**Course Structure for Postgraduate Programs of the Department of Computer Science & Engineering**

### Compulsory Courses

| Course No. | Course Title | Credit Hours |
|---|---|---|
| CSE 6000 | Project (M.Sc. Engg.) | 3 |
| CSE 7000 | Thesis (M.Sc. Engg.) | 18 |
| CSE 8000 | Thesis (Ph.D.) | 45 |
| CSE 6001 | Computer Arithmetic Analysis | 3 |

### Elective Courses

| Course No. | Course Title | Credit Hours |
|---|---|---|
| CSE 6002 | Selected Current Topics in CSE | 3 |
| CSE 6003 | Selected Current Topics in CSE | 3 |
| **Course No.** | **Course Title** | **Credit Hours** |
| **Algorithm and Computation** | | |
| CSE 6101 | Advanced Logic Design | 3 |
| CSE 6102 | Computational Geometry | 3 |
| CSE 6103 | Advanced Algorithms | 3 |
| CSE 6104 | Graph Theory | 3 |
| CSE 6105 | Advanced Algorithmic Graph Theory | 3 |
| CSE 6106 | Combinatorial Optimization | 3 |
| **Computer Aided Systems Design** | | |
| CSE 6201 | Advanced Computer Architecture | 3 |
| CSE 6202 | Computer Organization and Design | 3 |
| CSE 6203 | Advanced Microprocessors | 3 |
| CSE 6204 | Multicore Architecture | 3 |
| CSE 6205 | High-Performance Computer Architecture | 3 |
| CSE 6206 | Real Time Systems | 3 |
| CSE 6207 | Computer Aided Instrumentation and Sensor Application | 3 |
| CSE 6208 | Computer Aided Optoelectronics Application | 3 |
| CSE 6209 | User Interface Design and Development | 3 |
| **Authentication and Recognition** | | |
| CSE 6301 | Advanced Artificial Intelligence | 3 |
| CSE 6302 | Soft Computing | 3 |
| CSE 6303 | Machine Learning | 3 |
| CSE 6304 | Pattern Recognition | 3 |
| CSE 6305 | Speech Recognition | 3 |
| CSE 6306 | Natural Language Processing | 3 |
| CSE 6307 | Text-to-Speech Synthesis | 3 |
| CSE 6308 | Machine Translation | 3 |
| CSE 6309 | Evolutionary Algorithms | 3 |
| CSE 6310 | Data Mining and Warehousing | 3 |
| CSE 6311 | Biometrics | 3 |
| **Information and Software Management** | | |
| CSE 6401 | Analysis and Organization of Information Systems | 3 |
| CSE 6402 | Software Quality Assurance | 3 |
| CSE 6403 | Information System Audit | 3 |
| CSE 6404 | Software Project Management | 3 |
| CSE 6405 | Software Testing | 3 |
| CSE 6406 | Geographical Information System | 3 |
| **Multimedia Systems and Applications** | | |
| CSE 6501 | Advanced Digital Image Processing | 3 |
| CSE 6502 | Multimedia Systems | 3 |
| CSE 6503 | Statistical Signal Theory | 3 |
| CSE 6504 | Digital Filter Design | 3 |
| CSE 6505 | Computer Animation and Virtual Reality | 3 |
| CSE 6506 | Advanced Computer Graphics | 3 |
| CSE 6507 | Speech Signal Processing | |
| **Course No.** | **Course Title** | **Credit Hours** |
| **Networks and Communications** | | |
| CSE 6601 | Web Technology | 3 |
| CSE 6602 | Advanced Computer Networks | 3 |
| CSE 6603 | Wireless Sensor Networks | 3 |
| CSE 6604 | Wireless Ad Hoc Networks | 3 |
| CSE 6605 | Mobile Computing | 3 |
| CSE 6606 | Wireless Resource Management | 3 |
| CSE 6607 | Optical Fiber System | 3 |
| CSE 6608 | Optical Fiber Communication | 3 |
| CSE 6609 | Satellite Communication | 3 |
| CSE 6610 | Computer Ethics | 3 |
| **Database and Computer Systems** | | |
| CSE 6701 | Advanced Database Management System | 3 |
| CSE 6702 | High Dimensional Data Management | 3 |
| CSE 6703 | Distributed Database Systems | 3 |
| CSE 6704 | Parallel Computing | 3 |
| CSE 6705 | Embedded Systems | 3 |
| CSE 6706 | Advanced Operating Systems | 3 |
| CSE 6707 | Optimization Techniques for Compilers | 3 |

**CSE 6001**　　　　　　　　　　　　　　　　　Contact Hours/week: 3
**Computer Arithmetic Analysis**　　　　　　　　　Credit: 3

Integer Arithmetic, Floating Point Arithmetic; Single Precision and Double Precision; Interrupt Handling High-Speed Adders; Standard and Recorded Multipliers, Booth's Multiplier, Canonical and Multi Bit Scanning Multipliers, Array Multipliers; High Radix Non-Restoring Division, SKT Division, Robertson Division, Convergence Division and Cellular Array Dividers; Floating Point Processors; Binary Squares and Square Roots, Evaluation of Trigonometric Functions and Polynomials, Chen Convergence Computation, CORD1C Computations, Logarithmic Number System (LNS) Processor.

**CSE 6101**　　　　　　　　　　　　　　　　　Contact Hours/week: 3
**Advanced Logic Design**　　　　　　　　　　　　Credit:　3

Functional Decomposition and Symmetric Functions; Linear Sequential Machines; Reed-Muller Expansions and their Minimizations; XOR based Logic Design; Self-Timed Circuits; Asynchronous Design Techniques; Digital Logic Circuit Testing and Testable Design: Testing of Combinational and Sequential Logic Circuits, Design for Testability and Built-In Self Test; Digital Logic Simulation.

