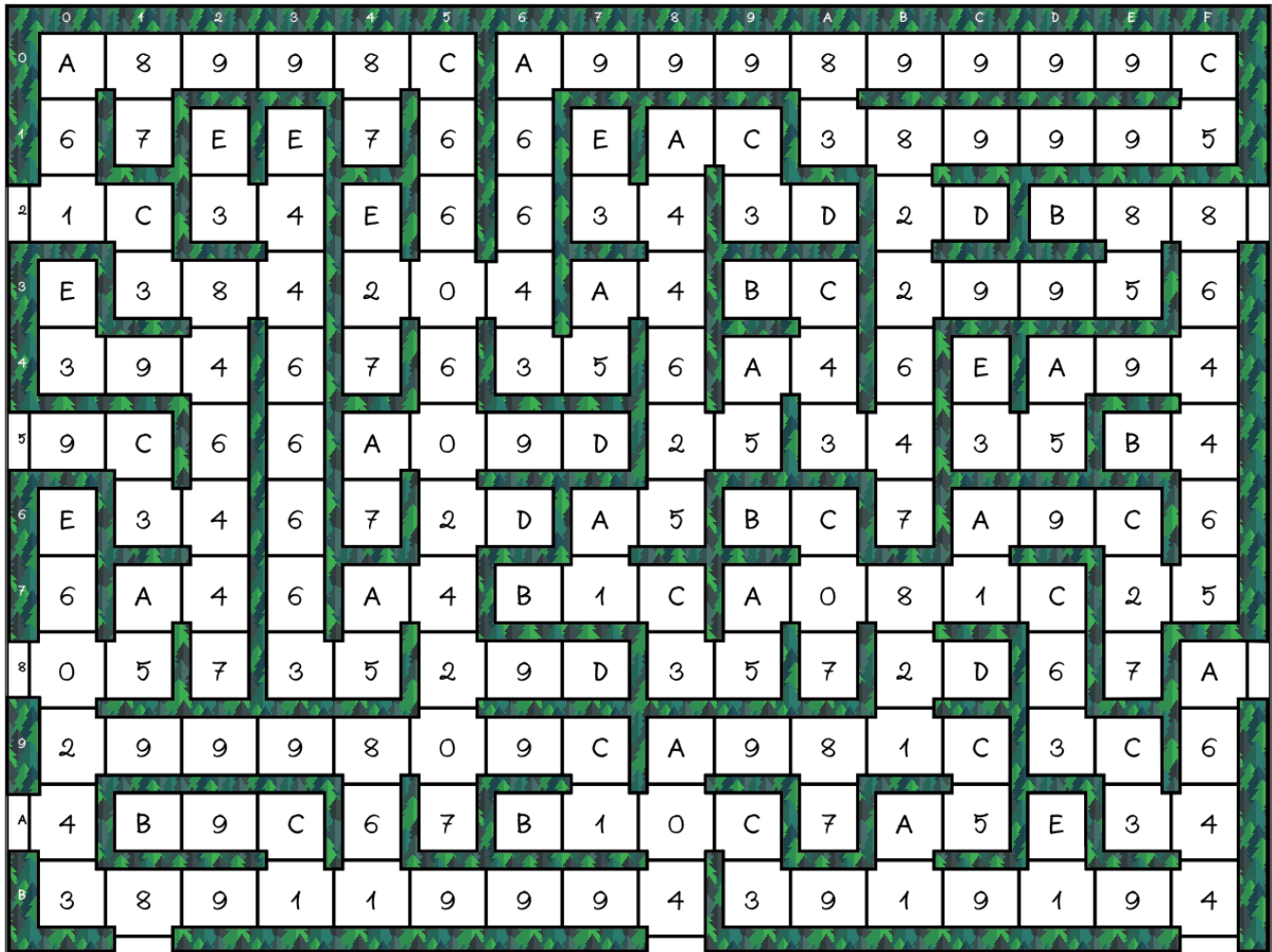


# Microprocessor Principles and Applications

An Introduction to Microcontrollers, Assembly Language, and Embedded Systems



# EE 346 Microprocessor Principles and Applications Syllabus

This course will be an introduction to modern RISC based microcontrollers and assembly language programming. We will use the Atmel AVR family of microcontrollers to teach hardware design of small, minimum-component systems performing simple task-oriented activities.

