MS (CS) Course Curriculum

Department of Computer Science

Department of Computer Science is committed to inculcate in its students strong analytical, critical, ethical and technical skills related to software development. The department with it's dedicated, hardworking and research oriented faculty along with well-equipped labs of international standard aims to produce quality computing experts for the betterment of economy, progress and development of our beloved country.

MS in Computer Science programme is designed in line with national and international academic standards to achieve the following goals:

- To develop understanding of theoretical concept and principles underlying the science of computing technology.
- To develop a strong foundation and enthusiasm in students for computer science in general and computing in particular.
- Application of theories to practice and application of computing knowledge and skills in research, industry, government and private organization, planning and development at all level of working.

To achieve its goals the Department of Computer Science offers MS in Computer Science with the following field of specializations:

i. **Information Management**
ii. **Software Design and Management**
iii. **Web Engineering**

MS in Computer Science is of Thirty (30) credit hours programme; Core courses carry fifteen (15) credit hours while the remaining fifteen (15) credit hours can be earned from the list of electives of the relevant specialization.

MS IN COMPUTER SCIENCE

Core Courses

CS-6001 Advanced Operating Systems
CS-6003 Advanced Algorithm Analysis
CS-6004 Theory of Programming Languages
CS-6006 Advanced Theory of Computation
CS-6008 Advanced Computer Architecture

Compulsory Core

- CS-7005 Research Methodology

General Electives

- CS-6099 Thesis

ELECTIVE COURSES FOR SPECIALIZATION IN INFORMATION MANAGEMENT

CS-6101 Advance Database Management System
CS-6103 Object Oriented Databases
CS-6108 User Interface Analysis and Design
CS-6109 Intelligent Systems
CS-6110 Advanced Machine Learning
CS-6113 Tools and Techniques in Data science
CS-7102 Advanced Data Warehousing
CS-7104 Web Based DBMS
CS-7105 Topics in Databases Management Systems
CS-7106 Database Security
CS-7107 Advanced Data Mining
CS-7111 Big Data Analytics
CS-7112 Deep Learning
CS-7113 Knowledge Management

ELECTIVE COURSES FOR SPECIALIZATION IN SOFTWARE DESIGN AND MANAGEMENT

CS-6201 Software Quality Assurance
CS-6202 Requirement Engineering
CS-6203 Software System Architecture
CS-6204 Software Design
CS-6205 Software Project Management
CS-6210 Software Configuration Management
CS-7206 Information Retrieval
CS-7207 Software Process Improvement
CS-7208 Software Risk Management
CS-7209 Software Measurement & Metrics
CS-7211 Component Based Software Engineering

ELECTIVE COURSES FOR SPECIALIZATION IN WEB ENGINEERING

CS-6302 Web Services
CS-6304 Mobile Commerce Technology
CS-6305 Advanced Web Systems & Technologies
CS-6306 Internet Banking
CS-6307 E-Commerce Strategies and Technology
CS-6308 Social Marketing and Social Networking Applications
CS-6311 Rich Internet Applications
CS-7301 Semantic Web
CS-7303 Cyber Crime and Security
CS-7309 Multimedia Databases
CS-7310 Web Mining
CS-7312 Social Network Analysis
CS-7313 Device-To-Device Communication
CS-7314 Advanced Cloud Computing
CS-7315 Advanced Wireless Networks
CS-7316 Advanced Cryptography and Network security
CS-7317 Advanced Data Communication and Networks

CS-7318 Mobile and Ubiquitous Computing
CS-7319 Internet of Things

COURSE DESCRIPTIONS

CS-6001 Advanced Operating Systems

Operating system structures, microkernel approach, Memory and I/O virtualization, Multimedia operating systems, Parallel and distributed systems, Protection mechanisms and authentication, Operating system design, case studies of various operating systems.

