Lecture #1

Welcome To 18-348!

18-348 Embedded System Engineering
Prof. Philip Koopman
Wednesday, 13-Jan-2016

Lectures:  Mon & Wed 10:30-12:20 AM, BH A53
Labs:     Mon-Thu 6:30-9:20 PM; Fri 1:30-4:20 PM, HH 1303
Recitations: Fri 10:30-11:20 AM, BH A53

Preview

◆ A Little Embedded Background/Motivation
  • “Embedded” is almost 100% of the market
  • Big CPUs don’t necessarily Rule

◆ Course Administrative Information
  • Grading
  • Course policies
  • This course has a lot of moving parts, so it takes a while to cover them all
    – In industry there are lots of moving parts to making a project work;
      the experience is really not all that different

◆ Lab Equipment
  • Hardware, Software
  • How the labs are going to work
  • Key idea: hands-on experience with lecture topics, NOT killer design projects!
    – There will be a larger last project, but complexity is mostly up to you
Instructor Background

◆ Prof. Phil Koopman
  • HH A-308
  • ece348-staff@ece.cmu.edu

◆ Research:
  • Dependable & secure embedded systems
  • Embedded real-time networking

◆ Engineering experiences outside Carnegie Mellon
  • US Navy submarine officer
  • Startup company that created an embedded CPU design
  • Embedded CPU designer for Harris Semiconductor
  • Embedded system architect for United Technologies (Otis, UT Automotive, Pratt & Whitney, Carrier, Norden, Sikorsky, …)
  • Numerous design reviews (~140 and counting) of industry embedded systems
  • Software safety expert for Toyota Unintended Acceleration lawsuits

Embedded System = Computers Inside a Product
A Common View of Computing

- Measured by: Performance, Cost
  - Compilers & OS matter

- The Chevy Volt has 10,000,000 lines of source code
  - That could easily be could be $250M worth of code
  - Where’s that part on this picture?

An Embedded System Designer’s View

- Measured by: Cost, Time-to-market, Cost, Functionality, Cost & Cost.

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CPU

MEMORY

CACHE

I/O

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SENSORS

A/D CONVERSION

CPU

D/A CONVERSION

HUMAN INTERFACE

DIAGNOSTIC TOOLS

AUXILIARY SYSTEMS (POWER, COOLING)

ELECTROMECHANICAL BACKUP & SAFETY

EXTERNAL ENVIRONMENT

SOFTWARE

MICROCONTROLLER

FPGA/ASIC

MEMORY
Small Computers Rule The Marketplace

- Everything here has a computer – but where are the Pentiums?

Microprocessor Unit Sales
All types, all markets worldwide

15 Million PCs per month in 2004 (15,000 on this graph)
(We’ll update this information in the economics lecture)
More Recent Data from 2007

- **About 10 billion Microcontrollers per year shipped**
  - Perhaps 250 million PCs shipped per year until recently
    - (tablets disrupting that market; maybe tablets are the new PC)
- 8-bit: $4.9 billion/yr
- 16-bit: $3.9 billion/yr
- 32-bit: $3.8 billion/yr (ARM is growing fastest here)
- **Automotive market:** $6 billion/yr
  

- **Course processor is Freescale: Their “68” family is 15% of market**
  - Freescale ships 100M of the class lab S12 microcontroller family per year
  

  **Guesses as to units shipped:**

- 8-bit MCUs often below $1 ~ 750 million/month
- 16-bit MCUs perhaps $1-$10 ~ 75 million/month
- 32-bit MCUs $10 or more ~ 25 million/month

  - Many systems-on-chip are embedding ARM, making analysis more complicated
  - (Yes, you can get a 32-bit CPU for $1. But that’s not the mainstream market … yet)

Breaking News – 2015 Survey

- **MCU Market Size $27B by 2020**
  - Potentially driven by “Internet of Things”
  - 16-bit CPUs are highest # units, and 31% of dollar value in 2014

Small CPUs Rule

- Until 2011, 8-bit CPUs had the most volume
  - In 2011, most CPUs sold are 16 bit CPUs (like the course CPU we use)
  - 16-bit CPUs gained traction as they approached $1 cost
- ARM is growing as a 32-bit platform…
  - But it hasn’t taken over the world yet!
- Desktop CPUs (Pentiums) are essentially 0% of the market by # units


The Big Market is the Sub-$1 CPU

- How much CPU can you put in a $20 thermostat? A $4 greeting card?
  - CPUs can become more pervasive as cost goes down
  - 32-bit CPUs will dominate when a complete 32-bit microcontroller costs $0.50
    - Almost there .. but not quite yet… see economics lecture for more

There Are Many Application Areas

Primary End Product of
*Embedded Systems Programming*
Subscribers (Dec. 1998)

Where Does This Course Fit?

