MEEN 433/667  Mechatronics

Basic principles of digital logic and analog circuits in mechanical systems; electrical-mechanical interfacing; sensors and actuators; digital control implementation; precision design and system integration. Three credit hours (2-3).

Instructor:

Won-jong Kim, Ph.D.
Associate Professor
223 Mechanical Engineering Office Building
(979)845-3645, phone
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http://alum.mit.edu/www/wjkim, webpage

TA (Volunteer):

Mr. Yalun Wen
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Mr. Ivan Cortes
(254)285-9575, phone
icorteso@tamu.edu, e-mail

Lectures:

MW 12:40 PM–1:30 PM at 206 ENPH

Labs:

F 12:40 PM–3:30 PM at 302 ENPH

Each lab consists of a 1-hour lab instruction followed by a 2-hour hands-on experiment. Lab attendance is mandatory.

Office Hours:

Dr. Kim: MWF 8:50 AM–10:00 AM at 223 MEOB or 204 ENPH, or by appointment
Mr. Wen: T: 2:00 PM–3:00 PM and R: 3:00 PM–4:00 PM at 408 ENPH, or by appointment
Mr. Cortes: during the lab hours, or by appointment

Textbooks (required):


We will cover Chaps. 3, 5–7, and 9–11 of AH and Chap. 8 of FP in class. Chaps. 1–2, 4, and 8 of AH are assigned to read in the first week.
References:

- H.-D. Chai (C), Electromechanical Motion Devices, Chaps. 4–7, Prentice Hall, 1998—for sensors and actuators.

Reading assignments will be given from these references. All references can be checked out for two hours from the Reserved Books Desk at Evans Library.

On-Line Course Materials:

A course web page is being established at ecampus.tamu.edu. You should be able to access the web page if you are registered for the course. All course-related material you will need, e.g. lecture slides, handouts, homework sets, solutions, lab descriptions, photographs of previous term projects, data sheets, manuals, and other useful materials will be placed.

Prerequisite: MEEN 364

- Dynamic systems and controls (MEEN 364)
- Sophomore-level electronics (ECEN 215)
- Hands-on instrumentation labs (MEEN 260)

Both ECEN 215 and MEEN 260 are prerequisite to MEEN 364. I expect you to be familiar with the following topics.

Dynamic systems and controls:
- Writing equations of motion and finding transfer function
- Determining system (time and frequency) responses
- Designing simple controllers (PID, etc.)
- Determining system stability

Sophomore-level electronics:
- Constitutive equations for passive elements, such as R, L, and C.
- Applying KVL and KCL for circuit analysis.
- Analyzing basic RLC circuits
- Analyzing basic OP Amp circuits
Hands-on instrumentation labs:
- Using basic instruments, such as oscilloscopes, function generators, power supplies, etc.
- Designing and performing basic engineering experiments.
- Writing technically sound proposals and reports.

I also expect that you are fluent in any programming language, such as C, Matlab, C++, Java, Fortran, or any assembly language.

**Course Objectives:**
- Understand key contemporary issues in system integration with sensors, actuators, and real-time controllers.
- Cultivate confidence in your capability to design a microcontroller-based mechatronic system.

**Course Learning Outcomes:**

Upon successful completion of this course, you will be able to:
- Understand state-of-the-art microcontroller structures and their applications.
- Understand basic working principles of active electronic devices, such as BJT, FET, CMOS, and OP amp.
- Read and understand manufacturers’ data sheets.
- Design combinational and sequential digital logic circuits with off-the-shelf ICs.
- Build analog and digital interface.
- Develop working knowledge in key sensors and actuators and their applications.
- Design and implement simple digital controllers.

**Grading:**
- Mid-term exam for 28%
- Final exam for 35% (approximately 6% from lab materials)
- Homework for 10% total
- Term project for 27%
- Lab attendance (If you miss a lab without university-approved excuses, 3% of the total grade per absence will be deducted.)
- Lab safety (See the section titled, Laboratory Safety on page 5. Upon each lab-safety violation, 1% of the total grade will be deducted.)

Class participation (up to 5%) will not be quantified, but may affect the final grades for those on grade borderlines. This class participation includes participation in discussion in lectures and labs and during office hours of the instructor and the TA, volunteering to answer/solve problems, and asking intelligent questions to enhance the class’s understanding of the course material.

**Exams:**
- Mid-term exam: 12:40 PM–2:40 PM, likely on Friday, October 28, 2016 at TBA
- Final exam: 10:30 AM–12:30 PM, Monday, December 12, 2016 at 206 ENPH. Comprehensive. Covers all lecture and lab materials.