CS-6003Advanced Algorithm Analysis

Fundamentals of formal techniques and the underlying mathematical theory, NP-completeness. Search Techniques, Randomized Algorithms. Heuristic and Approximation Algorithms. Asymptotic analysis of upper and average complexity bounds using big-O, little-O, and theta notation. Fundamental algorithmic strategies (brute-force, greedy, divide and conquer, backtracking, branch-and-bound, pattern matching, and numerical approximations) are covered. Standard graph and tree algorithms. Complexity classes, time and space tradeoffs in algorithms, using recurrence relations to analyze recursive algorithms, non-computable functions, the halting problem, and the implications of non-computability. Algorithmic animation. Mathematical concepts used in describing the complexity of an algorithm. Algorithm selection strategies.

CS- 6004 Theory of Programming Languages

Introduction: Models of Computation, Syntax and Semantics, Pragmatics, Language Design Principles. Syntax and Semantics: Context-Free Grammars, Regular Expressions, Attribute Grammars and Static Semantics, Algebraic Semantics, Axiomatic Semantics, Denotational Semantics. BNF grammars and Syntax, Operational Equivalence, Abstraction and Generalization, Expressions, Assignment Statement, and Control Structures, Functional Programming: The Lambda Calculus, Operational Semantics, Reduction Order, Recursive Functions, Logic Programming, Inference Engine, Concurrency.

CS-6006 Advanced Theory of Computation

Automata theory, formal languages, Turing machines, computability theory and reducibility, computational complexity, determinism, non-determinism, time hierarchy, space hierarchy, NP completeness, selected advanced topics.

CS-6008 Advanced Computer Architecture

Quantitative principles of Computer Design, Memory technology and optimizations, Virtual memory and virtual machines, Instruction level parallelism and its optimization, data level and thread level parallelism, Domain specific architectures.

CS- 6099Thesis

The aim of the thesis is to develop the students' ability in organizing, documenting and producing a non-trivial piece of work, starting from a brief description of what is wanted and

finishing with a preparation of a comprehensive document, which is presented before the thesis/project evaluation committee. Thesis is assigned to inculcate and evaluate the research and development abilities of the students. The student is required to choose and conduct research and/or development work theoretical or experimental, under the supervision and guidance of a Supervisor as per University rules.

CS-6101 Advanced Database Management System

Role and functions of database administration, data planning and information architectures, data centered information systems development. Advanced database manipulation with high-level languages and natural languages. Next Generation of DBMS; Object-Oriented DBMS.Data Warehousing, architecture, multidimensional databases, STAR schema, extract and transformation (ETL) tools, OLAP tools. Use of CASE tools to support information systems design and development. Maintaining data base integrity, technical, administrative and legal mechanisms. Deploying and managing data in a distributed (shared, networked) environment, database (SQL) servers, middleware tools to access enterprise databases on host computers. Organizational strategies for database administration, encouraging the use of advanced DBMS and supporting systems development and operations.

CS-6103 Object Oriented Databases

Refreshing, extension and formalization of basic concepts in object oriented programming and relational databases. Classes, objects, inheritance, polymorphism, encapsulation, static and dynamic binding, message sending, relational mathematics, normal forms. Handling of non-normalized structures. Extensions, generalizations of relational modeling and corresponding mathematics modeling. Object management systems. Concepts and problems. Persistent programming Methods and systems. Object database management systems. Modeling, meta programming, transaction, garbage collection, query handling. Prototypes and user interfaces. Problems related to temporal and spatial aspects. Existing systems. An overview of commercial and academic systems.

CS-6108 User Interface Analysis & Design

Introduction to HCL,HCL Paradigms, Design process; Know The User – Ethnography, Interviews, Questionnaires, etc., Requirements Gathering and Task Analysis, Understanding the Human –Cognitive Frameworks ,Mental Models ,Memory, Attention ,Big –Picture models of user: Characteristics, Gulf of Execution, Modeling the Human-Model Processor ,GOMS, Fits, User-Centered Design Principles, Design – Avoid Errors and Provide Help; Graphic Physiology ;Visual Structure; Icons ;Graphic color, Futuristic Videos, Prototyping-What, when ,why, how ,User Interface Software, Typography, Observational Techniques, Dialogue Styles-Command Language, WIMP, Direct Manipulation, Cognitive Walkthroughs, Dialogue Styles- Pen and PDA, Large Screen ,Speech ,Web Design, Design of cell phone Services and UIs.

