School of Engineering and Computer Science

LECTURES MANUALS

BACHELOR OF SCIENCE IN COMPUTER SCIENCE

MAJOR IN COMPUTER SCIENCE

In order to obtain a B.Sc. in Computer Science student must complete a minimum of 126 credits of coursework. This includes 42 credits of Foundation studies. The minimum requirement for the major is 69 credit hours including 6 credit hours for internship / senior project.

Major in Computer Science		**126 credits**
Foundation courses		**42 credits**
Communication Skills		**9 credits**
ENG 101	Listening and Speaking Skills	3
ENG 102	English Reading Skills	3
ENG 105	Business English	3
ENG 106	Advanced English Skills	3
ENG 202	Introduction to English Literature	3
Computer Skills		**4 credits**
CSC 101	Introduction to Computer Programming	3
CSC 101L	Lab for CSC101	1
Numeracy		**6 credits**
MAT 102	Introduction to Linear Algebra & Calculus	3
MAT 212	Probability & Statistics for Science & Engineering	3
Natural Sciences		**8 credits**
PHY 101	University Physics-I	3
PHY 101L	University Physics-I Lab	1
PHY 102	University Physics-II	3
PHY 102L	University Physics-II Lab	1
Social Sciences		**6 credits**
Humanities		**6 credits**
Live-in Field Experience		**3 credits**
Core Courses		**54 credits**
CSC 201	Discrete Mathematics	3
CSC 203	Data Structure	3
CSC 203L	Data Structure Lab	1
CSC 204	Computer Hardware & Digital Logic	3
CSC 204L	Labwork based on CSC 204	1
CSC 301	Finite Automata and Computability	3
CSC 305	Object Oriented Programming -I	3
CSC 305L	Object Oriented Programming Lab	1
CSC 306	Algorithms	3
CSC 311	Computer Organization & Architecture	3
CSC312	Microprocessor & Assembly Language	3
CSC 312L	Labwork based on CSC 312	1
CSC 401	Database Management	3
CSC 401L	Database Management Lab	1
CSC 466	Systems Analysis and Design	3
CSC 411	Compiler Construction	3
CSC 413	Design of Operating System	3
CSC 425	Artificial Intelligence	3
CSC 430	Computer Networks	3
CSC 430L	Labwork Computer Networks	1
CSC 445	Software Engineering	3
CSC 455	Web Application & Internet	3
Optional Courses (Any three)		**9 credits**
CSC 404	Embedded System	3
CSC 415	Object Oriented Programming-II	3
CSC 420	Image Processing	3
CSC 421	Machine Learning	3
CSC 422	Pattern Recognition	3

CSC 423	Theory of Fuzzy Systems	3
CSC 424	Neural Networks	3
CSC 426	Introductions to Robotics	3
CSC 432	Wireless Networking and Mobile Computing	3
CSC 435	Computer Graphics	3
CSC 440	Computer Simulation and Modeling	3
CSC 446	Project Management	3
CSC 447	Business Process Reengineering	3
CSC 450	Cryptography and Network Security	3
CSC 451	Data Mining and Warehousing	3
CSC 452	Database Systems Implementation	3
CSC 453	Distributed Database Systems	3
CSC 460	Multimedia Systems	3
CSC 465	E-commerce and Web Database	3
CSC 467	Project Management	
CSC 468	Business Process Reengineering	
CSC 469	Software Quality and Testing	
CSC 470	Introduction to Parallel Programming	3
CSC 480	Computer Vision	3
CSC 490	Special Topics in Computer Science	3
CSC 491	Advance Topic in Application Development	3
CSC 492	Entrepreneur Management	3
Internship Program or Senior Project		**6 credits**
CSC 498	Senior project	6
CSC 499	Internship Program	6
Minor		**15 credits**
MAT 201	Calculus - I	3
MAT 251	Calculus II	3
MAT 303	Linear Algebra and Differential Equation	3
Any Two from the following		
MAT 401	**Graph Theory**	**3**
MAT 403	Introduction to Mathematical Modeling	3
MAT 405	Optimisation Techniques	3
MAT 410	**Numerical Methods**	**3**
MAT 420	Computational Geometry	3
MAT 430	Introduction to Discrete Dynamical Systems	3

MINOR IN COMPUTER SCIENCE

There are two options of computer science minor. The first variant is oriented on hardware and networking. The second variant concentrates on development of programming skill. Both variants include several lab courses. Students must complete the prerequisites of the courses. Students from engineering school must take variant 2. Students from other majors may take up any of these variants.

VARIANT 1:

CSC204+L, CSC311, CSC 312+L, CSC413 and any one from the optional.

VARIANT 2:

CSC203+L, CSC306, CSC401+L and any two from the optional.

COURSE DESCRIPTION

CSC101 Introduction to Computer Programming **3 credits**

Introduction to computer program using a high level programming language (using object oriented approach). Topics to be covered are Identifiers; Data types; Variable; Constants; Different

operators; Basic Input Output; Control structures i.e., Conditional statements, Loops; Array; Functions; String. Primary emphasis is given to problem solving approach; Algorithm design and program development. Programming Language C++, Java.

CSC101L Labwork for CSC101 **1 credit**

CSC201 Discrete Mathematics **3 credits**
Proposition, first order logic, basic logical operations, truth tables, tautologies, contradictions, algebra of propositions, logical implications, logical equivalence, predicates, universal and existential quantifiers. Valid and invalid arguments. Proof of strategies (direct proofs, indirect proofs, proof by contradictions, proof by cases), mathematical induction. Review of set operations, Venn diagrams, basic identities on sets, Cartesian products. Basic definitions of relations, representation of relations, closures, equivalence relations, partial orderings. Basic definitions of functions, injective, surjective and bijective functions, inverse functions, composition of functions, recursively defined functions, countable and uncountable, sets, sequences and sums, recursively defined functions, matrices. Divisibility and modular arithmetic, greatest common divisors, Euclidean algorithm. Basics of counting, pigeonhole principle, permutations and combinations, generalized permutations and combinations, inclusion-exclusion, recurrence relations, solving recurrence relations, generating functions. Semigroups, monoid, groups, subgroups, cyclic groups, permutation groups, homomorphism and isomorphism of groups, rings and fields. Finite state machines, finite automata, languages and grammars. (Prerequisite: CSC 101)

CSC203 Data Structure **3 credits**
Elementary data structure: Elements of data representation and storage. Arrays and Linked Lists (singly linked list and doubly linked list). Abstract data types: Stack, Queue, Priority Queue. Comparative analysis of different implementations of ADTs (Array based and linked list based). BST (Binary Search tree), Heap. Efficient Priority Queue (Heap based). Complexity analysis of dictionary operations (Insertion/Deletion/search) on ADTs. Data structure as a facilitator of smart searching and sorting algorithms (Binary search, Heap sort). Graphs (Connectivity graph, Directed and Undirected graph). Balanced search tree: Red Black Tree. (Prerequisite: CSC 101)

CSC203L Labwork for Data Structure **1 credit**

CSC 204 Introduction to Computer Hardware and Digital Logic **3 credits**
Digital and analog systems. Number systems and codes; logic gates, Boolean algebra, arithmetic circuits, latches, register, counters, MSI logic circuits, flip-flops, A-D and D-A converters, IC logic families, memory devices, PLD, ASIC, FPGA. (Prerequisite: PHY 102)

CSC 204L Labwork for CSC204 **1 credit**

CSC 301 Finite Automata and Computability **3 credits**
Basic notions: string, prefix, suffix, substring, concatenation; Cardinality; Distinction between uncountable and countable infinite. Different proof techniques: Proof by construction, proof by contradiction, pigeon hole principle. Deterministic and non-deterministic Finite state automata; Regular language, regular expression. Equivalence of NFA and DFA. Pumping Lemma, non regular languages. Context free grammar (CFG) and Push down automata (PDA). Chomsky Normal form. Parsing. Turing machine. Universal Turing machine and Halting problem. Goedel numbering. Computability. P/NP. (Prerequisite: CSC 201)

