Master of Science Degree in Embedded Systems

This program is designed to prepare students for significant embedded computer-related careers in industry, automotive, various appliances and others. It is designed for students with a baccalaureate degree in computer engineering, computer science, electrical, electronic or communication engineering who want to strive for a balance of theory, hardware and software in computer system design.

Admission requirements:
- B.S. or equivalent degree in computer engineering, computer science, or electrical, electronic or communication engineering. Applicants without a background in digital logic and microprocessor-based systems, will be asked to take ECE 508 and/or ECE 570 before taking any other courses.
- Grade point average of 3.0 or better.
- Official GRE and TOEFL scores requirements are as described in the University Catalog.

Embedded Systems degree requirements
The program requires 32 credits of graduate coursework. The structure of credits is as follows:

Core requirement (at least 16 credits)
- ECE 570 Microprocessor-based Systems Design
- ECE 571 Mixed-signal Embedded Systems
- ECE 576 Embedded System Design with FPGAs
- ECE 572 Microcomputer-based Control Systems
- ECE 573 Embedded System Validation and Verification
- ECE 566 Micro and Nano Embedded Systems
- CSE 564 Computer Architecture

A core course may be substituted by another ECE course with prior approval provided the student has already taken an equivalent course.

Depth requirement (at least 12 credits)
(Only one project for 4 credits or one thesis for 8 credits can be taken)
- ECE 671 DSP in Embedded Systems (Prerequisites: ECE 570, or 571)
- ECE 666 Real-time Systems (Prereq ECE 570,or 571)
- ECE 664 Parallel Embedded Computer Architecture (Prereq: ECE 570 or 571)
- ECE 676 Advanced Embedded System Design (Prereq ECE576)
- ECE 672 Fault Tolerant Systems (Prerequisites: ECE 570 or 571)
- ECE 585 VLSI circuits and system design of Digital Chips
- CSE 665 Design Automation of Embedded Systems (CSE/ECE 570)
- ECE 690 Thesis for 8 credits
- ECE 590 Project for 4 credits

Electives 4 Credits
Four credits of electives from any 500- or 600-level ISE, SYS, ME, ECE or CSE courses (excluding CSE 505, 506, 507, and 508 courses).

Total: 32 Credits
Course Description

ECE 570 Microprocessor-based System Design (4 Credits)
Application of microprocessors and microcomputers to the solution of typical problems; interfacing microprocessors with external systems such as sensors, displays and keyboards; programming considerations, microcomputer system design. A laboratory design course, several short design projects and one large design project. This course integrates concepts learned in required courses and provides a design experience. The large design project includes cost/trade-off analysis, submitting a detailed written report and oral presentation of the project. Credit cannot be earned for more than one of ECE 470/570 and CSE 470/570. Offered fall and winter.

ECE 571 Mixed Signal Embedded System (4 Credits)
This course will discuss the design and analysis of embedded mixed-signal systems. Topics include study and comparison of mixed-signal microcontroller architectures, programmable digital peripherals, programmable analog peripherals, sensor and actuator interfaces, optical and analog isolation, communication standards, and development tools. A final project will be approached in a top-down fashion involving, system specification, functional partition, trade-off analysis, component design, integration, and performance evaluation. Offered Fall.

ECE 572 Microcomputer-based Control Systems (4 Credits)
Computer-aided engineering, analysis, design, evaluation of control systems. Microcomputer/microprocessor-based hardware and software development of digital controllers, estimators, filters. Data acquisition, signal conditioning and processing circuits, graphics displays. On-line system level and board-level microcomputer-based control experiments. Laboratory and projects emphasize real time applications, programming and hardware integration. With laboratory. Offered winter.

ECE 573 Embedded System Verification and Validation (4 Credits)
Topics covered include automotive embedded system requirements, verification during design, sneak circuit analysis, worst-case circuit analysis, design considering component tolerances and non-ideal behavior, thermal analysis, EMC analysis, FMEA analysis, grounding rules for circuits, six sigma, fault tolerance, risk analysis, reliability issues, trade-offs in design, delays in automotive networks, and software-in-the-loop and hardware-in-the-loop tests. Offered fall or winter.