CS-6109 Intelligent Systems

Introduction to Artificial Intelligence ,Logic Programming Using Prolog, Searching Techniques ,Knowledge Representation and Reasoning, Design & Development of Expert Systems, Basics of Natural Language Processing ,Design & Development of Neutral Network Applications ,Fundamentals of unsupervised learning techniques, Overview of decision tree learning ,Introduction to genetic algorithms ,Introduction to fuzzy systems, Components and architecture of a robot ,Intelligent agents and agent frameworks.

CS-6110 Advanced Machine Learning

Machine learning and statistical pattern recognition. Supervised learning: Part I (Graphical models (full Bayes, Naïve Bayes), Decision trees for classification & regression for both categorical & numerical data, Ensemble methods, Random forests, Boosting (Adaboost and Xgboost), Stacking; Part II (Four Components of Machine Learning Algorithm (Hypothesis, Loss Functions, Derivatives and Optimization Algorithms), Gradient Descent, Stochastic Gradient Descent, Linear Regression, Nonlinear Regression, Perceptron, Support vector machines, Kernel Methods, Logistic Regression, Softmax, Neural networks); Unsupervised learning: K-means, Density Based Clustering Methods (DBSCAN, etc.), Gaussian mixture models, EM algorithm, etc.; Reinforcement learning; Tuning model complexity; Bias-Variance Tradeoff; Grid Search, Random Search; Evaluation Metrics; Reporting predictive performance

CS-6113 Tools and Techniques in Data Science

Introduction to Data Science, Data Science Life cycle & Process (Asking Right Questions, Obtaining Data, Understanding Data, Building Predictive Models, Generating Visualizations) For Building Data Products, Introduction to Data (Types of Data and Datasets), Data Quality (Measurement and Data Collection Issues), Data pre-processing Stages (Aggregation, Sampling, Dimensionality Reduction, Feature subset selection, Feature creation etc.), Algebraic & Probabilistic View of Data, Introduction to Python Data Science Stack (Python, Numpy, Pandas, Matplotlib), Relational Algebra & SQL, Scraping & Data Wrangling (assessing, structuring, cleaning & munging of data), Basic Descriptive & Exploratory Data Analysis, Introduction to Text Analysis (Stemming, Lemmatization, Bag of Words, TF-IDF), Introduction to Prediction and Inference (Supervised & Unsupervised) Algorithms, Introduction to Scikit Learn, Bias-Variance Tradeoff, Model Evaluation & Performance Metrics (Accuracy, Contingency Matrix, Precision-Recall, F-1 Score, Lift, etc.), Introduction to Map-Reduce paradigm

CS-6201 Software Quality Assurance

Quality Assurance, Quality Engineering , Concepts, Issues, and Techniques, Test Activities, Management, and Automation, Coverage and Usage Testing Based on Checklists and Partitions, Input Domain Partitioning and Boundary Testing, Coverage and Usage Testing Based on Finite-State Machines and Markov Chains, Control Flow, Data Dependency, and Interaction Testing, Testing Techniques: Adaptation, Specialization, and Integration. Defect

Prevention and Process Improvement, Software Inspection, Formal Verification, Fault Tolerance and Failure Containment, Comparing Quality Assurance Techniques and Activities. Feedback Loop and Activities for Quantifiable Quality Improvement, Quality Models and Measurements, Defect Classification and Analysis.Risk Identification for Quantifiable Quality Improvement, Software Reliability Engineering.

CS-6202 Requirement Engineering

Role of requirements engineering in system development, Fundamental concepts and activities of requirements engineering, Information elicitation techniques, Fundamentals of goal-oriented requirements engineering, Modeling behavioral goals, Modeling quality goals, Goal modeling heuristics, Deriving operational requirements from goals, Requirements Specification, Requirements verification and validation, Management of inconsistency and conflict, requirements engineering risks, requirement change control board and process, the role of quality goals in the requirements selection process, Techniques for requirements evaluation, selection and prioritization, Requirements management, Requirements traceability and impact analysis.