**CSE 6102**　　　　　　　　　　　　　　　　　Contact Hours/week: 3
**Computational Geometry**　　　　　　　　　　　Credit: 3

Searching and Geometric Data Structures : Balanced Binary Search Trees, Priority-Search Trees, Range Searching, Interval Trees, Segment Trees, Algorithms and Complexity of Fundamental Geometric Objects: Polygon Triangulation and Art Gallery Theorem, Polygon Partitioning, Convex-Hulls 2- and 3- Dimension, Dynamic Convex-Hulls; Geometric Intersection: Line Segment Intersection and  the Plane-Sweep Algorithm, Intersection of Polygons; Proximity: Voronoi Diagrams, Delunay Triangulations, Closest and Furthest Pair: Visualization: Hidden Surface Removal and Binary Space Partition (BSP) Trees; Graph Drawings: Drawings of Rooted Trees (Layering, Radial Drawings, HV-Drawings, Recursive Winding), Drawings of Planar Graphs (Straight-Line Drawings, Orthogonal Drawing,  Visibility Drawings); Survey of Recent Developments in Computational Geometry.

**CSE 6103**　　　　　　　　　　　　　　　　　Contact Hours/week: 3
**Advanced Algorithms**　　　　　　　　　　　　　Credit: 3

Randomized Algorithms: Las Vegas and Monte Carlo Algorithms; Randomized Data Structures: Skip Lists; Amortized Analysis: Different Methods, Applications in Fibonacci Heaps; Lower Bounds: Decision Trees, Information Theoretic Lower Bounds, Adversary Arguments; Approximation Algorithms: Approximation Schemes, Hardness of Approximation; Fixed Parameter Tractability: Parameterized Complexity, Techniques of Designing Fixed Parameter Algorithms, Examples; Online Algorithms: Competitive Analysis, Online Paging Problem, K-Server Problem; External Memory Algorithms; Advanced Data Structures: Linear and Non-Linear Methods.

**CSE 6104**　　　　　　　　　　　　　　　　　Contact Hours/week: 3
**Graph Theory**　　　　　　　　　　　　　　　　Credit: 3

Introduction: Fundamental Concepts, Trees, Spanning Trees In Graphs, Distance in Graphs, Eulerian Graphs, Digraphs, Matching and Factors, Cuts and Connectivity, K-Connected Graphs; Network Flow Problems; Graph Coloring: Vertex Coloring and Edge Coloring, Line Graphs, Hamiltonian Cycles, Planar Graphs, Perfect Graphs.

**CSE 6105**　　　　　　　　　　　　　　　　　Contact Hours/week: 3
**Advanced Algorithmic Graph Theory**　　　　　　Credit: 3

Vertex Orderings: St-Numbering and Canonical Orderings; Graph Decompositions and Their Algorithmic Applications: Ear Decomposition, Canonical Decomposition, Tree Decomposition, Path Width and Tree Width, PQ-Tree, SPQR-Tree, Split Decomposition, Recursively Decomposable Graphs, Clique Separator Decomposition; Graph Representations: Implicit Representations, Intersection and Containment Representations; Graph Classes Defined by Forbidden Subgraphs; Graph Classes Defined by Elimination Schemes; Classes of Graphs with Bounded Treewidth and their Algorithmic Implications; Characterization, Construction and Recognition Algorithms for Some Special Classes of Graphs.

**CSE 6106**　　　　　　　　　　　　　　　　　Contact Hours/week: 3
**Combinatorial Optimization**　　　　　　　　　　Credit: 3

Introduction to Optimization; Linear Programming: Different Forms, Simplex Method, Primal-Dual Theory; Max-Flow: the Max-Flow-Min-Cut Theorem, Ford-Fulkerson Labeling Algorithm, Dijkstra's Algorithm, the Floyd-Warshall Algorithm; Some Network Flow Algorithms: the Minimum Cost Network Flow Method, Transportation Problem; Capacitated Transportation Problem, Assignment Problem; Integer Linear Programming; Relaxation; Cutting-Plane Algorithm; Branch and Bound Technique; Dynamic Programming; NP-Completeness; TSP and Heuristics; Approximation.

**CSE 6201**　　　　　　　　　　　　　　　　　Contact Hours/week: 3
**Advanced Computer Architecture**　　　　　　　Credit: 3

Introduction to High Performance Computing: Overview, Pipeline vs Parallel Processing; Parallel Architectures: Classification and Performance; Pipeline Processing: Pipeline Performance, Design of Arithmetic Pipelines, Multifiction Pipes, Concept of Reservation Table, Collision Vector and Hazards; Instruction Processing Pipes: Instruction and Data

Hazard, Hazard Detection and Resolution, Delayed Jumps, Delayed Execution; RISC Philosophy; Pipeline Scheduling Theory: Greedy Pipeline Scheduling Algorithm, State Diagram, Modified State Diagram, Latency Cycles, Optimal Cycles, Scheduling of Static and Dynamic Pipelines; Implementation of Pipeline Schedulers Interconnection Networks: Interconnection Network Classification, Single Stage/ Multistage Networks, Crossbars, Clos Networks, Benes Networks, Routing Algorithms; Omega, Cub-Connected and other Networks.