CSC 305 Object-oriented Programming I **3 credits**
Objects and classes; Constructors and destructor; Abstract Data Structures, Function chaining; Friend functions; Function and operator overloading; Composition and Inheritance; Dynamic polymorphism using virtual functions; Exception handling; Template functions and classes; Standard Template Library; Programming Languages C++/ Java/ C#. (Prerequisite: CSC 203)

CSC 305L Labwork for CSC305 **1 credit**

CSC 306 Algorithm **3 credits**

Fundamentals of algorithms, Complexity analysis, Asymptotic notations (Theta, Big O, Omega). Different sorting algorithms: Bubble/Insertion(N^2); Recursive sorting algorithms: Merge, Quick, Heap (NlgN); Decision tree analysis: nlgn bound on comparison based sorting. Sorting in linear time: Counting/ Radix sort. Spanning trees. Greedy algorithms: Shortest path (Dijkstra), MST (Minimum spanning tree algorithms: Kruskal, Prim). Hashing. NP problems (TSP). (Prerequisite: CSC 203)

CSC 311 Computer Organization and Architecture **3 credits**

Computer system: computer structures, components, functions. Memory: cache memory mapping, internal memory, external memory. I/O devices: modules, programmed and interrupt driven I/O, DMA, I/O channels and processors. Interfaces, central processing unit: Computer arithmetic: hardware design algorithms. Instruction cycle, Instruction pipelining, control units design: Hardware and microprogrammed, parallel organizations, RISC, CISC, Multicore Processor organization. (Prerequisite: CSC 204)

CSC 312 Microprocessor and Assembly Language **3 credits**

Organization of a computer. Introduction to 80X 86 families of microprocessors; Microprocessor Architecture, addressing mechanism, Instruction set, Instruction format. Assembly Language programming: assembling, linking, running and debugging programs. Controlling program development; Interrupt system. Microprocessor interfacing with memory and other devices. 8086 based system design, Programmable peripheral Interface: 8255A, 8251A, DMA controller 8237, Interrupt controller 8259A. Overview of advanced processors: 80386, Pentium and Multicore processors. (Prerequisite: CSC101, CSC 311)

CSC 312L Labwork for CSC212 **1 credit**

CSC401 Database Management Systems **3 credits**

Introduction to database and DBMS. Database development process, Database architecture; Database languages and Interfaces. E-R Model, Enhanced E-R model; Database Design Relational Data model, Integrity constraint, Transferring ERD to Relations; Introduction to normalization; Relational Algebra; Introduction to Structure Query Language; Programming with SQL and PL/SQL. Database security and administration. Object oriented data modeling; Distributed database. Specific database systems: Oracle. MS SQL Server. (Prerequisite CSC203, Senior Standing)

CSC401L Labwork for CSC401 **1 credit**

CSC 404 Embedded Systems **3 credits**

Provides a detailed overview of the important topics in the field. Typical examples of embedded systems; real time and safety critical issues; constraint driven design; systems integration; hardware-software partitioning and time-to-market considerations will be addressed. The subject will examine programmable devices, micro-controllers, application specific standard processors: importance of interrupts; re-configurable logic; system-on-a-chip; finite state machines; dataflow architectures; and distributed embedded systems. Software for embedded systems, including: programming languages and software architectures; interrupt servicing; multi-tasking; task communications and scheduling; verification: hardware-software co-simulation; and real-time operating systems will be introduced. (Prerequisite: CSC312)

CSC405 System Analysis and Design **3 credits**

Systems and models; Project management; Tools for determining system requirements; data flow diagrams; decision table and decision trees; Systems analysis: systems development life cycle models. Object oriented analysis: use-case modeling, Unified Modeling Language. Feasibility analysis, Structured analysis; systems prototyping; system design and implementation: application architecture, user interface design. Front-end and backend design; database design;

software management and hardware selection. Case Studies of Information Systems. (Prerequisite CSC401)

CSC 411 Compiler Construction **3 credits**

Introduction to Preprocessor, compiler, Assembler and Linker; Fundamental of compilers and interpreters; Scanning theory and practices; Grammar and parsing; Symbol tables; Run-time environment and storage organization; Lexical analysis; Syntax analysis; Semantic analysis; Syntax directed translation and type checking; Intermediate code generation; Code optimization; Code generation; Constructing prototype compiler-modules for a hypothetical language. (Prerequisite: CSC 301, CSC 305)

CSC 413 Operating Systems **3 credits**

Overview: Background, Computer-system structures, Operating system structures. Process Management: Processes and threads, Process synchronization, Deadlocks, CPU scheduling. Storage Management: Memory management, memory allocation, addressing, Swapping, paging, segmentation, Virtual memory organization, demand paging. File system, structure and access methods: File-system interface, File-system implementation, File protection. I/O Systems: I/O Systems, Mass-storage structure, Computer systems performance, network and security. Distributed Systems: Structure, file systems and coordination. (Prerequisite: CSC 311, CSC 305)

CSC 415 Object-oriented Programming II **3 credits**

Object oriented programming and introduction to GUI application development; Application Programming Interfaces (API); .NET Framework and Java packages; Multithreaded Programming; GUI Programming tools. Applications of OOP in database, networking and website development; Object oriented analysis and design; OOP in dynamic Languages like XML; Programming Languages C++/ Java/ C#. (Prerequisite: CSC 305)

CSC420 Image Processing **3 credits**

Introduction; Point operations; Histograms; Spatial operations; Affine transformations; Image rectification; Interpolation and other transformations; Contrast enhancement; Convolution operation, Magnification and Zooming; Fourier transform; Edge detection; Boundary extraction and representation; Mathematical morphology , Wavelets, compression. (Prerequisite: CSC 205, MAT 212, MAT303)

CSC 421 Machine learning **3 credits**

Introduction to Machine Learning; Classification of learning: Unsupervised and supervised learning, Connectionist learning, Reinforcement learning, Machine discovery; Supervised learning: Information theoretic decision tree learner, Best current hypothesis search, Candidate elimination (version space) algorithm, Learning in the first order Horn clause representation, Inductive logic programming, Application; Unsupervised learning: Hierarchical clustering, Category utility, Incremental and non-incremental algorithms for hierarchical clustering, Applications; Connectionist learning: Introduction to Neural Network, Feed forward and recurrent network, Perception, Multilayer feed forward network, Back propagation algorithm for training a feed forward network, Applications; Genetic Algorithms: Genetic operators, Fitness function, Genetic algorithm in supervised learning framework, Applications. (Prerequisite: CSC305, MAT 212, MAT 303)

CSC 422 Pattern Recognition **3 credits**

Basic concepts, Design concepts, Examples; Decision functions: Linear decision functions, Generalized decision functions; Pattern classification by distance functions: Minimum distance pattern classification, Cluster seeking; Pattern classification by likelihood functions: Bayes classifier; Structural pattern representation: Grammars for pattern representation, Picture description language and grammars, Stochastic grammars; Structural pattern recognition: String to string distance; Matching other structures: Relational structures, Graph matching, Matching by relaxation, Random graph. (Prerequisite: CSC 305, MAT 212, MAT 303)

CSC 423 Theory of Fuzzy Systems **3 credits**

Introduction to Neuro-Fuzzy and Soft Computing, Soft Computing and AI, Neural Networks, Fuzzy Set Theory, MF Formulation and Parameterization, Fuzzy Union, Intersection, and Complement, Fuzzy Rules and Fuzzy Reasoning, Fuzzy Inference Systems, Regression and Optimization, Supervised Learning Neural Networks, Neuro-Fuzzy Modeling, ANFIS, Neuro-Fuzzy Control, ANFIS Applications. (Prerequisite: CSC 305, MAT 303, MAT 212)