CS-6203 Software System Architecture

The architecture business cycle, Understanding and achieving quality attributes, Attribute-driven design, Documenting software architecture, Evaluating software architecture, Architecture reuse Life-cycle view of architecture design and analysis methods, The QAW, a method for eliciting critical quality attributes, such as availability, performance, security, interoperability, and modifiability, Architecture Driven Design, Evaluating a software architecture (ATAM, CBAM, ARID), Principles of sound documentation, View types, styles and views, Advanced concepts such as refinement, context diagrams, variability, software interfaces, and how to document interfaces, Documenting the behavior of software elements and software systems, Choosing relevant views, Building a documentation package, Future of Software Design, Architecture Description Languages , Introduction to AADL , AADL, Testing Architectures, Feature Modeling in SPLs, Testing a Family of Products.

CS-6204 Software Design

Software Processes, Software Design Basics, Software Architecture, Software Design Principles, Software Patterns, Design Patterns, Creational Design Patterns, Introduction to Architectural Patterns, Structural Design Patterns, Behavioral Patterns, Idioms, Anti-Patterns, Model Driven Architecture, Service Oriented Architecture (SOA)

CS-6205 Software Project Management

Software Crisis and Software Engineering, Classic Mistakes, Overview of Project Management, PMI Process Groups, Software project Phases, Project charter, Statement of Work (SOW), Development lifecycle models, matching lifecycles to projects, Project plans, Work Breakdown Structures (WBS), Estimation of effort and cost (Expert Judgment, FP and Use Case point methods),Project network diagram fundamentals, CPM, PERT, Gantt charts, Critical chain scheduling, Using MS Project -Assigning Resources, Resource leveling, Team models, Managing conflict and motivating, Status reporting, Project metrics, EVM,

Communications Techniques, Risk management and Change control Project Recovery, Documentation, Cutover/Migration, Post Project Reviews, Closing.

CS-6210 Software Configuration Management

Source Code Management, Build Engineering, Environment Configuration, Change Control, Release Management, Deployment, Architecting Your Application for CM, Hardware Configuration Management, Rightsizing Your Processes, Overcoming Resistance to Change, Learning From Mistakes, Establishing IT Controls and Compliance, Industry Standards and Framework.

CS-6302 Web Services

Web Services, Service-Oriented Architecture, SOA development lifecycle, Enterprise Service Bus, SOA analysis and design methods, HTTP and XML, Simple Object Access Protocol (SOAP), Web Service Description Language (WSDL), Universal Description, Discovery and Integration (UDDI), WS-I Basic and Related Profiles, REST, Web Services as Component-Based Software, Web service development API.

CS-6304 Mobile Commerce Technology

Characteristics and functions M-commerce technology, M-commerce applications, M-commerce trust, security, and payment, M-commerce business model, Current and emerging M-commerce services such as mobile financial services, mobile entertainment services, and location-based M-commerce services, Group-oriented mobile commerce services and transactions management, wireless user interface design, Design and develop mobile applications using a prominent mobile technology.

CS-6305 Advanced Web Systems & Technologies

Web Effort Estimation, Web Productivity Measurement and Benchmarking, Web Quality, Web Usability, Web System Reliability and Performance, Web Application Testing, Conceptual Modeling of Web Applications, Model-Based Web Application Development, Modeling Notation for Complex Web Applications, Statistics Analysis, W3C Web Content Accessibility Guidelines, Internationalization, Mobile Web Applications, Mobile Web for Social Development, Accessible Rich Internet Applications (WAI-ARIA), Declarative Web Applications, Web Components, Web 2.0 & Associated Technologies, Web Real Time Communication and Web Authoring.

CS-6306 Internet Banking

e-Banking, Informational websites, Transactional websites, Internet Banking components, Internet Banking Trends & Directions, Retail payment trends, The global payments landscape, Emerging products & technologies, Operating Strategies & Management Models, Product Development Life Cycle, Internet Banking products including the contactless card, mobile payments, biometrics, stored value cards and bit coins, Managing risk in Internet Banking activities, Internet Banking controls, Risk in new and emerging Internet Banking payments and Critical issues in Internet Banking Development.

