ENGINEERING (CORE COURSES)

INTRODUCTION

Engineering graduate programs require the study of some of the following general (core) graduate engineering courses.

0600-503	Statistical Concepts in Engineering	(3)
0600-504	Numerical Analysis and Computation	(3)
0600-505	Finite Element Methods	(3)
0600-506	Continuum Mechanics	(3)
0600-507	Mathematical Optimization	(3)
0600-508	Random Variables and Stochastic Processes	(3)
0600-510	Advanced Fluid Mechanics	(3)
0600-511	Computational Fluid Dynamics	(3)
0600-512	Advanced Engineering Mathematics I	(3)
0600-513	Advanced Engineering Mathematics II	(3)

COURSE DESCRIPTION

0600-503: STATISTICAL CONCEPTS IN ENGINEERING
CR: 3

Elements of probability theory, random variables, analytical models of random phenomena, reliability, factor of safety, safety margin, extreme value statistics, Monte-Carlo simulation, empirical determination of distribution models, confidence intervals, regression and correlation analysis, general applications to engineering design problems, stochastic processes.

0600-504: NUMERICAL ANALYSIS AND COMPUTATION
CR: 3

Norms, limits and condition numbers. Inverses of perturbed matrices. Integrative techniques for solving systems of equations. The LU, QR and singular value decompositions. Algorithms for the linear least squares and linear minimax problems. Computation of the eigenvalues of a matrix. the interpolation and polynomial approximation. Approximate methods for initial value problems and for boundary value problems.

0600-505: FINITE ELEMENT METHODS
CR: 3

Origin and basis of finite-element methods in continuum mechanics, stiffness method, assumed displacement field, potential energy and Rayleigh-Ritz method, types of elements, modeling, accuracy and convergence, solution techniques and computer application to structural and fluid mechanics.

0600-506: CONTINUUM MECHANICS
CR: 3

Cartesian tensors. Basic principles of continuum mechanics: deformation, displacement, strain, stress, conservation of mass, continuum thermodynamics and constitutive equations.

Illustrative applications in elasticity, fluid dynamics, viscoelasticity ad plasticity.

0600-507: MATHEMATICAL OPTIMIZATION
CR: 3

Basic Concepts: The gradient vector and the Hessian Matrix, multidimensional Taylor's theorem, linear and quadratic approximation of a function. Unconstrained optimization, necessary and sufficient conditions for optimality. Algorithms for single variable minimization, the Fibonacci search and the Golden section search, algorithms that use repeated polynomial interpolation. Algorithms for multi-dimensional minimization; The steepest descent, the Newton method and its variations, conjugate gradient algorithms such as the Flecter-Reeves, Polak and Ribieve, Quasi-Newton Methods such as the DEP-BFGS, Huang's family of algorithms. Constrained optimization: Necessary and sufficient conditions for constrained minima. Algorithms for constrained optimization: interior and exterior penalty function methods, augmented Lagrangian methods, Resen's gradient projection.

0600-508: RANDOM VARIABLES AND STOCHASTIC PROCESSES
CR: 3

Introduction to probability theory and engineering applications of probability. random variables and expected values. distribution of functions of random variables and applications of R.V. to system problems. Stochastic processes, correlation and power spectra, systems and random signals. Engineering decisions and estimation theories.

0600-510: ADVANCE FLUID MECHANICS
CR: 3

Motion of ideal, Newtonian, and non-Newtonian single-phase fluids. Continuity and Navier-Stokes equations for one and two dimensional flows. Turbulence and boundary layer theories. Flow through conduits, and porous medium. Homogenous and non-homogenous multiphase flow systems.

600-511: COMPUTATIONAL FLUID DYNAMICS
CR: 3

This course introduces students to the numerical and computational fluid dynamics. It will provide graduate students (Science and Engineering students) with techniques and approaches to solve numerical fluid mechanics problems encountered in real fluid flows. Methods for boundary layers, incompressible viscous flows, and inviscid compressible flows are studied. Finite differences and finite volume techniques are emphasized. The course utilizes using commercial CFD packages and MATLAB to solve fluid flow problems.

0600-512: ADVANCED ENGINEERING MATHEMATICS I
CR:3

Analytic function, residues, contour integration. Power series solutions of ordinary differential equations: Bessel's, Legendre's, Chebysheve's and Laguerre's functions. Matrix algebra eigenvalues, eigen-functions, and solutions of systems of differential equations. Software applications.