**CSE 6202**                                **Contact Hours/week: 3**
**Computer Organization and Design**              **Credit: 3**

Classification and Addressing Modes, Operands and Operations for Media and Signal Processing, Instructions for Control Flow, Encoding an Instruction Set; Pipelined and Superscalar Processors, Data Hazards, Dynamic Scheduling, Branch Prediction, Hardware based Speculation, Thread Level Parallelism; ILP with Software Approaches: Compiler Techniques, Static Branch Prediction, Static Multiple Issue, Advanced Compiler Support for ILP; Basic Techniques of Integer Arithmetic, Floating-Point Arithmetic, Speeding up Integer Addition, Speeding up Integer Multiplication and Division; Memory Technology, Raids, Organization for Improving Performance, Virtual Memory and Protection, Cache Organization, Reducing Cache Miss Rate and Penalty; Busses, Performance Measures, Designing I/O System, Reliability, Dependability and Availability; Symmetric Shared Memory Architectures, Cache Coherence Protocols, Distributed Shared Memory Architectures, Synchronization, Models for Memory Consistency, Multithreading. Interconnection Networks- Practical Issues, Network on Chip, Designing Cluster; Advanced RISC, CISC and Embedded Processors Architectures.

**CSE 6203**                                **Contact Hours/week: 3**
**Advanced Microprocessors**                   **Credit: 3**

Review of Different Microprocessors: 80486, 68040, V70, Gmicro Processors; Comparing the Architectures: RISC and CISC; Instruction Set of Machines: SPARC, INTEL, and MIPS; Study of Microprocessors: Pentium II, Alpha 21064, MIS 6400, PA-RISC; Math Coprocessors and Microprocessors.

**CSE 6204**                                **Contact Hours/week: 3**
**Multicore Architecture**                      **Credit: 3**

Fundamentals of Superscalar Processor Design; Limitations of ILP, Super Scalar Processor Design, Multi Threading, Thread Level Parallelism; Introduction to Multicore Architecture; Multicore vs MultiThreading, Symmetric Shared Memory Architectures, Distributed Shared Memory Architectures, Issues Related to Multicore Caches, Design of Mutlicore Core Caches, Levels of Caches, Cache Optimization, Models of Memory Consistency, Virtual Memory; Cache Coherence Protocols (MSI, MESI, MOESI), Scalable Cache Coherence, Snoop-based Multiprocessor Design:  Correctness Requirements, Design with Single-Level Caches and an Atomic Bus, Multilevel Cache Hierarchies,

Dealing with Split-Transaction Bus, Coherence for Shared Caches and Virtually Indexed Caches, TLB Coherence Overview of Directory based Approaches, Design Challenges of Directory Protocols, Memory based Directory Protocols, Cache based Directory Protocols, Protocol Design Tradeoffs, Synchronization; Powerpc Architecture; RISC Design, Powerpc ISA, Powerpc Memory Management, Power 5 Multicore Architecture Design, Power 6 Architecture; Cell Broad Band Engine Architecture, PPE (Power Processor Element), SPE (Synergistic Processing Element) Interconnection Network Design; Interconnection Topologies, Routing Techniques, Flow Control Mechanisms, Router Architecture, Arbitration Logic.

**CSE 6205**                                **Contact Hours/week: 3**
**High-Performance Computer Architecture**        **Credit: 3**

Basic Principles and Techniques in the Design of High Performance Computer Architecture; Memory Architecture: Cache Structure and Design, Virtual Memory Structures; Pipelined Processor Architecture; Pipeline Control and Hazard Resolution, Pipelined Memory Structures, Interrupt, Evaluation Techniques; Vector Processing, RISC and CISC Architecture; VLSI Architecture Issues.

**CSE 6206**                                **Contact Hours/week: 3**
**Real Time Systems**                         **Credit: 3**

Introduction: Hard Versus Soft Real Time Systems, Jobs and Processors, Deadlines and Timing Constraints, Hard and Soft Timing Constraints, a Reference Model of Real Time Systems: Processors and Resources, Temporal Parameters of Real Time Workload, Periodic Task Model, Precedence Constraints and Data Dependency, other Types of Dependencies, Functional Parameters,  Resource Parameters of Jobs and Parameters of Resources, Scheduling Hierarchy; Commonly used Approaches to Real Time Scheduling: Clock Driven Approach, Weighted Round Robin Approach, Priority Driven Approach, Dynamic Versus Static Systems, Effective Release Times and Deadlines, Optimality of EDF and LST, Challenges in Validating Timing Constraints in Priority Driven Systems, Offline Versus Online Scheduling, Clock Driven Scheduling: Notations and Assumptions, Static Timer Driven Scheduler, General Structure of Cyclic Schedules, Cyclic Executives, Improving Average Response Time of Aperiodic Jobs, Scheduling Sporadic Jobs; Priority Driven Scheduling of Periodic Jobs: Static Assumptions, Fixed Priority Versus Dynamic Priority Algorithms, Maximum Schedulable Utilization, Optimality of RM and DM Algorithms, Schedulability Test for Fixed Priority Tasks with Short Response Times, Schedulability Test for Fixed Priority Tasks with Arbitrary Response Times, Sufficient Schedulability Conditions  for RM and DM Algorithms; Scheduling Aperiodic and Sporadic Jobs in Priority Driven Systems: Assumptions and Approaches, Deferrable Servers, Sporadic Servers, Constant Utilization; Resources and Resource Access Control: Assumptions on Resources and their Usage, Effects of Resource Contention and Resource Access Control, non Preemptive Critical Sections, Basic Priority Inheritance Protocol, Basic Priority Ceiling Protocol, Stack based Priority Ceiling Protocol, Preemption Ceiling Protocol.