CSC 424 Neural Networks **3 credits**

Elementary Neurophysiology - Biological Neurons to Artificial Neurons. Adaline and the Medaline. Perceptron. Backpropagation Network. Bidirectional Associative Memories. Hopfield Networks. Counterpropagation Networks. Kohonen's Self Organizing Maps. Adaptive Resonance Theory. ART1 - ART2 - ART3. Boltzman Machines, Spatiotemporal Pattern Classifier, Neural Network models: Neocognitron, Application of Neural Networks to various disciplines. (Prerequisite: CSC 305, MAT 212, MAT 303)

CSC425 Artificial Intelligence **3 credits**

Principal ideas and development of artificial intelligence; intelligent agents; problem solving methods; search method; generation pruning and searching; knowledge and reasoning; Logic; uncertainty; probabilistic reasoning; heuristic search; puzzle solvers; expert system and data processing; simulative and cognitive process; natural language analysis and synthesis; representation design and design knowledge. (Prerequisite CSC301, CSC306, MAT212)

CSC 426 Introductions to Robotics **3 credits**

In addition to traditions rooted in mechanics and dynamics, geometrical reasoning, and artificial intelligence, the study of robot systems is growing to include many issues traditionally part of the computing sciences; distributed and adaptive control, architecture, software engineering, real-time systems, information processing and learning. In robotics, processing and its relationship to mechanical function are dependent on the target platform and the world in which it is situated. Designing an embedded computational system for sensory and motor processes requires that designers appreciate and understand all of these disciplines. This course is concerned with the design and analysis of adaptive, closed-loop physical systems. The focus will be sensory and motor systems that interpret and manipulate their environments. Toward this end, we will study mechanisms (kinematics and dynamics), actuators, sensors (with a focus on active vision), signal processing, associative memory, feedback control theory, supervised and unsupervised learning, and task planning. Interesting examples of integrated sensory, motor, and computational systems can be found in nature, so occasionally we will relate the subject matter to biological systems. Students will experiment with system identification and control, image processing, path planning, and learning on simulated platforms to reinforce the material presented in class. (Prerequisite: CSC 305, MAT 212, MAT 303)

CSC 430 Computer Networks **3 credits**

Basic concepts, categories of networks, network topologies, OSI model and TCP/IP protocol suite, TCP/IP applications, FTP, SMTP, HTTP and WWW, transport layer protocols, Internetworking devices, repeaters, bridges and routers, routing algorithms, IP addressing, sub netting, domain name systems, Network programming: Client-Server programming, socket programming, data link control protocols, LAN types and technology, MAC protocols, high speed LANs and Gigabit Ethernet, Wireless LANs, MAN, Circuit switching and Packet switching, ISDN, Frame Relay and ATM, SONET/SDH. Spectrum and bandwidth, Digital Transmission, encoding, modulations and demodulations, multiplexing: FDM, TDM and WDM, interfaces and modems, transmission media, fiber optic and wireless media, error detection techniques. (Prerequisite: CSC305, Senior Standing).

CSC 430L Labwork for CSC430 **1 credit**

CSC 432 Wireless Networking and Mobile Computing **3 credits**

Several topics related to wireless networking and mobile computing will be covered in this course. The topics include: cellular networks, multiple access protocols, channel assignment and resource allocation, mobility and location management, handoffs, routing, authentication, call admission control and QoS provisioning, network layer issues, wireless data networking (WAP, GSM, GPRS, CDMA, WCDMA), mobile ad hoc networks. (Prerequisite CSC430)

CSC 435 Computer Graphics **3 credits**

Output primitives and attributes; Line, circle and ellipse drawing algorithms; Two dimensional geometric transformation; Two dimensional viewing; Line, polygon, curve and text clipping algorithms; Parallel and perspective projections; Three dimensional object representation; Visualization of data sets; 3D transformations; Visible surface identification; Color models (RGB, YIQ, CMY, HSV); General computer animation, raster, keyframe; Graphics programming using OPENGL; Drawing 3D objects and scenes; Shading models (flat, smooth); Adding texture to faces; Adding shadows of objects; Fractals and self similarity; Random fractals; Ray tracing; Adding surface texture; Reflection and transparency. (Prerequisite: CSC 305, MAT 303)

CSC440 Computer Simulation and Modeling **3 credits**

Statistical background for simulation; system reliability; mathematical description of general dynamic systems; discrete event; discrete time and continuous time; queuing models; effects of queue disciplines; factors affecting queue systems; implementation and management of models; performance evaluation of models; simulation languages; SLAM. (Prerequisite CSC301, CSC305, MAT 212, MAT 303)

CSC445 Software Engineering **3 credits**

Introduction to the principles of software engineering. Software as product and process. Project management and planning; tracking and scheduling; risk analysis and quality assurance techniques.; configuration management. Project and process metrics, size and function oriented metrics. Software testing techniques: black box and white box techniques. Testing strategy: unit, integration and system testing.. Concepts of object-oriented, event-driven and network programming, client-server architecture, web engineering. The course focuses on taking a group development project from beginning to end. (Prerequisite CSC405)

CSC 446 Project Management **3 credits**

Overview of Project Management, Project tracking and scheduling, Risk management & 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, 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. The course focuses on taking a group development project from beginning to end. (Prerequisite: CSC445)

CSC 447 Business process Reengineering **3 credits**

Introduction to process centric understanding of business processes; analysis and modeling techniques of business practices as processes, analysis of processes of different categories of organizations operating both in private and public sectors; e-Governance, e-Commerce, process of generating software solutions for improving performance of business processes, process performance parameter determination and determination of optimum software features for performance improvement; ROI estimation and measurement framework determination for verification; over view of different enterprise resource planning (ERP) applications and their uses in BPR; implementation and organizational change management; process performance parameter collection and validation of ROI estimation. (Prerequisite: CSC445)

CSC 450 Cryptography and Network Security **3 credits**

Introduction; nature and types of security attacks, key based cryptography, symmetric and asymmetric key. Cryptanalysis. Fiestel cipher structure; conventional encryption algorithms, DES

and triple DES. Key distribution problem. Asymmetric cryptography: public key cryptography, message authentication, hash function, RSA and Diffie-Hellman algorithms. Model for network security. Digital signature, digital certificate. Quantum cryptography. (Prerequisite: CSC430, CSC306)

CSC 455 Web Applications and Internet **3 credits**

Web Technology - OSI & TCP/IP architecture, Internet Routing, IP addressing & Domain Name System. Overview of popular browsers; HTML and Cascading Style Sheet; Understanding HTTP, HTTPS, FTP, Client and Server side scripts; Scripting: JavaScript, AJAX (Asynchronous JavaScript and XML) and jQuery libraries; Web Servers: IIS, Apache; Designing dynamic websites: ASP.NET with SQL server, PHP with My SQL; Web security: Cryptography, Digital signature, Digital Certificate, Authentication & Firewall. (Prerequisite: CSC 305, CSC 401).

