

ENGR 323L: Embedded System Design
Department of Engineering, Trinity College, Spring 2025

Instructor: Taikang Ning, Ph.D. Professor of Engineering

Office hours: Tue & Thur 10:50-11:50AM @ MECC-343

Lectures & Labs: Mon & Wed 1:30 PM-4:10 PM @ MECC-320

Course outline: This course focus on embedded system design with an emphasis on hands-on implementation of application specific systems using microcontrollers. Students will integrate prior knowledge from other courses and apply them to translate application requirements to embedded system design specifics, including performance criteria, hardware components, system schematics, and required software components. Course topics consist of computer system architecture, CPU internal structure, microprocessor buses, memory mapping, multiple-interrupt design, and precise real-time control. MCS-51 assembly and C programming languages are introduced and extensively used in laboratory design projects. Lectures and laboratory experiments are coordinated to help students become familiar with embedded system design practices such as digital watch, biomedical instrumentation, DC motor control and other mechatronics examples.

References:

- 8051 Microcontroller: Tutorial and Guide
<http://www.circuitstoday.com/8051-microcontroller>
- *The 8051 Microcontroller* (3rd ed.) by Kenneth J. Ayala
- <https://www.circuitstoday.com/category/8051-projects>
- *Arduino*: <https://www.arduino.cc/>

Grading Policy: Midterm Exam-30%, Final Exam-35%, Labs & Assignments -35%

Lecture Topics:

- Microprocessor architecture design: Reduced Instruction Set Computer (RISC) vs. Complex Instruction Set Computer (CISC), general-purpose CPU, Digital Signal Processor (DSP) and microcontrollers (μ C)
- Architecture of basic 8051 microcontrollers and special function registers (SFRs)
- 8051-based embedded system with required memory expansion with RAM and ROM, I/O ports, power supply, crystal oscillator, and interrupt connections

- Assembly language and instruction sets of 8051 (MCS-51)
- Timers, internal and external interrupts, multiple interrupt latency control, precise timing control
- Analog to Digital (A/D) conversions: sampling frequency, anti-aliasing filter, quantization errors, transducers and calibration, and signal conditioning
- Serial communication through universal asynchronous receiver and transmitter (UART)
- ANSI C/C++ programming fundamentals; embedded-C programming: syntax, main program, header file, variable declaration, functions, and interrupt service routines
- LCD display interface – circuit interface, control registers configuration
- Pulse width modulation (PWM) and motor control
- Embedded systems design

Laboratory Projects:

- Schematic design of 8051 embedded systems
- wire-wrapped 8051 embedded system using multiple interrupts
- Generation of music notes
- LCD interface
- Multiprocessor communications with UARTs
- Motor control using pulse width modulation (PWM) and PID controller
- ECG and respiration monitoring (with A/D and bio-instrumentation)

Lecture and Laboratory Meeting Dates:

January - 22, 27, 29

February – 3, 5, 10, 12, 24, 26

March – 3, 5, 10, 12, 17, 19, 24, 26, 31

April – 2, 7, 9, 14, 16, 21, 23, 28, 30

Calendar Reminder

- 2/20-21 Trinity Day (no class)
- Spring Vacation: 3/15-3/23
- 4/30 Last day of class
- **Midterm Exam – 3/12 (Wed)**
- **Final Exam- 5/8 (Thur) 12:00 PM**