CEE 375 — Sensors, Electrical Circuits, and Signal Processing

Winter 2022

Instructor:	Jeff Scruggs, 2060 GG Brown, `jscruggs@umich.edu`
GSI:	Connor Ligeikis, `ligeikis@umich.edu`
Class locations:	1045 GGBL (classes & exams), 113 GFL (labs)
Website:	`https://umich.instructure.com/courses/412458`
Class Times:	MW, 10:30-11:30, F 2:30-4:30
Office Hours:	JS: M 1-2 (in-person), Th 4-5 (Zoom) CL: Tu 4-5 (Zoom), W 1-2 (in-person)
Texts:	There is no required text.
Prerequisite:	Physics 240 (strongly recommended)
Grading:	Homework (20%), Labs (20%), Midterms (20% each), Final (20%)

Description

This course introduces students to the fundamentals of collecting and processing experimental data for civil and environmental applications. The course is comprised of an introduction to DC and AC circuits, as well as coverage of various sensors used in the civil and environmental engineering fields. Hands-on laboratory experiments are conducted, in which circuits are built to interface various sensors with a computer, and signal processing and coding techniques are used to collect and interpret sensor data.

Course Details & Requirements

- **Minimum technological requirements**
  - This class contains a significant laboratory component.
    - The labs will be conducted using a kit which will be provided to you. The kit contains various electronic components and devices.
    - The kit is the property of the UM CEE Department, and must be returned at the end of the semester to receive a grade in the class.
    - In addition to the items in the kit, various labs will require you to supply additional common household items, such as batteries.
  - You will need to have regular access to a computer, preferably a laptop.
    - We will make use of Matlab (Release 2020b or newer). Matlab software licenses for UM students are free. See the following link for details: `https://teamdynamix.umich.edu/TDClient/76/Portal/KB/ArticleDet?ID=5448`
    - We will make extensive use of the Arduino UNO, which is an integrated circuit that interfaces with your computer. This interface is established via a USB-A connector. Many computers have other types of USB ports, and you may need to purchase an adapter.
    - Usage of the Arduino UNO also requires that you install free software called the Arduino IDE, which can be downloaded from the link below: `https://www.arduino.cc/en/software`
    - Although the format for all classes and labs will be in-person, they will also be broadcast synchronously via the class Zoom channel. Lectures will also be recorded on Zoom, for later viewing. If you choose to engage with the course remotely or asynchronously, you will need reliable internet service and a computer with a working camera and microphone installed.
  - All assignments will be submitted electronically. It is assumed that you can create and upload computer screenshots, digital photos, and short (e.g., 5-10 second) videos.

- **Lecture format:**
  - Lectures will be delivered in-person in 1045 GGBL on each Monday and Wednesday, as indicated on the last page of this syllabus. There will also be lectures for the first two Fridays (January 7 and 14) in lieu of a lab.
  - Lectures will be synchronously broadcast over Zoom, for those who need to participate remotely. Access to the Zoom link is available from the class `CANVAS` page. Lectures will also be recorded on Zoom, for later viewing.
  - The format of each lecture will be slides (some typeset and some hand-written), with short 5-minute interactive activities interspersed.
  - Lecture slides will be made available on `CANVAS` one day prior to the lecture.
- **Homework format:**
  - Each lecture will have an assignment consisting of 1-2 homework problems. Each assignment will be posted on `CANVAS` the same day that its corresponding lecture slides are posted.
  - The homework assignments will be due at 10:30 AM (Eastern) on the days shown in the schedule at the end of this syllabus.
  - All homework should be submitted electronically in `CANVAS`.
  - Homework will be graded approximately one week after it is due.
  - Homework will be graded out of 100 points.
  - Solutions will be posted after the late submission window has ended (as described below).
- **Lab format:**
  - There will be 10 laboratory exercises, to be completed throughout the semester, as indicated in the schedule at the end of this syllabus. Each laboratory exercise will be posted on `CANVAS` one week prior to the date listed on the syllabus.
  - Each laboratory exercise will involve the use of various electrical equipment provided to each student in their individual lab kit. Some labs will require students to furnish a few extra pieces of common household equipment themselves, such as batteries, etc.
  - On Fridays from 2:30-4:30 during weeks when there is a lab assigned, the class will meet in 113 GFL to work on it. The GSI will be available in 113 GFL to help students complete the lab projects.
  - Simultaneously with the in-person lab time (i.e., Fridays from 2:30-4:30), the instructor will be available via Zoom to assist students choosing to work on their labs remotely.
  - Students are encouraged to start the labs earlier than the Friday lab time, so that they can come prepared with questions about things with which they are having difficulty.
  - There are no lab reports required, but each lab has certain deliverables that must be submitted on `CANVAS` for a grade. These deliverables often include data, computer code, computer screen shots, and camera videos.
  - The deliverables for each lab are due by 10:30 AM (Eastern) on the Monday immediately following the Friday lab date.
  - Labs will be graded out of 100 points.