0600-513: ADVANCED ENGINEERING MATHEMATICS II
CR:3 PR:0600-512

Sturm-Liouville problem. Partial differential equations: Characteristic curves, separation of variables and integral transforms (Laplace and Fourier), method of characteristics. Wave, heat and diffusion-equations. Software applications.

MASTER OF SCIENCE
COMPUTER ENGINEERING

INTRODUCTION

The Department of Computer Engineering (College of Engineering and Petroleum) offers a Master of Science Program in **Computer Engineering**. Part-time and full-time students are admitted to this program. Research requirements include either thesis or non-thesis options. The program is designed to strengthen and broaden the scientific and engineering capabilities of participants. It is intended as a means of developing closer affinity to basic research and solving applied problems. The philosophy of the program reflects an interdisciplinary nature and embodies flexibility and choice variation to suit a multitude of needs. Specialization within the Computer Engineering program may be attained by selecting among various elective courses in areas such as networks and security, advanced database systems, computer aided design, and software systems.

According to the University Council decision dated 4/2/2007, Thesis students admitted with effect from September 2007 are exempted from the comprehensive examination.

PROGRAM REQUIREMENTS

The program requirements are:

30 (33) TOTAL COURSE CREDITS (non-thesis option in Parenthesis)

0 (3) COMPULSORY (credits in parenthesis)

0612-592	Seminar	(0)
0612-593	Project (non-thesis option only)	(3)

9 (9) CORE ELECTIVE COURSES (3 credits each)

Students may take more than 9 credit hours of core courses. In this case, the credit hours exceeding 9 count towards discipline (elective) course requirements.

0600-508	Random Variables and Stochastic Processes
0612-505	Advanced Operating Systems
0612-557	Advanced Algorithms
0612-568	Advanced Computer Architecture
0612-569	High-Performance Computer Networks

12 (21) ELECTIVE COURSES* (3 credits each)

The student chooses from the following courses with the approval of his/her supervisor.

0600-507	Mathematical Optimization
0612-502	Digital Image Processing

0612-503 Pattern Recognition
0612-508 Advanced Topics in Software Engineering
0612-509 Advanced Computer Graphics
0612-511 Privacy and Data Protection
0612-514 Progress and Impact of Computing
0612-523 Introduction to Artificial Intelligence
0612-527 Advanced Topics in Artificial Intelligence
0612-541 Database Management Systems: Design and Implementation
0612-543 Advanced Topics in Database System Design
0612-545 E-Commerce: Design and Implementation
0612-547 Digital Forensic
0612-548 Secure Software Systems
0612-549 Security Management, Policies and Risk Analysis
0612-551 Theory of Computation
0612-553 Distributed Computing
0612-555 Computer Security
0612-561 Parallel Computing
0612-562 Sequential Machine Theory
0612-564 Testing and Reliable Design of Digital Systems
0612-565 High-level Design of Digital Systems
0612-566 Wireless Computing Networks
0612-567 Modeling and Analysis of Communication Networks
0612-570 Physical Design Automation of Digital Systems
0612-571 Fault Tolerant Computing Systems
0612-572 Principles of VLSI Design
0612-573 Wireless Communication Systems
0612-574 Mobile Networking
0612-575 Advanced Topics in Computer Networks
0612-576 Modern Cryptography and Network Security
0612-580 Special Topics in Computer Engineering I
0612-581 Special Topics in Computer Engineering II

*A maximum of 3 credit hours (thesis students) and 6 credits hours (project students) can be taken from **core engineering**, any other engineering, science, computing science and engineering or joint graduate programs with the approval of the Graduate Program Director and Area Committee Chairman before registering the course. **Also, courses can be taken from the same graduate program courses.**

Cross-listed Courses
The student is not allowed to register two cross-listed courses in the same semester. In case a student completes two cross-listed courses in different semesters, only the first course will be calculated towards the degree.

Course Title (Electrical Engineering)	Course Title (Computer Engineering)
0610-524 Advanced Topics in Networking	0612-575 Advanced Topics in Computer Networks
0610-525 Digital Multimedia Compression	0612-502 Digital Image Processing
0610-526 Mobile Networking	0612-574 Mobile Networking
0610-527 Data and Network Security	0612-576 Modern Cryptography & Network Security
0610-528 Wireless Communication Networks	0612-573 Wireless Communication Systems
0610-537 Introduction to VLSI Design	0612-572 Principles of VLSI Design

9 COMPULSORY (Thesis Option Only)

0612-597 (0)
0612-598 (0)
2000-599 (9)

COURSE DESCRIPTION

0612-502: DIGITAL IMAGE PROCESSING
CR: 3

Introduction to Digital Image Processing covers digital techniques for image representation, enhancement, compression and restoration. Students will learn the fundamentals behind image processing methods and algorithms. We assume students have an understanding of linear systems and calculus. In addition, it is also helpful to have a familiarity with elementary probability theory and linear algebra.

