

# ECE3140 / CS3420

# Embedded Systems

## Lecture 1. Introduction

Prof. José Martínez



# Instructor

- Prof. José Martínez, ECE
  - Research area: computer architecture
  - Contact Information
    - 336 Rhodes Hall
    - [martinez@cornell.edu](mailto:martinez@cornell.edu)
    - (607) 255-1874
  - Office Hours: TBD
    - If my door is closed, then knock!
  - Teaching
    - ECE 3140/CS 3420: Embedded Systems
    - ECE 5750: Advanced Computer Architecture

# What is an Embedded System?

- A computer system: Hardware + Software
- Embedded in another device or physical world



Cornell Lab of Ornithology bird tags

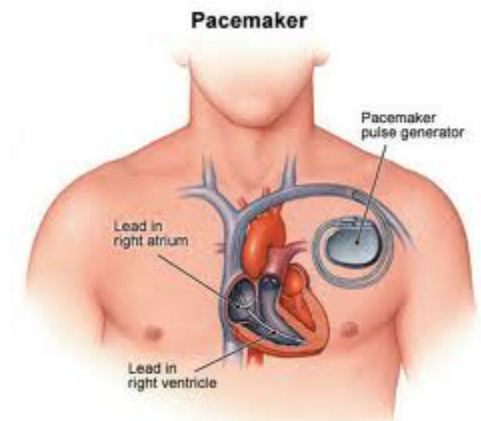


# Embedded Systems Attributes

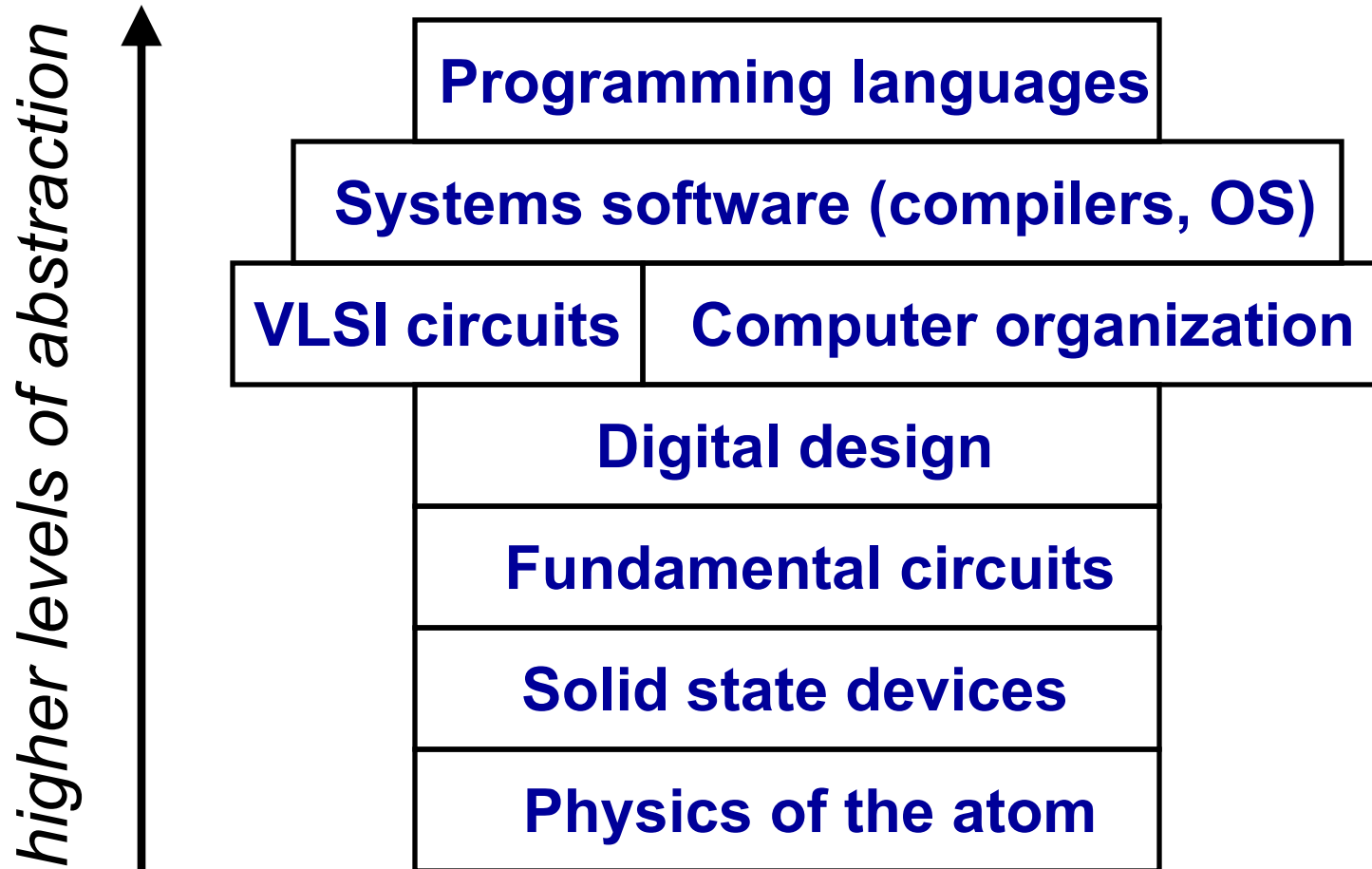
- **Interfacing with the world**
  - Sense environment & control device
- **Concurrency**
  - Manage multiple activities
- **Resource constraints**
  - Costs, power/energy, weight, size
  - Often fixed/limited functionality
- **Real-time constraints**
- **Reliability**
  - Long lifetime, environmental conditions
- **Security**
- **Diagnostics and maintenance**