- **What’s the difference between 18-348 & 18-349?**
  - Taught alternating semesters
  - **18-348 has more coverage of:**
    - Hardware design
    - Analog I/O
    - 8-/16-bit CPUs
      - Makes it easier to access raw HW
      - Different tradeoffs than big CPUs
    - But still touches on essentially all 18-349 topics, including real time
    - Either course is sufficient preparation for later courses

- **Embedded System Engineers are Generalists**
  - Often they write specifications, lay out printed circuit boards, write software, create tests, and give marketing presentations to customers too!
Course Contents

◆ Core skills that apply to essentially all embedded systems
  • Using a simpler CPU makes it easier to get at the “bare metal”

◆ Part 1 – Hardware and Software; Intro to I/O
  • Embedded HW; assembly language; embedded C
  • Bit manipulation; multiprecision math; optimization
  • Memory bus; serial ports; debug/test
  • Mid-Term Exam is Wed., Feb 24, 2016 – be there!

◆ Part 2 – Control, Interrupts, Concurrency, Scheduling
  • Counters/timers; watchdog timers; robust systems
  • Interrupts; concurrency; real time scheduling
  • Analog inputs; analog outputs; Filtering; feedback control
  • Advanced networking (Bluetooth; CAN)
  • Safety critical systems and other “kids don’t try this at home” topics
  • Second Exam is Wed., Apr 20, 2016 – be there!

◆ Weekly lab/project content
  • Weekly labs to give hands-on exposure to most lecture topics
  • Two-week project at end of course to demonstrate putting pieces together
    – Last week of classes leaves time to work on this; due finals week; no final exam
    – You pick the project; most of you will want to keep it simple

http://www.ece.cmu.edu/~ece348 always has the most up-to-date lecture schedule

Guide for Navigationally Impaired

18-348 Lab
HH 1303

Tech Electronics
1st floor

1st floor

TA office
hours held
here

Up steps into HH
front door

Prof.
Koopman
HH A-308

A-300
Security
Door

A-level Basement

Administrative
matters:
ECE Course Hub
HH 1112
Course Structure – 1

◆ Lectures – Mondays & Wednesdays 10:30-12:20
  • Anything presented in lecture is fair game, even if not in handouts
    – Textbook is meant to supplement and explain lecture material
  • Hard-copy handouts only (no electronic copies)
    – Ask someone to pick one up for you if you are missing class
    – TA will bring spare copies to following recitation; after that they are recycled.

◆ Recitations – Fridays 10:30-11:20
  • Q&A about lectures, pre-labs, lab skills, etc.
  • Walk-through of lab exercises – read lab assignment before recitation!
  • Generally an open book quiz to make sure you’re “getting it”

◆ Pre-Labs==Homework – Due each Friday at 9:00 PM
  • Bonus points for hand-in by 1:30 PM
    – Encourages you to find out if there are problems in time to ask at recitation
  • Individual work – individual grade – do NOT get help from lab partner!
  • Some traditional homework questions
  • Some preparation for the lab

Course Structure – 2

◆ Lab skills – evenings, topics follow lectures by ~1-2 weeks
  • Apply concepts from lecture in the lab after you see them in lecture
  • Teams of 2 (think about who you want as a lab partner) (not 3; not 1 – only 2)
    – A couple singles may need to switch lab sections to get balanced pairs
    – We can work out flexible lab demo arrangements to make this work
  • Joint effort for your team of 2; joint grade
  • Lab rooms are open as much as possible (normally 24x7), but are shared spaces
  • Demos must be done by YOUR ASSIGNED scheduled lab demo time
  • Lab writeups due on Wednesday following lab (9:00 PM)

◆ Tests
  • 1st Exam during class hours
  • 2nd Exam during class hours
  • You’re allowed one 8.5”x11” 2-sided “crib sheet” for exams only
    – Must be Hand Written in your own hand writing
    – Must have your name on it
    – Must be turned in with exam
    – Printouts of slides, non-hand-written, or someone else’s writing is prohibited
Course Materials