- **Exam format**
  - Midterm exams will be given during the Friday lab period, on the days indicated on the syllabus.
  - The midterm exams will be conducted remotely, and will be timed. On the date of the midterm, it will be posted on `CANVAS` at 2:30PM (Eastern). Solutions are due by 4:30PM (Eastern) the same day. Solutions should be submitted electronically via `CANVAS`. Late submissions will not be accepted unless prior approval is obtained.
  - The final exam will be conducted remotely, and will be timed. On the date of the final (April 26), the exam will be posted on `CANVAS` at 1:30PM (Eastern). Solutions are due by 3:30PM (Eastern) the same day. Solutions should be submitted electronically via `CANVAS`. Late submissions will not be accepted unless prior approval is obtained.
  - All exams are open-notes, open-computer, and open-internet.
  - Collaboration of any kind is prohibited on all exams.
- **Late submission policy**
  - For all homework and lab assignments, students can submit late but will have points deducted, according to the following schedule:

    By 10:30 AM (Eastern) 1 day late : -10
    By 10:30 AM (Eastern) 2 days late : -25
    By 10:30 AM (Eastern) 3 days late : -50

    Late days exclude weekends and university holidays. So, for example, if an assignment is due Friday and you submit it at 2pm on Monday, 25 points will be deducted.
  - Assignments submitted later than 10:30 AM (Eastern) 3 days late will not be graded.
  - Sometimes students have unavoidable and unexpected health and/or family issues which prohibit them from being able to comply with homework deadlines. In such circumstances, we want to work with you but in order to be fair to the other students, we need proof that your claim is legitimate.
    * To receive an extension for medical reasons, you must comply with the all of the following:
      · Obtain a signed note from a doctor, dated on or prior to the due date, attesting that you have a medical issue that prevents you from being able to meet schoolwork deadlines and participate in exams.
      · Submit the note to Dr Scruggs. An emailed scan of the note is fine, as long as it is dated and signed. However, it is required that you submit this note to Dr Scruggs on or prior to the time the assignment is due or the exam takes place.
      · It probably goes without saying, but forging a doctor's note is a violation of the honor code, and suspected violations will be referred to the Engineering Honor Council.
    * To receive an extension for a family emergency, please speak to Dr Scruggs directly.
- **Letter Grades**
  - For a numerical grade X out of 100, the baseline letter grade is:

A	$X \geqslant 93$	C	$73 \leqslant X < 77$
A-	$90 \leqslant X < 93$	C-	$70 \leqslant X < 73$
B+	$87 \leqslant X < 90$	D+	$67 \leqslant X < 70$
B	$83 \leqslant X < 87$	D	$63 \leqslant X < 67$
B-	$80 \leqslant X < 83$	F	$X < 63$
C+	$77 \leqslant X < 80$		

- Individual assignments, labs, and exams are not curved. However, at the end of the semester, depending on the distribution of the class grades, the scale above may be curved downward. Absolutely NO predictions will be made about the curve.

- **Collaboration:**
  - Discussion and interaction with colleagues on the homework and lab assignments is permitted and encouraged. However, anything you turn in for this class should constitute your own work, and reflect your own understanding of the material. Wholesale copying of your friends' solutions and computer code is never permitted unless explicit permission is given as part of the assignment.
  - The submission of another person's intellectual effort on an exam is (obviously) prohibited.
  - Class content from past years is off-limits, unless this content is distributed by the instructor.
  - Students are encouraged to use the class Piazza forum, which is accessible through `CANVAS`, to interact with each other on the homework assignments. However, please do not post verbatim solutions. The instructor will periodically monitor the Piazza forum to answer questions and participate in discussions.
  - Violations of the above are violations of the Honor Code. Suspected violations will be taken up with the CoE Honor Council. The participation in such an activity, even if you are submitting your own work, is also a violation of the Honor Code. The text of the Engineering Honor Code is available at: `https://elc.engin.umich.edu/honor-council/`

- **Getting help**
  - The instructor and the GSI will each hold weekly office hours.
  - Both virtual and in-person office hours will be held. Times for these office hours are shown at the top of the first page of this syllabus.
  - You are strongly encouraged to take full advantage of these office hours, especially if you are having difficulties.
  - Please feel free to contact Dr Scruggs via email if you would like to schedule separate one-on-one office hours.