**CSE 6207**  
**Computer Aided Instrumentation and Sensor Application**  
Contact Hours/week: 3  
Credit: 3

Review of Different Types of Sensors and their Operation Characteristics; Signal Conditioning and Driver Circuits; ADC and DAC Applications; Signal Multiplexing, Interfacing Techniques Interfacing External Circuit with PC, Serial and Parallel Port, Port Programming, Reading Data from Outside PC, Sending Data to Port Loop and Closed Loop Instrumentation; Practical Examples Dealing with Linear and Angular Displacement, Force, Light, Temperature and Acoustic Signals; Introduction to Different Types of Standard Interfacing Bus such as GPIB, HPIB IEEE488 etc.

**CSE 6208**  
**Computer Aided Optoelectronics Application**  
Contact Hours/week: 3  
Credit: 3

Elements of Optoelectronics Light and Laser Light; Laser System; Photo Detectors; Radiometry and Light Coupling Systems and Applications; Fiber Optics Telephone Link, Optical Imaging using CCD Cameras; Laser Scanning Camera, Interfacing Camera with PC.

**CSE 6209**  
**User Interface Design and Development**  
Contact Hours/week: 3  
Credit: 3

Human-Computer Interaction and the Importance of Good Interface Design; Interface Quality and Methods of Evaluation; Prototyping and Implementation Techniques. Task Analysis and Iterative Design Cycle; Dialog Techniques, Basic Computer Graphics, Use of Color and Sound; I/O Device; Menus and their Use; Command Languages; Screen Formatting; Natural Language Facilities.

**CSE 6301**  
**Advanced Artificial Intelligence**  
Contact Hours/week: 3  
Credit: 3

Introduction; Advanced Search Techniques in AI, Knowledge based System Design; Advanced Plan Generating Systems; Bayesian Network and Probabilistic Reasoning; Learning in Neural Belief Networks; Practical Natural Language Processing; Computer Vision; Introduction to Robotics.

**CSE 6302**  
**Soft Computing**  
Contact Hours/week: 3  
Credit: 3

Introduction to Soft-Computing Tools, Fuzzy Logic, Genetic Algorithms, Neural Networks and Probabilistic Reasoning; Application of Fuzzy Logic Concepts in Engineering Problems; Engineering Optimization Problem Solving using Genetic Algorithms; Neural Network Approaches in Engineering Analysis, Design and Diagnostics Problems; Applications of Probabilistic Reasoning Approaches.

**CSE 6303**  
**Machine Learning**  
Contact Hours/week: 3  
Credit: 3

Prediction as Regression and Classification; Bias-Variance Tradeoff Non-Parametric Approaches; Max-Margin and Support Vector Machines Basics of PAC Learning; Model Averaging and Ensembles Unsupervised Learning; Time Series Analysis and Prediction Sequential Models; Hidden Markov Models; Semi Supervised Learning, Graphical Models.

**CSE 6304**  
**Pattern Recognition**  
Contact Hours/week: 3  
Credit: 3

Introduction to Pattern Recognition and Applications to OCR, Speech Recognition, Fingerprints, Signatures etc; Commercial Importance of Applications; Introduction to Statistical, Neural and Structural Approaches; Statistical Pattern Recognition: Patterns and Classification, Discriminant Functions, Bayes Decision Rule, Nearest Neighbor Rule, Probability of Error; Linear Discriminant Functions: Perceptrons and Training, LMSE Approaches; Unsupervised Learning and Clustering; Feature Extraction; Neural Approach: Introduction to Artificial Neural Networks, Feed Forward Networks, Delta Rule and Back Propagation, Hopfield Networks and Unsupervised Learning, Adaptive Resonance Architectures, Related Techniques; Pattern Associators and Content Addressable Memories, Hardware Realizations; Syntactic Pattern Recognition: Formal Languages and Grammars Pattern Grammars and Higher Dimensional Grammars, Parsing, Automata Realizations, Stochastic Grammars, Grammatical Inference, Computational Learning Theory, Valiant's Framework.

**CSE 6305**  
**Speech Recognition**  
Contact Hours/week: 3  
Credit: 3

Introduction; Speech Signal: Production, Perception and Characterization, Signal Processing and Analysis; Pattern Comparison Techniques: Distortion Measures, Spectral-Distortion Measures, Time Alignment and Normalization; Recognition System Design and Implementation: Source-Coding, Template Training, Performance Analysis; Connected Word Models: Two Level DP, Level Building Algorithm, One-Pass Algorithm; Continuous Speech Recognition: Sub Word Units, Statistical Modeling, Context-Dependent Units; Task Oriented Models.

**CSE 6306**  
**Natural Language Processing**  
Contact Hours/week: 3  
Credit: 3

A Computational Framework for Natural Language; a Framework such as LFG, GPSG or PanIni in Some Depth; Partial Description of English or an Bengali Language in the

Framework, Lexicon, Algorithms and Data Structures for Implementation of the Framework; Introduction to Semantics and Knowledge Representation; Some Applications like Machine Translation, Database Interface.

**CSE 6307**                                    Contact Hours/week: 3
**Text-to-Speech Synthesis**                              Credit: 3

Introduction and Definition, Composition and Production of Speech; Human Hearing, Acoustics and Phonetics; Text Parsing and Processing: Grammars and Lexicons, Segmentation, Transducers; Morphological and Contextual Analysis; Phonetization: Phonemes, Modules and Systems; Intonation and Prosody: Levels, Acoustic, Perceptual and Linguistic Models, Prosodic Parsing; Techniques: Architectures, Formalisms, Databases, Rule Based, Formant, Concatenative, Linear Predictive and Stochastic Synthesis.