All exams are open-book, open-note. No electronic device except a calculator is allowed. In other words, you may bring any materials written or printed on paper media to the exams. However, any materials authored or collected by anyone else who took or is taking this course are strictly prohibited.
In addition, you may not share any materials with your classmates during the exams. You should expect substantial design problems (in hardware and software) that require creative application of the course materials.

Homework:

There will be 14 homework sets to be handed out every Monday. Each homework set is due the beginning of the class on its designated due dates. Homework sets may contain design problems (in software and hardware) to prepare you for the labs, exams and term project. Your homework must represent your own work. No late homework will be accepted.

Laboratory Safety:

Refer to the document titled, Laboratory Safety: Basic Student Guideline, posted at eCampus. You are asked to sign and return the safety contract to me by the first lab.

Term-Project Grading:

Term-project evaluations are scheduled on Friday, November 18, 2016 and during the term-project presentation on Monday, December 5, 2016.

- Term-project proposal for 4% (clear idea and goal (2%), well-thought-out milestones (2%))
- Satisfactory progress by November 18, 2016 for 4%
- Successful use of course materials for 8% (analog electronics (2%), digital logic (2%), sensors (2%), actuators (2%)). You must demonstrate the full functionality of each item in your final project presentation to get the full credit.
- Presentation for 5% (quality of presentation, (2%), achieving the project goal (3%))
- Term-project report for 6% (lab note (3%), term-project report (3%))
- Bringing a novel idea not covered in the course for bonus up to 5%

How to Choose Term-Project Topics:

See the above term-project grading policy and design your project so that you can demonstrate your knowledge and capabilities. If you borrow someone else’s ideas in part, you must cite proper references. Otherwise, it will be considered plagiarism. All term-projects must employ a microcontroller development kit or equivalent.

Term-Project Expenses:

There will be a small fund available for your term project, and you can purchase materials and supplies up to your budget that I approve. There are three methods to use this fund. (1) You yourself make an arrangement with your vendor to send the bill directly to our department with MEEN 433/667 listed as a reference or PO Number. If your vendor does not honor this request, (2) you may check out the TAMU purchase card from 100A MEOB and use the MEEN 433/667 course account 239134-10160 for your purchase. This card must be returned the same day, and you cannot write down the card number for future use. In other words, you should check out the card each time you make a purchase. In case there is any incident of abuse, this privilege will be revoked. (3) If you have a US social security number, you may make purchases out of your pocket and get reimbursed with the original receipts within 5~7 business days. You need my signature on your receipts. Note that TAMU will not reimburse any Texas sales tax you would pay. Some key parts may have a long lead time. You will be responsible for the consequence from any late delivery of parts.
The Mechanical Engineering Machine Shop located on the first floor of ENPH is available for your term project. You can use the machine tools in the machine shop free of charge for the term project if you do the labor yourself. A 3-D printer is also available free of charge for your term project.

Term-Project Proposal:

Each group brings an idea and submits a term-project proposal by the beginning of the lab on Friday, October 14, 2016. No late proposal will be accepted. The proposal must be type-written and may not exceed 5 single-spaced pages with 12-point fonts. Include sections representing (1) Objective and significance, (2) Design concept with representative diagrams, (3) Work plan with detailed milestones, (4) Budget and budget justification, and (5) Anticipated results.

Term-Project Presentations:

- Monday, December 5, 2016 at TBA. An approximately 15-minute time slot will be assigned to each group by random drawing.

Term-Project Report:

Each group must hand in lab notes and a type-written term-project report before their presentation time. No late submission will be accepted. The report must not exceed 10 single-spaced pages with 12-point fonts. Include sections representing (1) Objective and significance, (2) Professionally done engineering drawings for final design, (3) Experimental results, (4) Discussion and conclusions, and (5) Contributions of individual group members. On the report cover page, put the percentage effort made by each lab member and include the signatures of all lab members. Term-project proposals and reports will not be returned, so ensure you make copies for yourself.

Policy on Grading Complaints:

If you feel a mistake was made in grading any material, please first contact the person doing the grading within a week after the graded paper is distributed. If you are not satisfied with the resolution of the matter then talk to me. After the one week discussion period, we will not review your exams or change grades. Make your complaint to me in writing and via e-mail. Be specific about your complaints. Please note I do not negotiate my partial-credit policy with students.

Tentative Grading Policy:

- A: greater than 80%
- B: greater than 60% and less than 80%
- C: greater than 40% and less than 60%
- D, F: less than 40%

Absences:

Work missed due to absences will only be excused for University-approved activities in accordance with TEXAS A&M UNIVERSITY STUDENT RULES (see http://student-rules.tamu.edu/rule7.htm). Specific arrangements for make-up work in such instances will be handled on a case-by-case basis. In accordance with recent changes to Rule 7, please be aware that in this class any “injury or illness that is too severe or contagious for the student to attend class” will require “a medical confirmation note from his or her medical provider” even if the absence is for less than 3 days (see 7.1.6.2 injury or illness less than three days).
To Earn Graduate Credit:

MEEN 433/667 is a stacked course. University policy FS.18.033 requires that more rigorous activities be provided for graduate students to ensure work at the graduate level. To earn the MEEN 667 credit, you should design and successfully implement a real-time digital feedback controller in your term project. Failure in demonstrating real-time digital feedback control will lead to 10% point deduction in the overall course grade.

