Embedded System Engineering

INSTRUCTOR: Roger Kieckhafer
713 EERC
rmkieckh@mtu.edu
http://www.ece.mtu.edu/faculty/rmkieckh/

OFFICE HRS: M.W.F. 10:05-10:35 AM
12:05-12:35 PM
OR send an email (for easy questions),
OR make an appointment (for hard questions),
OR take a chance & just drop in.

LAB TA: Aref Majdara
amajdara@mtu.edu

OFFICE HOURS: T.B.A.
OR send an email (for easy questions),
OR make an appointment (for hard questions),
OR take a chance & just drop in.

1 General Information

TOPICS Covers the use of low-power microcontrollers in embedded sensing and control systems. Topics include: hardware-dependent C programming, commercial I/O devices, configuring I/O ports to interface with analog and digital sensors, actuators, transmitters, receivers, mobile robots, and wireless sensor nets.

PREREQUISITES: (CS 1141 or EE 2241) and (EE 3171 or EE 3173)

COURSE MATERIALS:

• Lecture Handouts: You are responsible for all material presented in lecture. Contact me as soon as practicable if you have a legitimate reason for missing any work (e.g. illness or death in the family). The sooner the better! In most cases, requirements can be modified or waived.

• Printed References: Listed on page 6 are the sources for most of the material presented in this course. However, all material you will need for exams will be presented in lecture.

If you get lost, do not go surfing for other references. Each author has his/her own style, notation, and assumptions; so jumping from book-to-book can do more harm than good. Instead, ask the instructor for help immediately; don’t wait until you are deeply and hopelessly lost.

• Course Web Page: Go to www.ece.mtu.edu/faculty/rmkieckh/ and click on the EE-4735 link. All references, users’ manuals, examples, and template files will be posted there.

• Real Bulletin Board: Homework solutions will be posted on the bulletin board in the Southeast corner of the 7th floor of the EERC (outside of room 738). Solutions will not be posted on-line.

• Canvas: will never ever be used in this course, at any time, for any purpose. Period. Even if a Canvas page for this course exists, it was not created by, and will not be used by, accessed by, or even recognized by the instructor. Nothing of value will ever be found there.
2 Admin and Grading Policies

GRADING COMPONENTS:

- **Homework**: Up to 12 homework assignments will be given, and all will be graded. All homeworks are worth 100 points. However, up to 15% of the points on an assignment are bonus points, awarded for handing in an honest, good-faith attempt.

  Unless otherwise specified, each is due by the end of lecture on its stated due date. Late homework is accepted, but is penalized by deducting 25 full points per working day, or fraction thereof. Once solutions are posted, late work can not be accepted for credit.

- **Laboratories**: Up to 10 Laboratory assignments will be given. Lab procedures, policies, and expectations are listed in Section 3 below.

- **Exam 0** is a take-home Prerequisite Review Exam, covering prerequisite material.

- **Exams 1 and 2** are in-class midterms, covering only material presented since the previous exam. After grading, you will take Exams 1 & 2 home, re-write them, and re-submit them for re-grading. The grades recorded will be the arithmetic means of the original grades and the re-write grades.

- **Final Project**: A final team-oriented design project will be assigned instead of a written final exam. Project procedures, policies, and expectations will be presented separately.

GRADING CURVES will be generated for each component of the final grade and then summed to obtain a final curve for the course. The relative weight of each component is shown Table 1.

- **Warning**: the re-write grading curves for Exams 1 & 2 will not be generous.
- **Warning**: A failing grade in lab yields an "F" for the entire course, regardless of the rest of the grades.

**Table 1: Weighting of Grade Components**

<table>
<thead>
<tr>
<th>Component</th>
<th>Max</th>
<th>Weight</th>
<th>Coverage</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam 0</td>
<td>100</td>
<td>12.5%</td>
<td>Prerequisite Exam</td>
<td>Stuff you once knew, but probably forgot</td>
</tr>
<tr>
<td>Exam 1</td>
<td>100</td>
<td>12.5%</td>
<td>Just part I of outline</td>
<td>half = original in-class grade</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>half = take-home re-write grade</td>
</tr>
<tr>
<td>Exam 2</td>
<td>100</td>
<td>12.5%</td>
<td>Just part II of outline</td>
<td>half = original in-class grade</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>half = take-home re-write grade</td>
</tr>
<tr>
<td>Homework</td>
<td>100</td>
<td>12.5%</td>
<td>Average of all assignments</td>
<td></td>
</tr>
<tr>
<td>Laboratories</td>
<td>200</td>
<td>25.0%</td>
<td>Average of all lab reports</td>
<td>Warning: Lab failure = Course failure</td>
</tr>
<tr>
<td>Final Project</td>
<td>200</td>
<td>25.0%</td>
<td>Proposal, Reports, &amp; Demonstration</td>
<td>Deadlines &amp; details T.B.A.</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>800</td>
<td>100.0%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**DOCUMENTATION**: Do not discard or lose any graded exams, homeworks or labs. They are your only proof in the event of a clerical error, grading error, or any other uncertainty regarding your grades.