CS-6307 E-Commerce Strategies and Technology

Electronic Commerce, E-Marketplaces, E-Tailing Products and Services, Online Marketing and Online Consumer Behavior, Business- to-Business E-Commerce, E-Government and E-Learning, Web 2.0, Social Networks and Search Engine Optimization, E-Commerce Security, Payment Solutions and Order Fulfillment, E-Commerce Strategy and Global Issues, Legal, Ethical and Tax Issues, E-Commerce Business Analysis and Development.

CS-6308 Social Marketing and Social Networking Applications

Social Marketing, The role of content marketing in a multi-channel marketing world, Business Objectives and User-Centred Content, Brand Storytelling and Branded Content, Content Marketing for Multiple Online and Traditional Channels, Devices and Context, Content Marketing Strategy, Challenges and Considerations in Content Marketing, online social networking applications and their design/development, Develop dynamic web sites and applications on social networking platforms using server-side programming technology to meet strategic marketing goals.

CS-6311 Rich Internet Applications

Key Characteristics of Rich Internet Applications, RIA Platforms, RIA Architectures, RIA Architecture Details, RIA Benefits, RIA Drawbacks, RIA Patterns, RIA Best Practices, Direct Web Remoting, Mashups, RIA Using different frame works, RIA using various Toolkits, Latest trends and technologies in RIA.

CS-7005 Research Methodology

It covers categories, techniques and process of doing research in Computer Science like Qualitative and Quantitative. It also addresses the process of formulating appropriate research questions/problems, objectives and hypothesis, techniques for reviewing literature, approaches for testing relationship and patterns. It introduces the essential aspects of designing, supporting and conducting a research project. This course covers research proposal, select an appropriate methodology with which to conduct the research and defend the methodology of their selection and understand the various tasks required to carry out the research.

CS-7102 Advance Data Warehousing

Advanced concepts involved in developing data warehouses and data marts, planning, design, implementation, and evaluation; review of vendor data warehouse products; cases involving contemporary implementations in business, government and industry; techniques for maximizing effectiveness through OLAP and data mining. Critical Factors to design data warehouse. Data management, Data quality, Performance usage, Business Intelligence, Analytics and Big Data, Data warehousing Architectures.

CS-7104 Web Based DBMS

Web based database processing environment. Design and implement a web based database suing MySQL. Developing script using PHP. Design code and implementation of a fully integrated database driven web site in PHP/MySQL environment. Development of Scripts

using ASP. Etc. Relational database servers, build a client server architecture and prototype client/server application to access database,

CS-7105 Topics in Database Management Systems

Modern database and information systems as well as research issues in the field. Object oriented, workflow, active, deductive, spatial, temporal and multimedia databases. recent advances in database systems such as data mining, on-line analytical processing, data warehousing, declarative and visual query languages, multimedia database tools, web and unstructured data sources, and client-server and heterogeneous systems.

CS-7106 Database Security

Information Security Fundamentals and the Types of Attacks-Information Security Fundamentals, Attackers and their attacks ; Information Security Framework ,Operating System and user Administration- Operating System and User Administration, Profiles, Passwords, Privileges and Roles, Authorization , Database Applications Security ,Virtual-Private Database; How the virtual Private Database works, Auditing, Data Dictionary, Encryption with Oracle, SQL Injection. Security algorithms.

CS -7107 Advanced Data Mining

Concepts of Data mining, data pre-processing and pre-mining,(noisy and missing data, data normalization and discretization), outlier detection, Data mining learning methods, Data mining classes (association rule mining, clustering, classification), fundamental of other algorithms related to data mining(fuzzy logic, genetic algorithm and neural network), decision trees, rules, patterns and trends. Statistical modeling, linear models, clustering. Real machine learning schemes, Comparing data mining methods, Predicting probabilities. Automatic data cleansing, Combining multiple models.