CSC 460 Multimedia Systems **3 credits**

Multimedia system architecture, Text, images and graphics, audio, video and animation. Data compression, JPEG and MPEG, DVI, AVI, multimedia files standards; overview of multimedia storage and retrieval technologies. Video and Image display systems, multimedia communication and database systems, multimedia user interfaces, and applications of multimedia systems. (Prerequisite: CSC305, CSC306)

CSC 461 Advanced Database Management Systems **3 credits**

This course covers new database technology with emphasis on object orientation. The focus is mainly on the data modeling aspect. Other aspects e.g., transactions, Concurrency control, Recovery system, Database system architectures, Parallel databases, Distributed databases. (Prerequisite: CSC401)

CSC 462 Database Systems Implementation **3 credits**

Detailed examination of techniques used in the implementation of relational, object-oriented and distributed database systems. Topics are drawn from: query optimisation, transaction management, advanced file access methods, database performance tuning. (Prerequisite: CSC305, CSC306, CSC401)

CSC 463 Distributed Database Systems **3 credits**

A detailed study of advanced topics related to relational database theory, query processing and optimisation, recovery techniques, concurrency control. Crash recovery. Distributed database systems: security and integrity. Other database paradigms such as deductive and object oriented issues. Heterogeneous databases. (Prerequisite: CSC 401)

CSC 464 Data Mining and Warehousing **3 credits**

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. (Prerequisite: CSC 306, CSC401)

CSC 465: E-Commerce and Web database **3 credits**

Electronic Commerce environment, modes, types; Intranet, intranet, extranet, VPN, and VAN; Security and authentication; Cryptography, key management, certificate authority, PKI, digital signature and digital certificate; Payment gateway; Electronic cash and electronic payment schemas: EDI, EFT, SWIFT. Secure transaction through credit cards and PayPal; Shopping cart; Cloud-hosting; Web database design, development and management; Integrating database with web applications, Web database security and access controls; Legal framework of e-Commerce. (Prerequisite: CSC 455)

CSC 470 Introduction to Parallel Programming **3 credits**

Parallel architectures; linear, mesh, binary, and hypercube connections; routing mechanisms; communication models; scalability and efficiency; Principles of parallel algorithm design: Design approaches, design issues, performance measurement & analysis, complexities, anomalies in parallel algorithms; parallel searching, parallel sorting, parallel graph and parallel computational algorithms; parallel programming paradigms: message passing, shared memory and multi-core parallel programming. (Prerequisite: CSC 305, CSC 306, CSC 311, MAT 303)

CSC 490 Special Topic in Computer Science **3 credits**
Selected advanced topic from the field of computer science and its applications. It may vary from time to time.

CSC 491 Advanced Topics in Application Development **3 credits**
Selected advanced topic related to different applications from the field of computer science and its applications. It may vary from time to time.

CSC 492 Entrepreneurship Development **3 credits**

CSC 498 Senior Project **6 credits**

CSC 499 Internship **6 credits**

MAT 201 Calculus I **3 credits**
Functions (and their visualization. limits, derivatives and integrals. Successive differentiation. Additional techniques of integration. Interpretations of the derivative, applications of the derivative to geometry, mechanics , marginality and optimization. Newton's method. Introduction to modeling. Definite integral, interpretations and properties of the definite integral, applications of the definite integral to geometry, mechanics, economics and modeling. Approximating definite integral, approximation errors and Simpson's rule, improper integrals. Taylor polynomials and series, convergence of series, finding and using Taylor's series, indeterminate forms, Fourier series. First order differential equations: Slope fields, Euler's method, separation of variables, linear equations, applications and modeling. (Prerequisite: MAT 102 or equivalent)

MAT 251 Calculus II **3 credits**
Calculus of vector functions, change of parameter, arc length, unit tangent and normal vectors, curvature, motion along a curve. Functions of several variables, visualization , limits and continuity, partial derivatives, differentiability and chain rules, Jacobians, tangent planes, total differentials, exact differential equations, directional derivatives and gradients, optimization. Double and triple integrals, change of variables, double integrals in polar coordinates, triple integrals in cylindrical and spherical polar coordinates, surface area and volumes. Vector calculus: Vector fields, divergence and curl, line integrals, independence of paths, conservative vector fields, Green's theorem, surface integrals, divergence and Stokes' theorems. (Prerequisite: MAT 211 and MAT 201)

MAT 303 Linear Algebra and Differential Equations **3 credits**
Systems of linear equations and matrices, vector spaces and subspaces, linear dependence and independence, dimensions and bases, linear transformations and matrices, eigenvalues and eigenvectors, changes of coordinates, orthogonality, diagonalization. First order ordinary differential equations (existence and uniqueness of solutions, solution techniques, direction fields and stability, modeling applications). Second and higher order linear equations (existence and uniqueness, fundamental set of solutions of homogeneous equations, Wronskian, reduction of order, equations with constant coefficients, method of undetermined coefficients, method of variation of parameters, solutions in series, Laplace transform method, modeling applications). Systems of linear differential equations (existence and uniqueness of solutions, eigenvalue method for homogeneous systems, method of variation of parameters for systems, Laplace transform method for systems, modeling applications).Introduction to nonlinear systems. (Prerequisite: MAT 251)

MAT 401 Graph Theories **3 credits**
Graphs and subgraphs, trees, connectivity, Eule tours and Hamjlton cycles, matchings, graph colorings, plana graphs and Euler's formula, directed graphs, network flows, counting arguments, graph algorithms. (Prerequisite: CSC201, MAT 251)

MAT 403 Introduction to Mathematical Modeling **3 credits**
An introduction to techniques of mathematical modeling involved in the analysis of meaningful and practical problems in many disciplines including mathematical sciences, operations research, engineering and the management and life sciences. Students will be encouraged to recognize and formulate problems in mathematical terms, solve the resulting mathematical problems and interpret the solution in real terms. (Prerequisite: MAT 303)

MAT 405 Optimization Techniques **3 credits**
Discrete , deterministic models of interest to social sciences. Linear programming, duality, simplex method, sensitivity analysis, convex sets. Selections from assignment, transportation, network flow, nonlinear programming problems. (Prerequisite: MAT 303)

MAT 410 Numerical Methods **3 credits**
Numbers and errors: Floating point number representation inside a computer; floating point computation; accuracy and precision; round-off errors and truncation errors; error propagation. Roots of equations: bracketing method; bisection method; false-position method; Newton–Raphson method. System of linear equations: Gaussian elimination; partial and complete pivoting; LU decomposition method; iterative techniques; tridiagonal and sparse systems. Interpolation: Newton's divided difference technique; Spline interpolation; Fourier approximation. Numerical integration: Rectangular and trapezoidal rule; Simpson's rule with equal and unequal segments; Spline quadrature; adaptive quadrature routines. Ordinary differential equation: Solution of first order differential equations; Euler method, Runge–Kutta method; adaptive Runge–Kutta method; general method for system of initial value problem. (Prerequisite: CSC 305, MAT 303)

MAT 420 Computational Geometry **3 credits**
Polygon triangulation; Polygon partitioning; Convex hull in two and three dimensions; Voronoi diagrams; Combinatorics; Sweep algorithms; Polygon intersection; Robot motion planning. (Prerequisite: CSC 305, Senior standing)

MAT 430 Introduction to Discrete Dynamical Systems **3 credits**
Iterations, orbits, graphical analysis, fixed and periodic points, bifurcations, the quadratic family, transition to chaos, iteration of two-dimensional maps, complex dynamics, Julia set, introduction to fractals. (Prerequisite: MAT 303, Senior Standing).

FOUR YEAR PLAN

FLEXIBLE LOAD:

Year 1 Semester 1 **Total 10 cr.** ENG101 MAT102 PHY101 PHY101L	**Year 1 Semester 2** **Total 10 cr.** ENG102 HUM1/SOC1 PHY102 PHY102L	**Year 1 Semester 3** **Total 13 cr.** ENG105 HUM1/SOC1 HUM2/SOC2 CSC101 CSC101L	**Year 1** **Total 33 cr.**
Year 2 Semester 1 **Total 10 cr.** CSC204 CSC204L HUM2/SOC2 MAT212	**Year 2 Semester 2** **Total 10 cr.** CSC201 CSC203 CSC203L MAT201	**Year 2 Semester 3** **Total 10 cr.** CSC311 CSC312 CSC312L MAT251	**Year 2** **Total 30 cr.**
Year 3 Semester 1 **Total 11 cr.** CSC301 CSC305 CSC305L CSC401 CSC401L	**Year 3 Semester 2** **Total 9 cr.** CSC306 CSC405 CSC455	**Year 3 Semester 3** **Total 12 cr.** CSC411 CSC413 CSC445 MAT303	**Year 3** **Total 32 cr.**
Year 4 Semester 1 **Total 10 cr.** CSC430 CSC430L CSC OP1 MAT OP1	**Year 4 Semester 2** **Total 12 cr.** CSC425 CSC OP2 CSC OP3 MAT OP2	**Year 4 Semester 3** **Total 6 cr.** CSC498 CSC499	**Year 4** **Total 28 cr.**
			Total Credit=123+3(LFE*)=126

*LFE can be done any time after 2nd year.