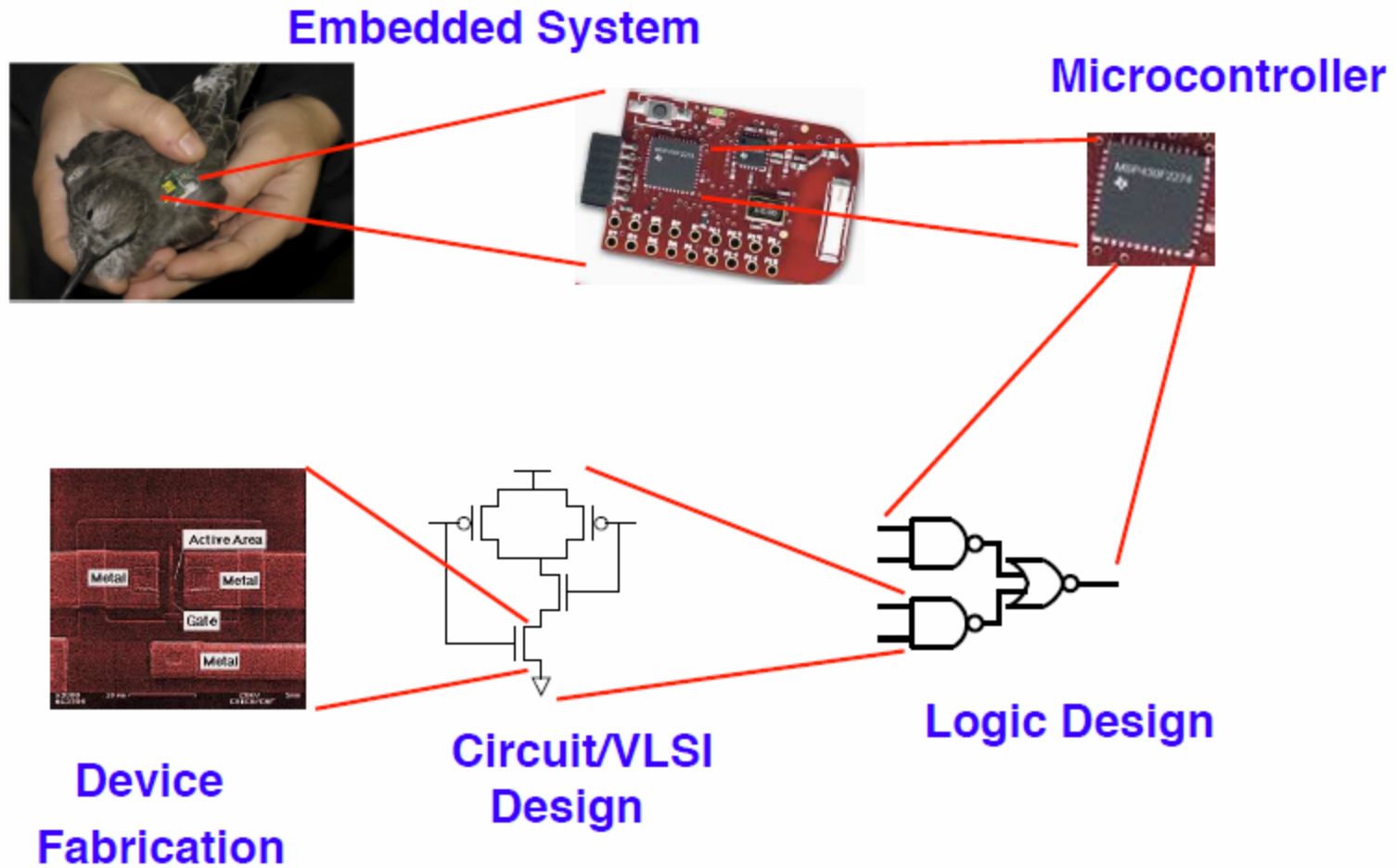
Quadcopter



# Abstraction Layers

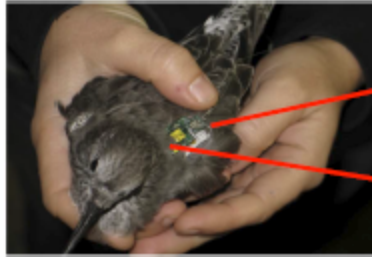


# 3140: Hardware-Software Integration



# 3140: Hardware-Software Integration

## Embedded System



## Microcontroller



## Applications

## Run-time System

```
while (event = getnext()) {  
    /* process event */  
    switch (event->type) {  
        case BUTTONUP:  
            win = event->W;  
            if (!win) break;  
            do_button (win);  
            break;  
        case BUTTONDOWN:  
            ...  
    }  
    ...  
}
```

## Programming Language

```
jal _getnext  
ori $a0,$0,0  
lw $t0,8($v0)  
lw $t0,12($t0)  
beq $t0,0,0x401834  
li $t1,4  
beq $t0,$t1,0x4018a0
```

## Assembly Language

```
0x0c004841  
0x00000000  
0x34040000  
0x8c480008  
0x00000000  
0x8d08000c  
0x10001834  
0x00000000  
0x24090004  
0x11090002  
...
```

