

# MECHATRONICS

Spring Semester 2015

- GOAL:** Provide a working familiarity of electronic devices and interfacing techniques. After completing this course, you should be better equipped to evaluate the relative merits of mechanical, electronic, and computational systems, and prepared to integrate such subsystems into effective mechatronic devices.
- PREREQUISITE:** Senior standing; or ME 586; or consent of instructor
- INSTRUCTOR:** Jeff Shelton  
E-mail: [shelton@purdue.edu](mailto:shelton@purdue.edu)  
Office Hours: By appointment or through e-mail (preferred)
- TEACHING ASSISTANT:** Manish Anand  
E-mail: [manand@purdue.edu](mailto:manand@purdue.edu)  
Office Hours: By appointment
- ORGANIZATION:** This class consists of lectures about major topics in mechatronics, and lab activities aimed at building basic professional competence. After completing seven lab exercises intended to develop fundamental skills, you will work on an open-ended project for the remainder of the semester. Much of this course involves collaborative efforts with classmates, and will be graded accordingly.
- DELIVERABLES:** To gain experience in fabricating small circuits, you will individually design and construct a printed circuit board (PCB) that implements a working “H-bridge.” Such circuits are used to control the speed and rotational direction of a DC motor. If you’ve not soldered before, you may find the “Soldering is Easy” comic (available online) to be a gentle introduction. Instructional videos will be provided to assist you in creating a circuit schematic, and in producing a functional PCB.
- In the first half of the course, you will work in small lab groups (usually 3 students) to complete seven lab exercises. Jointly prepared reports are to be submitted for each lab assignment. You will also submit an individually-prepared 3-page report that succinctly describes your recommended design concept for an autonomous vehicle that can address a proposed problem scenario.
- During the second half of the course, you will be part of a larger project team (usually 4 students) that designs, builds, and presents a functioning autonomous device to solve the problem scenario given to you earlier in the semester. Each project team is responsible for presenting interim progress reports to the class; you are expected to represent your team in making at least one such presentation.

Finally, a friendly competition will take place during the final week of classes, in which your team will demonstrate its device. Each project team is required to participate in the competition, make an oral presentation about their vehicle, and provide a written project report that documents their conceptual approaches (both successes and failures), prototypes, testing methods, and final design.

**EXAMINATION:** An open-book exam requiring the design and software coding of a finite-state machine to solve a sequential logic problem will be given mid-term. Exam re-grades must be requested in writing within one week after its original return date. There will be *no* make-up examinations.

**GRADING POLICY:** A total of 1000 points are available during the semester:

Final Project.....	400 pts (40%)
Lab Reports (7 @ 30 pts each).....	210 pts (21%)
Midterm Exam.....	130 pts (13%)
Instructor and Peer Evaluation .....	100 pts (10%)
Vehicle Concept Report .....	50 pts (05%)
Working H-Bridge.....	50 pts (05%)
Interim Progress Presentation.....	50 pts (05%)
Peer Evaluation Form (2 @ 5 pts each).....	10 pts (01%)
<b>TOTAL .....</b>	<b>1000 pts (100%)</b>

**COURSE WEBSITE:** The website URL is: <https://engineering.purdue.edu/ME588/>  
It contains the following:

- Syllabus:* An outline of the course content, which you are currently reading.
- Course Calendar:* Lecture and lab schedules, and report due dates.
- Course Notes:* PDF files containing the lecture material.
- Lab Material:* Lab instructions and related materials.
- Project Specification:* Information on final design project (posted in Week 3).
- Tutorials / User Manuals:* Information on hardware and software.
- FAQs:* Frequently asked questions and their answers.
- Links:* Sites you might find interesting.

Please visit this site *at least every other day* to check for announcements.

**BLACKBOARD:** The Blackboard URL is: <https://mycourses.purdue.edu>  
Blackboard will only be used to deliver announcements if the course website should become unavailable.

**LABS:** There are total of 7 structured labs in the first 8 weeks of the semester. They are designed to familiarize you with programming a microprocessor and designing basic interface electronics, digital logic, sequential logic, and handling digital/analog conversions. You will be working (mostly) in groups of three to complete the lab assignments.

The Mechatronics Laboratory is located in Room 1030 of the Mechanical Engineering Building. Lab stations are equipped with instruments and CAD software. All lab exercises should be carried out in ME 1030 during scheduled hours. Later in the semester, we *may* offer more open lab hours for your convenience. You are not to be in the lab without either the instructor or teaching assistant in the room.