CS - 7111 Big Data Analytics

Introduction to Big Data Analytics, Big Data Platforms, Data Store & Processing using Hadoop, Big Data Storage and Analytics, Big Data Analytics ML Algorithms, Recommendation, Clustering, and Classification, Linked Big Data: Graph Computing and Graph Analytics, Graphical Models and Bayesian Networks, Big Data Visualization, Cognitive Mobile Analytics.

CS - 7112 Deep Learning

Introduction to Deep learning, Review of Linear classification (Multi-class Support Vector Machines, Soft max) and Regularization, Gradient Descent & Stochastic Gradient Descent (SGD), Back propagation (Intuitions, back propagation, as flow graph), Introduction to Neural Networks (model of a biological neuron, activation functions, neural net architecture, representational power, etc.), Building Neural Networks (data preprocessing, loss functions, weight initialization, regularization, dropout, batch normalization), Learning Neural Networks (Learning and Evaluation gradient checks, sanity checks), Variants of SGD

(momentum, Adagrad/RMSprop, ADAM), Introduction to Convolutional Neural Networks (CNN) and its components (Convolution and Pooling Layers), Convolutional Neural Network case studies (AlexNet/ZFNet/VGGNet), Understanding and Visualizing Convolutional Neural Networks, Convolutional networks for other visual Recognition Tasks (Localization, Detection, Segmentation, etc.), Transfer Learning and Fine-tuning Convolutional Neural Networks, Introduction to Natural Language Processing (NLP), Learning word and sentences embedding (wordvec, glove, sentvec), Introduction to recurrent networks (RNNs, LSTMS, etc.), Applications of Recurrent neural networks to different NLP tasks (e.g. sentiment analysis, parsing, NER tagging, etc.), Introduction to Reinforcement Learning and QLearning, Deep Q-Networks (DQN) and Game playing using DQN, Introduction to Policy gradients and their applications.

CS - 7113 Knowledge Management

Contemporary issues in managing knowledge, intellectual capital and other intangible asset, understanding measurement issues, framework of knowledge management, processes and cycles involved in their management and the specific issues in managing knowledge based workers and the organizations, knowledge types and knowledge management, key tools and techniques used in knowledge management applications, evaluate major knowledge management issues, knowledge acquisition, assessment, evaluation, organization and dissemination, knowledge generation, knowledge coordination and codification, knowledge transfer and reuse, technologies and knowledge management strategies, recent trend, research challenges and opportunities in knowledge management.

CS-7206 Information Retrieval

Basic Concepts of IR, IR System Block, Diagram. Automatic Text Analysis, Indexing and Classification. Measures of Association.Clustering Algorithms. File Structures. IR Models. Search Strategies. Performance Evaluation.Online IR Systems & Interfaces Standards.Taxonomy and Ontology.Distributed and Parallel IR.Query Processing. Multimedia IR Models & Languages- Data Modeling Techniques to Represent Audio and Visual Document, Query Languages Indexing & Searching- Generic Multimedia Indexing Approach, Query Databases of Multimedia Documents, Display the Results of Multimedia Searches, One Dimensional Time Series, Two Dimensional Color Images, Automatic Feature Extraction. Searching the Web, Challenges, Characterizing the Web, Web Crawlers, Robot Exclusion, Web Data Mining, Metacrawler, Collaborative Filtering, Web Agents (Web Shopping, Bargain Finder...), Latest Development and Economics, Ethical, Legal and Political Issues related to Information Retrieval.

CS-7207 Software process Improvement

Process Modeling and Process Modeling Techniques (Introduction and ETVX), Process Modeling Techniques (IDEF0) Measuring and Analyzing the Current State of Process, CMM and Other process models, CMMI– I, PSP and TSP, Process Changes using PDCA and IDEAL models, Process Assessments, Base-lining, and Benchmarking, Project Management aspects related to process management ,Process Measurement, Process Metrics i.e. Maturity, Management, and Life Cycle Metrics, Fundamentals of Measurement and Experimentation,

GQM and its application to process management and improvement, Introduction to Quality Metrics, Software Engineering Measurements, Advance Topics in Software Process

CS-7208 Software Risk Management

Risk-Management Discovery, Risk-Management Process, Process steps, inputs, and outputs, Methods and tools, reusable process component. Risk-management Infrastructure, Training metrics, establishing a baseline for quantitative process improvement, infrastructure, Risk-Management implementation, standard process, Risk management activities, lifecycle planning, budgeting, scheduling and staffing, Crisis and Control, risk-management evolution stages, Effective and ineffective practices.

