, Defect rate and reliability, Defect prevention, Reduction and containment, Overview of different types of software review, Introduction to measurement and inspection process, Documents and metrics, Software Quality Metrics: Product Quality Metrics: Defect density, Customer problems metric, Customer satisfaction metrics, Function points, In-process quality metrics: Defect arrival pattern, Phase-based defect removal pattern, Defect removal effectiveness, Metrics for software maintenance: Backlog management index, Fix response time, Fix quality, Software quality indicators, Software Quality Management and Models: Modeling process, Software reliability models: The Rayleigh model, Exponential distribution and Software reliability growth models, Software reliability allocation models, Criteria for model evaluation, Software quality assessment models: Hierarchical model of software quality assessment. Software Quality Assurance: Quality Planning and Control, Quality |

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| | | improvement process, Evolution of software quality assurance SQA, Major SQA activities, Major SQA issues, Zero defect software, SQA techniques, Statistical quality assurance, Total quality management, Quality standards and processes, Software Verification, Validation & Testing: Verification and validation, Evolutionary nature of verification and validation, Impracticality of testing all data and paths, Proof of correctness, Software testing, Functional, structural and Error-oriented analysis & testing, Static and dynamic testing tools, Characteristics of modern testing tools. |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | Odd |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS009 |
| 4 | **Title of the subject** | Programming for Business Intelligence |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Upon course completion, students will be able to: Derive actionable insights from data, thus allowing to make data-driven, strategic and tactical business decisions. Design and implement an algorithm to conduct technical calculations, manipulate data and create graphical user interfaces. Identify the technological architecture that makes up Business Intelligence systems |
| 8 | **Brief Contents** | Business Intelligence (BI): Effective and timely decisions, Data, Information and knowledge, Role of mathematical models, BI architectures, Ethics and BI, Decision support systems: definition of system, Representation of the decision-making process, Definition of decision support system, Development of a decision support system, Customer Relationship Management (CRM), ERP, and BI, Importance of data and relevance in industry, Statistical learning vs. machine learning, Types and phases of analytics, Data pre-processing and cleaning: data manipulation steps, Normalizing data, Sampling, Missing value treatment, Outliers, Exploratory data analysis: data visualization using matplotlib, Seaborn libraries, Creating graphs, Summarizing data, Descriptive statistics, Univariate analysis, Bivariate analysis, Querying and reporting, Building Ad-Hoc queries, Building on-demand self-service reports, Enhancing and modifying data access, Pull-oriented data access, Push-oriented data access dashboards, Executive Information System (EIS) engine, Metric system and KPIs, business intelligence dashboards, Learning SQL query structure with examples, Data management and query system OLTP and OLAP and their data models, Data warehousing, ETL and data integration dashboard creation using Tableau, Power BI, The relevance of BI in application to analytics industry and different domains such as marketing models: relational marketing, Sales force management, Logistic and production models: supply chain |

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| | | optimization, Optimization models for logistics planning, Revenue management systems. |
| 9 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | Even |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS010 |
| 4 | **Title of the subject** | Strategic Planning of Information Systems |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The strategic use of information systems as a means for acquiring competitive advantage. Integration of concepts and methodologies with skills acquired in the field of information systems and technology in the development of a comprehensive information systems prototype. Measurable benefits in the alignment of business processes with information systems solutions. The course provides students with the opportunity to apply systems concepts and techniques in the design of an information system. |
| 8 | **Brief Contents** | Introduction to strategic information systems, Business environment issues, The process of strategic information systems, Current business situation analysis, Identify an opportunity, The role of business information systems, Information systems strategies, Strategic information systems management, Organization of the information systems technologies, Software, Hardware, Database, Communications, Networking, Evaluation of possible IS solutions, Project Management, Cost Benefit Analysis, Functional requirement, System specifications, Information systems benefits, Strategic information management, Managing the information resource |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | Odd |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS011 |
| 4 | **Title of the subject** | Business Systems Simulation |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Understanding the principles and techniques of simulation modeling for business systems. Understanding the key components of a business system and how they interact with each other. Learning how to analyse |

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| | | and interpret simulation results to make informed decisions. Understanding the limitations of simulation modeling and the assumptions that need to be made. Learning how to optimize simulation models to achieve business objectives. Understanding the ethical implications of simulation modeling and the importance of data privacy and security. Learning how to apply simulation modeling in different industries and applications, such as manufacturing, logistics, healthcare, finance, and customer service. |
| 8 | **Brief Contents** | Introduction to Business System Simulation: Overview of the benefits of simulation modeling, The various types of simulation models, and the different tools and software used for simulation modelling, System Dynamics: Modeling approach on the feedback loops and dynamic relationships between different variables in a system, Topics covered include stock and flow diagrams, feedback loops, and system dynamics models, Discrete-Event Simulation: Modeling the discrete events and processes that occur in a system, such as customer arrivals, order processing, and inventory movements, Topics covered include event scheduling, process modeling, and queuing theory, Agent-Based Simulation: Modeling individual agents or entities within a system, such as customers, employees, or machines. Topics covered include agent behaviour modeling, agent interactions, and emergent behaviour, Optimization and Analysis: Various techniques used to optimize a simulation model and analyse the results, including sensitivity analysis, scenario analysis, and statistical analysis. Applications of Business System Simulation: Case studies and examples of how simulation modeling is used in different industries and applications, such as manufacturing, logistics, healthcare, finance, and customer service. |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | Even |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS012 |
| 4 | **Title of the subject** | Service Operations Management |
| 5 | **Any prerequisite** | Operations Management |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Upon successful completion of the course, student should be able to: Define services along with their nature and classification. Assess factors related to location and capacity planning. Employ design principles in development of service delivery systems. Analyse requirements to ensure maintainability and reliability in services. |
| 8 | **Brief Contents** | Matrix of service characteristics, Taxonomy of services, Challenges in operations management of services, Aggregate capacity planning for services, Facility location, Subjective and objective factors, Service design and delivery systems, layouts in services, Job and work design in services-safety and physical environment, Effect of managing |

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| | | queues, Automation, Operations standards and work measurement, Determinants of quality in services, Measurement, control and improvement of quality of services, Concept of a total quality service, Dynamics of service delivery system, Scheduling for service operations, Personnel and vehicles, Supply chain and distribution of services, Maintainability and reliability in services, Total productive maintenance (TPM) in services, Case studies of exemplary professionally managed services. |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | Odd |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS013 |
| 4 | **Title of the subject** | Sustainable Supply Chain Management |
| 5 | **Any prerequisite** | Operations Management |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Upon successful completion of the course, student should be able to: Develop an understanding of the role of supply chain in an overall value creation. Analyse different modes of transportation, different design options of transportation network in a supply chain, their applicability under different contexts and the trade-offs in transportation design. Describe the importance of reverse logistics in market places as well as market spaces. Design sustainable supply chains. |
| 8 | **Brief Contents** | Evolution of SCM, Issues of SCM, Competitive strategy vis-à-vis supply chain strategy, achieving strategic fit, Managing inventory in a supply chain, Deterministic models, Probabilistic models (multi-period and single period). Managing risk and uncertainty in a supply chain: quick response strategy, Postponement strategy, Tailored sourcing strategy, Transportation in a supply chain: role of transportation in a supply chain, Modes of transportation and their performance characteristics, Design options for a transportation network, Trade-offs in transportation design, Supply chain coordination: Bullwhip effect - causes and consequences, Bullwhip effect quantification, Impact of centralized information on bullwhip effect, Mitigating strategies, Information sharing and incentives, Strategic sourcing in SCM: Role of sourcing in a supply chain, Framework for make/buy decisions, Supplier scoring and assessment, Supply contracts and supply chain performance, Big data analytics in SCM: Significance of big data in supply chain, Relevant tools, Reverse logistics: Reverse logistics in manufacturing organizations and ecommerce firms. |
| 9 | **Contents for lab** | SCM software like SAP SCM, Logility, Perfect Commerce, Oracle SCM etc. |

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|---|---|---|
| 1 | **Semester** | Even |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS014 |
| 4 | **Title of the subject** | Technology Management |
| 5 | **Any prerequisite** | Operations Management |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Upon successful completion of the course, student should be able to: Define types of innovation, innovators and innovation environment. Describe the nature and extent of technological change and potential roles of incremental and disruptive innovation in creating and sustaining firm competitiveness. Perform feasibility and viability of new product development proposal from various perspectives. |
| 8 | **Brief Contents** | Introduction, Understanding innovation, Levels and types of innovation, Key drivers of innovation, Sources of innovation, and the relationship between innovation and research and technology development. understanding creativity as a building block to innovation, Innovation management, Framework for the management of innovation, Public sector services innovation, Diffusion of innovation creating organizational innovative effectiveness, Strategic aspects of technology, Critical factors in managing technology innovations, Critical issues/factors in choice of technology and processes; Indian context, Technology portfolio, Open innovation, New technology transfer-channels, Modes, Levels and issues, Absorption, adaption and adoption of technology, Technology considerations in lean environment, Strategic role of R&D, New R&D approaches, Strategic evaluation of technology investments, New product development and life cycle management, Understanding product platform strategy, Commercialization of core competencies, Marketing new products and technologies, Role, rationale and requisites of a national technology policy, IPR and licensing issues, Role of WTO. |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | Odd |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS015 |
| 4 | **Title of the subject** | Technology and Operations Strategy |
| 5 | **Any prerequisite** | Operations Management |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Upon successful completion of the course, student should be able to: Appreciate the nature, need and scope of operations strategy. Describe the strategic role of transformation processes and associated flows. |