*Pre-lab:* A pre-lab assignment is part of the structured labs, and is to be handed in at the *beginning* of the lab period. It will be graded and returned during the lab. This preliminary work constitutes 10% of your lab report grade.

*Lab Report:* Each lab group is responsible for turning in a lab report that documents the results of the lab, and demonstrates the deliverables in a concise and organized manner. Negative results are as important as positive results. However, do not focus on uncontrollable factors such as equipment, time constraints, or lab partners. Rather, emphasize lessons learned and potential means for reducing similar difficulties in the final project, and in future endeavors. *Please see the course site for additional instructions about the lab report format.*

#### VEHICLE CONCEPT:

A problem statement (describing the problem scenario to be addressed with your final project) will be provided during the third week of the semester. You will have two weeks to develop a three-page report that describes your recommendation for an autonomous vehicle capable of solving the specified scenario. You are encouraged to comment on issues such as vehicle behavior, control logic, power distribution, mechanical operation, sensor integration, etc. (Do not spend a lot of time developing sophisticated CAD models for this report; neatly drawn hand sketches are sufficient if you feel illustrations will help you convey your ideas.)

#### H-BRIDGE:

During the first half of the course, we will provide (or point you to) videos that describe the use of schematic layout software (such as Eagle or KiCad). It will be your job to design, fabricate, populate, test, and debug a printed circuit board (PCB) that implements a functioning H-bridge circuit prior to Week 8, when you will use your H-bridge in your lab exercise. A mechanical template (size and interface points) will be provided to you, so that everyone's circuit has the same mechanical interface (and can thus be interchanged on the final project vehicles.) Your finished PCB must be unique (and not a duplicate of someone else's design).

#### FINAL PROJECT:

Lab time during the final 7 weeks of the semester is set aside for constructing and testing a final project. Project teams (of approximately 4 students each) will collaborate in designing, building, testing, and reporting on, their final project. An evening of competition at the end of the semester provides an opportunity for you to demonstrate your work. It is strongly suggested that your team pick a name and a theme; past history suggests that this inspires both creativity and teamwork. The final project problem statement will be posted on the course website during the third week of class.

*Interim Progress Reports:* Each project team is responsible for making short presentations about the progress of their final project during the second half of the semester. These presentations will take place during normal lecture periods, with odd-numbered teams presenting on Tuesday and even-numbered teams presenting on

Thursday. You will be responsible for at least one of these presentations on behalf of your team. After making a 3–5 minute oral presentation, you will be asked to field questions from the audience.

A PowerPoint template for these interim reports can be found on the course website. While you are free to customize the provided template, you will be limited to three slides containing text: 1) an “introductory” slide with team information, 2) a “status” slide with current progress, and 3) a “future” slide that highlights changes your team will be making as the project moves forward. You may include additional slides that contain photographs, illustrations, or charts (but not text!). Following the oral presentation, the instructor and fellow class members may ask questions for another 3–5 minutes. Thus, the total duration of an interim progress report should be no more than ten minutes.

Your final score for the interim progress report will be based on 75% of your interim report score, and 25% on the average score of your teammates. Thus, you are encouraged to work with your team to ensure that all team members make presentations that are complete, concise, and well-planned. It is up to you and your team to decide the order in which each of you will make your interim presentation. (Tentative interim report dates are given below.)

It is not necessary that you attend a presentation period if you are not delivering an interim report. However, you may wish to show up to see what problems other teams have encountered, ask questions of teams that have solved problems that you are currently facing, and to support your teammates in making strong presentations.

*Final Project Report:* There is no length specification for the final report, but try to keep it concise. Your final project grade will consider *both* the final report and the presentation/demonstration. You are writing for two audiences: 1) readers who want to find out if your solution will solve a similar problem; and 2) readers who want to reproduce what you have done. The report should be in a standard engineering report format, including:

- *Title:* descriptive and short.
- *Abstract:* capsule description of what is in the report. (In many cases the title and abstract are published without the rest of the report, so they need to stand on their own.)
- *Introduction:* what you are trying to do and why; your choice of a solution method.
- *Body:* one or more sections describing how you solved the problem.
- *Results:* description of experiments done and data obtained.
- *Discussion:* relate the results to the objectives.
- *Conclusion:* succinct statement of what was accomplished and what to do next.
- *Appendices:* relevant material not needed by the average reader.

GROUP ASSIGNMENTS: You will be part of two groups during the semester. You will have *lab partners* during the first half of the semester, and you will have *project partners* during the second half of the semester. Your project partners *will not be* the same as your lab partners, and all group assignments will be made by the instructor. Except for unusual extenuating circumstances, all group assignments are final.