- **Free required reading materials via course web site**
  - Some lectures have reading beyond book – see the web site
  - Processor Data Sheet
  - Some articles on embedded systems
  - Lab assignments
  - Get printed handouts at class or at following Friday recitation
    - If you miss those two opportunities get them from a friend; we don’t stockpile back issues

- **Required microcontroller module**
  - Get a kit at lab hours: 1 CPU module per student
    - 1 proto-board + 1 parts pack per team of 2 students
  - You can do much of the lab work at home with a Windows PC and USB port without the prototype board
    - You can do pre-lab 1 just with the simulator downloaded from course web page
  - A Mac might work, but we can only officially support the lab machine version of the windows build. (Development software is free download for student use)

- **Required text**
  - Can get new/used on-line (hint: try bookfinder.com or addall.com used book search)
  - Be sure to get 2nd Edition!
    - We can NOT use the newer 3rd edition due to deleted material

Registration & Grading

- **Grading**
  - A is 90% or above; B at 80%; C at 70%; D at 65% using following weights:
    - Pre-Labs: 15% (lowest 1 dropped, except double weight final lab)
    - Lab Demos: 14% (final demo counts double weight)
    - Lab Writeups 14% (lowest 1 dropped, except double weight final lab)
    - First Exam: 25%
    - Second Exam: 25%
    - Participation: 7% (lowest 2 dropped)
  - All assignments within a category are normalized (equally weighted)
  - All grading issues/appeals must be made in writing within **ONE WEEK** of hand-back!

- **No make-up events (labs, exams, recitations)**
  - If you have special needs (e.g., extra test time) give >30 days advance notice

- **Late penalty for Labs & Pre-Labs = 10% for first hour + 10% per day “N”**
  - Up to 1 hour: 90% of grade; 1 hour to 24 hours late: 81% of grade

\[
\text{LateGrade} = \text{RawGrade} \times 0.9^{N+1}
\]
“Extra Credit” and Bonus Points

◆ Pre-labs early hand-in
  • Bonus: hand in pre-lab before (1:30 PM) on Friday it is due
  • You can get 5% extra credit (grade multiplied by 1.05)
  • Go to recitation – the point is to make sure you know what questions to ask

◆ Pre-lab & lab bonus points
  • Intended only for students who are finding the course “easy” for some labs
    – A few points (10-20%) for doing extra work to make things more challenging
    – Gives you bragging rights, especially if you want a recommendation letter
  • If you are spending fewer than 12 hours per week, you should do the bonus assignments to get more out of the course
  • If you are spending more than 12 hours per week, you should not do these
    – Instead, spend your time getting pre-labs handed in early
    – Instead, spend your time studying for the tests before the last minute
    – Do not spend insane hours in the lab chasing these few points; that’s the wrong priority to have!

Multiple Choice Grading

◆ Most test questions are multiple choice
  • Requires more work for me to compose good questions
  • Less ambiguity and variation in grading
  • You have plenty of “essay” problems in homework and lab already
  • But, traditionally, has problems with quantization noise in grading

◆ Our approach – partial credit for multiple choice
  • One or more answers are correct (usually one, but sometimes more than one)
  • We will provide example questions for study/practice
  • You get credit in proportion to the number of correct answers you choose
    – 1 answer correct; you pick it = full credit
    – 1 answer correct; you pick two (one correct; one incorrect) = ½ credit
    – 2 answers correct; you pick one correct = full credit
    – Credit = ( # correct answers you pick ) / ( Total # answers you pick )
    – If unsure, you can guess two, and get half credit if one is true
    – If unsure, you can mark all answers and get ~20% credit (depending on question)
**WAIT LIST INFORMATION**

- Class has hard limit of 72 students, 5 lab sections
  - Attendance sheets show current status

- Lab sections
  - Need to have roughly even lab sections
  - It is always OK to demo early if you have an occasional conflict
  - Partial lab conflicts are OK
    - Just need to hit a ~30-minute demo window
    - AND, you can request a demo window that doesn’t conflict for you

- Let us know if you want to move to empty sections
  - Need to get sections reasonably balanced
  - If you want to partner with someone in a different section, let us know
    - Give us ALL available possibilities so we can figure out a workable schedule

- If waitlist/switch request, use Doodle Poll to let us know your possible sections

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**LAB PARTNER ANNOUNCEMENT**

- **WEDNESDAY** by about 5 PM:
  - send e-mail to ece348-staff@ece.cmu.edu with your lab partner choice; no mail means we will randomly assign you