**CSE 6308**                                    Contact Hours/week: 3
**Machine Translation**                                Credit: 3

Theoretical Problems: Definition, Context Dependency, Interpretation and Translation; Engineering Problems of Machine Translation: Maintainability, Tunability, Modularity and Efficiency; Linguistics-based MT: Compositionality and Isomorphism, Declarative Frameworks, Constraint-based Formalisms; Knowledge-based MT: Translation and Understanding, Design of Interlinguas, the Conceptual Lexicon; Statistics-based MT: E-M Algorithms, Alignment Of Bilingual Corpora, Translation Templates; Example-based MT: Similarity Measures, Levels of Comparison; Treatment of Context Dependency: Knowledge-based Transfer, Sublanguage-based MT, Translation Units.

**CSE 6309**                                    Contact Hours/week: 3
**Evolutionary Algorithms**                              Credit: 3

Introduction to Evolutionary Algorithm; Selection: Rank-based, Roulette Wheel, Stochastic, Local, Truncation and Tournament; Recombination: Discrete, Real Valued and Binary Valued; Mutation: Real Valued and Binary Valued; Reinsertion: Global and Local; Population Models; Co-Evolution: Cooperative and Competitive; Learnable Evolution Model; Fast Evolutionary Programming; Application of Evolutionary Algorithms to: System Design, Telecommunication, Robotics and other Industrial Areas.

**CSE 6310**                                    Contact Hours/week: 3
**Data Mining and Warehousing**                            Credit: 3

Basic Concept of Data Mining, Issues and Techniques; Data Warehouse and OLTP Technologies for Data Mining, Classification of Data Mining Techniques and Models, Data Pre-Processing, Data Mining Primitives, Query Languages and System Architecture, Characterization and Comparison; Mining Association Rules in Large Database; Cluster

Analysis, Multidimensional Analysis and Descriptive Mining of Complex Data Object; Data Mining in Distributed Heterogeneous Database Systems; Data Mining Applications and Future Research Issues.

**CSE 6311**                                    Contact Hours/week: 3
**Biometrics**                                      Credit: 3

Overview of Biometrics: Biometric Identification, Biometric Verification, Biometric Enrollment, Biometric, System Security; Authentication and Biometrics: Secure Authentication Protocols, Access Control Security Services, Authentication Methods, Authentication Protocols, Matching Biometric Samples, Verification by Humans; Common Biometrics: Finger Print Recognition, Face Recognition, Speaker Recognition, Iris Recognition, Hand Geometry, Signature Verification, Positive and Negative of Biometrics; Matching: Kinds of Errors, Score Distribution, Estimating Errors from Data, Error Rate of Match Engines.

**CSE 6401**                                    Contact Hours/week: 3
**Analysis and Organization of Information Systems**                Credit: 3

Organization Aad Representation of Information and Access to Information; Categorization, Indexing and Content Analysis; Use of Codes, Formats and Standards; Analysis and Evaluation of Search and Navigation Techniques; Project Management and Scheduling; Analysis of Information Needs and Systems Requirements; Design of Alternatives; Quantitative Methods and Tools for Decision Making; Documentation Management; Social and Behavioral Aspects of Information Production.

**CSE 6402**                                    Contact Hours/week: 3
**Software Quality Assurance**                            Credit: 3

Definition and Concept of Software Quality Assurance (SQA); Quality Models; Specification of Quality Requirements; Product Development and Delivery Issues; Software Development Processes and Maturity; Software Quality Management Process: Total Quality Management, Improvement Cycle, SQA Planning and Management, Organizing the SQA Effort; Software Verification and Validation; Typical Software Development Errors; Fagan Inspections; Software Audit; Software Testing: Testing Objectives and Testing Fundamentals, Testing Theory, Coverage Criteria, Equivalence Class Testing, Value-based Testing, Decision Table, Syntax and State Transition Testing, Statement and Path Testing, Branch and Condition Testing, Data Flow Testing, Thread-based Testing, Integration and Integration Testing, System Testing; Testing in Object-Oriented Systems; Test Tools and Test Automation; Test Management; Problem Reporting and Corrective Action.

**CSE 6403**                                     **Contact Hours/week: 3**
**Information System Audit**                                **Credit: 3**

Introduction; The Information Systems (IS) Audit Process, Management, Planning, and Organization of IS; Technical Infrastructure and Operational Practices and Infrastructure; Protection of Information Assets, Disaster Recovery and Business Continuity; Business Application System Development, Acquisition, Implementation and Maintenance; Business Process Evaluation and Risk Management.

**CSE 6404**                    **Contact Hours/week: 3**
**Software Project Management**              **Credit: 3**

Overview of Project Management; Project Tracking and Scheduling; Risk Management and Analysis; Cost Estimation Models; Project Metrics; Function Point Estimation; Software Quality Assurance; Program Verification and Validation Techniques; Software Testing Techniques, Black-Box and White-Box Techniques; Testing of Various Areas: Unit, Domain, Path, Equivalent Class based Portion, Component, Aggregation, System Testing, Requirement based Testing, Acceptance Testing; Software Reuse and Maintenance; Industrial Practices in Software Engineering; ISO Certification Standards for Software Quality Assurance; Software Capability Maturity Model and its Impact.

**CSE 6405**                    **Contact Hours/week: 3**
**Software Testing**                                **Credit: 3**

Objectives of Software Testing, Test Process, Testing and Development, Test Case, Test Execution, Test Harness, Testing and Debugging, Test Adequacy, Control Flow Graph, Errors, Faults and Failures, Types of Testing; Test Generation from Requirements: Equivalence Partitioning, Boundary Value Analysis, Category Partitioning, Fault Model for Predicates, Boolean Operator (BOR), Boolean Relational Operator (BRO) and Boolean and Relational Expression (BRE) Methods, Limitations of Test Generation from Requirements; Test Adequacy Assessment: Adequacy Criteria, Control Flow based Criteria, Data Flow based Criteria, Mutation based Criteria, Adequacy as a Stopping Criterion, Adequacy as a Tool for Test Enhancement; GUI Testing, Security Testing, Random Testing, Combinatorial Testing; Testing Tools: Open Source and Commercial Software Testing Tools.