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| | | Develop and analyse innovation, new product and process development strategies. Employ process of operations strategy in terms of sustainable alignment. |
| 8 | **Brief Contents** | Need for Operations Strategy, Impact of globalization on Operations Management, The Marketing link in the Operations Strategy -Role in competitive advantage, Time-based competitiveness and other criteria of success, The Sandcone model, Process of designing, analysing and implementing operations' strategies, Strategic management of transformation processes and flow strategies, Strategic choices in layout and capacity planning, Managing innovations and new product and process development strategies, Strategic purchasing and supply management, Outsourcing decisions, Strategic Purchasing Portfolio analysis, Operations improvement strategies, Breakthrough vs. continuous, The direct, Develop and deploy strategies, The market strategy, Bohn's stages of process matrix, Measures of performance, Process of Operations strategy, Sustainable alignment, Methodology of operations strategy formulation, Process of operations strategy formulation, Integrated management systems |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | Even |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS016 |
| 4 | **Title of the subject** | Total Quality Management |
| 5 | **Any prerequisite** | Basic Knowledge of Probability and Statistics |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | This course provides learners with an understanding of quality control and improvement systems. This course will help participants to: Understand the principles of total quality management. Choose appropriate statistical techniques for improving processes. Develop the organizational, competitive and economic potential of quality. Integrate fundamental principles with the practice of total quality management. |
| 8 | **Brief Contents** | Evolution and Importance of Total Quality Management: Introduction, Importance of Quality, Evolution of Quality, What is Total Quality Management, Quality Pioneers, Active Living and Health Environment for TQM: Quality Leadership and Management Commitment, Employee Empowerment, Organizational Culture and Change, Team Building, TQM Infrastructure: Supplier relation and partnership, Continuous Improvement process lesson, Developing TQM action plan, TQM and Other Continuous Improvement Systems: Quality Standards, Six Sigma, Benchmarking, Just in Time, Stabilizing and Improving a Process: Defining and Documenting a Process, Diagnosing and Improving a Process, Statistical Process Control, Variables and Attributes Charts, The Fork Model For Quality Management- Management's Commitment to Transformation Lesson, |

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| | | Education and Daily Management, Cross-Functional Management, Quality Policy Management |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | Odd |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS017 |
| 4 | **Title of the subject** | World Class Production Systems |
| 5 | **Any prerequisite** | Operations Management |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Upon successful completion of the course, student should be able to: Appreciate the concept and need of world class manufacturing. Employ frameworks of various product and process design structures and systems in modern manufacturing. Analyse the implementation of TQM, JIT and Theory of Constraints. Appreciate philosophy and principles of Japanese manufacturing especially Toyota Production System (TPS). |
| 8 | **Brief Contents** | World Class Manufacturing (WCM): Concepts and Evolution, Understanding the linkage between Operations Strategy and WCM, Agile Manufacturing: Distinction between flexibility and agility, Model for implementing flexible and agile manufacturing, Flexible Manufacturing System (FMS), Concepts and components, Modern product and process design concepts and considerations, Assembly lines and batch manufacturing; group technology (GT), Total Quality Management (TQM): Roadmap to Implementation of TQM in manufacturing, Six Sigma approach, Just-in-Time (JIT) and Lean Operations, Theory of constraints (ToC), Japanese manufacturing techniques particularly Toyota Production System, Japanese vs American manufacturing focus, Critical elements of JIT, Operational Framework for concurrent implementation of TQM and JIT, Total Productive Maintenance (TPM): Concepts and Evolution, Metrics of TPM, Overall Equipment Effectiveness (OEE), Roadmap to TPM implementation in modern manufacturing, Computer Integrated Manufacturing System (CIMS): A framework for computer integrated enterprise issues involved in CIMS, Benchmarks for excellence in operational performance with global examples, Significance of implementation of concurrent operations management initiatives, Metrics of operational excellence in global context. |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | Even |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS018 |
| 4 | **Title of the subject** | Emerging areas in Operations and Technology Management |
| 5 | **Any prerequisite** | Operations management |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Upon successful completion of the course, student should be able to: Describe role of sustainable operations management. Design operations management along globally dispersed distributed networks. Develop nimble factories for supporting a lot size of one. |
| 8 | **Brief Contents** | Digital supply chains, Computer aided design and integrated manufacturing, A Focus on the employee experience, Flexible, blended workplace environments, Mobile communications and collaboration, Scaling production according to demand, Building the customer relationship. |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | Odd |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS019 |
| 4 | **Title of the subject** | New Products and Services Development |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | On completion of the course, students will be able to: Describe the nature and techniques of innovation and new product development. Discuss and reflect on the role of marketing in different phases of new product development. Explain the phases and intermediate results in new product development process. Apply theories of innovation to demonstrate the best level of practice in each problem situation within the context of new product development. Develop and implement a new product strategy for an enterprise. |
| 8 | **Brief Contents** | Product Conception: Product Basics Consumer problems and unmet need Empathy, Personas, User Stories Identifying New Product Opportunities using Data Market Research for New Product Development Idea Generation & Need Analysis Concept testing using Surveys-Customer Discovery Product potentiality and Conjoint analysis Design Thinking for B2C, B2B Products and Services, Product Design: Product Design Process - 7 Stages Product specifications and features Visual Design Elements Tools for Design |

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| | | of Digital Products User experience (UX) design Introduction to Software Tools used to design Engineering Products Quality Function Deployment, Value engineering methodology, Iterative design optimisation, Design for manufacturing, Prototyping: What is Minimum Viable Products (MVP)? Types of MVP Hypothesis Testing, A/B Prototype development for Digital Products, Wireframing 3D Printing and 3D Cutting Material Selection for Engineering Product, Prototyping Prototype, Functionalisation using Electronics and Instrumentation, Role of Robotics and Automation in Prototyping, Usability and Beta Testing, Product Deployment: Production planning and control Material handling In-house Budgeting and Outsourcing Quality Assurance Protocols Principles of Lean: Lean Manufacturing and Management Regulations and Standards: ISO Intellectual Property and Trademarks Building Markets and Creating Demand for New products services, Simulated test marketing, and Launching of new products, Product Lifecycle Management: Organisation for Product Management Marketing Manager-Product Manager-Brand Manager Concept Approaches and Organisational role Product Manager-Functions and Tasks-Tools and Techniques The Product in Corporate Life, Corporate and Product Objective Product Strategy and Policy Optimum Product Pattern/Line Range Challenge Of Change-Opportunity and Risk-Product Innovation, Modification, Addition and Elimination Product Proposals-Sources, Generation, Processing and Selection Contemporary Challenges and opportunities in product<br>Management, Product Sales and Marketing: Brand Awareness, Consumer Brand Knowledge Product-line Decisions (extension, reduction), Product Category expansion Pricing Model and Strategy Product Costing Segmentation \| Target \| Positioning Sales Forecasting Distribution Channels Lead Generation-Role of Contacts and social media Customer Acquisition Customer retention, Commercialisation and Start-up: Introduction to Business Model Canvas Funding Requirement and Avenues Bootstrapping Team Building and Collaborations Customers and End Users Market Competition and Creating Barriers to Entry Deployment and Distribution Strategy Launching of Start-up: Rules and Steps Social media, Websites, and Digital Marketing Scale-up model and Sustainable growth plan |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | Even |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS020 |
| 4 | **Title of the subject** | Operational Intelligence |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Upon successful completion of the course, student should be able to: Describe the importance of data-driven operations along supply chains. Assess unbiased estimates of demand forecasting as well as optimization |

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| | | using various statistical methods. Employ mathematical models to capture and analyze data on supply chain carbon footprint. |
| 8 | **Brief Contents** | Problem-driven to Data-driven operations along supply chains, Big data in supply chain, Analytics in demand planning: Capturing demand data from different sources, Demand prediction models, Price optimization, Analytics in sourcing and procurement: In-house or outsource, Logistics and transportation, Supply chain contracts, Analytics in sales and operations planning: Differentiated service level to different products and customers, Location of plants, Product line mix at plants, Production planning and scheduling, Analytics in distribution: Location of distribution centre, Transportation and distribution planning, Inventory policies/order fulfilment at locations, Vehicle routing for deliveries, Analytics in reverse logistics in traditional and e-commerce firms: Location of return centres, Reverse distribution plan, Vehicle routing for returns collection, Analytics in supply chain carbon footprint |
| 9 | **Contents for lab** | Proficiency in using various software like SAS Business Analytics (SAS BA), Excel, Tableau, Microsoft Power BI etc. |