  - INCLUDE:
    - BOTH student names
    - BOTH student andrew IDs
    - Don’t use your Gmail account and just say “Me and Joe want to be partners”

  - If you want to partner with someone in a different section, make sure you tell us all sections (Mon-Fri) you can both make. Please be flexible. Use the Doodle Poll to do this.
  - If you don’t have a partner, send us mail saying so and we’ll assign you one

- If you are wait-listed, still pick a partner
  - Hard limit of 72 students (room capacity is listed as 73)
  - Usually all or almost all ECE students get in
Workload: 12 Unit Course = Target 12 hrs/week

- Goal for this year: MEDIAN student works about 12 hrs/week

![Graph showing student hours per week]

Web, Blackboard, E-mail

- Course home page is definitive source for information:
  - http://www.ece.cmu.edu/~ece348

- Blackboard used for
  - Posting grades
  - Course announcements (we expect you will check blackboard daily)

- E-mail use:
  - Asking questions about course content, labs, etc. should be done in person at office hours and the lab, not via e-mail!
  - Reasonable e-mail use includes:
    - Asking to schedule a special meeting of some sort outside office hours
    - Notifying staff of a technical problem (“lab equipment X is broken”)
    - Notifying staff of defects in assignments (“looks like a typo on assignment Y”)

- Send all course e-mails to: ece348-staff@lists.andrew.cmu.edu
  (if you send it elsewhere and it doesn’t get read, don’t be surprised)
Lab Partners

◆ Get a partner. We have limited lab facilities and staff
   • Perhaps pick somebody with complementary skills
   • (Like somebody who actually knows something about, say, hardware, or software if one of those is a weak spot for you.)

◆ Manage group dynamics.
   • It’s your problem …
     … unless you tell us early enough.
   • If you are awake all night worrying about your lab partner, you should be talking to us sooner rather than later
   • If you cover for your lab partner and it bites you later, don’t come crying to us

◆ Course lab philosophy
   • Lab is a place to demonstrate you “got” what the lectures were about
   • The lab is not a place for fancy design projects – take 18-549 for that!

Cheating

◆ No tolerance for cheating at all
   • READ the course policy on cheating on the course web page.
   • Penalty for being convicted of cheating is failing the course. No kidding.
   • If you think you are too smart for us to figure out you are cheating, think again
     – We will use MOSS and other techniques to find code copying
   • If you honestly aren’t cheating, don’t worry about this. Being “perfect” isn’t cheating.

◆ Examples of cheating behavior (non-comprehensive list):
   • Did someone else tell you how to do any aspect of your homework?
     – General discussions of lecture material are fine if not specific to homework
     – Lab partners collaborate on joint assignments only (not pre-labs)
     – Did you help someone else with their homework? (that’s cheating too)
   • Did you look at a previous semester solution or someone else’s solution?
     – Did you look up stuff on the web and use it in your solution?
     – Did you look at quizzes, or other stuff from a previous year not on blackboard?
   • Did you access anything other than the permitted “crib sheet” during an exam?
     – Did you let your eyes roam on to others’ papers during an exam?
   • Did you do homework sitting next to each other and ask leading TA questions?
     – “Dear TA, I think I should do it this way. Is that right?” (Is my friend taking notes of this?)
   • Are you involved in faking attendance or results at a class, lab, recitation, or exam?
Actual Examples of Cheating

◆ Doing prelabs (which are homeworks) as a group
  • Discussing lecture slides as a group is encouraged and fine
  • Discussing prelabs as a group is NOT ok – we want you to make your own mistakes and learn from them; don’t do your prelab next to your partner
  • Discussing labs with anyone other than your partner (and staff) is NOT ok

◆ Looking at or copying a prelab program you “found” in the lab
  • Erase your files when you leave the lab, or you risk being the same as someone else who copies you!
  • It is OK to look at your partner’s relevant prelab code after both of you have handed in your prelabs for grading

◆ Sharing a calculator
  • “I didn’t have a calculator with me, and it makes no sense for me to punch in numbers that my lab partner just punched in, so I just used his numbers”

◆ Looking at a previous year pre-lab or lab you find on the web
  • Showing someone else your prelab to help them, even if it is simply a cosmetic issue or otherwise just a general look rather than detailed copying

◆ We are really serious about this – no exceptions!
  • We have found you don’t really learn the stuff if you don’t do it on your own