## Machine Instructions

# Hardware for This Class

NXP FRDM-K64F

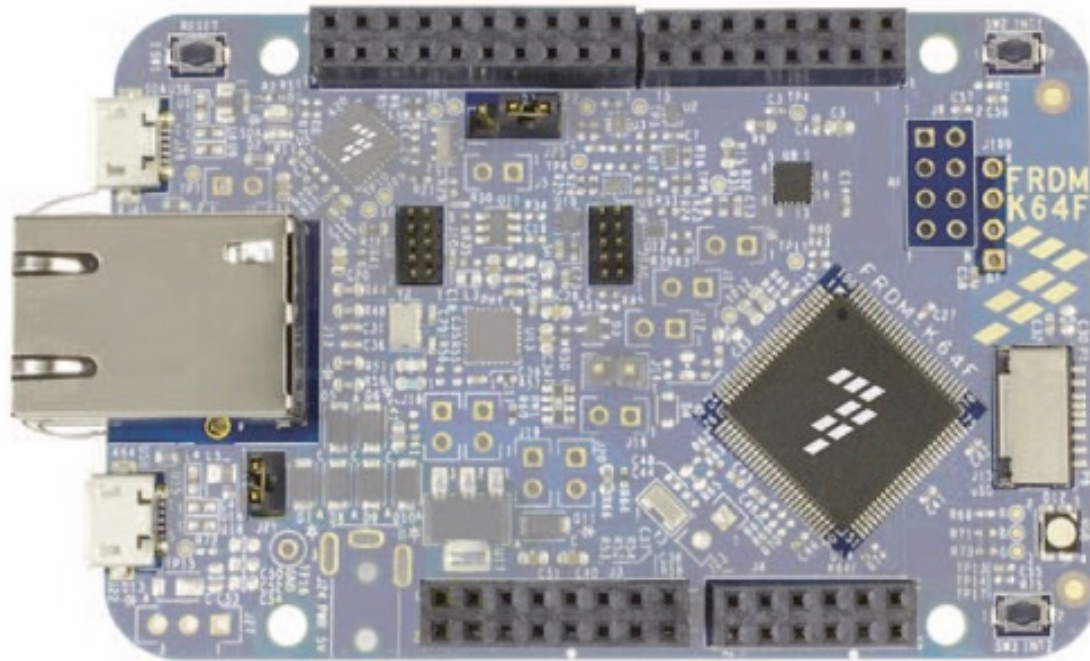
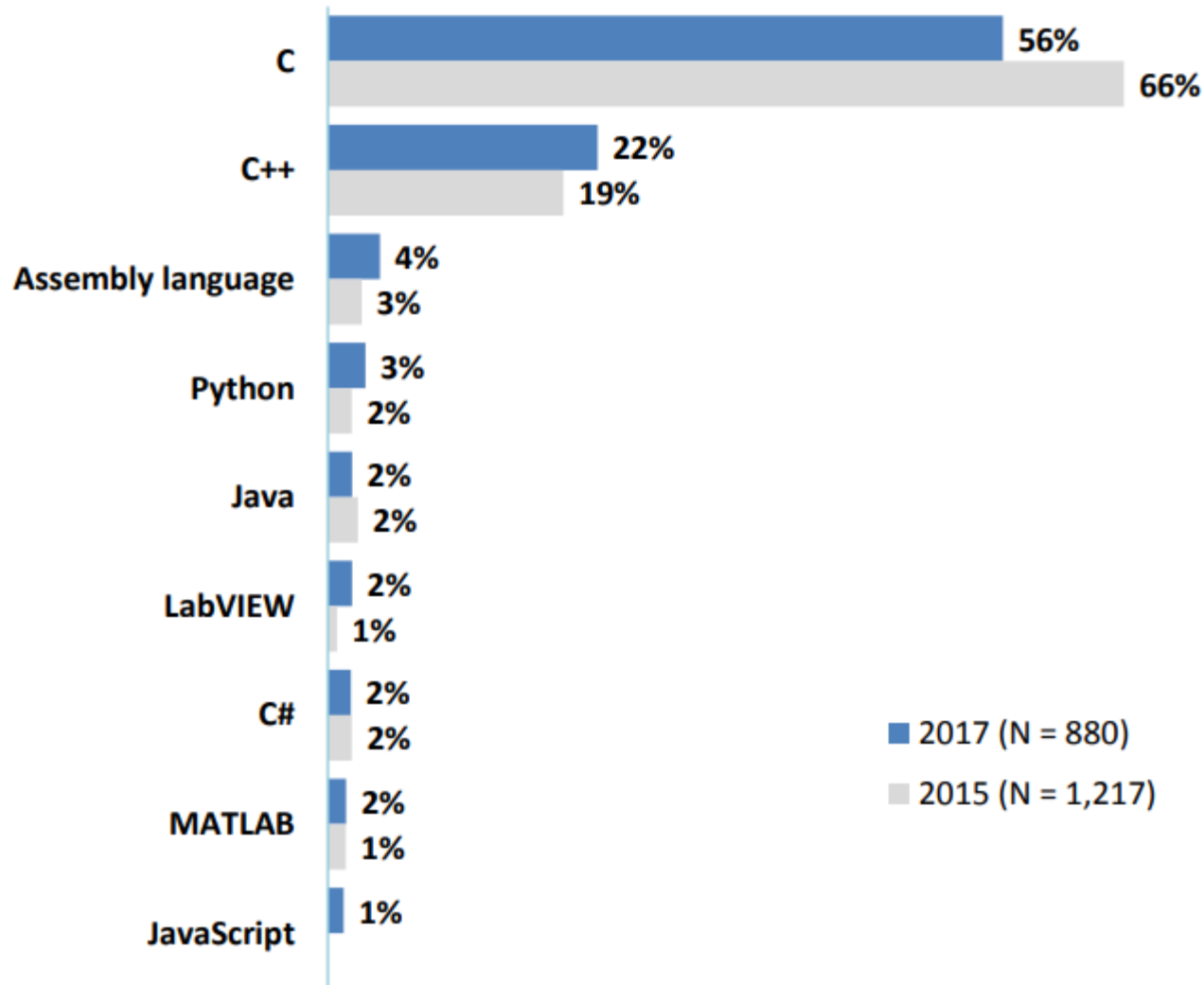