FAST TRACK:

Year 1 Semester 1 **Total 13 cr.** ENG101 HUM1/SOC1 MAT102 PHY101 PHY101L	**Year 1 Semester 2** **Total 14 cr.** CSC101 CSC101L ENG102 HUM1/SOC1 PHY102 PHY102L	**Year 1 Semester 3** **Total 13 cr.** CSC201 CSC204 CSC204L ENG105 HUM2/SOC2	**Year 1** **Total 40 cr.**
Year 2 Semester 1 **Total 13 cr.** CSC203 CSC203L CSC301 HUM2/SOC2 MAT212	**Year 2 Semester 2** **Total 14 cr.** CSC305 CSC305L CSC311 CSC212 CSC212L MAT201	**Year 2 Semester 3** **Total 13 cr.** CSC306 CSC401 CSC401L CSC411 MAT251	**Year 2** **Total 40 cr.**
Year 3 Semester 1 **Total 12 cr.** CSC405 CSC413 CSC455 MAT303	**Year 3 Semester 2** **Total 13 cr.** CSC430 CSC430L CSC445 CSC OP1 MAT OP1	**Year 3 Semester 3** **Total 12 cr.** CSC425 CSC OP2 CSC OP3 MAT OP2	**Year 3** **Total 37 cr.**
Year 4 Semester 1 **Total 6 cr.** CSC498 CSC499	**Year 4 Semester 2** **Total 0 cr.**	**Year 4 Semester 3** **Total 0 cr.**	**Year 4** **Total 6 cr.**
		Total Credit = 123 + 3(LFE*) =126	

*LFE can be done any time after 2nd year.

BACHELOR OF SCIENCE IN COMPUTER ENGINEERING

MAJOR IN COMPUTER ENGINEERING

In order to obtain a B.Sc. in Computer Engineering student must complete a minimum of 134 credits of coursework. This includes 42 credits of Foundation studies. The minimum requirement for the major is 77 credit hours including 6 credit hours for internship / senior project.

Major in Computer Engineering		**135 credits**
Foundation courses		**42 credits**
Communication Skills		**9 credits**
ENG 101	Listening and Speaking Skills	3
ENG 102	English Reading Skills	3
ENG 105	Business English	3
ENG 106	Advanced English Skills	3
ENG 202	Introduction to English Literature	3
Computer Skills		**4 credits**
CSC 101	Introduction to Programming	3
CSC 101L	Lab for CSC101	1
Numeracy		**6 credits**
MAT 102	Introduction to Linear Algebra & Calculus	3
MAT 212	Probability & Statistics for Science & Engineering	3
Natural Sciences		**8 credits**
PHY 101	University Physics-I	3
PHY 101L	University Physics-I Lab	1
PHY 102	University Physics-II	3
PHY 102L	University Physics-II Lab	1
Social Sciences		**6 credits**
Humanities		**6 credits**
Live-in Field Experience		**3 credits**
Core Courses		**28 credits**
CCR 201	Discrete Mathematics	3
CCR 203	Data Structure	3
CCR 203L	Data Structure Lab	1
CCR 204	Computer Hardware & Digital Logic	3
CCR 204L	Labwork based on CSC 204	1
CCR 305	Object Oriented Programming -I	3
CCR 305L	Object Oriented Programming Lab	1
CCR 306	Algorithms	3
CCR 311	Computer Organization & Architecture	3
CCR312	Microprocessor & Assembly Language	3
CCR 312L	Labwork based on CCR 212	1
CCR 413	Design of Operating System	3
Concentration		**29 credits**
ECR101	Introduction to Electrical Engineering	3
ECR101L	Labwork based on ECR101	1
CEN 210	Electronics Devices & Circuits	3
CEN 210L	Labwork based on CEN210	1
CEN 236	Electronics I	3
CEN236L	Labwork based on	1
CEN 336	Electronics II	3
CEN 336L	Labwork based	1
CEN 401	Database Management	3
CEN 401L	Database Management Lab	1
CEN 425	Artificial Intelligence	3
CEN 430	Computer Networks	3
CEN 430L	Labwork Computer Networks	1
CEN 445	Software Engineering	3

Optional Courses (Any three)		**9 credits**
CEN 330	Data Communication	3
CEN 404	Embedded Systems	3
CEN 405	MIS & System Analysis	3
CEN 412	Wireless Networking & Mobile Comm.	3
CEN 414	Digital System Design	3
CEN 420	Image Processing and Pattern Recognition	3
CEN 432	Electrical Drives & Instrumentation	3
CEN 435	Computer Graphics	3
CEN 440	Computer Simulation and Modeling	3
CEN 450	*Cryptography and Network security*	3
CEN 455	Web Application & Internet	3
CEN 465	E-Commerce & Web Database	3
CEN 470	Introduction to Parallel Programming	3
CEN 475	VLSI Design & Testing	3
CEN 480	Computer Vision	3
CEN 485	Telecommunication Engineering	3
CEN 490	Special Topic in Computer Engineering	3
Internship Program or Senior Project		**6 credits**
CSC 498	Senior project	6
CSC 499	Internship Program	6
Minor		**15 credits**
MAT 201	Calculus - I	3
MAT 251	Calculus II	3
MAT 303	Linear Algebra and Differential Equation	3
Any Two from the following		
MAT 401	**Graph Theories**	**3**
MAT 403	Introduction to Mathematical Modeling	3
MAT 405	Optimisation Techniques	3
MAT 410	**Numerical Methods**	**3**
MAT 420	Computational Geometry	3
MAT 430	Introduction to Discrete Dynamical Systems	3

MINOR IN COMPUTER ENGINEERING

Students who wish to do minor in Computer Engineering must take the following course. Students must have completed the prerequisites of the courses.

CCR203+L, CCR306, CCR311, CEN401+L, and any one course from optional.

COURSE DESCRIPTION

CCR201 Discrete Mathematics **3 credits**

Proposition, first order logic, basic logical operations, truth tables, tautologies, contradictions, algebra of propositions, logical implications, logical equivalence, predicates, universal and existential quantifiers. Valid and invalid arguments. Proof of strategies (direct proofs, indirect proofs, proof by contradictions, proof by cases), mathematical induction. Review of set operations, Venn diagrams, basic identities on sets, Cartesian products. Basic definitions of relations, representation of relations, closures, equivalence relations, partial orderings. Basic definitions of functions, injective, surjective and bijective functions, inverse functions, composition of functions, recursively defined functions, countable and uncountable, sets, sequences and sums, recursively defined functions, matrices. Divisibility and modular arithmetic, greatest common divisors, Euclidean algorithm. Basics of counting, pigeonhole principle, permutations and combinations, generalized permutations and combinations, inclusion-exclusion, recurrence relations, solving recurrence relations, generating functions. Semigroups, monoid, groups, subgroups, cyclic

groups, permutation groups, homomorphism and isomorphism of groups, rings and fields. Finite state machines, finite automata, languages and grammars. (Prerequisite: CSC 101)

CCR203 Data Structure **3 credits**
Elementary data structure: Elements of data representation and storage. Arrays and Linked Lists (singly linked list and doubly linked list). Abstract data types: Stack, Queue, Priority Queue. Comparative analysis of different implementations of ADTs (Array based and linked list based). BST (Binary Search tree), Heap. Efficient Priority Queue (Heap based). Complexity analysis of dictionary operations (Insertion/Deletion/search) on ADTs. Data structure as a facilitator of smart searching and sorting algorithms (Binary search, Heap sort). Graphs (Connectivity graph, Directed and Undirected graph). Balanced search tree: Red Black Tree. Prerequisite: CSC 101