**EXTRA CREDIT** will be neither given nor accepted for any reason. So don’t even ask.

**INSTRUCTOR’S DISCRETION** may be used in extremely rare cases to raise (but not lower) a borderline final grade. It will be used only when (in my opinion) a gross statistical aberration has occurred which is so unique and so blatantly obvious that there is no question of fairness or favoritism.
3 Laboratory Policies

3.1 Lab Attendance

Lab sessions meet every week. Some labs are conducted in teams. You are expected to enter the lab ready, willing, and able to contribute to your team's success on that lab. Thus, you are required to attend your scheduled lab session and to participate fully in all activities. If it is determined that a particular team member is slacking off or hitch hiking (going along for the ride without carrying a fair share of the load), the instructor may deduct points from that person's grade for the affected assignments.

If you are absent from lab without a valid reason, you will receive a Zero on that lab. If you do have a valid reason for missing lab, notify the TA (ahead of time if practicable) & arrange a time to make it up.

Usually, you can complete each lab in the time allotted. However, if you need more time, arrange for extra time to complete the work with your TA.

3.2 Lab Assignments and Grading

Each lab assignment comprises two parts worth a total of 200 points:

50 points = Pre-Lab Assignment: One per individual person.

- Pre-Labs must be done individually, with no collaboration or assistance from any other students.
- Pre-labs must be completed prior to the lab and handed in at the start of your lab session.
- Late Pre-Labs will not be accepted.
- If your Pre-Lab assignment is substantially incomplete, the lab TA may refuse to allow you to participate in executing that lab, earning you a Zero for that entire Lab assignment.
- All software source code written for a Pre-Lab assignment must be:
  - Printed out & appended to the Pre-Lab sheet for hand-in.
  - Brought to lab on a flash drive (for use in the lab).

150 Points = Lab Execution & Report: One report per team is to be submitted.

- Each Lab Report must include, in this order (with no additional cover pages):
  1. The completed, original copy of the Signoff/Data Sheet from the Lab Assignment,
  2. Typed answers to the questions in the Considerations section of the Lab Assignment.
  3. Hardcopies of all final working Software source code,
  4. The completed, original copy of the Lab Feedback Sheet from the Lab Assignment.
- Each Lab Report is due at the start of the first lab session following completion of the lab work.
- Late Lab Reports will be penalized 25 points per working day (or fraction thereof).

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1 All software source code must comply with the Embedded Programming Style Guide for this course.

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4 Tentative Course Outline

<table>
<thead>
<tr>
<th>Lecture Topic</th>
<th>Hrs</th>
<th>Primary References</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I Introduction &amp; Basics</strong></td>
<td>10.5</td>
<td></td>
</tr>
<tr>
<td>1 Syllabus, Introduction to Embedded Systems</td>
<td>1.0</td>
<td>Dav08 Ch 1, EZ-UG, 2274-DS</td>
</tr>
<tr>
<td>2 MSP430 – Architecture Introduction</td>
<td>1.0</td>
<td>Dav08 Ch2, FamUG Ch1</td>
</tr>
<tr>
<td>3 Embedded C Programming in MSP430 Context</td>
<td>1.0</td>
<td>Dav08 Ch 3.2 &amp; 4.2, C-CRG</td>
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<tr>
<td>4 MSP430 – GPIO Pins &amp; Configuration</td>
<td>1.0</td>
<td>Dav08 Ch 7, FamUG Ch 8</td>
</tr>
<tr>
<td>5 MSP430 IRQs &amp; Low Power Modes</td>
<td>1.0</td>
<td>Dav08 Ch 6, FamUG Ch 2</td>
</tr>
<tr>
<td>6 MSP430 Timers, Capture, &amp; PWM DAC</td>
<td>2.0</td>
<td>Dav08 Ch 8, FamUG Ch 12 &amp; 13</td>
</tr>
<tr>
<td>7 Toys – Servo Motors</td>
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<td>Other</td>
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<tr>
<td>8 Intro to ADCs &amp; MSP430 ADC Ports</td>
<td>1.5</td>
<td>Dav08 Ch 9.2-9.5, FamUG Ch 22</td>
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<tr>
<td>Exam 1 - Preview &amp; Comp. Day ²</td>
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</tr>
<tr>
<td><strong>II Standard I/O Ports &amp; Protocols</strong></td>
<td>12.5</td>
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<tr>
<td>1 MSP430 USCI Port – UART Mode &amp; RS232</td>
<td>1.2</td>
<td>Dav08 Ch 10, FamUG Ch 15</td>
</tr>
<tr>
<td>2 Toys – Mobile Robot &amp; Accessories</td>
<td>0.8</td>
<td>Other</td>
</tr>
<tr>
<td>3 MSP430 USCI Port – SPI mode</td>
<td>1.0</td>
<td>Dav08 Ch 10, FamUG Ch 16</td>
</tr>
<tr>
<td>4 MSP430 USCI Port – I2C Mode</td>
<td>1.2</td>
<td>Dav08 Ch 10, FamUG Ch 17</td>
</tr>
<tr>
<td>5 Toys – Digital to Analog Converters (DACs)</td>
<td>0.8</td>
<td>Other</td>
</tr>
<tr>
<td>6 Toys – 3-Axis Accelerometer</td>
<td>1.0</td>
<td>Other</td>
</tr>
<tr>
<td>Specification of Final Projects</td>
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<td>Project RFP</td>
</tr>
<tr>
<td>7 Wireless Comm - PHY Layer Principles</td>
<td>1.0</td>
<td>Other</td>
</tr>
<tr>
<td>8 Wireless Comm - cc2500 Transceiver</td>
<td>1.5</td>
<td>2500-DS, EZ-UG</td>
</tr>
<tr>
<td>9 Toys – More fun &amp; useful stuff</td>
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<td>Various &amp; Sundry</td>
</tr>
<tr>
<td>Exam 2 - Preview &amp; Comp. Day ²</td>
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</tr>
<tr>
<td><strong>III Wireless Networks &amp; Protocols</strong></td>
<td>3.0</td>
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<tr>
<td>1 Wireless Comm - MAC Layer Principles</td>
<td>1.0</td>
<td>Other</td>
</tr>
<tr>
<td>2 Case Study - IEEE 802.15.4 &amp; Zigbee</td>
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<td>Other</td>
</tr>
<tr>
<td>3 Case Study - IEEE 802.11 &amp; WiFi</td>
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<td>Other</td>
</tr>
<tr>
<td><strong>Course Total</strong></td>
<td>26.0</td>
<td></td>
</tr>
</tbody>
</table>