Image from NXP, formerly Freescale Semiconductors



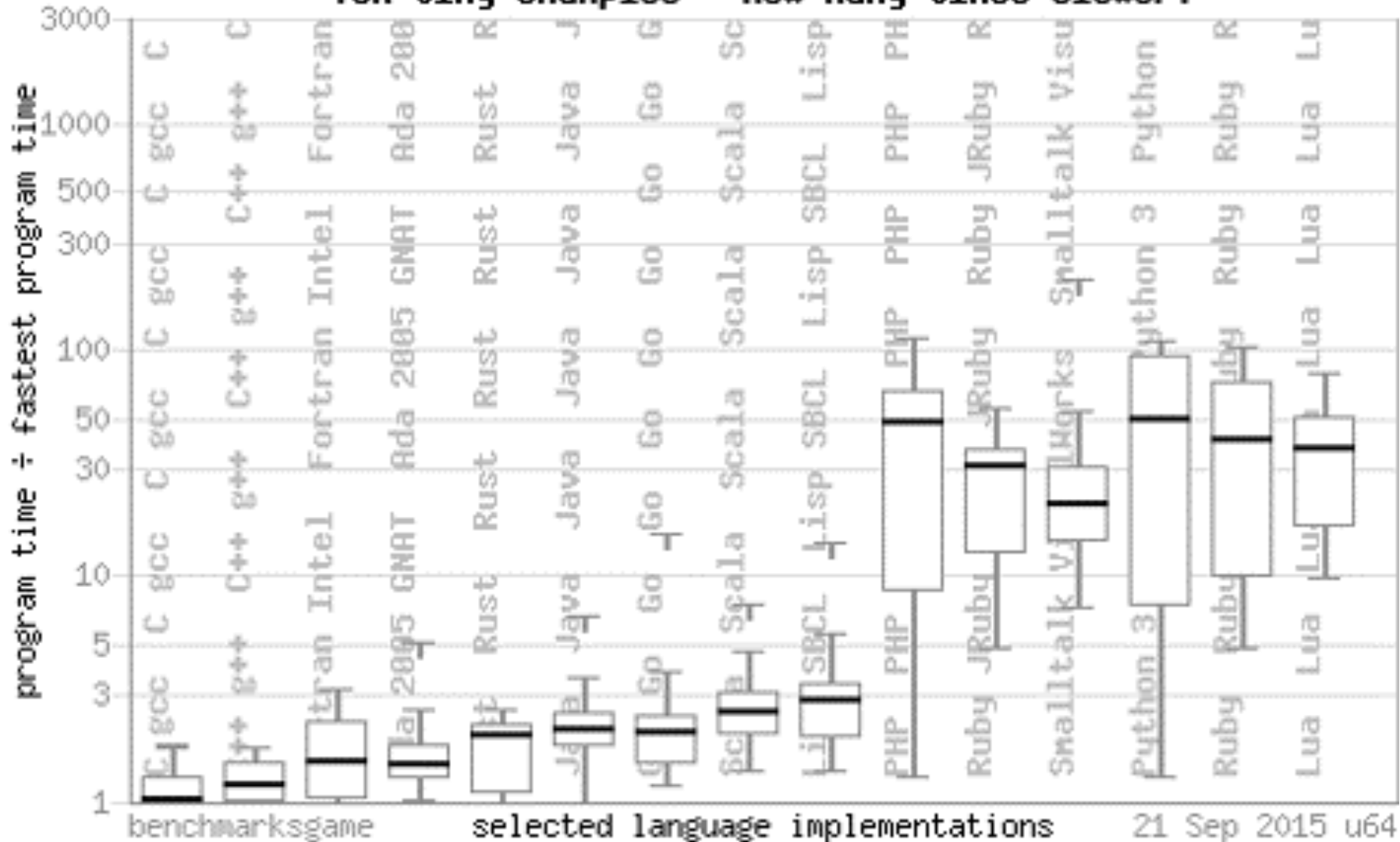
# Programming Languages for Embedded Systems



Source: EETimes. 2017 Embedded Markets Study

# Why Assembly and C?

Ten tiny examples - How many times slower?