CCR203L Labwork for Data Structure **1 credit**

CCR 204 Introduction to Computer Hardware and Digital Logic **3 credits**
Digital and analog systems. Number systems and codes; logic gates, Boolean algebra, arithmetic circuits, latches, register, counters, MSI logic circuits, flip-flops, A-D and D-A converters, IC logic families, memory devices, PLD, ASIC, FPGA. (Prerequisite: PHY 102)

CCR 204L Labwork for CSC204 **1 credit**

CCR 301 Finite Automata and Computability **3 credits**
Basic notions: string, prefix, suffix, substring, concatenation; Cardinality; Distinction between uncountable and countable infinite. Different proof techniques: Proof by construction, proof by contradiction, pigeon hole principle. Deterministic and non-deterministic Finite state automata; Regular language, regular expression. Equivalence of NFA and DFA. Pumping Lemma, non regular languages. Context free grammar (CFG) and Push down automata (PDA). Chomsky Normal form. Parsing. Turing machine. Universal Turing machine and Halting problem. Goedel numbering. Computability. P/NP. Prerequisite: CSC 201

CCR 305 Object-oriented Programming I **3 credits**
Objects and classes; Constructors and destructor; Abstract Data Structures, Function chaining; Friend functions; Function and operator overloading; Composition and Inheritance; Dynamic polymorphism using virtual functions; Exception handling; Template functions and classes; Standard Template Library; Programming Languages C++/ Java/ C#. (Prerequisite: CSC 203)

CCR 305L Labwork for CSC305 **1 credit**

CCR 306 Algorithm **3 credits**
Fundamentals of algorithms, Complexity analysis, Asymptotic notations (Theta, Big O, Omega). Different sorting algorithms: Bubble/Insertion(N^2); Recursive sorting algorithms: Merge, Quick, Heap (NlgN); Decision tree analysis: nlgn bound on comparison based sorting. Sorting in linear time: Counting/ Radix sort. Spanning trees. Greedy algorithms: Shortest path (Dijkstra), MST (Minimum spanning tree algorithms: Kruskal, Prim). Hashing. NP problems (TSP). Prerequisite: CSC 203

CCR 311 Computer Organization and Architecture **3 credits**
Computer system: computer structures, components, functions. Memory: cache memory mapping, internal memory, external memory. I/O devices: modules, programmed and interrupt driven I/O, DMA, I/O channels and processors. Interfaces, central processing unit: Computer arithmetic: hardware design algorithms. Instruction cycle, Instruction pipelining, control units design: Hardware and microprogrammed, parallel organizations, RISC, CISC, Multicore Processor organization. (Prerequisite: CSC 204)

CCR 312 Microprocessor and Assembly Language **3 credits**

Organization of a computer. Introduction to 80X 86 families of microprocessors; Microprocessor Architecture, addressing mechanism, Instruction set, Instruction format. Assembly Language programming: assembling, linking, running and debugging programs. Controlling program development; Interrupt system. Microprocessor interfacing with memory and other devices. 8086 based system design, Programmable peripheral Interface: 8255A, 8251A, DMA controller 8237, Interrupt controller 8259A. Overview of advanced processors: 80386, Pentium and Multicore processors. (Prerequisite: CSC101, CSC 204)

CCR 312L Labwork for CSC212 **1 credit**

CCR 413 Operating Systems **3 credits**
Overview: Background, Computer-system structures, Operating system structures. Process Management: Processes and threads, Process synchronization, Deadlocks, CPU scheduling. Storage Management: Memory management, memory allocation, addressing, Swapping, paging, segmentation, Virtual memory organization, demand paging. File system, structure and access methods: File-system interface, File-system implementation, File protection. I/O Systems: I/O Systems, Mass-storage structure, Computer systems performance, network and security. Distributed Systems: Structure, file systems and coordination. (Prerequisite: CSC 311, CSC 305)

ECR 101 Introduction to Electrical Engineering **3 credits**
Passive electrical components. Electric circuit concepts and relationship to field theory. Kirchhoff's laws. Node and mesh analysis of resistive networks. Network theorems. Controlled sources. Transient conditions. Sources of periodic signals. Average and r.m.s. values. Circuit models of diodes and transistors. Combinational logic principles and circuits.

ECR 101L Lab work based on ECR 101 **1 credit**

CEN 210 Electronic Devices and Circuits **3 credits**
Semiconductors: Junction diode characteristics; Operation and small signal models of diodes; Circuit application of diodes. Bipolar transistor: Characteristics; BJT biasing and thermal stabilization; CE, CB, CC configurations; Small signal low frequency h-parameter models and hybrid-π model. Amplifiers: voltage and current amplifiers; Operational amplifiers; Off-set null adjustments; Differential input and output impedance, frequency response and noise. Oscillators: Hartley, Colpitts & Wine-Bridge oscillators. Introduction to JFET, MOSFET, PMOS, NMOS and CMOS: Biasing and application in switching circuits. Silicon controlled rectifier (SCR), TRIAC, DIAC, UJT: Characteristics and application. Introduction to rectifiers, active filters, regulated power supply. Introduction to IC fabrication techniques. (Prerequisite: ECR 101)

CEN 236 Electronics I **3 credits**
Frequency analysis of amplifiers. Design and analysis of feedback amplifiers. Amplifier stability analysis. Operational amplifiers and comparators. Schmidt triggers. Waveform generators: sinusoidal, square, triangular. A-D and D-A converters. (Prerequisite: CEN 104)

CEN 236L Labwork for Electronics I **1 credit**

CEN 330 Data Communication **3 credits**
Data: representation, signal encoding, signal analysis; Data Transmission Channel: channel capacity, transmission line characteristics, Baseband and Broadband transmission; Transmission media: guided and unguided; Transmission networks; Transmission modulation techniques, modems and interfaces; Multiplexing techniques; Error handling; Switching techniques; Introduction to advanced data communication technologies and Internet.

CEN 336 Electronics II **3 credits**
Operating principles and fabrication technologies of electronic and photonic devices. Devices covered include: pn diodes, BJTs, MOSFETs, LEDs, solar cells, lasers and optical waveguides as used in communication systems and microwave devices. Ebers-Moll model of the BJT. BJTs &

MOSFETs in analogue and integrated circuits, including TTL, ECL and CMOS. Principles and key technologies involved in micro fabrication of integrated circuits. Non-idealities of devices resulting from realistic architectures and the effect of these non-idealities on the operation and design of circuits and systems. (Prerequisite: CEN 236)

CEN 336L Labwork based on CSE336 **1 credit**

CEN 392 Computer Peripherals and Interfacing **3 credits**

CEN 401 Database Management Systems **3 credits**

Introduction to database and DBMS. Database development process, Database architecture; Database languages and Interfaces. E-R Model, Enhanced E-R model; Database Design Relational Data model, Integrity constraint, Transferring ERD to Relations; Introduction to normalization; Relational Algebra; Introduction to Structure Query Language; Programming with SQL and PL/SQL. Database security and administration. Object oriented data modeling; Distributed database. Specific database systems: Oracle. MS SQL Server. (Prerequisite: CCR203)

CEN 401L Labwork for CSC401 **1 credit**

CEN 404 Embedded Systems **3 credits**

Provides a detailed overview of the important topics in the field. Typical examples of embedded systems; real time and safety critical issues; constraint driven design; systems integration; hardware-software partitioning and time-to-market considerations will be addressed. The subject will examine programmable devices, micro-controllers, application specific standard processors: importance of interrupts; re-configurable logic; system-on-a-chip; finite state machines; dataflow architectures; and distributed embedded systems. Software for embedded systems, including: programming languages and software architectures; interrupt servicing; multi-tasking; task communications and scheduling; verification: hardware-software co-simulation; and real-time operating systems will be introduced. (Prerequisite: CCR212)