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|---|---|---|
| 1 | **Semester** | Odd |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS021 |
| 4 | **Title of the subject** | Compensation Management |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The aim of this subject is to develop students' understanding of the concepts of compensation and rewards in the organization. In particular the subject is designed to develop the underpinning knowledge and skills required to understand the one of the complex management functions i.e. compensating employees and its importance. This subject introduces the student to the basics compensation structure and differentials. It familiarizes the students with the practice of various management techniques and its expected results like job evaluation etc. The learner is apprised about the latest issues in management related to compensation in order to make the students abreast about the recent trends in the area. |
| 8 | **Brief Contents** | Introduction to compensation and rewards, Objective of compensation and rewards, Introduction to framework of compensation policy, Labor market characteristics and pay relatives, Wage determination: Introduction to compensation, rewards, wage levels and wage structures, Introduction to wage determination process and wage administration rules; Introduction to factors influencing wage and salary structure and principles of wage and salaries administration, Introduction to the theory of wages: Introduction to minimum, fair and living wage, Introduction to nature and objectives of job evaluation; Introduction to principles and procedure of job evaluation programs, |

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| | | Introduction to basic job evaluation methods; Introduction to Implementation of evaluated job, Introduction to determinants of incentives, Introduction to classification of Rewards, Incentive payments and its objectives, Introduction to wage incentives in India; Introduction to types of wage incentive plans, Introduction to prevalent systems & guidelines for effectives incentive plans; Introduction to non- monetary incentives, Introduction to cafeteria style of compensation, Introduction to problems of equity and bonus, Profit sharing & stock options, Introduction to features of fringe benefits, Introduction to history and growth factors, Coverage of benefits, Introduction to employee services & fringe benefits in India |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | Even |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS022 |
| 4 | **Title of the subject** | Change Management |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Effective management within organizations requires an understanding of various behaviour and processes. Managers need to know why people behave as they do in relation to their jobs, their work groups and their organizations. This knowledge of individuals' perceptions, motivational attitudes and behaviour will enable managers to not only understand themselves better, but also to adopt appropriate managerial policies and leadership styles to increase their effectiveness. The major objective of this course is to provide students with a better understanding of behavioural processes and thereby enable them to function more effectively in their present or future roles as managers of human resources. |
| 8 | **Brief Contents** | Definition of Organization Development (OD), OD and planned change from other forms of organization change, Describe the historical development of OD, Describe and compare three major perspectives on changing organizations, Introduce a General model of planned change, Describe how planned change can be adopted to fit different kinds of conditions, Understand the essential character of OD practitioners, Understand the necessary competencies required of an effective OD practitioner, Understand the roles and ethical conflicts that face OD practitioners, Reinforce the definition of an OD practitioner as anyone who is helping a system to make planned change, Describe the steps associated with starting a planned change process, Equip students with a general framework of diagnostic tools from a systematic perspective, Define diagnosis and to explain how the diagnostic process provides a practical understanding of problems at the organizational level of analysis, Discuss criteria for effective interventions, Discuss issues, considerations, constraints, ingredients, and processes associated |

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| | | with intervention design, Give an overview of the various interventions, Understand the issues associated with evaluating OD interventions, Understand the process of institutionalizing OD interventions and the factors that contribute to it, Understand the importance of data feedback in the OD process, Describe the desired characteristics of feedback content, and Describe the desired characteristics of the feedback process. |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | Odd |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS023 |
| 4 | **Title of the subject** | Corporate Social Responsibility |
| 5 | **Any prerequisite** | None |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Upon course completion, students will be able to: Develop skills in recognizing and analysing ethical issues. Define cross cultural variations and similarities in organizational practices in corporate social responsibility and business ethics. Understand sources of organizational ethical culture and to design ethical programs designed to accomplish specific objectives in organizations. Develop ethical leadership skills and practices |
| 8 | **Brief Contents** | Business ethics- an overview, Concepts and theories of business ethics, Emerging business ethics issues, Ethical decision making in business, Creating an ethical organization globalization and business ethics, Stakeholders and business ethics, Social responsibility and ethics, Issues in social responsibility, Implementing stakeholders' perspective, Stakeholder and issue management approaches, Managing corporate responsibility with external stakeholders, Corporate governance and ethical leadership, Kohlberg's six stages of moral development, Levels of ethical analysis, Concept of corporate integrity, Issues in corporate governance, good corporate governance - obligations towards society and stake holders, Ethics in consumer protection, Role of government agencies, SEBI, judiciary in ensuring ethical practices, Ethics and Indian business, Marketing ethics, Ethics in human resource management, financial management, banking and insurance. |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | Even |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS024 |
| 4 | **Title of the subject** | Competency Management |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The aim is to give students a better idea of how to work with their employees to make today's competency-based performance reviews more effective and a more positive experience. Begin to think of it differently: as a partnership or a collaborative effort. |
| 8 | **Brief Contents** | Introduction to competency: definition and history of competency, Basic components of competency (Knowledge(K), Skill(S), Attitude(A)), Performance Vs competency, Difference between competence and competency, Type of competency generic vs key competency, Functional and technical competency, Leadership and managerial competency, Need for competency framework, Limitation and learning from competency framework, Myth about competency, Competency development & its models: Need and importance of competency development, Stages in developing competency model, Types of competency Model – core/generic, Job specific, Managerial / leadership, Custom, development of personnel competency framework, competency mapping: procedures / steps-determining objectives and scope, Clarifying implementation goals and standards, create an action plan, Define competency-based performance effectiveness (key result area (KRA) & key performance indicators (KPI)), Tools for data collection, Data analysis, Validating competency model, Mapping future jobs, and single incumbent jobs, Using competency profile in HR decisions, Mapping competency for recruitment and selection, Training and development, Performance and compensation, Competency driven career and culture: Role of competency in career progression, Transactional competency, Tradition competency and transformational competency, Evaluation of career through KSA (Knowledge, Skill, and Attitude) Competency-based succession and career planning, corporate competency driven culture. |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | Odd |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS025 |
| 4 | **Title of the subject** | Human Resource Information System |
| 5 | **Any prerequisite** | Human Resource Management |
| 6 | **L-T-P** | 3-0-0 |

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| 7 | **Learning Objectives of the subject** | To review and understand the basic concepts and principles of human resource information system and to apply the same to the real world. To explore strategic value of HRIS and its contribution to organizational success. To review the leading HRIS software. To explore the ways of identifying best HRIS based on industry specificity and ROI. |
| 8 | **Brief Contents** | Introduction to HRIS, Acquisition and HRIS costs, Needs Assessment; HR metrics, Database concepts and applications in HRIS, Change management and data validation, HRIS design and implementation considerations, HR administration and HRIS, Job analysis, Security and privacy issues, Emerging trends in HRIS. |
| 9 | **Contents for lab** | Case study exercises<br>Class projects and exercises |

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|---|---|---|
| 1 | **Semester** | Even |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS026 |
| 4 | **Title of the subject** | Emerging Areas in Human Resource |
| 5 | **Any prerequisite** | Human Resource Management |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To recap the major concepts and theories of HRM. To explore the emerging areas of HRM. To understand practical applications of theory relevant to today's workplace. To explore contemporary topics in Human Resource Management. To build strong foundation and relevant skill set required in today's workplace. |
| 8 | **Brief Contents** | Setting the hybrid work model for collaboration, Human leadership, Working in the metaverse, Managing international human resources, Managing human resources in small and medium enterprises, Strategic human resource management, Change management, People analytics, The transition from employee well-being to healthy organization, Diversity, equity and inclusion |
| 9 | **Contents for lab** | Case study exercises<br>Class projects and exercises<br>Role playing |

| | | |
|---|---|---|
| 1 | **Semester** | Odd |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS027 |
| 4 | **Title of the subject** | Organization Theory & Development |
| 5 | **Any prerequisite** | No |

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| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Describe how the need to increase organizational efficiency and effectiveness has guided the evolution of management theory. Explain the principle of job specialization and division of labor, and tell why the study of person-task relationships is central to the pursuit of increased efficiency. Identify the principles of administration and organization that underlie effective organizations. |
| 8 | **Brief Contents** | Explain what is meant by the term organization, Classify the three levels of managers and identify the primary responsibility of each group, Describe the difference between managers and operative employees. Explain the skills and roles manager, Describe the value of studying organization. Identify the relevance of popular humanities and social science courses to management practices, Trace the change in theories about how managers should behave to motivate and control employees, Explain the contributions of management science to the efficient use of organizational resources, Explain why the study of the external environment and its impact on an organization has become a central issue in management thought, Describe forces that act as stimulants to change, Summarize the sources of individual and organizational resistance to change, Summarize Lewin's three-step change model. Explain the values underlying most OD efforts, Contrast process reengineering and continuous improvement processes, Identify properties of innovative organizations**,** List characteristics of a learning organization, Describe potential sources of stress, Organizational Development Techniques, Explain individual difference variables that moderate the stress–outcome relationship |
| 9 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | Even |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS028 |
| 4 | **Title of the subject** | Leadership & Talent Management |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Leadership and Talent Management primarily focus on managerial leadership as opposed to parliamentary leadership or emergent leadership in informal groups. The objective of this module is to present the theory and research on leadership and talent management in formal group. |
| 8 | **Brief Contents** | Define leader and explain the difference between managers and leaders, Summarize the conclusions of trait theories of leadership, Describe the Fiedler contingency model, Summarize the path goal model of leadership, Explain situational leadership, Identify the qualities that characterize charismatic leaders and authentic leaders, Meaning of |