0612-503: PATTERN RECOGNITION
CR: 3

Machine learning, statistical pattern classification, feature extraction and selection, va rious learning algorithms, cluster analysis, image processing, syntactic approach and practical applications on analysis of various biomedical data, character recognition, and speech recognition.

0612-505: ADVANCED OPERATING SYSTEMS
CR: 3 PR: Consent of Instructor

Selected advanced Operating Systems topics; control of disks and other input/output devices; file-system structure and implementation; network structures; distributed system structures and file systems; introduction to distributed and real-time systems; distributed algorithms; logical clocks; reliability and security; case studies.

0612-508: ADVANCED TOPICS IN SOFTWARE ENGINEERING
CR: 3

Selected topics in the area of software engineering such as emerging areas of research in software engineering; Object-oriented design and analysis; Configuration management; Software testing; Reverse engineering; Software reusability; Distributed and web-based software development; Fault-tolerant software development; Case tools for design and analysis, configuration management, and testing.

0612-509: ADVANCED COMPUTER GRAPHICS
CR: 3

Three-dimensional transformations and perspective systems and techniques for displaying and shading solid areas, hidden-element elimination, display device characteristics, device independent systems, and user interface design.

0612-511: PRIVACY AND DATA PROTECTION
CR: 3

Introduction to the issues of privacy and data protection, information collection, cookies, profiling, traffic monitoring analysis, data mining, data matching, surveillance technology, censorship,

encryption, identification, anonymity, codes and policies, law, privacy in workplace, and ethical issues.

0612-514: PROGRESS AND IMPACT OF COMPUTING
CR: 3 PR: Consent of Instructor

This course concentrates on recent research in computing that affects future directions in science, engineering and technology, hence upon modern society. For example, standards (e.g., E-Commerce technologies, and software life cycle processes such as ISO/IEC 12207) have immense effect on industry and society. Students explore such topics through conducting research. The course introduces skills necessary for research including surveying, scrutinizing methods and outcomes, designing tools, and preparing technical manuscripts.

0612-523: INTRODUCTION TO ARTIFICIAL INTELLIGENCE
CR: 3 PR: Consent of Instructor

Introduction to AI. History of AI. Knowledge representation: First order logic, Predicate logic, and Semantic net. Blind search. Heuristic search. Machine planning. Machine learning. Agents. Natural language processing.

0612-527: ADVANCED TOPICS IN ARTIFICIAL INTELIGENCE
CR: 3 PR: 0612-523 or Consent of Instructor

Advanced AI topics will be discussed in-depth. Student will survey recent research in topics such as, but not limited to, natural language processing, cognitive modeling techniques, machine learning techniques, evolutionary algorithms, fuzzy logic, expert systems, robotics, knowledge system engineering (knowledge-based software engineering), and neural network computing.

0612-541: DATA BASE MANAGEMENT SYSTEMS: DESIGN AND IMPLEMENTATION
CR: 3

Database management systems architecture; conceptual database models; relational, semantic, object-oriented, and object-relational databases; implementation techniques for database systems; file organization and data placement techniques; query processing; concurrency control; rollback and recovery techniques; integrity and consistency; transaction processing.

0612-543: ADVANCED TOPICS IN DATABASE SYSTEM DESIGN
CR: 3 PR: 0612-541 or Consent of Instructor

Design and implementation of database management systems in support of advanced technologies and applications, such as: geographical information systems (GIS) temporal and spatial databases, multimedia databases data mining data warehousing, distributed database systems, or other advanced topics in the area of database and information systems. We will focus on current issues in database and information system design.

0612-545: E-COMMERCE: DESIGN AND IMPLEMENTATION
CR: 3 PR: 0612-541 or Consent of Instructor

Fundamental and emerging technologies such as networking infrastructures, data management tools, application servers, design tools, security systems, personalization tools, and electronic payment systems; case studies dealing with the existing business models and business processes; design and implementation of a major E-Commerce project using the state of the art tools. Proficiency in an object-Oriented programming language (such as Java) is expected from all students.

0612-547: DIGITAL FORENSIC
CR: 3 PR: 0612-505,508 or Consent of Instructor

Overview of data representation, hexadecimal representation and different file type representations. Review on assembly language and code reverse engineering. Digital Forensics lab requirements. Digital Forensic process: technical and legal aspects. Types of Digital evidences. Extracting evidences from different OS platforms. Overview of network, Email, database and mobile Forensics. Students will be exposed to reverse engineering and code analysis. Students will do exercises on several Forensics tools.