## Course Schedule<sup>1</sup>

The following outline of classes is subject to change.

### Class 1 and 2 – Introduction to Microcontrollers and Assembly Language Programming

- [Introduction to Microcontrollers](#) and the **ATmega32U4**
- [Arduino the Documentary](#)
- Introduction to the Microcontrollers and Assembly, plus The History of the Computer and Microcontrollers
- Special Topics (*covered in lab*) How to Move a Bit

### Class 3 – The AVR RISC Microcontroller Architecture

- AVR RISC Load-Store Architecture, The Register File, and the ALU
- Harvard Memory Model, Flash Program and Data Memory (RAM and EEPROM)
- Special Topics (*covered in lab*) An Introduction to the 3DoT Board and the IR-Shield, plus How to Solder IR sensors.

### Class 4 – Addressing Modes Part I: Working with the AVR Load-Store Architecture

- Introduction to Addressing Modes, Instruction Types, The AVR Instruction Set
- Program and Data Addressing Modes, How to "Address" the data: Data – Direct (Load-Store Instructions), I/O Direct, Register Direct, Flash Program – Direct, and Relative

### Class 5 and 6 – Arithmetic and Logic Instructions

- Rotate and shift Instructions, Addition and subtraction of unsigned and signed numbers, the Status Register (SREG), Multiplication and Division
- Working with bits, and byte-wide logical instructions
- Tuesday, September 7<sup>th</sup> – **Quiz 1**

### Class 7 and 8 – Branching and Looping

- Unconditional and Conditional Program Control Transfer plus Bit and Bit-test Instructions
- Looping Constructs
- Special Topics (*covered in lab*) Design Strategies and the Test Bench

### Class 9 – Subroutine Basics

- The AVR Stack, Call and Return Instructions,
- Why and When to use Subroutines

### Class 10 – The ATmega32U4 I/O Port Structure

- Pin description of the ATmega32U4 and 3DoT, I/O Registers and Port Programming

### Class 11 – Midterm

- The AVR Microcontroller & Assembly Language Programming

Midterm #1	Tuesday September 28 <sup>th</sup>
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<sup>1</sup> These dates may change.

### Class 12 and 13 –Timers

- Timer/Counter Design, Timer Modes, Program Example (Normal Mode)

### Class 14 to 16 – Interrupts

- Interrupts vs. Polling, Using Interrupts, Interrupt Service Routines,
- Timer Interrupt Example
- External Interrupts, Interrupt Processing, and Interrupt Priorities
- Thursday October 14<sup>th</sup> – **Quiz 2**

### Class 17 and 18 – Addressing Modes Part II: AVR Addressing Indirect

- Program and Data Addressing Modes – *Review*, How to "Address" the data: Data – Direct (Load-Store Instructions), I/O Direct, Register Direct, Flash Program – Direct
- Dynamic data access using Indirect Addressing Modes (e.g., Buffers and Look-Up Tables)

### Class 19 and 20 – Midterm

- Midterm 2 Review – The AVR Instruction Set and Peripheral Programming

Midterm #2	Thursday October 28 <sup>th</sup>
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### Class 21 and 22 – Working with the Stack

- Implicit and Explicit Stack Operations, Stack Initialization, Stack Operation on a Call instruction, Program Examples

### Class 23 to 24 – Arduino Scripting Language and C++

- Introduction to Arduino Scripting Language and C++
- ATmega32U4 GPIO Port programming Example

### Class 25 to 27 – Serial Communications and the ATmega32U4

- Basics of Serial Communication
- The ATmega32U4 Serial Peripheral Interface (SPI)
- The ATmega32U4 Two-Wire (TWI) and Inter-Integrate Circuit (I2C)
- More C++ Programming Examples
- Tuesday November 30<sup>th</sup> – **Quiz 3**

### Class 28 – Special Topics

- Watchdog Timer
- Instruction Encoding and Decoding

### Class 29 – Final Review

## **DO NOT FORGET**

Makeup exams may be taken if you received my permission prior to the exam. Makeup exams will be harder the same ones taken by the class; however, grading will be on the same curve.