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| | | talent, Talent or human capital of an organization, Why talent/human capital management? Functions of talent management. |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | Odd |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS029 |
| 4 | **Title of the subject** | Training & Development |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To develop an understanding from the point of view of the individual employee. Improve the individual's level of awareness. Increase an individual's skill in one or more areas of expertise. Increase an individual's motivation to perform their job well. |
| 8 | **Brief Contents** | Overview of training, Trends in training, Career opportunities in training important concepts and meanings, Why conduct a training needs analysis, When to conduct a TNA, The TNA model, The framework for conducting a TNA, Output of TNA, Approaches to TNA, Introduction to the design of training organizational constraints developing objectives, Why use training objectives, Overview of the training design ,Matching methods with outcomes , Lectures and demonstrations , Games and simulations, On-the-job & off the job training, Development of training, implementation, transfer of training. Evaluation of training, Rationale for evaluation, Resistance to training evaluation |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | Even |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS030 |
| 4 | **Title of the subject** | Management of Employee Relations |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To develop an understanding of the interaction pattern among labour, management and the State. To build awareness of certain important and critical issues in Industrial relations. To impart basic knowledge of the Indian Industrial relations system and its distinctive features. |

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| 8 | **Brief Contents** | The evolution of Industrial relations, understand the scope and objectives of Industrial relations, Essential of Industrial relations, participants of Industrial relations and dynamics of their participation, perspective and approach, The system of industrial relation in India, the historical perspective of Industrial relations, Describe the trends in Industrial relations management, The changing characteristics of Industry and workforce in India, Describe the demand for labour, The challenges to industrial relations, Labour laws pertaining to Industrial relations viz Trade Union act, Industrial dispute act, Factories act, A paradigm shift from Industrial relations to Employee relations, Understand the Employee relations management. Describe the differences in perspective of employee relations and industrial relations. |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | Odd |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS031 |
| 4 | **Title of the subject** | Corporate Restructuring |
| 5 | **Any prerequisite** | Financial Reporting and Control<br><br>Financial Engineering and Management |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The objective of this course is to sensitize the students about the need for corporate restructuring for achieving fast growth and maximize shareholders' value in the context of ever-increasing competition thrown up by liberalization and globalization of Indian economy. The focus of this course, however, will be to analyse the decisions in a financial perspective emphasizing valuation. |
| 8 | **Brief Contents** | Opening of the economy, Global view, Indian scenario, Economic liberalization, Corporate restructuring- mergers, acquisitions, and demergers, Mergers and amalgamations, Search for a merger partner, Negotiations, steps, and formalities, Demergers-divestitures, Spin off, Equity carved out, Split off, Split up, Reconstruction, Modes of demerger, Tax aspects, Advantages, and procedure of reverse merger-Requirements, Takeover by reverse bid, Techniques of and procedure for organizing takeover bids, Search for acquisition of target company, Procedure for takeovers and acquisitions, Valuation and exchange ratio-valuation of listed and unlisted companies, Modes of valuation, Fixing price for acquisition, Determination of share exchange ratio on merger, Feasibility analysis for cash acquisition, Valuation practices in India, Funding of merges and acquisitions-financing alternatives, Management buyouts, Leveraged buyouts, Post-merger management-accomplishment of objectives, Performance after merger, Mergers and accusations overseas by Indian corporates |
| 9 | **Contents for lab** | No |

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|---|---|---|---|
| 1 | 2 | **Semester** | Even |
| 2 | 3 | **Type of course** | Elective |
| 3 | 4 | **Code of the subject** | MS032 |
| 4 | 5 | **Title of the subject** | Corporate Tax Planning |
| 5 | 6 | **Any prerequisite** | No |
| 6 | 7 | **L-T-P** | 3-0-0 |
| 7 | 8 | **Learning Objectives of the subject** | After the completion of this course, students will be able to understand and apply corporate tax provisions to real life business problems efficiently using appropriate concepts of taxation laws for corporate tax planning. |
| 8 | 9 | **Brief Contents** | Concept of tax planning, Tax management, Tax evasion, Tax avoidance, Corporate tax in India, Types of companies, Residential status of companies and tax incidences, Tax liability and minimum alternative tax, Tax on distributed profits of companies, Tax planning with reference to setting up a new business, locational aspect, Nature of business, Form of business, Tax planning with reference to financial management decision-capital structure, Dividend including deemed dividend and bonus shares, Tax planning with reference to specific management decisions - Make or buy, Own or lease, Repair or replace, Tax planning with reference to employee remuneration, Tax Planning with reference to business restructuring- Amalgamation, Demerger, Slump sale, Transfer between holding and subsidiary companies, Tax deducted at source, Advance Tax, Double taxation relief, Goods and service tax planning, Transfer pricing and taxation. |
| 9 | 10 | **Contents for lab** | No |

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|---|---|---|---|
| 1 | 2 | **Semester** | Odd |
| 2 | 3 | **Type of course** | Elective |
| 3 | 4 | **Code of the subject** | MS033 |
| 4 | 5 | **Title of the subject** | Economic and Financial Modeling |
| 5 | 6 | **Any prerequisite** | No |
| 6 | 7 | **L-T-P** | 3-0-0 |
| 7 | 8 | **Learning Objectives of the subject** | The students will be able to: Learn the skills for framing finance and economy modeling. Develop problem solving abilities in the context of both macroeconomics and microeconomics. Analyze the company / industry performance on relevant financial parameters using historical information on companies |
| 8 | 9 | **Brief Contents** | Economic Modelling: Classical model of national income; distribution of national income to the households; fiscal policy and the allocation of resources between consumption, investment and government purchases; modelling economic growth, Modelling inflation; net exports; capital flows and exchange rates in the long run; Mundell |