Useful Websites:

- Textbook: http://www.engr.colostate.edu/mechatronics
- Arduino: https://www.arduino.cc
- Fairchild Semiconductor Corp.: http://www.fairchildsemi.com
- Texas Instruments, Inc.: http://www.ti.com
- ASCII Code Table: http://www.asciitable.com or http://www.jimprice.com/jim-asc.htm

ADA Statement:

The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact the Department of Student Life, Services for Students with Disabilities, in Room 126 of the Koldus Building or call 845-1637.

Academic Integrity:

Aggie Honor Code: “An Aggie does not lie, cheat, or steal, or tolerate those who do.”

Upon accepting admission to Texas A&M University, a student immediately assumes a commitment to uphold the Honor Code, to accept responsibility for learning and to follow the philosophy and rules of the Honor System. Students will be required to state their commitment on examinations, research papers, and other academic work. Ignorance of the rules does not exclude any member of the Texas A&M University community from the requirements or the processes of the Honor System. For additional information please visit: aggiehonor.tamu.edu

On all course work, assignments, and examinations at Texas A&M University, the following Honor Pledge shall be preprinted and signed by the student:

"On my honor, as an Aggie, I have neither given nor received unauthorized aid on this academic work."

_________________________
Signature of Student

Schedule:

On the next page is a tentative schedule. The pace will be adjusted as the semester progresses. The numbers in parentheses to the right of the topics indicate the corresponding chapters of the textbook. Reading assignments are given in addition to corresponding textbook reading.
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<thead>
<tr>
<th>Wk</th>
<th>Monday</th>
<th>Wednesday</th>
<th>Friday (labs)</th>
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<tbody>
<tr>
<td>1</td>
<td><strong>Course Overview (1)</strong>&lt;br&gt;AH 1–2</td>
<td><strong>Semiconductor Electronics (3)</strong>&lt;br&gt;semiconductor physics, band theory, doping, PN-junction diode, Zener diode, light-emitting diode (LED)</td>
<td>No lab&lt;br&gt;AH 4; SS 3</td>
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<td>2</td>
<td><strong>BJT (3)</strong>&lt;br&gt;bipolar-junction transistor (BJT), BJT common-emitter operation&lt;br&gt;HH 1–2.9; SS 4</td>
<td><strong>BJT Applications (3)</strong>&lt;br&gt;BJT applications for switching, semiconductor manufacturing&lt;br&gt;MS 1, 9</td>
<td><strong>µC Overview (7)</strong>&lt;br&gt;microcontroller architecture, instruction set&lt;br&gt;AH 7.1–7.4; MK 10–12; HH 11</td>
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<td>3</td>
<td><strong>Digital Circuits (6)</strong>&lt;br&gt;DL (diode logic), DTL, TTL (transistor-transistor logic)</td>
<td><strong>Combinational Logic (6)</strong>&lt;br&gt;number system, Boolean algebra, truth table, DeMorgan’s theorem, bubble pushing, half adder, full adder</td>
<td><strong>C Programming</strong>&lt;br&gt;C language, communication&lt;br&gt;AH 7.7; KR</td>
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<td>4</td>
<td><strong>Combinational Logic (6)</strong>&lt;br&gt;Karnaugh map, logic minimization, binary subtractor&lt;br&gt;MK 1–5</td>
<td><strong>Combinational Logic (6)</strong>&lt;br&gt;binary parallel adder, carry look-ahead, comparator, parity generator/checker</td>
<td><strong>Digital I/O and A/D (8)</strong>&lt;br&gt;I/O and data acquisition&lt;br&gt;AH 8; HH 9.15–9.26; MK 13</td>
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<td>5</td>
<td><strong>Combinational Logic (6)</strong>&lt;br&gt;decoder/demultiplexer, multiplexer/data selector, encoder</td>
<td><strong>Sequential Logic (6)</strong>&lt;br&gt;timing chart, RS latch, D flip-flop (FF), JK FF, T FF, switch debounce circuits</td>
<td><strong>Interrupts</strong>&lt;br&gt;polling and interrupts&lt;br&gt;HH 10</td>
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<td>6</td>
<td><strong>Sequial Logic (6)</strong>&lt;br&gt;master-slave FF, edge-triggered FF, FF with data lockout&lt;br&gt;MK 6</td>