CS-7209 Software Measurements & Metrics

Foundations of measurement theory, models of software engineering measurement, software products metrics, software process metrics and measuring management. Measurement theory (overview of software metrics, basics of measurement theory, goal-based framework for software measurement, empirical investigation in software engineering).Software product and process measurements (measuring internal product attributes: size and structure, measuring external product attributes: quality, measuring cost and effort, measuring software reliability, software test metrics, object-oriented metrics) Measurement management.

CS-7211 Component Based Software Engineering

Introduction to CBSE, Reuse, Basic Concepts in CBSE, Modeling components with UML, Open-COM component model, Fractal component model, Component Models and Technology, Component contracts component specification techniques, Component integration and Predictable composition, Service Oriented Computing - Key Concepts and Principles,SOA.

CS-7301 Semantic Web

Knowledge Representation and the Semantic Web, Web Ontology Language OWL, Description logics and classifiers, Description Logics Syntax, Semantics, and reasoning problems, Methods for developing and evaluating anthologies. Common problems and patterns in ontology development, Application development using the OWL API.

CS-7303 Cyber Crime and Security

Security weaknesses and vulnerabilities in network protocols and equipment, Web Traffic – CGI, Penetration testing, Foot printing and Intelligence gathering, Packet Sniffing, Intruders and Malicious code, Denial of Service attacks, VPNs, Intrusion Detection Systems, Packet-filters, Application-Level, DMZ, Encryption techniques, Public Key Infrastructure, Trusted Third Parties, Certificates and C.A's, Digital Signatures and message digests, MD5, SHA,

HMAC, SSL, IPSec, PGP, S/MIME, WEP/WAA, Rainbow tables, Hashing, Birthday Paradox, Legal issues and Computer Misuse Act.

CS-7309 Multimedia Databases

Multimedia Data, The Human Sensory System and Multimedia, Database Approach for the Management of Multimedia Information, Multimedia Databases, Object-Oriented Multimedia DBMS, SQL and Multimedia, Multimedia Query Specification Language, Querying Multimedia Data, Modeling Multimedia Databases, Using Multimedia Metadata, Multimedia Database Architecture and Performance, Multimedia and the Internet, Quality-of-service Issues, Dealing with Text Databases, Content-dependent Metadata, Dealing with Image Databases, Dealing with Video Databases, Model for Interactive Retrieval of Videos and Still Images.

CS-7310 Web Mining

Web usage, content, and structure mining, Use of Machine Learning and Computational Intelligence Techniques for web mining and information networks, mining information sites and streams, Web crawling, indexing, ranking and filtering algorithms using content and link analysis summarizing and analyzing web information, mining opinion and reviews, identifying and mining social networks and social media, Applications for searching, classification, recommendation, and Web intelligence.

CS-7312 Social Network Analysis

Nodes, edges, adjacency matrix, one and two-mode networks, node degree, connected components, giant component, average shortest path, diameter, breadth-first search, preferential attachment, betweenness, closeness, eigenvector centrality, network centralization, community clustering, community structure, modularity, overlapping communities, Small world network models, optimization, strategic network formation and search, Contagion, opinion formation, coordination and cooperation, Unusual applications of SNA, SNA and online social networks.