Course Lab Microcontroller: MC9S12C128

◆ MC9S12C128:
  • “M” = “Motorola” … but spun off as new company “Freescale”
  • C9S = “C” for CMOS technology; “9S” is general model number
  • “12” = mostly code compatible with older 68HC12 chip and 68HC11
  • C = Has a CAN network controller (might be useful for 18-549 projects!)
  • 128 = 128KB of on-chip flash memory (and 12KB of RAM)

◆ General specs
  • 16-bit CPU
  • 4-25 MHz bus; 3.3V to 5V operation
  • Timers, A-to-D converters, pulse generator … lots of cool stuff on chip
  • Very popular mid-range microcontroller sold for use in automotive applications

◆ Web site has Data “Sheet” (684 pages)
  • Industrial automation and automotive
Lab Module – Axiom CSM12C32 / Freescale

- This is the module you’re using
  - Includes development tools – 1 per student
  - You can use it at home with your own Windows PC

- User Components Provided
  - 8-bit microcontroller
  - 5V power supply
  - 5-pin header
  - Jumper wires
  - 2 I/O channels
  - 1 UART
  - Pin headers
  - 4 MHz clock oscillator
  - Power input selection header
  - On-board 5V regulator
  - Optional power input/output from connector #1

Specifications:
- Module size: 3.8" x 2.0"
- Power input: +9V typical, -6V to -20V
Lab Hardware – project board

◆ CPU module plugs into this board
  • Prototype area; LEDs; Switches; etc.
  • 1 per team of 2 students

Lab Software

◆ CodeWarrior IDE
  • Integrated editor, C compiler, debugger
  • Also supports assembly language
  • Official support for windows
    – Might work on Mac with emulation software, but we don’t support that
    – Linux probably does not work

◆ Can develop with lab module
  • Cross-compiled from PC onto lab module via serial cable

◆ Can develop with project board + lab module
  • Cross-compiled from PC through project board via USB or serial cable

◆ Go to lab this week and pick up your equipment
  • We’ll announce when it is available
  • Recitation Friday will explain how to use the equipment and prepare you for next week’s lab
  • You only need the simulator for the pre-lab, which is on the course web site
Look For The Schedule Grid On Web Page

◆ Below might change – web site has up to date version

| Wk # | Week of    | Mon (Sec E) | Tue (Sec A) | Wed (Sec B) | Thu (Sec C) | Fri (Sec D) | Lab Report Date | Prelab Due Date | Fri. Recitation
|------|------------|-------------|-------------|-------------|-------------|-------------|----------------|----------------|----------------|
| 1    | 11-Jan 2016| No Lab      | No Lab      | Open Lab    | Open Lab    | Open Lab    | None           | 1              | 1.2
| 2    | 18-Jan     | **M.E.K Day** | 1           | 1           | 1           | 1           | None           | 2              | 2.3
| 3    | 25-Jan     | 1           | 2           | 2           | 2           | 2           | 1              | 3              | 3.4
| 4    | 1-Feb      | 2           | 3           | 3           | 3           | 3           | 2              | 4              | 4.5
| 5    | 8-Feb      | 3           | 4           | 4           | 4           | 4           | 3              | 5              | 5.6
| 6    | 15-Feb     | 4           | 5           | 5           | 5           | 5           | 4              | 6              | 6.7
| 7    | 22-Feb     | 5           | **TEST**    | Open Lab    | Open Lab    | 6           | None           | None           | 7.8
| 8    | 29-Feb     | 6           | 6           | 6           | 6           | **BREAK**   | 5              | None           | No Recitation
|     |            |             |             |             |             |             |     | 7 Due Thursday |
| 13   | 11-Apr     | 10          | 10          | Open Lab    | Open Lab    | Cameral     | Cameral        | None           | None           | No Recitation
| 14   | 18-Apr     | Open Lab    | Open Lab    | Cameral     | Cameral     | None        | None           | None           | Optional In-Lab |
| 15   | 25-Apr     | Open Lab    | Open Lab    | Open Lab    | Open Lab    | None        | None           | None           | Optional In-Lab |
| 16   | 2-May Finals | TBD        | TBD         | TBD         | TBD         | TBD         | 11 Due (Thursday) | None | No Recitation