21 Sep 2015 u64

# Topics

- Assembly language programming
  - Link to a high-level programming language: C
- Interrupts and I/O
- Managing interrupts: Concurrency
  - Concurrency models
  - Tasks/threads
  - Synchronization
- Real-time constraints and scheduling
- Communication protocols

# Computer Engineering Curriculum

- ECE/ENGRD 2300: Digital Logic and Computer Organization ← **Required**
- ECE 2400/ENGRD 2140: Computer Systems Programming ← **Recommended**
- **ECE 3140/CS 3420** ← **This class**
- CS 4410: Operating Systems
- ECE 4740: Digital VLSI
- ECE 4750/CS 4420: Computer Architecture
- ECE 4760: Designing with Microcontrollers
- ECE 57xx/CS 54xx: Grad-level classes

# Class Overview

- Lectures
  - TR 1:25-2:40pm in 155 Olin Hall
- Sections
  - Help with material, lab
  - Supplementary material
- Labs
  - Implementation of concepts covered in class
- Problem sets
  - Review material, preparation for prelims
- In-class quizzes
  - See if you are keeping up with the class

# Grading

- Problem sets: 5%
- Quizzes: 10%
- Exams: 40%
  - Prelim 1: 17%
  - Prelim 2: 23%
- Labs: 45%

# Textbook

- No required textbook
  - We will draw materials from many places
- References
  - “Embedded Systems Fundamentals with ARM Cortex-M based Microcontrollers: A Practical Approach” by Alexander G. Dean
  - “Hard Real-Time Computing Systems: Predictable Scheduling Algorithms and Applications” by G. Buttazzo, PDF available through Cornell library
- Reading
  - We will release papers and other resources as we cover each topics

# Problem Sets and Quizzes

- Problem sets: Paper-and-pencil problems
  - Checked for completeness, but not graded for correctness
- Quizzes
  - Covers previous week's lectures
  - At the beginning of a class (typ. Tuesday)
  - **Use iClicker**
  - No make-up
  - Lowest quiz score will be dropped
  - 25% participation, 75% performance



# Exams

- Evening prelims
  - Prelim 1 (17%) - March 19<sup>th</sup>
  - Prelim 2 (23%) – April 30<sup>th</sup>
  - No books, notes, or electronics of any kind
- No Final Exam

# Labs

- Six labs: 5 fixed assignments and 1 project
  - We will suggest topics
  - Whatever you want (within reason)
- All lab assignments are done as a group of two
- No scheduled lab sessions
  - You can do them at home
  - Open lab hours to provide help

# Submission Guidelines

- Use CMS
  - <http://cms.csuglab.cornell.edu/>
- Make sure to include name and netid
- Submissions must be your own individual effort
  - Sharing written solutions strictly prohibited
  - Discussing problems, approaches, etc. permitted
- Check your submission
  - Hash value

# Rules

## ■ Late Policy

- CMS marks submissions late the instant they are due
- You must upload an assignment before the deadline
- Marked late = ZERO (your lowest non-zero score)
- You are allowed ONE “slip day” (24 hours)
  - No need to request it

## ■ Regrade Policy

- Submit a regrade request on CMS if you feel a grading mistake has been made
- The regrade request must be received within one week after a grade is released

# Resources

- **Piazza:**
  - Announcements, material, questions (self-enroll)
  - Look up answers before posting a question
  - You may send questions privately to staff through Piazza, but *only* if they contain sensitive/private information
- **Email: Generally not allowed (and ignored)**
  - Exception: Email to instructor of sensitive/private nature

# Course Expectations

- Engineering solves world problems by using technology creatively. I invite and expect every student to **contribute creatively** as part of their learning process.
- Success in engineering depends critically on teamwork. I invite and expect every student to **engage in constructive discourse, to bring their perspective, and to be accepting of others'**.
- **Degrading, abusing, harassing, silencing, or dismissing others** in the process **is not acceptable** behavior. It is also bad engineering.
- I invite and expect every student to **maintain the highest ethical standards.**

# Academic Integrity

- Search for “Cornell AIC”
  - <http://cuinfo.cornell.edu/Academic/AIC.html>
- Discussions are encouraged
- Sharing solutions is **not** permitted
  - Not submitting far better than cheating
  - In case of doubt, **refrain** and ask
- Use discussion boards consistently with the AIC!