**CSE 6406**                    **Contact Hours/week: 3**
**Geographical Information System**            **Credit: 3**

Introduction to GIS/LIS, Database Design and Development, Feature Extraction from Satellite Imagery, Data Acquisition using GPS, Spatial Analysis, Digital Cartography and Visualization.

**CSE 6501**                    **Contact Hours/week: 3**
**Advanced Digital Image Processing**          **Credit: 3**

Image Sampling and Quantization; Image Smoothing, Sharpening and Contrast Enhancement in Spatial and Frequency Domains: Basic Gray Level Transformation, Histogram Processing, Image Subtraction, Image Averaging, Gaussian and Laplacian Filters in Spatial and Frequency Domains, Convolution Theorem; Image De-Noising: Noise Models, Noise Reduction by Spatial and Frequency Domain Filters, Mean Filter, Adaptive Filter, Bandpass and Band Reject Filters, Notch Filter, Inverse Filter, Minimum Mean Square Error Filter; Multi-Resolution Image Processing: Wavelet Transform in One and Two Dimensions, Tree Structured Wavelet Transform, Pyramid Structured Wavelet Transform, Curvelet Transform; Morphological Image Processing: Erosion, Dilation, Opening, Closing, Hole Filling, Connected Components, Thinning, Skeletons, Extension of Morphological Operations to Gray Scale Images; Image Segmentation: Thresholding, Region based Segmentation, Contour based Segmentation, Graph based Segmentation; Color Image Processing: Color Models and Transformations, Edge Detection and Segmentation in Color Images, Color Image Compression; Digital Image Security; Image Content Feature Extraction, Representation and Image Retrieval; Concept Learning and Object Recognition.

**CSE 6502**                    **Contact Hours/week: 3**
**Multimedia Systems**                          **Credit: 3**

Overview to Multimedia Systems; Multimedia Storage; Data Compression Techniques for Audio and Video; Synchronization; Multimedia Networking and Protocols; QOS Principles; Video Streams on ATM; Mobile Multimedia Communications; Operating System Support for Multimedia; Hypermedia System; Standards for Multimedia; Multimedia Database and Multimedia Applications.

**CSE 6503**                    **Contact Hours/week: 3**
**Statistical Signal Theory**                    **Credit: 3**

Representation of Deterministic Signals: Orthogonal Representation of Signals; Dimensionality of Signal Spaces; Construction of Orthogonal Basis Functions; Time-Bandwidth Relationship: RMS Duration and Bandwidth, Uncertainty Relations; Random Processes: Definition and Classification, Stochastic Integrals, Fourier Transforms of Random Processes, Stationary and Non-Stationary Processes, Correlation Functions; Ergodicity, Power Spectral Density, Transformations of Random Processes by Linear Systems; Representation of Random Processes (Via Sampling, K-L Expansion and Narrow Band Representations), Special Random Processes (White Gaussian Noise, Wiener-Levy Processes, Shot-Noise Processes, Markov Processes); Optimum Filtering : Matched Filters for Deterministic Signals in White and Colored Gaussian Noise; Wiener Filters for Random Signals in White and Colored Gaussian Noise; Discrete and Continuous Time Filters.

**CSE 6504**  
**Digital Filter Design**  
Contact Hours/week: 3  
Credit: 3

Discrete Time Signals and Systems Z Transforms; Structures for Digital Filters; Designs Procedures for FIR and IIR Filters.

**CSE 6505**  
**Computer Animation and Virtual Reality**  
Contact Hours/week: 3  
Credit: 3

Introduction to Virtual Reality, Virtual Reality Systems, Real-Time Computer Graphics, Overview of Application Areas; Virtual Reality Systems: Virtual Environment, Computer Environment, VR Technology, Modes of Interaction; Virtual Reality Hardware: Sensor Hardware, Display Systems, Acoustic Hardware, Integrated VR Systems; Virtual Reality Software: Modeling of Virtual Worlds, Simulation, VR Toolkits; 3D Computer Graphics: the Virtual World Space, Perspective Projection, Stereo Vision, 3D Clipping, Colour Theory, 3D Modeling, Illumination Models, Shading Algorithms, Hidden Surface Removal, Realism; Geometrical Transforms; Frames of Reference, 3D Transforms, Instances, Picking, Flying, Scaling the VE, Collision Detection; Animating the Virtual Environment: Animation, the Dynamics of Numbers, Updating Real-Time Graphics, Shape and Object Inbetweening, Free-Form Deformation; Human Factors: Perception, Persistence of Vision, Stereopsis, Sound Perseption, Equilibrium; Physical Simulation: Simulation of Physical Systems, Mathematical Modeling, Collisions, Projectiles, Introduction to Dynamics, Motion Kinematics.

**CSE 6506**  
**Advanced Computer Graphics**  
Contact Hours/week: 3  
Credit: 3

Computer Graphics: Introduction to Computer Graphics, Mathematical Foundations, 2D Translation, Scaling, Rotation and Shear, Windowing Transformations, Instance Transformations, Structured Graphics; 3D Translation, Scaling, Rotation; Multimedia: Introduction to Multimedia, Presentation Graphics, Desktop Publishing, Production Planning and Design, User Interface Design, Hypermedia Authoring Concepts, Multimedia Sound, File Compression, JPEG, MPEG, Digital Video, Designing Web-based Multimedia, Multimedia Distribution.