REFERENCES: [1] *Hands-On Electronics*, D.M. Kaplan and C.G. White, Cambridge University Press, 2003  
[2] *The Art of Electronics*, Horowitz and Hill, Cambridge Press.  
This is an excellent, all-purpose reference text for electronic applications.  
[3] *The Mechatronics Handbook*, CRC Press, 2002.  
[4] *Integrated Electrical and Electronic Engineering for Mechanical Engineers*, C. Fraser and J. Milne, McGraw-Hill, 1994.

LAB PERIODS: Room ME 1030D  
Tuesdays or Wednesdays, 2:30–5:20 pm  
January 20–April 29

LECTURES: Room ME 2053  
Tuesdays and Thursdays, 12:30–1:20 pm  
January 13–March 12  
(Additional lecture material to be provided online)

MID-TERM EXAM: Room ME 2053  
Thursdays, 12:30–1:20 pm  
March 12 (tentative)

INTERIM REPORTS: Room ME 2053  
Tuesdays and Thursdays 12:30–1:20 pm  
First Presentation: March 24<sup>th</sup> or 26<sup>th</sup>  
Second Presentation: March 31<sup>st</sup> or April 2<sup>nd</sup>  
Third Presentation: April 7<sup>th</sup> or 9<sup>th</sup>  
Fourth Presentation: April 14<sup>th</sup> or 16<sup>th</sup>

FINAL PRESENTATION: Room ME 1030D  
Thursday, 6:00 pm  
April 30, 2015 (tentative)

## MATERIAL LIST (PRICES NOT GUARANTEED):

Items need not be purchased from SparkFun Electronics; the listed part numbers and prices are simply provided for your convenience. However, try to obtain parts that are electrically and physically equivalent. Also, several versions of the Arduino microcontroller are currently available, so please verify that you are getting the “Uno R3” model.

Required Material	Location	Unit Price	Quantity	Cost
USB Cable (A-B connector)	<a href="http://www.sparkfun.com/products/512">http://www.sparkfun.com/products/512</a>	\$3.95	1	\$3.95
Arduino Uno R3 / Microcontroller	<a href="http://www.sparkfun.com/products/11021">http://www.sparkfun.com/products/11021</a>	\$24.95 for 1 \$22.46 for 10+	1	\$24.95
Arduino Software	<a href="http://arduino.cc/en/Main/Software">http://arduino.cc/en/Main/Software</a>	Free	1	\$0.00
<b>Total Cost</b>				<b>\$28.90</b>

Optional Material	Location	Unit Price	Quantity	Cost
Breadboard	<a href="http://www.sparkfun.com/products/112">http://www.sparkfun.com/products/112</a>	\$9.95 for 1 \$8.96 for 10+	1	\$9.95
Jumper wires	<a href="http://www.sparkfun.com/products/11026">http://www.sparkfun.com/products/11026</a>	\$4.95 for 1 \$4.46 for 10+	1	\$4.95
Wire Striper	<a href="http://www.sparkfun.com/products/8696">http://www.sparkfun.com/products/8696</a>	\$4.95 for 1 \$4.46 for 10+	1	\$4.95
DIP switch	<a href="http://www.sparkfun.com/products/8034">http://www.sparkfun.com/products/8034</a>	\$1.50 for 1 \$1.35 for 10+	1	\$1.50
NPN 2N3904 transistors	<a href="http://www.sparkfun.com/products/521">http://www.sparkfun.com/products/521</a>	\$0.50 for 1 \$0.45 for 10+	3	\$1.50
Potentiometer	<a href="http://www.sparkfun.com/products/9288">http://www.sparkfun.com/products/9288</a>	\$0.95 for 1 \$0.86 for 10+	1	\$0.95
Push buttons	<a href="http://www.sparkfun.com/products/9190">http://www.sparkfun.com/products/9190</a>	\$0.50 for 1 \$0.45 for 10+	2	\$1.00
LEDs	<a href="http://www.sparkfun.com/products/532">http://www.sparkfun.com/products/532</a> <a href="http://www.sparkfun.com/products/533">http://www.sparkfun.com/products/533</a> <a href="http://www.sparkfun.com/products/9650">http://www.sparkfun.com/products/9650</a>	\$0.35 for 1 \$0.32 for 10+	2 Green 2 Yellow 8 Red	\$4.20
<b>Total Cost</b>				<b>\$29.00</b>