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| | | | Fleming model of business cycle; Edgeworth-Bowley box and the production possibility curve, Financial Modelling: Introduction to financial modeling; basic excel for financial modeling (formatting of excel sheets; use of formula functions; data filter and sort; charts and graphs; table formula and scenario building; vlookup; pivot tables), Introduction to financial statement analysis; financial reporting mechanics; income statement; balance sheet; cash flow statement; financial analysis techniques; inventories; long lived assets; non-current liabilities; financial statement application, Financial ratio analysis for financial statement interpretation; time value of money; long term financing; cash flow waterfall & resolve circular reference problem in interest during construction. |
| 9 | 10 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | Even |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS034 |
| 4 | **Title of the subject** | Entrepreneurial Finance |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Students will be able to Understand the importance of financial management and managing a new venture. Learn analyzing the various sources of investment and also know the support provided by the state and central government for entrepreneurship. Determine the various financial supp ort schemes provided different institutions to the entrepreneurs. |
| 8 | **Brief Contents** | Financing and managing new venture: Importance of financial management as an integral part of entrepreneurship; conducting a feasibility analysis; what lenders and investors look for in a business plan, Sources of Finance: Various sources of investment; basics of venture capital and angel investment; start-up culture; various measures of encouragement and support being provided by the state and central government for strengthening the entrepreneurial culture, Institutional Financial Support: Schemes and functions of rate of Industries; District Industries Centres (DICs); Industrial development corporation (IDC); State financial corporation (SFCs); Small scale industries development corporations (SSIDCs); Khadi and village industries commission (KVIC); Technical consultancy organisation (TCO); Small industries service institute (SISI); National small industries corporation (NSIC); Small industries development bank of India (SIDBI). Evaluating new venture: Project evaluation; Real options and risk assessment, Financial assessment of new venture: Measuring and evaluating financial performance; financial strategy and capital structure |
| 9 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | Odd |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS035 |
| 4 | **Title of the subject** | Management of Financial Services |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Students will be able to Enable participants, understand the financial services industry, regulatory environment, financial analysis, and risk management. Learn investment management, banking operations, financial planning, and financial technology, and ethics and professionalism. Determine the financial markets, financial intermediation and different financial services. |
| 8 | **Brief Contents** | Introduction to Financial Services: Financial services; Financial services sector in India: overview of financial services in India; nature scope and types of financial services: fund based and non-fund based financial services; venture capital: concept and types; regulatory framework; private equity; strategic secrets of private equity, investment strategies, hedge funds; new venture financing; risk & return in venture capital, Mutual Funds and Pensions Funds: Mutual funds and pensions funds; insurance services; bank assurances; reinsurances; securitization; Indian banking and financial crisis; asset reconstruction companies; depositaries; credit cards; micro/macro finance; financial inclusion, Plastic Money - Concept and different forms of plastic money - credit and debit cards, pros and cons. Credit process followed by credit card organizations. Factors affecting utilization of plastic money in India, Financial Depository: Depository – introduction, concept, depository participants; functioning of depository systems; process of switching over to depository systems; benefits; depository system in India; dematerialization and rematerialization role; objectives and functions of SEBI and its guidelines relating to depository system, Credit Rating & Merchant Banking: Credit Rating: the concept and objective of credit rating, various credit rating agencies in India, credit rating agencies – importance, issue, difference in credit rating, rating methodology and benchmarks, are Indian credit rating credible? International credit rating agencies – crisis of confidence?, Merchant Banking: origin and development of merchant banking in India scope, organizational aspects and importance of merchant bankers. latest guidelines of SEBI w.r.t. merchant bankers. Debt Securitization & Risk Management in Banks: Debt Securitization: meaning, features, scope and process of securitization. factoring: development of factoring types & importance, procedural aspects in factoring, financial aspects, prospects of factoring in India, Risk Management in Banks: credit risk management, operational risk management, market risk management, corporate treasury management, liquidity risk management, governance risk and compliance. |
| 9 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | Even |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS036 |
| 4 | **Title of the subject** | Financial Risk Management |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Understand the concept of financial risk and a comprehensive understanding of the various types of financial risks that organizations face. Developing the skills to identify and measure financial risk using various quantitative and qualitative techniques. Understanding to develop and implement the strategies to manage financial risk. Understanding the regulatory environment surrounding financial risk. |
| 8 | **Brief Contents** | Overview of financial risks, Risk, expectations, and asset prices, Volatility behavior and forecasting, Market risk measurement, Value-at-Risk and its implementation, Credit and counterparty risk, Leverage and leverage risk, Liquidity risk, Extreme events and market risk measurement, Assessing the accuracy of Value-at-Risk, Incorporating extreme events into risk measurement, Credit risk measurement, Portfolio credit risk measurement, Structured credit risk, Financial crises, Overview of regulatory policy, Regulatory capital and liquidity standards, Financial stability regulation |
| 9 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | Odd |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS037 |
| 4 | **Title of the subject** | Personal Wealth Management |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | After completion of the course, students will be able to understand personal financial planning as an approach for investment, insurance, taxation, and retirement and can identified the best combination of different financial products in view of different time horizons and propositions of risk return trade-off. |
| 8 | **Brief Contents** | Introduction and importance of personal wealth management, Concept of personal financial planning, Objective of personal financial planning, Steps involve in personal financial planning process, Emergence of personal financial planning in India, Financial institutions and products, Concept of risk, Types of risk, Measuring risk, Understanding return, Concept of compounding, Real and nominal rate of return, Tax adjusted return, Risk adjusted returns, Asset classes, Portfolio construction, Practical asset allocation and |

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| | | rebalancing strategies, Portfolio monitoring and re-balancing, Need for insurance, Requirement of an insurable risk, Role of insurance in personal finance, Steps involve in insurance planning, Insurance products, Products and functions of life and non-life insurance business, Need of life insurance, Retirement planning process, Estimation of retirement corpus, Determination of retirement corpus, Retirement products, Understand income tax principles, Tax aspects of investment products, Personal tax planning, Estate planning. |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | Even |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS038 |
| 4 | **Title of the subject** | International Finance |
| 5 | **Any prerequisite** | Financial Engineering and Management |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Students will be able to understand the significance of financial management in the global context particularly for MNCs, importance of foreign exchange market and international financial institutions, and applications of financial instruments of the international financial markets for the working capital and financing decisions. |
| 8 | **Brief Contents** | Concept and comparison of international trade, International business, International finance, International trade theories, Balance of payments and capital account convertibility, Development of international monetary system, Nominal, real and effective exchange rates, Determination of exchange rates, Factors influencing exchange rates, Theories of exchange rate behaviour; International financial institutions, Major participants in foreign exchange market, Spot market and forward market, Markets for currency futures and options, Foreign exchange rates, Techniques of exchange rate forecasting, Nature and Measurement of Foreign Exchange Exposure, Management of Foreign Exchange Exposure, Theories of Foreign direct investment, International capital budgeting- Evaluation criteria, Computation of cash flows, Cost of capital, Adjusted present value approach, Evaluation and management of political risk, International Portfolio Investment-concept of optimal portfolio, modes of international portfolio investment, An overview of international financial markets, Channels for international flow of funds, Multilateral development banks, International banking, International financial instruments, Financial swaps, Management of interest rate risk, Working capital policy, Management of current assets, Financing current assets, Foreign trade documentation, Modes of payments in international trade, Methods of trade financing. |
| 9 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | Odd |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS039 |
| 4 | **Title of the subject** | Project Appraisal and Finance |
| 5 | **Any prerequisite** | Elementary Financial Management |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The course aims at providing an understanding of project identification, feasibility study of the project and project report preparations. It facilitates the knowledge about different sources of financing and financial appraisal technique. It provides an acquaintance about social cost benefit analysis with understanding for different types of project risk and also post assessment of the project. |
| 8 | **Brief Contents** | An introduction to project appraisal, Project appraisal and evaluation , Project life cycle, Project cycle management , Cost benefit analysis of Private and public sector projects; Identification of investment opportunities – industry analysis review of project profiles, – feasibility study , Project identification and formulation , Generation of project ideas, Basic principles of project analysis entrepreneurship concept, Theory and perspective, Market feasibility analysis of a project, Need for market analysis, Demand and supply analysis, Collection analysis, primary /secondary data, Forecasting of market growth; Market forecasting techniques, Technical appraisal of a project, Technology tie ups and diffusion; Management of technology and business, Financial feasibility analysis: Estimation of cost of project & means of financing, Arrangement of funds, Traditional sources of financing: Equity shares, preference shares, Debentures / bonds, loan from financial institutions, Alternative sources of financing: FDI & FII, private equity, securitization, venture capital, Different business/project support government schemes, Government funding for projects, Startup schemes of government, Projected cash flows of project, Appraisal criteria, NPV,IRR, PI, PBP, ARR, Economic analysis of a project : Social cost benefit analysis – rationale of SCBA, direct and indirect cost and benefits, shadow price efficiency and equity in project appraisal, UNIDO approach, Little Mirrlees approach, Environment impact assessment of a project and social impact assessment of a project, Risk and sensitivity Analysis, taxonomy of risks, break even analysis, Sensitivity analysis, Risk analysis using simulation models and decision trees, Monitoring and evaluation of a project – PERT / CPM, Monitoring mechanism, valuation and lessons, project audit, Preparation of project report, Case analysis. |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | Even |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS040 |
| 4 | **Title of the subject** | Security Analysis and Portfolio Management |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The objective of this course is to help students gain an understanding of the evolving domestic and international investment landscape in general, and the Indian capital market with special emphasis on the availability of different financial products and stock exchange operations. It aims to provide a thorough understanding of portfolio management theory and practice. With the goal of assisting the participants in making wise investment choices in the context of portfolio investment, significant theories, techniques, laws, and advancements in investment theory will be covered. |
| 8 | **Brief Contents** | Investment Alternatives and Objectives, Organization and Mechanics of Securities Markets, Types of Security Markets and their Functions, Stock Exchanges, Depository, Stock Indices, Role of Regulatory Authorities, and various participants in markets, Market Microstructure, Risk and Return dynamics, Utility Theory, Portfolio Theory, CAPM Capital Asset Pricing Model (CAPM), Arbitrage Pricing Model (APT), Multi-factor Models, Sharpe's Single Index Model, Lagrange Multiplier Theory, Basics of futures and options, Fundamental Analysis: Macroeconomic activities and security markets, The Cyclical indicator approach, Monetary variables, Business cycles and industry sectors, Evaluating Industry life cycle, Analysis of industry competition and industry rate of returns, Company analysis, Analysis of Financial statement and Stock valuation, Technical analysis: Assumption, Advantages, Challenges, Types of Charts, Technical Trading Rules, and Indicators, Introduction to Efficient Market Hypothesis, Random Walk Model, Forms of EMH, Empirical Evidence, Bond Fundaments, Valuation and Bond Yield, Term structure, Bond Theorems, Bond Portfolio Management Strategies, Passive and Active Management, Portfolio Management, Portfolio Objectives, Evaluation of Portfolio Performances, Application of Portfolio performance measures |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | Odd |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS041 |
| 4 | **Title of the subject** | Consumer Behavior |
| 5 | **Any prerequisite** | No |