**CSE 6507**  
**Speech Signal Processing**  
Contact Hours/week: 3  
Credit: 3

Production and Classification of Speech Sounds; Pole-Zero Models; Homomorphic Signal Processing; Short-Time Fourier Transform Analysis and Synthesis; Filter-Bank Analysis and Synthesis, Sinusoidal Analysis and Synthesis; Pitch Estimation and Speech Coding; Speech Recognition and Synthesis.

**CSE 6601**  
**Web Technology**  
Contact Hours/week: 3  
Credit: 3

Introduction to Advanced Web Technology; Technological Issues: XML Processing, RDF Processing, Middleware Technologies (CORBA, IIOP), RMI, RPC; Taxonomies and Ontologies for Advanced Web Applications: Ontology Modeling, Languages for Representing Ontologies on the Web, Rules and Inferences; Web Services, Design and Modeling of Web Services, Technologies for Implementing Web Services; Current Applications of Advanced Web Technologies.

**CSE 6602**  
**Advanced Computer Networks**  
Contact Hours/week: 3  
Credit: 3

Overview of OSI Model, TCP/IP, Circuit Switching and Packet Switching, Multiplexing, Routing and Congestion Control and Deadlock Prevention; Driving Forces for High Speed Networking, High Speed Lans, Fast Ethernet and Gigabit Ethernet, FDDI and DQDB, Frame Relay Architecture, Standards and Protocols, Switched Multi Megabit Data Services, ATM Standards Protocols, ATM Lans, Optical Communication and SONET/SDH, Broadband Access Technologies, X-DSL; BISDN Protocol and Architecture, Broadband Service Aspects and Access Architecture, Broadband Transmission Networks, Broadband Intelligent Network; Broadband Access Network Technology, Encryption and Network Security, Advanced Topics for Network Management.

**CSE 6603**  
**Wireless Sensor Networks**  
Contact Hours/week: 3  
Credit: 3

Introduction: Applications; Localization and Tracking: Tracking Multiple Objects; Medium Access Control: S-MAC, IEEE 802.15.4 and Zigbee; Geographic and Energy-Aware Routing; Attribute-based Routing: Directed Diffusion, Rumor Routing, Geographic Hash Tables; Infrastructure Establishment: Topology Control, Clustering, Time Synchronization; Sensor Tasking and Control: Task-Driven Sensing, Information-based Sensor Tasking, Joint Routing and Information Aggregation; Sensor Network Databases: Challenges, Querying the Physical Environment, In-Network Aggregation, Data Indices and Range Queries, Distributed Hierarchical Aggregation; Sensor Network Platforms and Tools: Sensor Node Hardware, Sensor Network Programming Challenges.

**CSE 6604**  
**Wireless Ad Hoc Networks**  
Contact Hours/week: 3  
Credit: 3

Introduction: Applications and Motivations; Broadcasting Protocols: Algorithmic Aspect, Optimization Techniques, Power-Efficient Broadcasting; Routing Protocols: DSDV, AODV, DSR, Position based Routing Protocols, Load Balancing Techniques, Multi-Path Routing; Medium Access Control Protocols: Reservation-based MAC Protocols, Bluetooth Technology, IEEE 802.11 based MAC Protocols; Channel Propagation Models; Topology

Control Protocols; Power Aware Protocol Design; Cross Layer Design Principles; Mobility Awareness; Fairness and Security Issues: Attacks and Preventions; Stimulating Cooperation: Self Policing Schemes, Economic Incentive based Schemes.

**CSE 6605**      Contact Hours/week: 3
**Mobile Computing**      Credit: 3

Cellular Networks: Channel Allocation, Multiple Access, Location Management, Handoffs; Wireless Networking: Wireless Transmission Basics, MAC Protocols, Routing, Transport, Ad-Hoc Networking; Applications: Mobility Adaptations, Disconnected Operations, Data Broadcasting, Mobile Agents; others: Security, Energy Efficient Computing, Impact of Mobility on Algorithms.

**CSE 6606**      Contact Hours/week: 3
**Wireless Resource Management**      Credit: 3

Resource Management Architecture: Evolution and Components of Qos and Cross-Layer Architecture for Bandwidth Management; Tri-Band and Smart Antenna; Handoff Management; Mobility Prediction; Resource Management and Connection Admission Control; Bandwidth Allocation and Scheduling: Real-Time Guaranteed and Fair Real-Time Scheduling; Inter-Domain Radio Resource Management; High Performance Broadband Architecture; Wireless Truthful Computing; Resource Allocation of Spatio-Temporal Division Multiple Access Control; Resource Management Schemes for Connectivity: Piconet and Scatternet; Energy Efficient MAC Layer Protocols for Wireless Ad-Hoc Networks; Routing and Resource Discovery for Wireless Ad-Hoc Networks: Qos based Routing, Topology Management, Efficient Resource Discovery, Hybrid Routing Protocols and Localization; Energy Efficient Broadcasting and Multicasting Algorithms; Power-Conserving Broadcasting and Multicasting Algorithms; Scopes of Increasing Wireless Resources, Research and Future Developments.

**CSE 6607**      Contact Hours/week: 3
**Optical Fiber System**      Credit: 3

Review of Semiconductor Physics: Radiative Recombination; Leds, Optical Cavity, DH and other Lasers; P-I-N and APD Detectors, Detector Noise; Optical Fibers: Ray and Mode Theories, Multimode and Single-Mode Fibers, Attenuation, Dispersion. Gaussian Beams; Power Coupling, Splices and Connectors.