CS-7313 Device-To-Device Communication

Introduction to Device-to-Device (D2D) communications, D2D communication protocols and method, Spectrum allocation in D2D communications, D2D communication architecture, D2D communication features, D2D from 4G to 5G, RRM in D2D, Multi-hop D2D communications, resource management, challenges and advantages in Multi-hop D2D communication, Propagation and neighbor discovery, Security in D2D communication, Applications, IoT in 5G

CS-7314 Advanced Cloud Computing

Cloud Computing Foundations, the motivations for cloud, elastic computing and its advantages, the emerging technologies supported by cloud, types of clouds and cloud providers, cloud infrastructure and virtualization, data center infrastructure and equipment, virtual machines, containers, virtual networks, virtual storage, emergent trends and practices, cloud security, monitoring, automation, orchestration, automated replication and parallelism,

managed machine learning systems, cloud programming paradigms, the map reduce paradigm, the role of DevOps, data science case studies and projects

CS-7315 Advanced Wireless Networks

Introduction, Existing Technologies and Topologies, Emergence of Wireless in Data Networks, Wireless Ad-hoc Networks, Wireless Sensor Networks (WSN), Mobile Ad-hoc network (MANET), Vehicular Ad-hoc Network (VANET), Evolution of Networks, Cloud and Mobile Computing, Convergence of Networks and Technologies, Fifth Generation (5G) Networks, 5G Mobile Edge Computing & FOG Computing, 5G Massive Internet of Things (IoT), Social and Environmental Impact of 5G, Challenges for a Modern Wireless Networks, Potential Research Areas in Wireless Networks

CS-7316 Advanced Cryptography and Network Security

Security Trends, Security Attacks, Services and Mechanisms, Block Cipher Algorithms, Stream Cipher Algorithms, Number Theory, Extended Euclid Algorithm, Pseudorandom number generators, Modern Public Key Cryptosystem, Key Exchange algorithms, Rabin Cryptosystem, Hash Function, Message Authentication, Digital Signature, Key Exchange and Management, Cryptographic Hash Function, Secure Hash Algorithm (SHA), Digital Signature Standard (DSS), Cryptanalysis, Time-Memory Trade-off Attack, Identity-based Encryption (IBE), Attribute-based Encryption (ABE), Side-channel attack, The Secure Sockets Layer (SSL), Pretty Good Privacy (PGP), Introduction to Quantum Cryptography, Blockchain, Bitcoin and Cryptocurrency, Internet Security Protocols and Standards Internet Authentication Applications, Wireless Network Security, Kerberos, X.509Authentication Service, Public Key Infrastructure, Web Security, Security in IoT, State-of-the art Topics in Cryptography and Network Security.

CS-7317 Advanced Data Communication and Networks

Advanced concepts in computer networking, protocol design, verification and testing, medium access protocols for next-generation networks, error detection and correction schemes, distributed routing algorithms concepts and mathematical analysis, switching architectures, Quality of service architectures, admission control and scheduling algorithms, flow and congestion control, multi-cast architectures and protocols, network security, and data compression.

CS-7318 Mobile and Ubiquitous Computing

Introduction and objectives of mobile and ubiquitous computing, frameworks and technology integration, core technologies, applications and implications for society, innovative materials, design of new computational artifacts, sensor technology, middleware for fine grained distributed systems, context aware systems, theory of complex systems, artificial intelligence techniques for coordination of behavior (multi agent systems) and new forms of interaction, Specialization in middleware for ubiquitous computing with a bias on support for collaborative applications, context aware functionalities and tangible interfaces, current research challenges in ubiquitous computing.

CS-7319 Internet of Things

Introduction to IoT, IoT Smart Object Capabilities, Application Domains and Use Cases, IoT Enabling Technologies, IoT Components and Architecture, Technologies in Each Layer of the Architecture, Sensors and Sensing Technology, Anatomy of IoT Devices, RFIDs, Wireless Networking, Introduction to Arduino Programming, Introduction of IoT with Raspberry Pi, IoT specific data processing and analytics, MAC Layer of Wireless Networks, Routing Layer of Wireless Networks, IoT Protocol Stack, Application Layer Protocol, MQTT, CoAP, Application Layer Protocol, Network Layer Protocol, 6LoWPAN, Service Discovery Protocol, Social IoTs, Ongoing and Future IoT Challenges