Before turning in any lab please review "Lab Instructions" on BeachBoard.

## General Class Information

### Grading Procedure<sup>2</sup>

These represent the maximum percentage you can receive in each area in the determination of your final grade. In the happy event you score over 100% in a given area, that percentage will be limited to 100%.

Category	Number	Weight %	Total %
Quizzes and Misc.	<i>Varies</i>	<i>Varies</i>	15
Midterms	2	15	30
Lab Projects	6	<i>Varies</i>	30
Final	1	25	25

### Contact Information

Instructor — G. C. Hill

Office — *Not applicable*

Hours<sup>3</sup> — Tuesday and Thursday from 11:00 p.m. to 1:00 p.m.<sup>4</sup>  
Zoom by Appointment: <https://csulb.zoom.us/j/85606252981>

E-mail — [hellogaryhill@gmail.com](mailto:hellogaryhill@gmail.com)

Website(s) — <http://web.csulb.edu/~hill/ee346/>  
<https://www.arxterra.com/classes/advanced-arduino-assembly/class-lectures/>

### Class Prerequisites

- Introduction to Programming and Applications for Electrical Engineers EE186 *or equivalent*
- Digital Logic Design (EE 201)
- Computing Methods in Engineering (EE202)

### Class Meetings

Lecture

Section 05 — Tuesday and Thursday from 2:00 to 2:50 p.m.  
Zoom: <https://csulb.zoom.us/j/87405951354>

Lab

Section 06 — Tuesday and Thursday from 3:00 to 4:15 p.m.

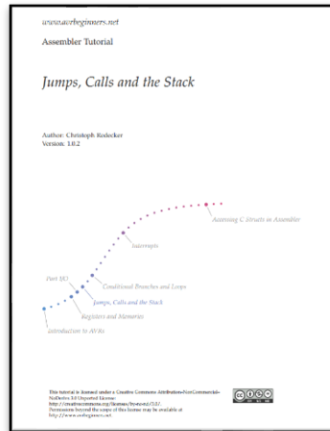
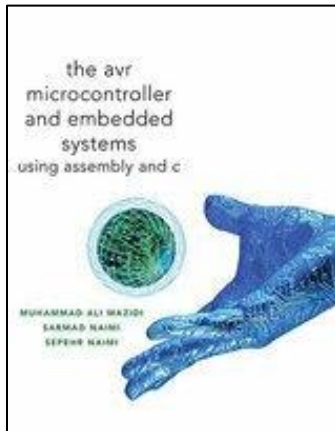
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<sup>2</sup> See University, College and Department rules for information on withdrawing from the class. I do not give incomplete (I) grades.

<sup>3</sup> If I am not in my office, look for me in ECS-316 and VEC-425

<sup>4</sup> Please request an appointment during these hours.

## Materials



- Textbooks — The AVR Microcontroller and Embedded Systems using Assembly and C) by Muhammad Ali Mazidi, Sarmad Naimi, and Sepehr Naimi *out-of-print*  
Atmel 8-bit AVR Microcontroller [ATmega32U4 Datasheet](#)
- Reference — Atmel 8-bit AVR Microcontroller [ATmega32U4 Summary](#)  
Atmel 8-bit AVR Instruction Set [doc0856.pdf](#)  
[AVRBeginners.Net](#) by Christoph Redecker  
[Arduino in a Nutshell](#) by Jan Borchers  
Atmel AVR Assembler User Guide [doc1022.pdf](#)  
[Arxterra - Getting Started](#)
- Help — [Humans for Robots Discord Channel](#)  
[AVR Freaks](#)
- Lab Supplies — 3DoT Maze Kit
- Software — [AVR Studio 4 \(Recommended\)](#) or ATMEL [Studio 7](#).  
Independent of which Studio version you download, you will also need [WinAVR](#), and the [Arduino IDE](#).  
All download software is **FREE**. Labs assume AVR Studio 4.