Footnotes:
[1] 50 mins = 1 hr, 28 hours = 1 theoretical semester, 27 hours = 1 real-world semester.
[2] Exam Compensation Days will be scheduled as convenient, not necessarily the day after the exam.
5 Legal & Ethical Issues

5.1 Copyrights
All written and/or verbal material presented in this course is the IP of the instructor(s). It exists for the exclusive use of tuition-paying MTU students who are formally enrolled in this course. Any material embedded from outside sources is used with permission of the original copyright holder and/or as permitted under Title 17 USC Ch 1, Sec. 110 regarding educational uses of copyrighted material.

Outside the context of this course, any reproduction, republication, reposting, repackaging, and/or other reuse of any part of any course materials, text, diagrams, assignments, and/or solutions without the case-specific, written permission of the instructor is strictly prohibited, and may violate federal law.

5.2 Academic Integrity Rules
You are obligated to obey the Michigan Tech Academic Integrity Policy in its entirety (http://www.admin.mtu.edu/usenate/policies/p109-1.htm). In particular, for this course, you may engage in conceptual discussions about topics presented in lecture and/or other reference materials outside the context of any take-home assignment (e.g. Homeworks, Labs, & Exam 0). However:

1. Do not collaborate, cooperate, share resources, or even discuss any question or answer on any assignment with anyone other than an instructor, grader, and/or TA for this course.

2. Do not read, refer to, use, or even possess any assignments, questions, solutions, or any other materials from previous semesters of this course (a.k.a. Scoop).

3. Do not aid, abet, provide materials to, or in any way assist another student in violating these rules.

5.3 Penalties for Infractions
In accordance with standard practice, if the instructor even suspects that the above rules have been violated, the case will be referred to the Office of Academic and Community Conduct for investigation. If that office finds a student "responsible" for violating these rules, then the offending student will receive a default final letter grade of "F" for the entire course. However:

- If this is the offender's first offense at MTU;
- and the offender has fully cooperated with the investigation & admitted to the offense;
- and the offender has told the truth, the whole truth, & nothing but the truth to the investigator(s);
- and after the instructor has consulted with the ECE Department Chair;
- then the instructor may, at his sole discretion, opt to exercise some degree of mercy and apply a less severe penalty to the offender's final course letter grade; which penalty is, in the instructor's judgment, befitting to his interpretation of the nature, scope, & severity of the offense.

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2 Clearly, you may discuss Lab Reports (but not Pre-Labs) with your lab partner(s).
   Also, clearly, you may discuss your Final Project with members of your own project team, but no other students.
6 Sense and Nonsense

Every year, various minions in the MTU bureaucracy decree ever more topics that instructors are "required" to include in their syllabi and/or present on the first day of class. We will not waste precious class time discussing them verbally. Therefore, URLs to these "required" topics are listed below.

Unfortunately, some of them really are important enough that you should read them at least once. Then, you can decide for yourself which ones make sense and which are just bureaucratic nonsense.

https://www.mtu.edu/hr/current/notices/evac-flyer.pdf
http://www.mtu.edu/deanofstudents/students/disability/policy/
http://www.admin.mtu.edu/usenate/policies/p109-1.htm
http://www.admin.mtu.edu/admin/boc/policy/ch5/
http://www.mtu.edu/equity

7 References


[2500-DS] *CC2500: RF Transceiver Data Sheet (SWRS040A)*, T.I., Rev.1.2, 2006. (cc2500-TxRx-DS.pdf)

[Other] Other relevant texts, manuals, data sheets, etc – will be provided as needed.