CEN 405 System Analysis and Design **3 credits**

Information attributes. Management Information System: subsystems. Information system components and design factors. Systems and models; Project management; Tools for determining system requirements; data flow diagrams; decision table and decision trees; Systems analysis: systems development life cycle models. Object oriented analysis: use-case modeling, Unified Modeling Language. Feasibility analysis, Structured analysis; systems prototyping; system design and implementation: application architecture, user interface design. Front-end and backend design; database design; software management and hardware selection. Case Studies of Information Systems. (Prerequisite: CEN401)

CEN 412 Wireless Networking and Mobile Computing **3 credits**

Several topics related to wireless networking and mobile computing will be covered in this course. The topics include: cellular networks, multiple access protocols, channel assignment and resource allocation, mobility and location management, handoffs, routing, authentication, call admission control and QoS provisioning, network layer issues, wireless data networking (WAP, GSM, GPRS, CDMA, WCDMA), mobile ad hoc networks. (Prerequisite CEN 330)

CEN 414 Digital System Design **3 credits**

Design of memory subsystems using SRAM and DRAM; PLA design; Microoperations: Inter-register transfer, arithmetic operations, logic operations, shift operations; Design of various components of a computer: ALU, control unit (hardwired, microprogrammed); Computer bus standards; Design of a computer; Digital Systems in control, communication and instrumentation. (Prerequisite: CCR 204)

CEN 420 Image Processing and Pattern Recognition **3 credits**

Digital image representation: acquisition, storage and display systems; sampling and quantization: uniform and non-uniform sampling; image geometry: perspective transformation, synthetic camera approach, stereo imaging; image transforms: fast Fourier transform, discrete Fourier transform, sine/cosine transform; image enhancement; spatial and frequency domains; smoothing and sharpening; gray-level binary images: thresholding, half-toning; image restoration: degradation model; constrained and unconstrained restoration; inverse filtering; Wiener filtering; image compression: source encoding/decoding, channel encoding/decoding. (Prerequisite: CCR305, MAT 303)

CEN 425 Artificial Intelligence **3 credits**

Principal ideas and development of artificial intelligence; intelligent agents; problem solving methods; search method; knowledge and reasoning; Logic; uncertainty; probabilistic reasoning; puzzle solvers; expert system and data processing; simulative and cognitive process; natural language analysis and synthesis; representation design and design knowledge. (Prerequisite CSC301, CSC306)

CEN 430 Computer Networks **3 credits**

Basic concepts, categories of networks, network topologies, OSI model and TCP/IP protocol suite, TCP/IP applications, FTP, SMTP, HTTP and WWW, transport layer protocols, Internetworking devices, repeaters, bridges and routers, routing algorithms, IP addressing, sub netting, domain name systems, Network programming: Client-Server programming, socket programming, data link control protocols, LAN types and technology, MAC protocols, high speed LANs and Gigabit Ethernet, Wireless LANs, MAN, Circuit switching and Packet switching, ISDN, Frame Relay and ATM, SONET/SDH. Spectrum and bandwidth, Digital Transmission, encoding, modulations and demodulations, multiplexing: FDM, TDM and WDM, interfaces and modems, transmission media, fiber optic and wireless media, error detection techniques. (Prerequisite: CSC305).

CEN 430L Labwork for CSC430 **1 credit**

CEN 435 Computer Graphics **3 credits**

Output primitives and attributes; Line, circle and ellipse drawing algorithms; Two dimensional geometric transformation; Two dimensional viewing; Line, polygon, curve and text clipping algorithms; Parallel and perspective projections; Three dimensional object representation; Visualization of data sets; 3D transformations; Visible surface identification; Color models (RGB, YIQ, CMY, HSV); General computer animation, raster, keyframe; Graphics programming using OPENGL; Drawing 3D objects and scenes; Shading models (flat, smooth); Adding texture to faces; Adding shadows of objects; Fractals and self similarity; Random fractals; Ray tracing; Adding surface texture; Reflection and transparency. (Prerequisite: CCR 305, MAT 303)

CEN 440 Computer Simulation and Modeling **3 credits**

Statistical background for simulation; system reliability; mathematical description of general dynamic systems; discrete event; discrete time and continuous time; queuing models; effects of queue disciplines; factors affecting queue systems; implementation and management of models; performance evaluation of models; simulation languages; SLAM. (Prerequisites MAT 212, MAT 303, Senior standing)

CEN 445 Software Engineering **3 credits**

Introduction to the principles of software engineering. Software as product and process. Project management and planning; tracking and scheduling; risk analysis and quality assurance techniques.; configuration management. Project and process metrics, size and function oriented metrics. Software testing techniques: black box and white box techniques. Testing strategy: unit, integration and system testing.. Concepts of object-oriented, event-driven and network programming, client-server architecture, web engineering. The course focuses on taking a group development project from beginning to end. (Prerequisite CEN405)

CEN 450 Cryptography and Network Security **3 credits**

Introduction; nature and types of security attacks, key based cryptography, symmetric and asymmetric key. Cryptanalysis. Fiestel cipher structure; conventional encryption algorithms, DES and triple DES. Key distribution problem. Asymmetric cryptography: public key cryptography, message authentication, hash function, RSA and Diffie-Hellman algorithms. Model for network security. Digital signature, digital certificate. Quantum cryptography. Prerequisite: CEN430, CCR306.

CEN 455 Web Applications and Internet **3 credits**

Web Technology - OSI & TCP/IP architecture, Internet Routing, IP addressing & Domain Name System. Overview of popular browsers; HTML and Cascading Style Sheet; Understanding HTTP, HTTPS, FTP, Client and Server side scripts; Scripting: JavaScript, AJAX (Asynchronous JavaScript and XML) and jQuery libraries; Web Servers: IIS, Apache; Designing dynamic websites: ASP.NET with SQL server, PHP with My SQL; Web security: Cryptography, Digital signature, Digital Certificate, Authentication & Firewall. (Prerequisite: CCR305, CEN401).

CEN 465 E-Commerce and Web database **3 credits**

Electronic Commerce environment, modes, types; Intranet, intranet, extranet, VPN, and VAN; Security and authentication; Cryptography, key management, certificate authority, PKI, digital signature and digital certificate; Payment gateway; Electronic cash and electronic payment schemas: EDI, EFT, SWIFT. Secure transaction through credit cards and PayPal; Shopping cart; Cloud-hosting; Web database design, development and management; Integrating database with web applications, Web database security and access controls; Legal framework of e-Commerce. (Prerequisite: CEN 455)

CEN 470 Introduction to Parallel Programming **3 credits**

Parallel architectures; linear, mesh, binary, and hypercube connections; routing mechanisms; communication models; scalability and efficiency; Principles of parallel algorithm design: Design approaches, design issues, performance measurement & analysis, complexities, anomalies in parallel algorithms; parallel searching, parallel sorting, parallel graph and parallel computational algorithms; parallel programming paradigms: message passing, shared memory and multi-core parallel programming. (Prerequisite: CCR 305, CCR 306, CCR 311, MAT 303)

CEN 475 VLSI Design and Testing **3 credits**

VLSI Technology: MOS transistor and inverter characteristics, complex CMOS gates and functional circuits. Design and operation of large fan-out and fan-in circuits; Clocking methodologies; Techniques for data path and data control design. VLSI layout partitioning, placement routine, and writing in VLSI Reliability aspects and testing of VLSI. (Prerequisite: CEN 336, Senior Standing)

CEN 490 Special Topic in Computer Engineering **3 credits**

Selected advanced topic from the field of computer engineering and its applications. It may vary from time to time.