0612-548: SECURE SOFTWARE SYSTEMS
CR: 3

This course will study approaches, mechanisms, and tools used to make software systems more secure. We will motivate the study by discussing common software security vulnerabilities such as buffer overflows, cross-site scripting and injection attacks. Then we will look at architectural

approaches to building secure software (e.g., confinement, virtual machines, trusted computing), secure design principles and patterns, software analysis, secure programming techniques, run-time enforcement of security policies, code reviews and security testing. The course will also cover topics such as the importance of usability to building secure software systems.

0612-549: SECURITY MANAGEMENT, POLICIES AND RISK ANALYSIS
CR: 3

Overview of security management: assets, vulnerabilities, threats, attacks, security tools, models and procedures. Role of policy making in the context of information security. Common practices to risk management and analysis. Fundamentals of cryptology, secure networking and access control. Problems and potential solutions associated with designing and implementing operating system and application security. Frameworks commonly used for governance and compliance control. Incident and disaster response.

0612-551: THEORY OF COMPUTATION
CR: 3

Regular expressions and finite automata. Turning machines and equivalent models of computation, the Chomsky hierarchy, context-free grammars, push-down automata, and computability. Machine models of effective computability; sub-recursive hierarchies; P and NP problems; effective and efficient reducibility; time, space, and abstract complexity.

0612-553: DISTRIBUTED COMPUTING
CR: 3

Distributed system examples, implementation issues, parallel vs. distributed systems, review of communication and networking, distributed system models, message-passing vs. shared memory models, synchronous vs asynchronous systems, guarded actions non-determinism, atomic operations, scheduling and fairness issues, program correctness, safety and liveness properties, distributed mutual exclusion, distributed snapshot, distributed reset, wave algorithms, termination detetction, distributed deadlock, randomized algorithms, synchronous message passing, Hoare's CSP, clients and servers, faults in distributed systems, classification of faults, fault masking vs. fault recovery, self-stabilizing and adaptive distributed systems, gracefully degradable systems, waitfree systems, distributed consensus, leader election, clock synchronization.

0612-555: COMPUTER SECURITY
CR: 3

Overview of computer security: security concepts, threats, attacks, assets, security functional requirements and security architecture. Cryptographic tools: symmetric ciphers, public-key encryption, message authentication, digital signatures, key management and random number generation. Authentication protocols. Access control mechanisms. Security policies and models. Intrusion detection and prevention systems. Security auditing and assurance. Security management, risk assessment and security controls.

0612-557: ADVANCED ALGORITHMS
CR: 3

Selections from design, analysis, optimization, and implementation of algorithms; Computational complexity, complexity classes, randomized algorithms, probabilistic algorithms, distributed algorithms, parallel algorithms; algorithm correctness and general theory of algorithms; algorithms for particular application areas including: Graphs and Networks; Cryptography.

0612-561: PARALLEL COMPUTING
CR: 3

Introduction to theoretical issues in parallel computation. Topics: Parallel machine models. Design and analysis of algorithms for systolic arrays: arithmetic operations, simple graph algorithms. Algorithms for hypercube-related networks: sorting, routing. PRAM model of computation. Basic PRAM algorithms: prefix computation, sorting, shortest paths, minimum-weight spanning tree. Reducing the processor-time product. simulation of stronger PRAM models by weaker ones. Complexity issues: definition of NC and P-completeness; some simple lower bounds.

0612-562: SEQUENTIAL MACHINE THEORY
CR: 3

Structure of sequential machines, partition theory and decomposition of machines, modular realization of sequential machines, regular expressions, information lossless machines and linear sequential machines.

0612-564: TESTING & RELIABLE DESIGN OF DIGITAL SYSTEMS
CR: 3 PR: Consent of Instructor

Fundamentals of digital circuits test such as fault modeling, automatic test generation, and testability measures, Design for Testability (DFT), Built-in-Self-test (NIST), Memory Test, emerging topics in test and reliable design.

0612-565: HIGH-LEVEL DESIGN OF DIGITAL SYSTEMS
CR: 3

Topics include: High level synthesis, scheduling and allocation techniques, architecture style selection, two level logic minimization algorithms, multiple-value minimization and multi-level circuit synthesis. The course usually involves a project.