- **Disputing grades**
  - If you feel a homework assignment or exam has been graded incorrectly, please contact us. However, please begin the discussion with the person who actually did the grading. (Don't hesitate to ask who that is, if you're not sure.)
  - If the grader was the GSI and, and after discussing the matter with them you still feel confused about your grade, contact Dr Scruggs.
  - The letter grade you receive in the class is non-negotiable. However, a request to re-calculate the grade will be honored, if you feel a mistake has been made.

- **Learning Resources**
  - There are countless texts on circuits, all of which cover basically the same ground. Don't hesitate to "shop around" for one you like.
  - Here are a few textbooks available online from the UM Library:
    * Irwin, DA. Basic Engineering Circuit Analysis. (10th ed.). 2011. `https://search.lib.umich.edu/catalog/record/99187275216206381`
    * Navi, M. Schaum's Outlines: Electric Circuits. 2014. `https://search.lib.umich.edu/catalog/record/99187387140806381`

    - Powell, R. Introduction to Electric Circuits. 1995.
      https://search.lib.umich.edu/catalog/record/99187342555506381
    - Kumar, KSS. Electric Circuits and Networks. 2009.
      https://search.lib.umich.edu/catalog/record/99187293008506381
    - Shynk, JJ. Mathematical Foundations of Linear Circuits and Systems. 2016.
      https://search.lib.umich.edu/catalog/record/99187429235806381
- If you're old-fashioned and prefer physical books, some classic texts are those by Dorf or Nilsson.
- For learning more about sensor technologies, the following text is very useful:
    - Fraden, J. *Handbook of Modern Sensors*. 2010.
      https://search.lib.umich.edu/catalog/record/990169506880106381
- For learning more about Arduino hardware and programming, your best bet is to check out the Arduino website: https://www.arduino.cc/. There, you will find a language reference, tutorials, and lots of other resources.

Class schedule: (Tentative - Last updated 1/1/22)

#	Date	Lecture/Quiz Topic	Lab activity	Due*
1	Wed 1/5	Introduction		
2	Fri 1/7	Voltage and current		
3	Mon 1/10	Resistance		
4	Wed 1/12	Kirchhoff's laws		HW1
5	Fri 1/14	Equivalent resistance		HW2
	Mon 1/17	[No class (MLK)]		
6	Wed 1/19	Resistive circuits		HW3
7	Fri 1/21	-	Lab1: Resistive networks	HW4
8	Mon 1/24	Arduino overview		Lab1
9	Wed 1/26	Sensing - basic concepts		HW5
10	Fri 1/28	-	Lab2: Arduino orientation (part 1)	HW6
11	Mon 1/31	Analog-to-digital conversion		Lab2
12	Wed 2/2	Diodes		HW7
13	Fri 2/4	-	Lab3: Arduino orientation (part 2)	HW8
14	Mon 2/7	Transistors		Lab3
15	Wed 2/9	Operational amplifiers		HW9
16	Fri 2/11	-	Lab4: Light sensing	HW10
17	Mon 2/14	Op-amp circuits		Lab4
18	Wed 2/16	Instrumentation amplifiers		HW11
19	Fri 2/18	**Midterm 1**		
20	Mon 2/21	Resistive sensing		
21	Wed 2/23	Strain gauges		HW12
22	Fri 2/25	-	Lab5: Temperature sensing	HW13
	2/28-3/4	[Spring Break!]		
23	Mon 3/7	Inductors and capacitors		Lab5
24	Wed 3/9	RC/RL circuits		HW14
25	Fri 3/11	-	Lab6: Strain gauges	HW15
26	Mon 3/14	RLC circuits		Lab6
27	Wed 3/16	LC op-amp circuits		HW16
28	Fri 3/18	-	Lab7: Oscilloscope	HW17
29	Mon 3/21	Intro to AC circuits		Lab7
30	Wed 3/23	Phasor notation		HW18
31	Fri 3/25	**Midterm 2**		
32	Mon 3/28	Application of phasors to AC circuits		
33	Wed 3/30	Element impedance		HW19
34	Fri 4/1	-	Lab8: Piezoelectric vibration sensing	HW20
35	Mon 4/4	AC circuit analysis		Lab8
36	Wed 4/6	Op-amp filters		HW21
37	Fri 4/8	-	Lab9: Surface transducer	HW22
38	Mon 4/11	Accelerometer basics		Lab9
39	Wed 4/13	Survey of other sensors		HW23
40	Fri 4/15	-	Lab10: Accelerometers	HW24
41	Mon 4/18	Wrap-up		Lab10
	Wed 4/26	**Final Exam (1:30-3:30pm)**		

* All HW and Labs due by 10:30 AM Eastern, on the date shown.