CEN 498 Senior Project **6 credits**

CEN 499 Internship **6 credits**

MAT 201 Calculus I **3 credits**

Functions (and their visualization. limits, derivatives and integrals. Successive differentiation. Additional techniques of integration. Interpretations of the derivative, applications of the derivative to geometry, mechanics, marginality and optimization. Newton's method. Introduction to modeling. Definite integral, interpretations and properties of the definite integral, applications of the definite integral to geometry, mechanics, economics and modeling. Approximating definite integral, approximation errors and Simpson's rule, improper integrals. Taylor polynomials and series, convergence of series, finding and using Taylor's series, indeterminate forms, Fourier series. First

order differential equations: Slope fields, Euler's method, separation of variables, linear equations, applications and modeling. (Prerequisite: MAT 102 or equivalent)

MAT 251 Calculus II **3 credits**

Calculus of vector functions, change of parameter, arc length, unit tangent and normal vectors, curvature, motion along a curve. Functions of several variables, visualization , limits and continuity, partial derivatives, differentiability and chain rules, Jacobians, tangent planes, total differentials, exact differential equations, directional derivatives and gradients, optimization. Double and triple integrals, change of variables, double integrals in polar coordinates, triple integrals in cylindrical and spherical polar coordinates, surface area and volumes. Vector calculus: Vector fields, divergence and curl, line integrals, independence of paths, conservative vector fields, Green's theorem, surface integrals, divergence and Stokes' theorems. (Prerequisite: MAT 211 and MAT 201)

MAT 303 Linear Algebra and Differential Equations **3 credits**

Systems of linear equations and matrices, vector spaces and subspaces, linear dependence and independence, dimensions and bases, linear transformations and matrices, eigenvalues and eigenvectors, changes of coordinates, orthogonality, diagonalization. First order ordinary differential equations (existence and uniqueness of solutions, solution techniques, direction fields and stability, modeling applications). Second and higher order linear equations (existence and uniqueness, fundamental set of solutions of homogeneous equations, Wronskian, reduction of order, equations with constant coefficients, method of undetermined coefficients, method of variation of parameters, solutions in series, Laplace transform method, modeling applications). Systems of linear differential equations (existence and uniqueness of solutions, eigenvalue method for homogeneous systems, method of variation of parameters for systems, Laplace transform method for systems, modeling applications).Introduction to nonlinear systems. (Prerequisite: MAT 251)

MAT 401 Graph Theories **3 credits**

Graphs and subgraphs, trees, connectivity, Eule tours and Hamjlton cycles, matchings, graph colorings, plana graphs and Euler's formula, directed graphs, network flows, counting arguments, graph algorithms. (Prerequisite: CSC201, MAT 251)

MAT 403 Introduction to Mathematical Modeling **3 credits**

An introduction to techniques of mathematical modeling involved in the analysis of meaningful and practical problems in many disciplines including mathematical sciences, operations research, engineering and the management and life sciences. Students will be encouraged to recognize and formulate problems in mathematical terms, solve the resulting mathematical problems and interpret the solution in real terms. (Prerequisite: MAT 303)

MAT 405 Optimization Techniques **3 credits**

Discrete , deterministic models of interest to social sciences. Linear programming, duality, simplex method, sensitivity analysis, convex sets. Selections from assignment, transportation, network flow, nonlinear programming problems. (Prerequisite: MAT 303)

MAT 410 Numerical Methods **3 credits**

Numbers and errors: Floating point number representation inside a computer; floating point computation; accuracy and precision; round-off errors and truncation errors; error propagation. Roots of equations: bracketing method; bisection method; false-position method; Newton–Raphson method. System of linear equations: Gaussian elimination; partial and complete pivoting; LU decomposition method; iterative techniques; tridiagonal and sparse systems. Interpolation: Newton's divided difference technique; Spline interpolation; Fourier approximation. Numerical integration: Rectangular and trapezoidal rule; Simpson's rule with equal and unequal segments; Spline quadrature; adaptive quadrature routines. Ordinary differential equation: Solution of first order differential equations; Euler method, Runge–Kutta method; adaptive

Runge–Kutta method; general method for system of initial value problem. (Prerequisite: CSC 305, MAT 303)

MAT 420 Computational Geometry **3 credits**
Polygon triangulation; Polygon partitioning; Convex hull in two and three dimensions; Voronoi diagrams; Combinatorics; Sweep algorithms; Polygon intersection; Robot motion planning. (Prerequisite: CSC 305, Senior standing)

MAT 430 Introduction to Discrete Dynamical Systems **3 credits**
Iterations, orbits, graphical analysis, fixed and periodic points, bifurcations, the quadratic family, transition to chaos, iteration of two-dimensional maps, complex dynamics, Julia set, introduction to fractals. (Prerequisite: MAT 303, Senior Standing).

FOUR YEAR PLAN

FLEXIBLE TRACK:

Year 1 Semester 1 **Total 10 cr.** ENG101 MAT102 PHY101 PHY101L	**Year 1 Semester 2** **Total 10 cr.** ENG102 HUM1/SOC1 PHY102 PHY102L	**Year 1 Semester 3** **Total 13 cr.** ENG105 HUM1/SOC1 HUM2/SOC2 CSC101 CSC101L	**Year 1** **Total 33 cr.**
Year 2 Semester 1 **Total 10 cr.** ECR101 ECR101L HUM2/SOC2 MAT212	**Year 2 Semester 2** **Total 11 cr.** CCR204 CCR204L CEN210 CEN210L MAT201	**Year 2 Semester 3** **Total 13 cr.** CCR203 CCR203L CCR201 CEN314 MAT251	**Year 2** **Total 34 cr.**
Year 3 Semester 1 **Total 14 cr.** CCR301 CCR305 CCR305L CCR311 CCR312 CCR312L	**Year 3 Semester 2** **Total 10 cr.** CCR306 CEN401 CEN401L CEN404	**Year 3 Semester 3** **Total 12 cr.** CEN411 CCR413 CEN405 MAT303	**Year 3** **Total 36 cr.**
Year 4 Semester 1 **Total 10 cr.** CEN430 CEN430L CEN OP1 MAT OP1	**Year 4 Semester 2** **Total 12 cr.** CEN425 CEN OP2 CEN OP3 MAT OP2	**Year 4 Semester 3** **Total 6 cr.** CSC498 CSC499	**Year 4** **Total 28 cr.**
		Total Credit = 131 + 3(LFE*) = 134	

*LFE can be done any time after 2nd year.

FAST TRACK:

Year 1 Semester 1 **Total 13 cr.** ENG101 HUM1/SOC1 MAT102 PHY101 PHY101L	**Year 1 Semester 2** **Total 14 cr.** CSC101 CSC101L ENG102 HUM1/SOC1 PHY102 PHY102L	**Year 1 Semester 3** **Total 13 cr.** ECR101 ECR101L ENG105 HUM2/SOC2 MAT212	**Year 1** **Total 40 cr.**
Year 2 Semester 1 **Total 14 cr.** CCR204 CCR204L CEN210 CEN210L HUM2/SOC2 MAT201	**Year 2 Semester 2** **Total 13 cr.** CCR203 CCR203L CCR201 CEN314 MAT251	**Year 2 Semester 3** **Total 14 cr.** CCR301 CCR305 CCR305L CCR311 CCR312 CCR312L	**Year 2** **Total 41 cr.**
Year 3 Semester 1 **Total 13 cr.** CCR306 CEN401 CEN401L CEN404 MAT303	**Year 3 Semester 2** **Total 15 cr.** CSC411 CSC413 CEN405 CEN OP1 MAT OP1	**Year 3 Semester 3** **Total 16 cr.** CEN425 CEN430 CEN430L CEN OP2 CEN OP3 MAT OP2	**Year 3** **Total 44 cr.**
Year 4 Semester 1 **Total 6 cr.** CSC498 CSC499	**Year 4 Semester 2** **Total 0 cr.**	**Year 4 Semester 3** **Total 0 cr.**	**Year 4** **Total 6 cr.**
		Total Credit = 131 + 3(LFE*) = 134	

*LFE can be done any time after 2nd year.