MS GRADUATE PROGRAM IN COMPUTER ENGINEERING

INTRODUCTION

The increased interaction between computing and communication in recent years is changing the landscape of computer engineering. There is now an obvious shift in the role of computers from that of only computation to that of manipulation and communication of information. *Computer networks and communications* have revolutionized the way many industries conduct their business over cyberspace. We are truly witnessing major moves into the information society.

This shift brings with it new opportunities, but also new challenges. One of the main challenges is that computer engineering now covers a wide range of multidisciplinary topics, such as computer networks and communication, VLSI, hardware and software co-design, distributed and real time system design, data as well as multimedia communication, wireless networks and supercomputers.

The envisioned role of computer engineering is to study, analyze and utilize the *interaction* between its fast changing disciplines; hardware, software, and application domains. It is this fact that really differentiates the fast growing Computer Engineering field from the field of Electrical Engineering and that of Computer Science.

PROGRAM REQUIREMENT AND PLAN

The Computer Engineering MS program has three main elements. The *first* is the core courses, which establish the necessary common competence level for all students. The core courses are designed to equip students with sufficient knowledge to embark on a more in-depth study of any specific aspect of computer engineering. The *second* is the elective courses, which build upon the core. Students choose three COE electives in addition to two technical electives to further broaden their horizon in graduate level courses (in COE, or related disciplines). The *third* component of the curriculum is the thesis.

A typical program plan will take two years to be completed by a full-time student. The plan calls for at least one full semester to be dedicated to the thesis research work

REQUIREMENT OF THE MS PROGRAM IN COMPUTER ENGINEERING

Number of Program Credit Hours	24
Number of Thesis Credit Hours	6
Core Courses	Three COE Core Courses • COE 501 Computer Architecture • COE 540: Computer Networks • COE 561: Digital System Design and Synthesis
COE Electives	Three COE Electives from the Graduate Computer Engineering Course list
Technical Electives	Two Graduate-Level Technical Elective Courses
Seminar	• COE 599: Seminar

CURRICULUM DESIGN

Graduate COE courses have been grouped into the following four Computer Engineering areas

- Computer Architecture, and Parallel & Distributed Computing
- VLSI, Digital Systems Design & Automation
- Computer Networks
- Computer Systems and Applications

To ensure breadth of coverage, students are required to take three core courses one from each of the first three major areas: COE 501 Computer Architecture, COE 540 Computer Networks, and COE 561 Digital Systems Design and Synthesis. These courses cover, at an advanced level, the underlying key aspects of the above-identified major COE areas.

Students enrolled in the program must also satisfactorily pass three COE elective courses. Students may select these courses from course lists of the above four COE areas.

Students are also required to pass two other elective courses that may be chosen from outside the COE department.

DESCRIPTION OF THE MS PROGRAM IN COMPUTER ENGINEERING

DEPARTMENT ADMISSION REQUIREMENTS

Students admitted to the Computer Engineering MS program must satisfy the following requirements:

1 A 4-year BS in COE or closely related discipline with a GPA of at least 3 out of 4,
2 A TOEFL score of at least 520,
3 An acceptable GRE score,
4 A minimum of two recommendation letters from faculty acquainted with the student's academic performance,
5 A statement of purpose written by the applicant.

ACADEMIC PROGRAM

All candidates for the MS degree in Computer Engineering must satisfy the overall requirements of KFUPM in addition to the following:

1 All students enrolled in the MS program in Computer Engineering are required to complete 24-semester-credit hours of graduate courses, (not including thesis). These courses should be selected from the student's program of study which has been approved by the Graduate Committee, the Department Chairman, and the Deanship of Graduate Studies.

2 Three core courses (9 semester credit hours) are required of all students:

COE 501: Computer Architecture (3-0-3)
COE 540: Computer Networks (3-0-3)
COE 561: Digital System Design and Synthesis (3-0-3)

3 Three COE graduate-level electives to be chosen from the following 4 subject areas of Computer Engineering. Students are allowed to take up to ***four*** *courses, including the corresponding core course, from any of the first three subject areas. For the network area, it should be noted that network courses with ICS or CSE prefixes would count towards this upper bound. An ICS or CSE course is considered as a network course if it is listed in the Network courses in the COE-ICS joint Network MS Program.*

Computer Architecture and Parallel Processing Systems

COE 502: Parallel Processing Architecture
COE 503: Message Passing Multiprocessing Systems
COE 504: Heterogeneous Computing
COE 505: Fault Tolerant Computer Systems
COE 509: Special Topics in Architecture and parallel processing.

