ECE 2022. Introduction to Digital Circuits and Computer Engineering - **DELETED** (merged into 2029)

The objective of this course is to expose students (including first year students) to basic electrical and mathematical concepts that underlie computer engineering while continuing an introduction to basic concepts of circuits and systems in a hands-on environment. Experiments representing practical devices introduce basic electrical engineering concepts and skills which typify the study and practice of electrical and computer engineering. In the laboratory, the students construct, troubleshoot, and test analog and digital circuits that they have designed. They will also be introduced to the nature of the interface between hardware and software in a typical microprocessor based computer.

**Topics:** Sets, functions, Boolean algebra, digital switching logic, the transistor as switch, circuit design of logic gates, design of combinational logic circuits, software and hardware interfacing including analog/digital and digital/analog conversion.

**Recommended background:** ECE 2010 and MA 1022.

ECE 2029. Introduction to Digital Circuit Design - **Replacement for 2022 and 3801**

Digital circuits are the foundation upon which the computers, cell phones, and calculators we use every day are built. This course explores these foundations by using modern digital design techniques to design, implement and test digital circuits ranging in complexity from basic logic gates to state machines that perform useful functions like calculations, counting, timing, and a host of other applications. Students will learn modern design techniques, using a hardware description language (Verilog) to design, simulate and implement logic systems consisting of basic gates, adders, multiplexers, latches, and counters. The function and operation of Programmable Logic Devices, such as FPGAs, will be described and discussed in terms of how an HDL logic design is mapped and implemented. Experiments involving the design of combinational and sequential circuits will provide students a hands-on introduction to basic digital electrical engineering concepts and the skills needed to gain more advanced skills.

In the laboratory, students will construct, troubleshoot, and test the digital circuits that they have developed using a hardware description language. These custom logic designs will be implemented using FPGAs and validated using test equipment.

**Topics:** Number representations, Boolean algebra, design and simplification of combinational circuits, arithmetic circuits, analysis and design of sequential circuits, and synchronous state machines.

**Lab exercises:** Design, analysis and construction of combinational and sequential circuits; use of hardware description languages to implement, test, and verify digital circuits; function and operation of FPGAs.

**Recommended background:** Introductory Electrical and Computer Engineering concepts covered in a course such as ECE 2010 or RBE 2001, and MA 1022.

**Note:** Students will not be able to receive credit for both ECE 2022 and ECE 2029.

2049 Embedded Computing in Engineering Design - **Replacement for 2801**

Embedded computers are literally everywhere in modern life. For every PC-style computer made each year the are approximately 100 embedded computer devices produced. On any given day we interact with and depend on dozens of small computers to make coffee, run cell phones, take pictures, play music play, control elevators, and so on. Using popular everyday devices like music players and cell phones as case studies, students in this course are introduced to the unique computing and design challenges posed by embedded systems. Students then solve real-world design problems using small resource (time/memory/power) constrained computing platforms. Along the way, students will learn about the hardware and software structure of a modern embedded devices and about interaction between embedded computers and the physical world. Emphasis is placed on interfacing embedded processors with common sensors and devices (like gyros, accelerometers, GPS and wireless) and building the skills needed to use embedded processors in systems design.

**Topics:** Number/data representations, structured program design using C, microprocessor and microcontroller architecture, program development and debugging tools for a small target processor, hardware/software dependencies, use of memory mapped peripherals, design of event driven software, time and resource management.

**Lab exercises:** In lab students will solve commonly encountered embedded processing problems to create usable devices. Starting with a requirements list students will use the knowledge gained during the lectures to implement solutions problems which explore topics such as user interfaces, interfacing with the physical world, logic flow, and timing and time constrained programming. Exercises will be performed on microcontroller and/or microprocessor based embedded systems using cross platform development tools appropriate to the target platform.

**Recommended background:** ECE 2010 or 2029? and C language programming (CS 2301 or similar). Note: Students who have received credit for ECE2801 may not receive credit for ECE2049.
ECE 2801  Foundations of Embedded Computer Systems - DELETED  (merged into 2049)

This course introduces the C and assembly language programming concepts that are needed to develop microprocessor and microcontroller-based computer systems. Beginning with the fundamentals of computer architecture and organization, students learn assembly language and how C and assembly language programs running on microprocessors are used to solve problems that require interactions between a computer and the physical world. Students in this course will also learn about the hardware and software structure of a modern computer system and how hardware, software, and the passage of time must be managed in an embedded system design. Other issues that will be addressed as appropriate include overall embedded system development, software maintenance, programming for reliability, and product safety.

Topics: Number systems, software flow diagrams, models for system state and state transitions, microprocessor and microcontroller architecture, mixed C and assembly language programming, program development and test tools, operating system interfaces, hardware/software dependencies, and time and resource management.

Lab exercises: Introductory C and assembly language exercises and more advanced problems which explore topics such as logic flow, real time programming, maintainability and software maintenance cycles. Exercises will be performed on microcontroller and/or microprocessor based embedded systems using cross platform development tools appropriate to the target platform.

Recommended background: ECE 2022 (for ECE students) or CS 2011, and C language programming (CS 2301 or similar).