0612-566: WIRELESS COMPUTING NETWORKS
CR: 3

Overview of the fundamental concepts in networks, wireless technology, and mobile computing. Energy-aware adaptation for mobile applications. Understanding the current routing protocols for studies of medium access control techniques for wireless communications. Design principles that are crucial for building the foundation for the design and construction of future generations of wireless computing networks (wireless ad hoc, sensor, and ubiquitous networks).

0612-567: MODELING AND ANALYSIS OF COMMUNICATION NETWORKS
CR: 3

Review of some important probability distributions and their properties; Markovian processes; Markovian queues; renewal theory; semi Markovian processes and the M/G/1 queue; priority queues; case studies: random access systems; polling systems; multiplexers and switching systems.

0612-568: ADVANCED COMPUTER ARCHITECTURE
CR: 3

Classification of parallel processing system - SIMD and MIMD machines - Multiprocessor systems and interconnection networks - Case studies of parallel processing systems - Parallel processing design issues: Programming languages, operating systems, user interfaces - VLSI computing systems: systolic arrays, wavefront arrays.

0612-569: HIGH-PERFORMANCE COMPUTER NETWORKS
CR: 3

Alternative network architectures; study of the network functions and protocols in high performance networks; routing and switching; transport protocols in high-performance networks; integrated and differentiated service models and protocols; congestion and flow control protocols; broadbank ISDN and ATM; high-speed local and metropolitan area networks; advanced topics in high-performance networking.

0612-570: PHYSICAL DESIGN AUTOMATION OF DIGITAL SYSTEMS
CR: 3

Fundamentals of graph theory, partition, floor planning, placement, and routing. Programming techniques and algorithms; shortest/longest path, all-pairs shortest path, dynamic programming, linear programming, non-linear programming, evolutionary approaches, simulated annealing, and hyper-algorithms.

0612-571: FAULT TOLERANT COMPUTING SYSTEMS
CR: 3

Fault modeling, redundancy techniques and reliability evaluation, error detecting and correcting codes, self-checking circuits, fault diagnosis, software fault tolerance, error mitigation methods, partial concurrent error detection, online test, reconfiguration and voting, software reliability and redundancy, hardware fault tolerance, fault detection in cryptographic systems.

0612-572: PRINCIPLES OF VLSI DESIGN
CR: 3

The course will cover basic theory and techniques of digital VLSI design in CMOS technology. We use full-custom techniques to design basic cells and regular structures such as data-path and memory. There is an emphasis on modern design issues in interconnect and clocking. Students will design small test circuits using various CAD tools. Circuits will be verified and analyzed for performance with various simulators.

0612-573: WIRELESS COMMUNICATION SYSTEMS
CR:3 PR: Consent of Instructor

Wireless communication principles, the cellular concept, radio propagation and modulation techniques, channel coding and equalization,

multiple access techniques and wireless communication networks, wireless systems standards.

0612-574: MOBILE NETWORKING
CR: 3

Introduction and fundamentals. Medium Access Control Protocols. Cellular Networks. Wireless Internet. 4-G Systems and Pervasive Networking. Security in Mobile Networks.

0612-575: ADVANCED TOPICS IN COMPUTER NETWORKS
CR: 3

The students will review the fundamental design and analysis issues in computer networks, especially at the physical layer to the transport layer, including networking overview, multi-protocol network, intelligent network, ad-hoc and sensor network, mobile networking and current trends in the high-speed networks.

0612-576: MODERN CRYPTOGRAPHY AND NETWORK SECURITY
CR: 3

Information theoretic security. Fundamentals of secure networks and cryptography. Number theory for cryptography. One-way hash functions. Message authentication codes. Encryption and privacy: public key and symmetric key. Digital signatures schemes. Authentication and integrity methods and protocols. Elliptic curves cryptography. Firewalls. Virtual private networks. Transport layer security.

0612-580: SPECIAL TOPICS IN COMPUTER ENGINEERING I
CR: 3 PR: Consent of Instructor

An upper division of graduate technical elective treating topics in engineering mostly not covered in other courses, chosen at the discretion of the Graduate Program Committee.

0612-581: SPECIAL TOPICS IN COMPUTER ENGINEERING II
CR: 3 PR: Consent of Instructor

An upper division of graduate technical elective treating topics in engineering mostly not covered in other courses, chosen at the discretion of the Graduate Program Committee.

0612-592: SEMINAR
CR: 0

Following the directions of the graduate program committee related to thesis or project.

0612-593: PROJECT
CR: 3

0612-597: THESIS
CR: 0

0612-598: THESIS
CR: 0

2000-599: THESIS
CR: 9