Embedded System Engineering

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

OFFICE HRS: M.W.F. 12:35 – 1:25 PM
OR send an email (for easy questions),
OR make an appointment (for hard questions),
OR take a chance & just drop in.

LAB TA: Puneeth Ramesh
puneethr@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 3170 or 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 4 are the sources for most of the material in this course. If you get lost, do not go surfing for other references. Each author has his/her own style, assumptions, and notation, 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/](http://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 9 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 final exam. Project procedures, policies, and expectations will be presented separately.

**GRADING CURVES** will be generated for each component of the final grade (exams, homework average), and then summed to obtain a final curve for the course. The relative weight of each component is shown Table 1. Warning: the re-grade curves for Exams 1 & 2 will *not* be generous.

<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 already studied 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>
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<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></td>
</tr>
<tr>
<td>Final Project</td>
<td>200</td>
<td>25.0%</td>
<td>Oral PDR, Written Rep't, &amp; Demo</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>
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</table>

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

**HITCH HIKER PENALTIES**: Labs and Final Projects are conducted in teams. 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.

**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.

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3 Laboratory Policies

3.1 Lab Attendance
Lab sessions meet every week. 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 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) and arrange a time to make up that lab.

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 the 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: ¹
  - 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:
  1. The completed, original copy of the Signoff/Data Sheet from the Lab Assignment, listing the names of all team members.
  2. Typed answers to the questions in the Considerations section of the Lab Assignment.
  3. Hardcopies of all final working Software source code ¹.
- 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).

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

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# Tentative Course Outline

<table>
<thead>
<tr>
<th>Lecture Topic</th>
<th>Hrs&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Primary References</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I Introduction &amp; Basics</strong></td>
<td><strong>10.5</strong></td>
<td>Dav08 Ch 1, EZ-UG, 2274-DS</td>
</tr>
<tr>
<td>1 Syllabus, Introduction to Embedded Systems</td>
<td>1.0</td>
<td>Dav08 Ch 2, FamUG Ch1</td>
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<tr>
<td>2 MSP430 – Architecture Introduction</td>
<td>1.0</td>
<td>Dav08 Ch 3.2 &amp; 4.2, C-CRG</td>
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<td>3 Embedded C Programming in MSP430 Context</td>
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<td>Dav08 Ch 7, FamUG Ch 8</td>
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<td>4 MSP430 – GPIO Pins &amp; Configuration</td>
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<td>Dav08 Ch 6, FamUG Ch 2</td>
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<td>5 MSP430 Timers, Capture, &amp; PWM DAC</td>
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<td>Dav08 Ch 8, FamUG Ch 12 &amp; 13</td>
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<td>7 Devices: Servo Motors</td>
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<td>Other</td>
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<td>8 Intro to ADCs &amp; MSP430 ADC Ports</td>
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<td>Dav08 Ch 9.2-9.5, FamUG Ch 22</td>
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<td>Exam 1 - Preview &amp; Comp. Day&lt;sup&gt;2&lt;/sup&gt;</td>
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<td><strong>II Standard I/O Ports &amp; Protocols</strong></td>
<td><strong>11.0</strong></td>
<td>Dav08 Ch 10, FamUG Ch 15, 16, 17</td>
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<tr>
<td>1 MSP430 USCI Port – Introduction</td>
<td>0.5</td>
<td>Dav08 Ch 10, FamUG Ch 15, 16, 17</td>
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<tr>
<td>2 MSP430 USCI Port – SPI mode</td>
<td>1.0</td>
<td>Dav08 Ch 10, FamUG Ch 16</td>
</tr>
<tr>
<td>3 MSP430 USCI Port – I2C Mode</td>
<td>1.0</td>
<td>Dav08 Ch 10, FamUG Ch 17</td>
</tr>
<tr>
<td>4 MSP430 USCI Port – UART Mode &amp; RS232</td>
<td>1.0</td>
<td>Dav08 Ch 10, FamUG Ch 15</td>
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<tr>
<td>5 Sabertooth MotorCntlr &amp; Glue Logic</td>
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<td>Other</td>
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<tr>
<td>6 Specification of Final Projects</td>
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<td>Project RFP</td>
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<tr>
<td>7 Wireless Comm - PHY Layer Principles</td>
<td>1.5</td>
<td>Other</td>
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<tr>
<td>8 Wireless Comm - cc2500 Transceiver</td>
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<td>2500-DS, EZ-UG</td>
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<tr>
<td>9 Project Specific I/O Devices</td>
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<td>Various &amp; Sundry</td>
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<tr>
<td>Exam 2 - Preview &amp; Comp. Day&lt;sup&gt;2&lt;/sup&gt;</td>
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<tr>
<td><strong>III External Devices &amp; Networks</strong></td>
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<td>Dav08 Ch 10, FamUG Ch 16</td>
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<tr>
<td>1 Other Commercial I/O Devices</td>
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<td>Various &amp; Sundry</td>
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<tr>
<td>2 Wireless Comm - MAC Layer Principles</td>
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<td>Other</td>
</tr>
<tr>
<td>3 Case Study - IEEE 802.15.4 &amp; Zigbee</td>
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<td>Other</td>
</tr>
<tr>
<td>4 Case Study - IEEE 802.11 &amp; WiFi</td>
<td>1.0</td>
<td>Other</td>
</tr>
</tbody>
</table>

**Course Total** | **26.5** |

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.

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5 Legal, Ethical, & Political Issues

5.1 Academic Integrity

It is acknowledged that homework and labs will be topics of discussion among students. However:

- All discussions must terminate before you start working on the assignment, i.e. once you actually start executing the assignment, you may no longer collaborate, cooperate, or even discuss it with anyone except the instructor or TA.

- In particular, all software written for this class must be written independently. You may not copy, borrow, or steal any code or algorithms from anyone (except your lab partner).

If the instructor suspects that these rules have been violated, the case can be referred to the judicial affairs office for their judgment and disposition.

5.2 Copyrights

All written and/or verbal material presented in this course is the IP of the instructor. It exists for the exclusive use of tuition-paying MTU students who are formally enrolled in this course. Any material copied 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 express, case-specific, written permission of the instructor is strictly prohibited, and may constitute a violation of federal law.

5.3 Other Stuff

Other legal/ethical/admin/etc rules/policies/procedures/etc required by MTU/MI/USA/etc are at the following URLs. If you have not already read them, it is a really good idea to do so – at least once.

http://www.mtu.edu/dean/conduct/policy/academic-integrity/ http://www.admin.mtu.edu/aao/

6 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.