Computer Networks Area

COE 541: Local and Metropolitan Area Networks
COE 542: High-Speed Networks
COE 543: Mobile Computing and Wireless Networks
COE 549: Special Topics in Computer Networking Technologies
CSE 551# Computer and Network Security
CSE 552: Network Management
CSE 553 Fault Tolerance and Reliability in Computer Networks
CSE 554 Modeling and Analysis of Computer Networks
CSE 555 Protocol Engineering
CSE 559 Special Topics in Computer Network Design and Management

Digital System Design and Automation

COE 562: VLSI System Design
COE 566: VLSI ASIC Design
COE 567: Digital System Modeling and Verification
COE 571: Digital System Testing
COE 572: Computer-Aided Design of Digital Systems
COE 579: Special Topics in Digital Systems Design and Automation

Computer Systems and Applications

COE 584: Robotics
COE 585: Switching Theory
COE 586: Computer Arithmetic
COE 587: Performance Evaluation and Analysis
COE 588: Modeling and Simulation
COE 589: Special Topics in Computer Systems and Applications
COE 591: Neural Networks
COE 592: Human Computer Interface Engineering
COE 593: Multimedia
COE 594: DSP Systems and Architectures
COE 595: Hardware/Software Co-design of Embedded Systems
COE 596: Intelligent Computing
COE 597: Real Time Systems

4 Two electives are to be selected from a list of approved graduate courses from within or outside the COE Department. They must, however, be taken from departments of a *related discipline*, e.g. ICS, Math, EE, and SE. The student advisor must approve the two courses. The total credit hours of elective courses taken from outside the COE Department should not exceed six

5 The student must complete a thesis on an approved topic in Computer Engineering under the supervision of his graduate thesis committee.

6 The student should present a seminar that describes recent research findings in Computer Engineering as well as attend the technical seminar series organized by the COE department. This requirement is satisfied by the zero-credit hours seminar course COE 599 (1-0-0).

7 Students admitted on a provisional basis, should satisfy any conditions, e.g. remedial courses, required to attain regular status.

DEGREE PLAN

Course No.	Title	LT	LB	CR
FIRST SEMESTER				
COE 5xx	COE Core I	3	0	3
COE 5xx	COE Core II	3	0	3
COE 5xx	COE Elective I	3	0	3
SECOND SEMESTER				
COE 5xx	COE Core III	3	0	3
COE 5xx	COE Elective II	3	0	3
XXX xxx	Elective Course I	3	0	3
THIRD SEMESTER				
COE 5xx	COE Elective III	3	0	3
XXX xxx	Elective Course II	3	0	3
COE 599	Seminar	1	0	0
FORTH SEMESTER				
COE 610	MS Thesis Work	0	0	6

The two XXX xxx electives *may* be taken from the graduate courses from within or outside the Computer Engineering Department. Students must obtain departmental approval for the selected courses.

COURSE DESCRIPTION

COE 501 Computer Architecture (3-0-3)

Classification of computer systems, architectural developments, computer performance. Linear and nonlinear pipeline design, instruction and arithmetic pipeline, superscalar. Memory hierarchy, cache and virtual memory, cache coherence, memory system performance. Parallel architectures, performance measures, SIMD and MIMD architectures, interconnection networks. The students are expected to carry out research projects in related field of studies.

Equivalent to: ICS 536
Prerequisite: COE 308 or Equivalent.

COE 502 Parallel Processing Architectures (3-0-3)

Introduction to parallel processing architecture, sequential, parallel, pipelined, and dataflow architectures. Vectorization methods, optimization, and performance. Interconnection networks, routing, complexity, and performance. Small-scale, medium-scale, and large-scale multiprocessors. Data-parallel paradigm and techniques. Multithreaded architectures and programming. The students are expected to carry out research projects in related field of studies.

Prerequisite: COE 308 or Equivalent.

COE 503 Message Passing Multiprocessing Systems (3-0-3)

Introduction to message passing multiprocessor systems. Message communication models and their correctness. Message passing system architecture & languages. Architectural support for message passing. Processor time allocation. Inter module message communication. Real time applications of message passing systems. Future trends and new technologies. The students are expected to carry out research projects in related field of studies.