ECE 3801 Advanced Logic Design - DELETED  (merged into 2029)

This course introduces students to the design of the complex logic systems underlying or supporting the operation of computer systems and interfaces. Students learn how to use advanced computer-aided design tools to develop and simulate logic systems consisting of MSI components such as adders, multiplexers, latches, and counters. The concept of synchronous logic is introduced through the design and implementation of Mealy and Moore machines. Hardware description languages are introduced and used to describe and implement combinational circuits. Students will also learn how to use programmable logic devices to implement customized designs.

Topics: Review of logic gates and design and simplification of combinational circuits. Arithmetic circuits, MSI devices, analysis and design of sequential circuits, synchronous state machines and programmable logic. Introduction to hardware description languages.

Lab exercises: Design, analysis and construction of combinational and sequential circuits, use of computer-aided engineering software for schematic entry and digital analysis, introduction to hardware description languages and programmable logic devices.

Recommended background: ECE 2022 (for ECE students) or CS 2011.


ECE 3803 Microprocessor System Design – LAST OFFERED D TERM  (merged into 3849)

This course builds on the computer system material presented in ECE 2801. It covers the architecture, organization and instruction set of microprocessors. The interface to memory (RAM and EPROM) and I/O peripherals is described with reference to bus cycles, bus timing, and address decoding. Emphasis is placed on the design, programming and implementation of interfaces to microprocessor systems using a mixture of C and assembly language.

Topics: bus timing analysis, memory devices and systems, IO and control signaling, bi-directional bus interfaces, instruction execution cycles, interrupts and polling, addressing, programmable peripheral devices, interface design issues including analog/digital and digital/analog conversion. Mixed language (C and Assembler) programming.

Laboratory exercises: Use of standard buses for advanced IO design and programming, mixed language programming, standard bus timing, and interface design and implementation. Development of a complete standalone embedded computer system.

Recommended background: ECE 2801 and ECE 3801 or an equivalent background in advanced logic design, and microprocessor architecture. CS 2301 or CS 2303 or an equivalent background in C programming.

ECE 3810 Advanced Digital System Design - LAST OFFERED D TERM  (merged into 2029 and 3829)

This is an introductory course addressing the systematic design of advanced digital logic systems. The emphasis is on top-down design starting with high level models using VHDL as a tool for the design, synthesis, modeling, and testing of highly integrated digital devices. The integration of tools and design methodologies will be addressed through a discussion of system on a chip (SOC) integration, methodologies, design for performance, and design for test/testing.
ECE Department: New Computer Engineering Courses (March 6, 2012)

**Topics:** 1) hardware description languages, system modeling, synthesis, simulation and testing of digital circuits; 2) design integration to achieve specific SOC goals including architecture, planning and integration, and testing; 3) use of soft core and IP modules to meet specific architecture and design goals.

**Laboratory exercises:** VHDL models of combinational and sequential circuits, synthesizing these models to programmable logic devices, simulating the design, test-benches, system design and modeling, integration of IP and high level SOC design methodologies.

**Recommended background:** ECE 3801, ECE 2201, and experience with programming in a high-level language such as C.

**Suggested background:** ECE 3803.

**ECE-3829: Advanced Digital System Design with FPGAs – NEW COURSE**

This course covers the systematic design of advanced digital systems using FPGAs. The emphasis is on top-down design starting with high level models using a hardware description language (such as VHDL or Verilog) as a tool for the design, synthesis, modeling, test bench development, and testing and verification of complete digital systems. These types of systems include the use of embedded soft core processors as well as lower level modules created from custom logic or imported IP blocks. Interfaces will be developed to access devices external to the FPGA such as memory or peripheral communication devices. The integration of tools and design methodologies will be addressed through a discussion of system on a chip (SOC) integration, methodologies, design for performance, and design for test.

**Topics:** 1. hardware description languages, system modeling, synthesis, simulation and testing of digital circuits; 2. design integration to achieve specific system design goals including architecture, planning and integration, and testing; 3 use of soft core and IP modules to meet specific architecture and design goals.

**Laboratory exercises:** Students will design and implement a complete sophisticated embedded digital system on an FPGA. HDL design of digital systems including lower level components and integration of higher level IP cores, simulating the design with test benches, and synthesizing and implementing these designs with FPGA development boards including interfacing to external devices.

**Recommended background:** ECE2029 and ECE 2049

**Notes:** Students may not receive credit for ECE3829 if they have received credit for ECE 3810.

**ECE 3849. Real-Time Embedded Systems - NEW COURSE**

This course continues the embedded systems sequence by expanding on the topics of real-time software and embedded microprocessor system architecture. The software portion of this course focuses on solving real-world problems that require an embedded system to meet strict real-time constraints with limited resources. On the hardware side, this course reviews and expands upon all the major components of an embedded microprocessor system, including the CPU, buses, memory devices and peripheral interfaces. New IO standards and devices are introduced and emphasized as needed to meet system design, IO and performance goals in both the lecture and laboratory portion of the course.

**Topics:** Cross-compiled software development, embedded system debugging, multitasking, real-time scheduling, inter-task communication, software design for deterministic execution time, software performance analysis and optimization, device drivers, CPU architecture and organization, bus interface, memory management unit, memory devices, memory controllers, peripheral interfaces, interrupts and interrupt controllers, direct memory access.

**Laboratory exercises:** Programming real-time applications on an embedded platform running a real-time operating system (RTOS), configuring hardware interfaces to memory and peripherals, bus timing analysis, device drivers.

**Recommended background:** ECE 2029 and ECE 2049.