*(See blackboard for Lab 11 prelab, demo & writeup information)*

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How Lab Sessions Will Work

◆ Homework/Pre-Lab
  • Start early! – Be done enough to ask intelligent questions at recitation Friday
    – (If you haven’t read the assignment, don’t expect TAs to spoon-feed you!)
  • Hand in pre-labs Friday evening at 9 PM via afs
    – 5% bonus points for early hand-in by 1:30 PM

◆ After Pre-lab Hand-In (we urge you to hand in even earlier!!)
  • Work with your partner on a solution strategy for the lab demo
  • Spend some time in the lab to make sure your stuff will work

◆ During scheduled lab time
  • Arrive prepared
  • Do your demo at assigned demo slot
    – Early demos are fine, but students with assigned time slot have priority
  • Lab writeups are due at 9 PM Wednesday a week or so later via afs
  • TA may leave 1 hour before end of lab if nobody is there at 8:20 PM
    – If you are going to arrive after 8:20PM send e-mail to course staff
Lab Writeups

**Lab writeup content**
- Lab assignment will specify writeup
- You must actually follow directions – points off even for “minor” things like forgetting to put your name in comments within the code
  - **You MUST follow file name conventions!**
    - This is a huge problem for us if you don’t
    - 1 minute/student * class size => 1 hour of wasted time for us
- Usually has three elements:
  - Code listings, circuit diagrams
  - Answers to questions (sketch a curve of this measurement, etc.)
  - How can we make the lab better for next time?

**Electronic hand-in via afs**
- Writeup
- We will spot-check to make sure code really works
- Do your writeup right after the lab; don’t wait

**IMPORTANT: save your lab code!**
- Some labs require code from previous labs
- Try out version management software (Git may work, but hates .xlsx files)
- **Do NOT** use software that makes your code publicly available (e.g., Google)

Lab Hours & Expectations

**Scheduled lab times**
- We will schedule demo slots – be there when it is your slot!
- This means partial conflicts with lab session are OK, but tell us the situation

**During schedule lab times**
- Be there when it is your section (e.g., Section A is Tuesday night)
- Don’t get in the way when it isn’t your section
- Our class has priority during our lab times (other class has priority in theirs)

**At other times**
- TAs have office hours in the lab
- Use the lab as much as possible
- But, you can do a lot of the course work on the MCU module with your laptop or home PC!

**If you see a problem in the lab, let us know right away via e-mail**
- Missing equipment, supplies have run out, safety issues
- Too hot/too cold, anything that doesn’t seem right
- Also can notify Tech Electronics (but tell us too)
2014 FCE Comments

◆ “It’s a course that teaches a lot about real world cases and hence is very useful for job interviews.”

◆ “The Embedded Systems programming was useful, but what was more so was the mindset behind the course: learning how to set up and create an engineering project from ground-up.”

Should You Go To Recitation?

◆ Low recitation attendance predicts a low course score
**Should You Attend Lecture?**

Unedited 18-348 Spring 2014 FCE comment:

“Very great course. I didn't go to too many lectures because I had a full schedule, and I did not want to have to wake up at 10:30 after staying up late into the night, but I wish I had gone to class. Also, I applied to a **Tesla embedded systems internship, and didn't get the job.** But I'm pretty sure that, **had I shown up to class,** I would have been able to answer the technical questions much better (they were on CRC checking and communications between MCU and pc).”

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**Is It All About Putting In Hours?**

**Hours does not necessarily correlate with course grade**

- This doesn’t mean hours don’t matter! It means that material is easier for some than for others.

[Graph showing hours vs. course grade for 18-348 Spring 2014]
Review  *(This Is Where You Get Exam Hints)*

◆ Course overview
  • Course organization
  • Assignments: Pre-labs, labs, weekly quizzes, mid-term exam, final exam
  • Cheating policy

◆ WEDNESDAY (before 4 PM):
  send e-mail to 348 TAs <ece348-staff@lists.andrew.cmu.edu> with your lab partner choice; no mail means we can randomly assign you

◆ Lab orientation
  • Lab #1 is just to make sure you can use all the lab hardware and software
    – Pre-lab due on Friday

Lab Skills For This Lecture

◆ Board hook up
  • Be able to correctly hook up cables and power without board damage

◆ Download and execute program
  • Be able to down-load a pre-prepared program and run it:
    – On simulator
    – On microcontroller module
    – On module + proto-board
    
      – Assembly language program
      – C program
    
    • General idea of Lab #1 – make sure you can get everything to work so that in Lab #2 we can get on to doing real stuff.

*(Don’t worry, lab skills will get a more challenging after this!!)*