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| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Explaining the basic concepts of Consumer Behavior and its linkages to marketing.<br><br>Examine how markets are segmented, and brands are positioned.<br><br>Analyse the phenomenon of consumer learning about a brand and forming perceptions about it.<br><br>Compare how the theoretical aspects of Consumer Behaviour are practiced in real scenarios by marketers and brands. |
| 8 | **Brief Contents** | Consumers, Marketers, and Technology, Consumer Behavior and Technology, Market Segmentation and Real-Time Bidding, The Consumer as an Individual, Consumer Motivation and Personality, Consumer Perception and Positioning, Consumer Learning, Consumer Attitude Formation and Change, Communication and Consumer Behavior, Persuading Consumers, From Print and Broadcast to Social Media and Mobile Advertising, Reference Groups and Communities, Opinion Leaders, and Word-of-Mouth, Social and Cultural Settings, The Family and Its Social Standing, Cultural Values and Consumer Behavior, Cross-Cultural Consumer Behavior: An International Perspective, Consumer Decision-Making, Marketing Ethics, and Consumer Research, Consumer Decision-Making and Diffusion of Innovations, Marketers' Ethics and Social Responsibility, Consumer Research. |
| 9 | **Contents for lab** | Case study exercises |

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|---|---|---|
| 1 | **Semester** | Even |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS042 |
| 4 | **Title of the subject** | Advertisement and Sales Promotion Management |
| 5 | **Any prerequisite** | Marketing Management |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To understand the key concepts of advertising and sales promotion. To explore an organisation's numerous copy and media decisions. To understand the link between advertising and sales promotion for enhancing brand equity |
| 8 | **Brief Contents** | Role of integrated marketing communication, Role of IMC in marketing process, Marketing and promotions process, Organizing for advertising and promotion: the role of Ad agencies and other marketing communication organizations, Perspectives on consumer behavior, The communication process, Source, message and channel factors, Establishing objectives and budgeting for the promotional program, Creative strategy: planning and development, Media planning and strategy, Media decisions, Evaluation of broadcast media, The internet and interactive media, International advertising and promotion, Advertisement effectiveness, Sales promotion, Linkage between advertising and sales promotion, Brand equity, Regulation of |

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| | | advertising and promotion, Evaluating the social, ethical, & economic aspects of advertising & promotion. |
| 9 | **Contents for lab** | Case study exercises<br>Class projects and exercises<br>Field projects and company visits |

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|---|---|---|
| 1 | **Semester** | Odd |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS043 |
| 4 | **Title of the subject** | Product and Brand Management |
| 5 | **Any prerequisite** | Marketing Management |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | After completion of this course students will be able to understand the concept of product and brand management, branding as marketing strategy; brand equity and its measurement, and operational aspects of brand management. |
| 8 | **Brief Contents** | Introduction and concept of product management, Management of new product development process, Understanding and managing product life cycle, Introduction to brand management, Brand management process, Brand choice decisions and models, Brand identity, Brand communication, Brand positioning, Brand image and personality, Brand valuation, Brand tracking and monitoring, Building brands in Indian market, Launching a new brand, Revitalizing brands, Brand extension strategies, Brand portfolio management, Managing brands across geographical borders, Managing brand experience, Digital branding, Employment branding, Co-branding. |
| 9 | **Contents for lab** | No |

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|---|---|---|
| 1 | **Semester** | Even |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS044 |
| 4 | **Title of the subject** | E-Marketing |
| 5 | **Any prerequisite** | Marketing Management |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To explore frameworks for the successful planning and execution of e-campaign strategies. To understand ROI enhancement, customer lifetime value and firm profitability aligned with business goals through e-marketing. To plan and implement search engine and social media campaigns in simulated environments. To understand leveraging digital marketing funnel for better customer engagement. To |

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| | | understand reach, engagement and conversions with paid and unpaid e-campaigns. To measure and optimize the e-campaigns through different matrices. Strategic application of digital marketing best practice. |
| 8 | **Brief Contents** | Marketing in the digital world, Exploring customer behaviour and customer journey in digital world, Crafting and executing digital strategy, Aligning business strategy, Reaching and engaging the customer, Strategies for paid and unpaid e-campaigns, Display, social media and e-mail campaigns, User experience and transformation, True personalization, Customer service, Content strategy, Matrices for strategy evaluation, Digital analytics, Emerging technologies |
| 9 | **Contents for lab** | Case study exercises<br>Class projects and exercises<br>Field projects and company visits |

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|---|---|---|
| 1 | **Semester** | Odd |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS045 |
| 4 | **Title of the subject** | Retail Management |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Upon successful completion of the course, students should be able to: Demonstrate an understanding of how retailers develop a retail mix to build a sustainable competitive advantage. Explain how retailers use marketing communications to build a brand image and customer loyalty. Understand the integration of merchandise management and supply chain strategies leading to excellent customer service. Understand the financial implication of strategic retail decisions. Demonstrate an understanding of decisions retailers make to satisfy customer needs in a rapidly changing and competitive environment. |
| 8 | **Brief Contents** | Introduction to the world of Retailing : A. History of retail, B. Retail overview and present scenario C. Concept and Functions performed by retailers D. Emerging Trends and career opportunities in retailing, Types of Retailers: A. Retailer characteristics B. Retail Formats - Store based, Non-store based, Web based C. Various format within store based retailing e.g. specialty store, hyper market, supermarket, buying decision process : A. The buying process - need recognition, information search, evaluation of alternatives. B. Social factors influencing the buying process family, reference groups and culture retail market strategy: A. Definition of retail and market strategy B. Target market C. Building a sustainable competitive advantage like - customer's loyalty, location, human resource management, distribution and information system, vendor relations. D. Growth strategies - Market penetration, market expansion, retail format development diversification, integration, E. Global retail strategies F. Strategic retail planning process, Choosing retail location: A. Types of |

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| | | locations - Unplanned locations free standing sites B. Evaluation of area for location C. Evaluating specific area for locations, HRM In Retailing: A. Human resource planning, Recruitment and selection, training and development of retail employees. B. Motivation of retail employees, C. team building in retailing D. Employee Rewards and Incentives, Store Planning: Design & Layout, Retail Image Mix, effective retail space management, floor space management, Retail Supply Chain Management: A. Introduction to supply chain management B. The distribution across centres C. Collaboration between retailer and vendor in SCM D. Inventory Management E. Warehousing F. Transportation G. Use of IT in SCM, Customer Relationship Management - The CRM process 9. Retail Information System Instructrual Strate, Merchandise Pricing: Concept of Merchandise Pricing, Pricing Objectives, External factors affecting a retail price strategy, Pricing Strategies, Types of Pricing. |
| 9 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | Even |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS046 |
| 4 | **Title of the subject** | International Marketing |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The course aims at providing knowledge to students to the global business activities, marketing in international business and global forces transforming the international business today. Participants will learn to plan effectively for the marketing of consumer and business needs and wants on an international level. Special emphasis will be placed on cultural and environmental aspects of international trade, and integration of culture and marketing functions. |
| 8 | **Brief Contents** | An Overview of International Marketing: The Scope and Challenge of International Marketing, The Dynamic Environment of International Trade, The Cultural Environment of Global Markets: History and Geography: The Foundations of Culture, Cultural dynamics in assessing Global markets, Culture, Management style, and Business systems, The Political environment: A Critical concern, The International legal environment: Playing by the rules , Assessing Global Market Opportunities: Developing a Global Vision through Marketing Research, Economic Development and the Americas, Europe, Africa, and the Middle East, The Asia Pacific Region, Developing Global Marketing Strategies: Global marketing management: Planning and Organization, Products and services for consumers, Products and services for businesses, International marketing channels, Integrated marketing communications and International advertising, Personal selling and Sales management, Pricing for international markets, Implementing Global Marketing |

| | | |
|---|---|---|
| | | Strategies: Inventive Negotiations with International Customers, Partners, and Regulators |
| 9 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | Odd |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS047 |
| 4 | **Title of the subject** | Sales and Distribution |
| 5 | **Any prerequisite** | Marketing Management |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To understand the key concepts of sales and distribution. To explore an organisation's numerous distribution and sales channels. To broadly look at the role of sales and distribution as a key element within marketing strategy. To equip with basic skills required in sales and distribution management. |
| 8 | **Brief Contents** | Sales management and the business enterprise, Sales management, personal selling, and salesmanship, Setting personal-selling objectives, Determining sales-related marketing policies, Formulating personal-selling strategy, The effective sales executive, The sales organization, Sales department relations, Sales personnel management, Recruitment and selection, Sales training, motivation and compensation, Evaluation and supervision, Sales budget, Territories, control and cost analysis, Marketing channels, Managing channel partners, Channel information system, Logistics and supply chain management, International sales and channel management |
| 9 | **Contents for lab** | Case study exercises<br>Class projects and exercises<br>Field projects and company visits |

| | | |
|---|---|---|
| 1 | **Semester** | Even |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS048 |
| 4 | **Title of the subject** | Marketing Research |
| 5 | **Any prerequisite** | Basic knowledge of statistics and research methodology |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To understand the formulation of marketing problem into a feasible research question. To design and execute a basic survey research project. To understand the research tools and techniques for executing a marketing project and decision making. |