ECE 576 Embedded System Design with FPGAs (4 Credits)
Topics covered include the use of hardware description languages such as VHDL / Verilog and C in the design of embedded systems containing an FPGA, CPU design, device drivers for
FPGA cores, high-level design tools to specify, simulate and synthesize designs to FPGAs, and design examples. Hardware and software design; project-oriented course. (Prerequisites: ECE 570 or 571) Offered Winter

ECE 566 Micro- and Nano-Embedded Systems (4 Credits)
This course will focus on introducing micro-scale embedded systems. This includes digital, analog, mixed-mode, and micro-electromechanical systems (MEMS). An introduction to basic fabrication techniques for analog and micro-electromechanical systems will be given. The course will focus on applications that have been developed and are currently under development using mixed-mode embedded systems and MEMS, particularly for automotive, consumer products, sensors, and biomedical applications. An introduction to technology of nano-scale will be given.

ECE 664 Parallel Embedded Computer Architecture (4 Credits) (Cross list with CSE 664)
Parallel computer systems: SIMD, MIMD, Shared memory, NUMA, UMA architectures, multiple bus, interconnection network, distributed memories, message passing structures, hierarchical caches, snooping controller design, directory-based cache coherency, performance evaluation of parallel systems, instruction level parallelism, practical small multiprocessor system design issues, large scalable multiprocessor systems, grid computer performance, chip multiprocessor system (multiple cores), network processors and the future of parallel architectures. Prerequisite: CSE 564 or ECE 570. Offered in fall.

ECE 666 Real-Time Computing Systems (4 Credits) (old CSE 666)
This course emphasizes hard and soft real-time computer system design for single-processor and multi-core embedded systems and distributed real-time systems. Topics covered include characterizing real-time systems, measuring performance, task assignments, scheduling, fault tolerant scheduling, run-time error handling, run-time support, kernel, real-time databases, real-time communication, software development techniques; practical applications. Prerequisites: ECE 570 or 571. Offered in winter.

ECE 671 DSP in Embedded Systems (4 Credits) (old CSE 671)
This course emphasizes design of embedded systems using Digital Signal Processing microprocessors, and special DSP FPGA chips. Topics covered include, DSP microprocessor architecture, advanced instructions, addressing modes, interrupt, system design considerations, interfacing serial and parallel I/O, memory structure, arithmetic manipulations, software development tools, multiple DSP processor system design, and embedded system applications. Applications include automotive, multimedia, and wireless communications. Performance measurement, benchmarking and DSP system simulation, testing and debugging. The students will do a set of lab projects and a large embedded system design project. Prerequisite: ECE 570 or 571. Offered in fall.
ECE 672  Fault Tolerant Systems (4 Credits)

This course focuses on fundamental concepts and dependable computing and design methodologies for fault tolerant computing systems. Topics covered include hardware fault tolerance, software fault tolerance, information redundancy, check pointing, fault tolerant networks, reconfiguration-based fault tolerance, and simulation techniques. Students will gain familiarity with the core and contemporary literature in the area for dependable computing. Prerequisites: ECE 570 or 571. Offered in winter.

ECE 676 Advanced Embedded System Design (4 Credits) (old CSE 678)

Design of high-speed reconfigurable embedded systems using both a microprocessor and an FPGA. Topics and exercises include designing and implementing an intelligent system using various microcontrollers, profiling and analyzing code for performance, designing and implementing special-purpose processors on an FPGA to work cooperatively with the microcontroller for significant performance gains, fuzzy logic for embedded systems, standards and interface issues between the microcontroller and FPGA-based system, and design for low power mobile systems. Project-oriented course. Prerequisites: ECE 576. Offered in fall.

ECE 585 VLSI Circuits and Systems Design of Digital Chips (4 Credits)

Design techniques for rapid implementation and evaluation of Very Large Scale Integrated Circuits (VLSIC), including behavioral, functional, logic, circuit, device, physical IC fabrication, and layout issues. CMOS and pseudo NMOS technology, inverters, logic and transmission gates switching characteristics and processing. Reliability, yield and performance estimation. The course is project oriented. Students start with concepts and finish with actual Application Specific Integrated Circuits (ASICs) using modern CAD tool suites. Offered winter. ECE 585 replaces EE 585. This course also has a lab component.

ECE 508 Digital Logic and Microprocessor Design (4 Credits) (same as ECE 378)

Development of components and techniques needed to design basic digital circuits and systems for controllers, computers, communication and related applications. Design and analysis of combinational and sequential logic circuits using a hardware description language such as VHDL. Design of dedicated microprocessors and their implementation in an FPGA. With laboratories. Offered fall and winter.

(Credit not applicable to MS in Embedded Systems)