Prerequisite: COE 442 or Equivalent.

COE 504 Heterogeneous Computing (3-0-3)

Taxonomy of heterogeneous computing. Introduction to mixed-mode and multimode heterogeneous systems. Network heterogeneous computing: design issues, architecture, programming paradigm and environment, mapping, load balancing and scheduling. Applications and Case studies. The students are expected to carry out research projects in related field of studies.

Prerequisite: COE 308 or Equivalent.

COE 505 Fault Tolerant Computer Systems (3-0-3)

Fundamental concepts in the theory of reliable computer systems Design. Hardware and software reliability techniques. Evaluation of fault-tolerant computer systems. The practice of reliable system design. Case studies. Fault-tolerant multiprocessor design. The students are expected to carry out research projects in related field of studies.

Prerequisite: COE 308 or Equivalent.

COE 509 Special Topics in Computer Architecture and PP (3-0-3)

Advanced topics selected from current issues in Computer Architecture and Parallel & Distributed Systems.

Prerequisite: Graduate Standing.

COE 540 Computer Networks (3-0-3)

Computer Networking concepts. Basic Terminology; Protocols; Communication Architectures; OSI Reference Model; Protocol suites. Data Link Layer; ARQ Strategies; Analysis of ARQ Strategies. Multi-access communication. Introduction to ATM. Delay Models in Data Networks; Introduction to performance analysis; Little's Theorem; Single queue models; Network of queues. Network layer. Routing in Data Networks. Flow and Congestion Control. Transport layer. Application Layers.

Equivalent to: EE 674
Prerequisite: COE 442 or ICS 432 or Consent of Instructor.

COE 541 Local and Metropolitan Area Networks (3-0-3)

Protocols and Network Architectures. Various Technologies for Local and Metropolitan Area Networks (LANs and MANs). Classes of LANs and MANs. LAN and MAN design issues and Standards. LAN and MAN performance modeling and analysis. Internetworking. Examples of LANs and MANs. Case studies. Emerging LAN/MAN technologies.

Prerequisite: COE 540 or Consent of Instructor.

COE 542 High-Speed Networks(3-0-3)

Protocols and Network Architecture. Local high speed networks. Broadband Metropolitan and Wide Area Networks. Impact of high speed on communication protocols and networks. Fiber optic networks. Design and performance issues of high speed networks. Standard high speed protocols and networks. Examples of high speed networks. Case studies. Emerging technologies for high speed networks.

Prerequisite: COE 540 or Consent of Instructor.

COE 543 Mobile Computing and Wireless Networks (3-0-3)

Introduction to mobile computing and wireless networks. Designing computer networks to support computer mobility. Wireless network architecture and ad-hoc networks. Mobility standards, e.g. mobile IP. Mobility systems issues (e.g. performance &bandwidth). Quality of Service guarantees, reliability, and security in mobile computing environment. Access protocols for wireless networks.

Prerequisite: COE 540 or Consent of Instructor.

COE 549 Special Topics in Computer Networking Technologies (3-0-3)

State-of-the-art topics from the areas of various transmission technologies.

Prerequisite: Consent of Instructor.

COE 561 Digital System Design & Synthesis (3-0-3)

Digital system design methodologies. Hardware Description Languages (HDLs). System design, modeling and verification at various levels of abstraction. Introduction to testing: Fault models and test generation strategies, DFT and BIST. Delay models and timing verification. Principles of High-Level Synthesis (HLS)-internal representation (DFG, SFG, etc); scheduling, allocation and binding. Controller and data path synthesis. Introduction to physical Design, logic synthesis and technology mapping.

Prerequisite: COE 308 or Equivalent.

COE 562 VLSI System Design (3-0-3)

Review: The MOS transistor, transistor sizing, circuit layout, static versus dynamic logic, combinational and sequential logic. Deep submicron device models and scaling, interconnect models. Clocking strategies, clock skew, setup, hold & propagation delays, self-timed logic, I/O design. Dynamic characteristics of MOS circuits: effects of signal slew rate on propagation delay. Dynamic logic circuits: domino, CVSL, charge sharing. Design considerations of regular structures: ROM's, PLA's, adder and multiplier architectures. CAD tools for layout and design capture. CMOS memories: architecture, design constraints. ROM, SRAM and DRAM cells. Single and double-ended bit line sensing. Multiport register files. The course is project-oriented stressing the use of CAD tools through class projects.