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| 8 | **Brief Contents** | Introduction to Marketing Research: Marketing research an introduction, marketing research process design, Research design formulation: Measurement and scaling, questionnaire designing, sampling and sampling distributions, Sources and collection of data: Secondary data sources, Data collection: survey and observation, experimentation, fieldwork and data preparation, Descriptive statistics and data analysis: Measures of central tendency, measures of dispersion, hypothesis testing for single population and two populations, ANOVA and Experimental designs, hypothesis testing for categorical data (chi-square test), correlation and simple linear regression analysis, Multivariate analyses (multiple regression analysis, discriminant analysis, conjoint analysis, factor analysis, cluster analysis, multidimensional scaling and correspondence analysis, Result presentation: Presentation of results, report writing, Applications of marketing research: Marketing mix research: Product, price, place and promotion research |
| 9 | **Contents for lab** | Descriptive statistics and data analysis: Measures of central tendency, measures of dispersion, hypothesis testing for single population and two populations, ANOVA and Experimental designs, hypothesis testing for categorical data (chi-square test), Correlation and simple linear regression analysis, Multivariate analyses (multiple regression analysis, Discriminant analysis, conjoint analysis, factor analysis, Cluster analysis, Multidimensional scaling and correspondence analysis |

| | | |
|---|---|---|
| 1 | **Semester** | Odd |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS049 |
| 4 | **Title of the subject** | Service Marketing |
| 5 | **Any prerequisite** | Basic knowledge of Marketing Management |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To provide an in-depth appreciation and understanding of the unique challenges inherent in managing and delivering quality services. To develop an understanding of the ‘state of the art’ of service management thinking. To understand the marketing concepts in the perspectives of services. |
| 8 | **Brief Contents** | Service Marketing Introduction : Meaning and nature of services, classifications of services, Introduction to service marketing, Evolution of service marketing, Service marketing mix and Gaps model: 7Ps of service marketing, service gaps framework, perceived service quality, model of service marketing, Service design and service delivery: Introduction to service design and service delivery, service delivery process, service encounters and moments of truth, employee role in service delivery, role of service provider, intermediaries involved in service process and delivery, managing demand and supply of service, STP strategy for Services: Need for segmentation of |

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|---|---|---|
| 9 | | services, bases of service segmentation, segmentation strategies in service marketing, need for targeting and positioning strategies for services, Consumer behaviour in service marketing: Customer expectations in services, Service costs experienced by consumer, the role of consumer in service delivery, customer responses in services, customer delight, service failure and recovery, Emerging issues in Service marketing: Strategic approach in service marketing, Service marketing in e-commerce and e- marketing, Telemarketing services |
| 9 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | Even |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS050 |
| 4 | **Title of the subject** | Strategic Marketing |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | On completion of this course, the student will be able to: Understand and critically discuss the marketing activities that impinge on our daily lives as business managers and citizens. Critically evaluate key marketing theory, concepts, research and current practice. Discuss critically decision-making processes and frameworks for selecting marketing objectives, target markets and marketing mixes. Discuss critically how marketing practice is influenced by contemporary challenges in the operating environment. Apply theoretical frameworks to real-world marketing innovation challenges: identifying their key features and implications, setting appropriate marketing objectives and evaluating alternative marketing strategies. |
| 8 | **Brief Contents** | Fundamentals of Marketing Strategies, Marketing management for a turbulent era, The marketing fit with corporate and business strategies, Capturing key Marketing environmental insights, Customer insights and customer connections , Capturing marketing insights for demand measurement, Market segmentation and target marketing, Conducting Marketing audits, Branding and positioning, Marketing strategies for competitive and market scenarios, The integrated marketing mix, Marketing Metrics and Analytics, Organising, planning, delivering and measuring market performance, Innovation and Marketing Strategy, Marketing Channels and Pricing, Marketing Communications, Digital and Social media marketing, Marketing strategy to the bottom of the pyramid, Frugal & Grass root marketing |
| 9 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | Odd |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS051 |
| 4 | **Title of the subject** | Public Policy and Processes |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Upon successful completion of the course, student should be able to: Describe formulation and implementation of policies. Employ role of various institutions and interest groups in policy formulation and implementation process. Assess role of various stakeholders in influencing policy processes and associated outcomes. |
| 8 | **Brief Contents** | Concepts and Theories of Public Policy and Processes: Understanding public policy, Policy types, Approaches to policy making- various models of policy making and their relevance, Institutions and its role in Public Policy: Policy making institutions in India: Judiciary, executive and legislature, How policy making is accomplished in India, Constitutional/statutory bodies and its role in policy process, Political institutions, Changing role of institutions: new public management, New governance model, Role of networks in shaping public policy, Policy Process: Formulation of policies: Principal phases of policy process: issue identification/agenda setting, Stakeholder consultation and review, Transparency in policy formulation, Identifying the main actors/stakeholders in the policy process, Idea of political power and influence, Regional versus national interest, Policy Process: implementation of policies: policy implementation, Identifying implementation gaps, Feedback on policies, Policy implementation as a political process: political economy, Service Delivery, Accountability and people's participation: role of decentralization and local governance, Policy Change: Identifying role of domestic and international actors in determining policy choices, Endowments and Constraints on their power to determine policy choices civil Society/pressure groups/networks and its role in influencing policy decisions, Market (private sector/business) as an agent in influencing policy decisions, Media and its role in public policy |
| 9 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | Even |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS052 |
| 4 | **Title of the subject** | Public Private Partnerships |
| 5 | **Any prerequisite** | |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Upon successful completion of the course, student should be able to: Understand the role of cooperation between public and private sectors in delivering public services; to develop understanding of PPP models |

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| | | and their contextual suitability; and employ various types of partnerships and assess their consequences. |
| 8 | **Brief Contents** | PPP Concept, Benefits and Limitations- Public service delivery and roles of government, recent trend of reforms on public service delivery, basic theories of pubic private partnership (PPP)<br><br>PPPs Models- Concept and practices of outsourcing, Competition between private and public sectors, such as competitive sourcing and market testing, concept and practices of various types of private finance initiative (PFI), recent issues in PFI practices, theories and practices of deregulation, involvement of citizens, non-profit organization (NPOs) and social enterprises in public service delivery, Basic theories and practices of executive agencies and public corporations, theories and practices of privatization, recent practices to bring outsourced public services back in-house<br><br>Government Role for Creating an Enabling PPP Environment-Conventional and innovative approaches for improving government procurement, practical models of shared services in public sector, advantages and disadvantages of PPP, strategies, steps, monitoring, evaluation of PPP, skills and resources required for managing PPP<br><br>Risk Identification and Allocation- Risk assessment, value for money (VfM) and commercial feasibility exercises, risk identification, political risks, market risks, challenges for public service delivery and possible (desirable) future directions<br><br>PPP Structure and Financing- Financing options, profitability assessment, funding cost, project attractiveness. |
| 9 | **Contents for lab** | N/A |

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|---|---|---|
| 1 | **Semester** | Odd |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS053 |
| 4 | **Title of the subject** | Sustainable Development |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | To enhance students understanding of the SDGs to create a better-informed citizenry, which will lead to a more sustainable action by all and for all. To understand the basic concept of Sustainable Development (SD), the environmental, social and economic dimensions. To know the history of the SD idea. To Be able to discuss the conflicts which are involved in the SD concept on the national as well as on the global scale. To be familiar with potential strategic options for SD (efficiency, sufficiency). To be able to discuss the (dis-advantages) of instruments for SD. To understand the SD challenge for companies, their responsibility and their potentials for action. |
| 8 | **Brief Contents** | Sustainability, sustainable development, and the sustainable development goals; SDGs overview, goals, and targets, Instruments for |

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| | | sustainable development, SDG Goal part-1 : Poverty, Hunger, Good health and Well-being, SDG Goal part-2 : Gender equality, Reduced inequalities, SDG Goal part-3 : Clean water and sanitation, Affordable and clean energy, SDG Goal part-4: Quality education, Decent work and Economic growth, SDG Goal part-5 Industry, Innovation, and Infrastructure; SDG goal part- 6: Sustainable cities and communities, Responsible Consumption and Production, SDG Goal part-7 Climate action, Life below water, Life on land; SDG Goal part-8 Peace, Justice, and Strong institutions, #17 Partnerships for goals, Implementing the SDGs, Monitoring, Evaluation, Reporting, Beyond sustainability to radical transformation, Company perspectives |
| 9 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | Even |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS054 |
| 4 | **Title of the subject** | Management of Rural and Social Sector |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Course is designed to inculcate students with realistic understanding of rural segment and society for the application of managerial and technological learning. |
| 8 | **Brief Contents** | Indian rural and social sectors, Rural and sector economic development, Different rural and social sector reform programmes of Asia; Local, National and International focuses and policies for economic reforms of rural and social sectors. |
| 9 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | Odd |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS055 |
| 4 | **Title of the subject** | Information Technology Enabled Services |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Understand the business strategy and business implications for strategic IT planning. Equip students to understanding the concepts of IT infrastructure library and services |