**CSE 6608**      Contact Hours/week: 3
**Optical Fiber Communication**      Credit: 3

Fiber Optic Transmitter and Receiver Designs; Link Analyses; Line Coding; Coherent Optical Communication Systems; Multiplexing Schemes; Local Area Networks, FDDI, SONET and SDH; Fiber Optic Sensors and Signal Processing; Optical Amplifiers; Photonic Switching; Solutions in Optical Fibers.

**CSE 6609**      Contact Hours/week: 3
**Satellite Communication**      Credit: 3

Introduction; Historical Background and Overall Perspective; Satellite Network Modeling; Link Calculations; FM Analysis; TV Transmission; Digital Modulation; Error Control; Multiple Access; FDMA, TDMA, CDMA; Orbital Considerations; Launching; Atmospheric Effects; Transponders; Earth Stations; VSATs.

**CSE 6610**      Contact Hours/week: 3
**Computer Ethics**      Credit: 3

Responsibilities of Computer Scientists: Responsibilities Influences by Growth in Computer Use and Networks, Professional and Ethical Responsibilities; Intellectual Property; Piracy; Hacking, Viruses, Liability, Privacy, Crime and Civil Liabilities.

**CSE 6701**      Contact Hours/week: 3
**Advanced Database Management System**      Credit: 3

Physical Storage and Indexing Structures; Query Processing Algorithms, Query Optimization; Transaction Processing and Serializability, Concurrency Control, Recovery, Parallel and Distributed Databases; Xquery and XML Query Evaluation; Emerging Database Trends, Data Mining, Data Warehousing, Object Oriented Database, Spatial and Temporal Database.

**CSE 6702**      Contact Hours/week: 3
**High Dimensional Data Management**      Credit: 3

Spatial Database Systems; Spatial Data Types; Indexing and Querying Spatial Data; Spatial Networks; Temporal Database Systems; Moving Object Data Management Systems; Moving Object Indexing Techniques; Query Processing on Moving Object Data; Multidimensional Indexing Methods; Similarity Search; Dimension Reduction Methods; Time Series Data; Indexing Techniques for Massive Time Series Data; State-Of-The-Art Systems for Managing High Dimensional Data; Emerging Issues in High-Dimensional Data Management Systems.

**CSE 6703**      Contact Hours/week: 3
**Distributed Database Systems**      Credit: 3

Relational Database Theory, Query Processing and Optimization; Recovery Techniques, Concurrency Control; Crash Recovery; Distributed Database Systems: Security and Integrity; Database Paradigms: Deductive and Object Oriented Issues; Heterogeneous Databases.

**CSE 6704**  Contact Hours/week: 3
**Parallel Computing**  Credit: 3

Fundamental Theoretical Issues in Designing Parallel Algorithms and Architectures; Parallel Computers based on Interconnection Networks such as Hyper Cubes, Shuffle-Exchanges, Trees, Meshes and Butterfly Networks; Parallel Algorithms for Arithmetic, Linear Algebra, Sorting, Fourier Transform, Recurrence Evaluation and Dense Graph Problems; Use of Graph Embedding Techniques to Compare Different Networks; Shared Memory based Parallel Computers; Algorithms for List Ranking, Maximal Independent Set, Arithmetic Expression Evaluation, Convex Hull Problems and others; Message Routing on Multidimensional Meshes, Butterfly Networks, Hyper Cubes, Shuffle Exchange Networks, Fat-Trees and others; Simulation of Shared Memory on Networks; Routing on Expander-based Networks; Limits to Parallelizability and P-Completeness; Thompson Grid Model for VLSI; Layouts for Standard Interconnection Networks; Lower Bound Techniques for Area and Area Time-Squared Tradeoffs; Area-Universal Networks.

**CSE 6705**  Contact Hours/week: 3
**Embedded Systems**  Credit: 3

Introduction to Embedded Systems, Hardware/Software Code Sign, Embedded Micro Controller Cores, Embedded Memories, Examples of Embedded Systems, Sensors and Interfacing Techniques, Real-Time Concepts, Real-Time Operating Systems, Required RTOS Services/Capabilities (in Contrast with Traditional OS); Resource Management/Scheduling Paradigms: Static Priorities, Static Schedules, Dynamic Scheduling, Best Effort Current Best Practice in Scheduling (E.G. Rate Monotonic Vs. Static Schedules); Real World Issues: Blocking, Unpredictability, Interrupts, Caching; Examples of Oss for Embedded Systems: RT Linux, VRTX. Programming Languages for Embedded Systems E.G., Handel-C and Esterel, System Support for Embedded Systems, Selected Embedded System-based Applications: Processcontrol, Robotics, etc; Software Development Methodology: Model based Development, Statecharts, etc. Case Studies, Controlling an Injection Molding Process, Flight Simulator, Digital Call Center Handler, Codec.

**CSE 6706**  Contact Hours/week: 3
**Advanced Operating Systems**  Credit: 3

In-Depth Analysis of Advanced Topics of Operating Systems: Performance Analysis of Memory Management and Scheduling Algorithms; Advanced Virtual Memory Issues; Advanced Issues in Interprocess Communication; File System Design; Multiprocessor and Distributed Operating Systems: Highly Concurrent Machines; Distributed Synchronization and Resource Allocation Algorithms; Distributed File System and Transactions, Security Issues; Interfaces with Network Protocols.

**CSE 6707**  Contact Hours/week: 3
**Optimization Techniques for Compilers**  Credit: 3

Control Flow and Data-Flow Analysis, Program Optimisation and Code Generation Across Basic Blocks, Procedures and Complete Programs; Interprocedural and Intraprocedural Analysis, Intermediate Representations, Register Allocation and Scheduling in the Context of Modern Uniprocessors; Dependence Analysis and Loop Transformations: Building Blocks for Optimising for Memory Hierarchies and Parallel Machines.

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