Prerequisite: COE 360 or Equivalent.

COE 566 VLSI ASIC Design (3-0-3)

Review: MOS transistor, transistor sizing, circuit layout, and static versus dynamic logic. MOS logic optimization of delay and area. ASIC design methodologies, full custom versus semi-custom. ASIC library design, cell characterization, design area and delay. Standard-cell design methodology, propagation delay, design area, critical path, placement and routing of cells, design optimization and back annotation. Gate arrays and silicon compilers. Programmable ASICs, programmable logic cells, and programmable I/O, programmable interconnect. Hardware description languages, technology mapping and synthesis. Test techniques of ASICs, fault models, boundary scan and DFT. The course emphasizes hands on experience through the use of available design tools for the design of ASIC VLSI.

Prerequisite: COE 360 or Equivalent.

COE 567 Digital System Modeling & Verification (3-0-3)

Introduction and approaches to digital system verification. Simulation versus Formal verification. Levels of hardware modeling (circuit, switch, gate, RTL, and Behavioral levels). Logic, RTL, and Behavioral level simulation. Principle of Formal hardware modeling and verification. Mathematical logic (First order logic, Higher Order Logic, Temporal Logic). Abstraction mechanisms for hardware verification. Automated theorem provers. Verification using Specific Calculus. Formal verification versus formal synthesis. Future trends in hardware verification.

Prerequisite: Consent of Instructor.

COE 571 Digital System Testing (3-0-3)

Issue of VLSI testing, test Economics. Fault models: Transistor level faults, Single and Multiple stuck at faults, Bridging faults, Functional faults, Delay faults. Automatic Test Pattern Generation for Combinational logic: Path sensitization, D-algorithm, Critical path, PODEM, FAN, CMOS testing. Sequential logic testing. Design For Testability. Built-in Self-test (BIST). Functional testing, Testing of regular architectures, Testability measures. Delay testing. Testing of systems on chip.

Prerequisite: (COE 308 and COE 360) or Equivalent.

COE 572 Computer-Aided Design of Digital Systems (3-0-3)

The VLSI Design Process. Layout Styles. Graph and Circuit Partitioning. Floorplanning Approaches. Placement Heuristics. Routing: Maze Routing, Line Search Algorithms, Channel Routing and Global Routing. Layout Generation. Layout Editors and Compaction.

Prerequisite: (COE 360 and ICS 353) or Equivalent.

COE 579 Special Topics in Digital Sys. Design and Automation (3-0-3)

Advanced topics selected from current issues in the area of digital system design and automation.

Prerequisite: Consent of Instructor.

COE 584 Robotics (3-0-3)

Morphological structures of robotics systems. Design and analysis of motion coordination systems for robot arms, geometric and variational approaches. Robot languages and programming, effector and object levels. Trajectory planning and collision avoidance. Force sensing and compliance. Robotic vision and intelligence. Space robotics and remotely controlled robotic systems.

Equivalent to: SE 532 and EE603

Prerequisite: COE 305 or Equivalent.

COE 585 Switching Theory (3-0-3)

Review of Switching Algebra, Complex Gates, Boolean Algebra, Multiple-Valued Logic, Switch Network, Transient Analysis, Symmetric Functions, Unate Functions, Threshold Functions, Multiple-Output Network, Programmable Arrays, Fault Models, Test sets, Multi-Stage Networks, Sequential-Circuit Analysis, Finite-state Machines, Multiple-Pulse and Non-Pulse Circuits, Asynchronous Circuit Design.

Prerequisite: COE 308 or Equivalent.

COE 586 Computer Arithmetic (3-0-3)

Fixed point arithmetic: addition, subtraction, multiplication, division, fixed point ALUs. Floating point arithmetic: normalization, rounding, addition, subtraction, multiplication, division, floating point ALU. Modeling of Arithmetic Processors. Elementary functions. Nonconventional Number Systems.

Prerequisite: COE 308 or Equivalent.

COE 587 Performance Evaluation and Analysis (3-0-3)

Simulation of the functions of a computer systems, Analytical and stochastic methods of performance, Graph models for multiprocessors and parallel processing. Performance measures. Performance evaluation techniques. Application areas. The modeling cycle. Flow analysis. Bottleneck analysis. Hierarchical modeling. Case studies.