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| 8 | **Brief Contents** | Business Strategy: Challenges- opportunities, Interconnection establish principles before practice, IT strategy, Application strategy, Technology strategy for IT, IT management strategy, Developing IT strategy for competitive advantage, Stages of IT strategy development and implementation, Challenges of IT and business strategy alignment, Inhibitors of business and IT strategy alignment, Three-D framework for Business and IT strategy alignment, Business implications for IT strategy and planning, Strategic IT planning, Motivations, SITP Process: Prevalent planning approaches difficulties, Best practices for achieving good SITP, SITP approaches: Prevalent researches, Defining EITA, Contents of a typical enterprise IT architecture, Standard for enterprise IT architecture, Technology Management strategy framework, Information Technology Infrastructure Library (ITIL), ITIL overview- ITIL Service- support processes, Incident management, Problem management, Service delivery, Service level management- Financial management, Capacity management, IT Service continuity management (ITSCM), Availability management, Imperatives for outsourcing, IT management layers- Variants of outsourcing, Business process outsourcing, Insourcing. |
| 9 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | Even |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS056 |
| 4 | **Title of the subject** | Management of Non-Formal Organization |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | The Non-Informal sector is the backbone of the Indian Economy. The understanding of the issues related to the informal sector is necessary to have a better understanding of the Indian economy. This course would try to educate the researcher on different issues related to the informal sector in India and across the developing countries. This paper would enable the management student and potential researcher to conduct some in-depth research work in the unorganized sector. |
| 8 | **Brief Contents** | Introduction: Why the Informal Economy Matters to Management, Concept, Features and Types of Non formal sector, Difference between formal and informal organisation, Function of Non formal sector ,Formalizing informal sector, Challenges of the informal economy for the field of Management, Theoretical Foundations: A General Equilibrium approach, Communication, Visibility, and the Informal Economy, Technology in Non formal sector – Application and challenges, Management of The ICT in Non informal sector, Small Business in the informal Economy, Informal Financial Services: A Proposed Research Agenda, The hidden enterprise culture: Entrepreneurship in the Non informal sector, Organization and |

| | | |
|---|---|---|
| | | Contract in the Informal Economy, Comparative Economic Organization Revisited: Hybrid Governance in the Informal Economy, Factors Influencing the Registration Decision in the Informal Economy, Informal Firms in India What Do We Know and Where Does the Research Go, Healthcare in the Informal economy, Subsistence Entrepreneurs and Formal Institutions: Semi-formal Governance among Indian Entrepreneurs, Learning From India's Aadhaar Project, Lesson form Akshyapatra',Lesson from 'Arvind Eye care' |
| 9 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | Odd |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS057 |
| 4 | **Title of the subject** | Healthcare System Management |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Upon successful completion of the course, student should be able to: Delve into the components and functions of health care provider organizations and assess the unique challenges involved in managing complex health care organizations. Appraise the motivations and interests of key internal and external stakeholders and managing expectations and communicating with these stakeholders. Weigh common problems and decisions faced by health care managers, and explore the implications of various alternative strategic solutions |
| 8 | **Brief Contents** | Issues in health management: leadership, management and motivation, Organizational behavior and management thinking, Strategic planning, Information systems, Complexity and purpose of health care organizations, For profit and non-profit organizations, Management responsibilities and health care operations, Management code of ethics and ethical decision-making, Care and cure processes, Operations management, Impact of the pandemic on providers and caregivers, Physician practice management, The post-pandemic health care system, Strategic planning, Industry consolidation |
| 9 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | Even |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS058 |
| 4 | **Title of the subject** | Emerging Areas in Management of Social Sector |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Upon successful completion of the course, student should be able to: Apply social work skills, values and ethical responsibilities to leadership, management and supervision practices. Describe and critique selected theories, research and practice approaches relevant to effective and socially just leadership and management in human service organizations. Create a plan for strategic change using concepts, processes and skills related to leadership, management, and organization development. |
| 8 | **Brief Contents** | Corporate governance, Project management, Social entrepreneurship for sustainable development, Strategic planning for social sector organizations, Essentials of managing a social organization, Understanding financial statements, Measuring project results, Systems and tools for impact measurement, Social impact marketing and sales management, Scaling a social enterprise, Attracting & raising capital, Market regulation and compliance. |
| 9 | **Contents for lab** | No |

| | | |
|---|---|---|
| 1 | **Semester** | Even |
| 2 | **Type of course** | Elective |
| 3 | **Code of the subject** | MS059 |
| 4 | **Title of the subject** | Infrastructure Management |
| 5 | **Any prerequisite** | No |
| 6 | **L-T-P** | 3-0-0 |
| 7 | **Learning Objectives of the subject** | Understanding the importance of infrastructure in supporting economic development, quality of life, and public safety. Understanding the roles and responsibilities of different stakeholders involved in infrastructure management, including government agencies, private sector organizations, and community groups. Developing skills in infrastructure asset management, including maintenance, repair, and replacement of infrastructure assets. Understanding the principles of sustainable infrastructure development and management, including considerations of environmental and social impact. Developing an understanding of risk management, including identifying, assessing, and mitigating risks associated with infrastructure systems. Understanding the legal and regulatory frameworks governing infrastructure development and management. Developing an |

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| | | understanding of the financing and funding mechanisms for infrastructure projects, including public-private partnerships and other innovative financing approaches. |
| 8 | **Brief Contents** | Introduction to Infrastructure Management: Definition and scope of infrastructure, Importance of infrastructure management, Historical development of infrastructure management, Types of Infrastructure: Transport, Water and wastewater infrastructure, Energy infrastructure management, Telecommunication management, Asset Management: Asset inventory and condition assessment, life cycle costing, risk management, Funding and Financing of Infrastructure: Public sector funding, private sector funding, public -private partnership, Project Management: Project identification and selection, project planning and design, project procurement and contracting, construction management and supervision. Infrastructure Policy and Regulation: Government policy on infrastructure, regulatory framework for infrastructure management, environment regulations and considerations, Emerging trends in Infrastructure management: new technologies for infrastructure management, Sustainability and resilience considerations, Future challenges and opportunities in infrastructure management |
| 9 | **Contents for lab** | No |

# Curriculum & Contents

# Dual Degree Program (M. Tech. + PhD)

**Offered by**

**Department of Computer Science and Engineering**

**Department of Information Technology**

विश्वजीवनामृतं ज्ञानम्

## ABV-Indian Institute of Information Technology & Management, Gwalior

# SCHEMA

## Dual Degree Program – M. Tech. and PhD

**Offered by:**

**Department of Computer Science and Engineering (M. Tech. (CSE)**
**and**
**Department of Information Technology (M. Tech. (IT) and PhD)**

| **Semester – I** | | | | | |
|---|---|---|---|---|---|
| **SN** | **Subject Code** | **Course Title** | **Component** | **L-T-P** | **Credits** |
| | | All courses as per the 1st semester of the M. Tech. program | M. Tech. | | |
| | | | | Credits | |

**Note:**

- **Supervisor allocation and formation of SRC**

| **Semester – II** | | | | | |
|---|---|---|---|---|---|
| **SN** | **Subject Code** | **Course Title** | **Component** | **L-T-P** | **Credits** |
| | | All courses as per the 1st semester of the M. Tech. program | M. Tech. | | |
| | | | | Credits | |

**Note:**

- **Exit option for Post Graduate Diploma**

| **Semester – III** | | | | | |
|---|---|---|---|---|---|
| **SN** | **Subject Code** | **Course Title** | **Component** | **L-T-P** | **Credits** |
| 1 | | M. Tech. Elective/MOOC | PhD* | 3-0-0 | 3 |
| 2 | | Elective/MOOC as per PhD ordinance | PhD* | 3-0-0 | 3 |
| 3 | | M. Tech. Research Credits | M. Tech. | | 12 |
| | | | | Credits | 18 |

**Note:**

- **Students with a planned exit follow the M. Tech. course structure from the next semester onwards.**

***Convertible to M.Tech. in case of an exit without PhD.**

| **Semester – IV** | | | | | |
|---|---|---|---|---|---|
| **SN** | **Subject Code** | **Course Title** | **Component** | **L-T-P** | **Credits** |
| 1 | | Research Credits | Flexible | | 15 |
| | | | | Credits | 15 |

**Note:**

- **Students with abrupt exit can convert PhD Research Credits into M. Tech. research credits, re-defend PhD Research Credits as M. Tech. Research Credits with a letter grade and exit as an M. Tech.**

| Semester V and onwards | | | | | |
|---|---|---|---|---|---|
| **SN** | **Subject Code** | **Course Title** | **Component** | **L-T-P** | **Credits** |
| 1 | | Research Credits | Flexible | | As per PhD Ordinance |

**Note:**

- **Students with abrupt exit can convert PhD Research Credits into M. Tech. research credits, re-defend PhD Research Credits as M. Tech. Research Credits with a letter grade and exit as an M. Tech.**

**Note: The M.Tech. course content is identical to that of the M.Tech. CSE/IT of the corresponding departments (Computer Science and Engineering, and Information Technology)**

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