<td><strong>Sequential Logic (6)</strong>&lt;br&gt;shift register, data converter/transmitter, binary ripple counter&lt;br&gt;MK 7; HH 8</td>
<td><strong>Encoder</strong>&lt;br&gt;interface with polling and interrupts</td>
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<td>7</td>
<td><strong>Sequential Logic (6)</strong>&lt;br&gt;synchronous counter, BCD (binary-coded-decimal) counter, counter applications</td>
<td><strong>Field Effect Transistor (FET) (3)</strong>&lt;br&gt;JFET, MOSFET (metal-oxide semiconductor FET), MOSFET switch, CMOS (complementary MOS), SS 5</td>
<td><strong>Logic Gates and FFs (6)</strong>&lt;br&gt;RS latch, D FF, JK FF, binary counter&lt;br&gt;AH 7.6</td>
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<td>8</td>
<td><strong>Large-Scale IC (6)</strong>&lt;br&gt;CMOS logic and memory, flash memory, TTL-CMOS interfacing&lt;br&gt;HH 3, 9.1–9.14; MK 9, 14</td>
<td><strong>Position Sensors (9)</strong>&lt;br&gt;capacitance probe, LVDT, laser distance sensor, laser interferometer, optical encoder</td>
<td><strong>555 Timer and OP Amp</strong>&lt;br&gt;monostable and astable oscillators&lt;br&gt;HH 5.12–5.20</td>
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<td>9</td>
<td><strong>Specialty Sensors (9)</strong>&lt;br&gt;strain gauge, accelerometer, thermocouple, load cell, pyrometer&lt;br&gt;S 3–4</td>
<td><strong>Electromechanical Actuators (10)</strong>&lt;br&gt;voice-coil actuator, DC motor, PM motor, stepper motor&lt;br&gt;WM 4; BV 1, 3, 4–5; C 4–7</td>
<td><strong>Mid-Term Exam</strong>&lt;br&gt;12:40 PM–2:40 PM at TBA</td>
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<td>10</td>
<td><strong>Smart-Material Actuators (10)</strong>&lt;br&gt;piezoelectric, magnetostrictive, ionic-polymer actuators</td>
<td><strong>Analog Signal Processing (5)</strong>&lt;br&gt;voltage regulator, OP amps, differential amplifier, instrumentation amplifier, anti-aliasing filter, active filter&lt;br&gt;HH 2.15–2.25, 4, 5.1–5.11, 6–7</td>
<td><strong>Sensors and Actuators</strong>&lt;br&gt;interface with temperature sensor, IR (infrared) range sensor, and solenoid valve/relay</td>
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<td>11</td>
<td><strong>Analog Signal Processing (5)</strong>&lt;br&gt;low-frequency amplifiers, pulse-width modulation (PWM) amplifier, ground-loop elimination&lt;br&gt;AH 7.8–7.9; HH 15</td>
<td><strong>Discrete-Time Systems (FP 8)</strong>&lt;br&gt;difference equation, Z-Transform</td>
<td><strong>PWM</strong>&lt;br&gt;PWM, DC motor driving&lt;br&gt;AH 10.5</td>
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<td>12</td>
<td><strong>Digital Control (FP 8)</strong>&lt;br&gt;design by emulation, digital PID and lead-lag compensators</td>
<td><strong>Digital Control (FP 8)</strong>&lt;br&gt;root locus, zero-order-holder (ZOH) equivalence</td>
<td><strong>DC Motor Control</strong>&lt;br&gt;digital controller design and implementation</td>
</tr>
<tr>
<td>13</td>
<td><strong>Real-Time Control (FP 8)</strong>&lt;br&gt;real-time control implementation</td>
<td><strong>Mechatronic Systems (11)</strong>&lt;br&gt;precision design, interfacing, sensor mounting&lt;br&gt;S 1–2</td>
<td>No lab, Thanksgiving</td>
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<tr>
<td>14</td>
<td><strong>Mechatronic Systems (11)</strong>&lt;br&gt;control architecture, system integration&lt;br&gt;S 5, 7</td>
<td><strong>Term-Project Prep.</strong>&lt;br&gt;HH 12</td>
<td><strong>Term-Project Prep.</strong></td>
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</table>
MEEN 433/667  Mechatronics
Fall 2016
Instructor: Prof. Won-jong Kim

Questionnaire

Name:
Email address:
Phone number:
TAMU ID:
TAMU Department:
Are you a senior, a master’s student, or a doctoral student?
Advisor (if applicable):

Have you taken ECEN 215 (or equivalent)?                Yes.   No.
Have you taken MEEN 260 (or equivalent)?                Yes.   No.
Have you taken MEEN 364 (or equivalent)?                Yes.   No.

What would you like to learn from this course?

Will the course materials be useful for your research? If so, please tell me about your research briefly.