Equivalent to: ICS 532

Prerequisite: STAT 319 or Equivalent.

COE 588 Modeling and Simulation (3-0-3)

The simulation cycle. Discrete-event simulation approaches. Probability and statistics in simulation. Random number generation. Building valid and credible simulation models. Output data analysis. Simulation software. Distributed and parallel simulation. Applications to computer systems. Case studies.

Equivalent to: ICS 533, SE518
Prerequisite: ICS 202, STAT 319 or SE 205 or Consent of Instructor.

COE 589 Special Topics in Computer Systems and Applications (3-0-3)

Advanced selected topics in computer systems and applications.

Prerequisite: Graduate standing and Consent of Instructor.

COE 591 Neural Networks (3-0-3)

Fundamental concepts of neural computing. Terminology. Main neural networks architecture single/multilayer perceptrons, feedback(recurrent)/feedforward information flow; and their supervised/unsupervised learning models. Backpropagation, self - organizing, adaptive resonance, auto/heteroassociation neural memory models. Neurocomputing implementation, applications, performance evaluation. Literature survey of the most recent neural networks development.

Equivalent to: ICS 586 and EE560

Prerequisite: Graduate standing and Consent of Instructor.

COE 592 Human Computer Interface (HCI) Engineering (3-0-3)

Components of Human Computer Interaction, Human - Computer interaction theories, Mental Models, Conceptual Models, Principles and Methods of User-Centered Design, User-information processing capabilities and limitations, Graphics User-Interface GUI, Guidelines, Prototyping, Standards, Evaluation.

Equivalent to: SE 569

Prerequisite: Graduate standing and Consent of Instructor.

COE 593 Multimedia (3-0-3)

Time-Frequency Representation, Predictive Coding, Speech Analysis and Synthesis, Image Understanding and Modeling, Image Compression Techniques, Color Models and Color Applications, 3-D Representation, Illumination Models, Graphics Systems, MPEG Standards, Video Compression, Video Conferencing.

Equivalent to: ICS 538

Prerequisite: Graduate standing and Consent of Instructor.

COE 594 DSP Systems and Architectures (3-0-3)

Classification of DSP Functional Units, Programmable DSP Architectures, Video Processors, Fine Grain Image Processors, Application Specific DSP Architectures, DSP Linear Array Architectures and their Synthesis, Mapping of DSP Algorithms, Algorithmic and Architectural Transformation for DSP, VLIW DSP Architectures, Multimedia Processor Architectures, Memory Architecture for DSPs, Programmability of Advanced Architectures.

Prerequisite: COE 308 or Equivalent.

COE 595 Hardware/Software Co-design of Embedded Systems (3-0-3)

Embedded System Design Considerations, Classical Design Methods, co-representation, Performance Modeling, Co-design Trade-offs, Functional Decomposition, Partitioning, Design methodologies, Co-design Environments, Abstract Models, Recent Techniques in Co-design, Case Studies.

Prerequisite: COE 308 or Equivalent.

COE 596 Intelligent Computing (3-0-3)

Prepositional Logic, Predicate Logic, Modal Logic, Context-dependant computations, Situated Representation, Spatial-Temporal Knowledge, Spatial-Temporal Models, Spatial-temporal Reasoning, Situated Concepts, Situated Logic, Situated Decision Making, Architectures for Intelligent Computing, Case Studies.

Prerequisite: Graduate standing and Consent of Instructor.

COE 597 Real Time Systems (3-0-3)

Introduction, System Specifications and Architecture, Modeling and Analysis with Time Constraints, Real-Time Systems Design, Performance metrics, Performance evaluation under extreme conditions, Hardware/Software trade-off for Real Time Systems, Applications and Case Studies.

Prerequisite: Graduate standing and Consent of Instructor.

COE 599 Seminar (1-0-0)

Graduate students are required to attend the seminars by faculty members, visiting scholars, and fellow graduate students. Additionally, each student must present at least one seminar on a timely research topic. Among other things, this course is designed to give the students an overview of research in COE, and a familiarity with research methodology, journals and professional societies in his discipline. Graded on a Pass or Fail basis.

Prerequisite: Graduate standing.

COE 610: Computer Engineering Master Thesis (0-0-6)

The student has to undertake and complete a research topic under the supervision of a faculty member in order to probe in depth a specific problem in Computer Engineering.

Prerequisite: COE 599.