## Fun Stuff

- C++ to Assembly — Compiler Explorer <https://godbolt.org/> Select Arduino Uno from drop-down menu.
- Videos — [Arduino the Documentary](#)  
[The Game Boy, a hardware autopsy - Part 1: the CPU](#)  
[The Game Boy, a hardware autopsy - Part 1.5: a few mistakes and register F](#)  
[The Game Boy, a hardware autopsy - Part 2: memory mapping](#)
- Game — [Tessellated Intelligence System TIS100](#)

## Tutoring

*It is currently assumed that tutoring will be available via zoom. However, as of the writing the COE Tutoring home page has not been updated.*

Take advantage of free peer tutoring to keep up your grades in the most challenging classes. Tutoring is available for undergraduate engineering students in departmental courses for Electrical Engineering, Mechanical & Aerospace Engineering, Civil Engineering, Computer Engineering/Science, and Chemical Engineering.

Tutoring is on a first-come-first-serve, walk-in basis. Tutors are available Monday-Thursday in the Fall and Spring terms. All tutoring sessions take place in the Engineering Student Success Center (ESSC) in EN2, Room 300 between the hours of 9:00 a.m. – 6:00 p.m.

Visit the [website](#) for detailed tutoring schedules.

## Study Groups

*While I still encourage study groups, these should be done remotely (e.g. Zoom).*

I encourage you to prepare for quizzes and exams in study groups. If you are new to the University and are having difficulty finding a group to study with, please contact me.

Do not do labs as a group. Turning in a copy of a lab, from any source, will result in a zero on both the prelab and lab, and at the lab instructor's discretion additional disciplinary action.

## Sheet of Notes

On selected quizzes and exams, you are allowed one (1) 8 ½ x 11 page of notes. The area you can write notes on will be indicated before each quiz or exam. As a rule, the notes should be a summary of information pertaining to the AVR Microcontroller and other material covered in class. The notes must comply with the following rules:

- The page of notes **must be handwritten** except for tables and figures.
- Your sheet of notes may contain tables and figures, notes, etc.
- The sheet of notes may **not** contain copy-paste of lectures, questions and answers, and **any code examples or code segments (2 or more sequential instructions)**.
- Please do not bring a magnifying glass or provide a copy of your notes to someone else to use during the exam.

In addition to the sheet of notes you may bring a 4-function calculator (+, -, x, /). Other than square root and rudimentary memory functions, the calculator may not support any other math operations. **These calculators are available at the Outpost convenience store.**

*The traditional handout will now be included will be made available in a downloadable form before the first midterm.*

Before the first midterm, you will be given a 4-page handout (CSULB Shield, I/O Ports, Instruction Set), which you may use during the exam. **Please do not write on this 4-page handout.**

## Plagiarism

**COE has a zero-tolerance policy for cheating or plagiarism.** *Note:* Any time another person's work is used without giving them proper credit, it is considered plagiarism and cheating. Any individual caught cheating on quizzes, exams, homework, or lab projects will be punished. At the instructor's sole discretion one or more of the following actions may be taken.

- A requirement that the work be repeated.

- Assignment of a score of zero (0) for the specific demonstration of competence, resulting in the proportional reduction of final course grade.
- A reduction of one letter grade from your final course grade
- Assignment of a failing final grade.
- Referral to the Office of Judicial Affairs for possible probation, suspension, or expulsion.
- The official CSULB Policy on Cheating and Plagiarism can be found here: [http://web.csulb.edu/divisions/aa/catalog/current/academic\\_information/cheating\\_plagiarism.html](http://web.csulb.edu/divisions/aa/catalog/current/academic_information/cheating_plagiarism.html)

## **Computers and Mobile Devices**

*While the following material was written for in-class lectures, it remains true for zoom meetings.*

During the lecture, the computers in lab and any laptop or tablet should be used for looking at the lecture material and/or to take notes only. These devices may not be used for browsing the web or linking to any social media sites. These devices may be taken offline at the instructor's discretion.

During class, cell phones should be muted and put away (i.e., not on the tabletop, lap, floor, etc.). During quizzes and exams students will not have access to these devices.

Please ask the instructor before recording audio or taking any pictures or videos in class/lab