**College of Engineering**

## 1. COURSE NAME AND NUMBER

M E 376 - Introduction to Mechatronics

## 2. CREDITS AND CONTACT HOURS

4 credits, 7 contact hours per week

## 3. CANVAS COURSE URL

https://canvas.wisc.edu/courses/374171

## 4. COURSE DESIGNATIONS AND ATTRIBUTES

None

## 5. MEETING TIME AND LOCATION

Lecture: M/W/F 8:50AM - 9:40AM, Location: 2121 Mechanical Engineering

Lab: T/TH 8:50AM - 10:50AM, Location: 2145 Mechanical Engineering

## 6. THE COURSE IS

Elective for the B.S. in Mechanical Engineering

## 7. INSTRUCTIONAL MODE

In person

## 8. CREDIT HOUR POLICY

### 8.1 How the course meets the credit hour policy

- This class meets for **three, 50-minute lectures** and **two, 2-hour labs each week** over the fall semester
- Some lab assignments takes only one lab section, and some may take longer
- The students are expected to work on extra course learning activities (e.g., reading assignments, homework, preparing for lab, studying, etc)

- The total amount of time that students are expected to spend on ME 376 study is **12 hours/week** (inside lecture/labs and outside), which well reflects the workload of a 4 credit course

### 8.2 Regular and Substantive Student-Instructor Interaction

- Regular interaction occurs weekly during scheduled **lecture hours** in addition to **scheduled lab times**, **attendance required (and graded).**
- Substantive Interaction is provided in the form of direct instruction, providing feedback on student work, instructor provided course content, and facilitation of course content discussion.

## 9. INSTRUCTORS AND TEACHING ASSISTANTS

### 9.1 Instructor Title and Name

**Lei Zhou, Ph.D.**

Assistant Professor in ME & ECE departments
lei.zhou@wisc.edu
Please write emails to me starting with **[ME 376]** in the caption which helps getting more timely response
Office hour: Wednesdays 9:40-11am, ME 2246

### 9.4 Teaching Assistants

**Bolun Zhang** bolun.zhang@wisc.edu
**Megh Doshi** megh.doshi@wisc.edu

TA Office hours: Thursday lab session time at ME 2145

## 10. OFFICIAL COURSE DESCRIPTION

Fundamentals of DC and AC circuit analysis and design, stressing tools needed to understand circuits typically used in instrumentation and control of physical systems (sensors/actuators); an introduction to the design of active and passive linear circuits for buffering and filtering signals; an introduction to digital circuits, Boolean logic, programming, especially as needed for computer interface operations in mechanical engineering applications (example: embedded microcontrollers). Laboratory exercises.

## 11. REQUISITES

- M E 340 or concurrent enrollment
- MATH 320, 319, or 376
- PHYSICS 202, 208, or 248 or graduate/professional standing

## 12. LEARNING OUTCOMES

### 12.1 Course Learning Outcomes

- Describe and mathematically represent circuit element properties and their analogies to mechanical systems.
- Apply Kirchoff's and Ohm's laws to design and analyze AC & DC circuits.
- Design and apply active and passive AC and DC circuits for instrumentation or control systems.

- Design and analyze signal conditioning circuits utilized in instrumentation or control systems.
- Write software to configure hardware, drive state machines, and control algorithms
- Utilize digital logic, computer interfaces, sensors, actuators, and programming approaches to solve mechanical engineering problems.
- Communicate with experts in the various disciplines associated with instrumentation of and computer control of machines and processes.

### 12.2 ABET Student Outcomes

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

3. an ability to communicate effectively with a range of audiences

5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives

6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions

7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

## 13. BRIEF LIST OF TOPICS TO BE COVERED

- Circuit Test/Analysis Tools
- AC/DC circuit analysis/design
- Op-amps for signal conditioning
- Transistor circuits
- Digital Signals/Boolean Logic
- Microcontroller interfaces / Digital I/O
- Analog to Digital and Digital to Analog Conversion
- Select High Level Computer Programming Language(s)
- Communication interfaces between processors.
- Actuators i.e. Motors
- Sensors i.e Position or Velocity
- Closed Loop Control

## 14. DISCUSSION SESSIONS

Selected weeks will have discussions during lecture time. No extra discussion sections arranged.

## 15. LABORATORY SESSIONS

Students are expected to perform in person lab exercises in partner groups and individually submit Canvas lab summary quizzes and homework assignments.

## 16. REQUIRED TEXTBOOK, SOFTWARE & OTHER COURSE MATERIALS

**Textbooks:**
**This course has three major texts:**

a) Introduction to Mechatronics and Measurement Systems 5th Ed. 2019 ISBN 978-1-259-89234
b) Alexander, Charles K. *Fundamentals of electric circuits*. McGraw-Hill,, 2013.

c) Patt, Yale N., and Sanjay J. Patel. "Introduction to Computing Systems; Bits & Gates to C C++ and Beyond." (2020).

You can purchase these books in paper copies, but not required.
**McGraw Hill Connect license, no extra cost aside from tuition. Registering MHConnect through our canvas course provide online e-book access.**
**This e-book will be used for readings and homework assignments.**

**Other references:**

- J. David Irwin and David V. Kerns, Essentials of Electrical and Computer Engineering, Pearson-Prentice Hall, 2004, ISBN# 0-13-923970-7
- Smaili and F. Mrad, Applied Mechatronics, Oxford University Press, 2008, ISBN# 978- 0-19-530702-3
- Agarwal, Anant, and Jeffrey H. Lang. Foundations of Analog and Digital Electronic Circuits. San Mateo, CA: Morgan Kaufmann Publishers, Elsevier, July 2005. ISBN: 9781558607354.
- Anant Agarwal. 6.002 Circuits and Electronics. Spring 2007. Massachusetts Institute of Technology: MIT OpenCourseWare, https://ocw.mit.edu . License: Creative Commons BY-NC-SA.

## 17. ASSESSMENTS

- **Homework assignments (20%)**
  - Weekly homework (~12 in total) and reading assignments will be assigned on Canvas
  - Due Thursdays end of the day. ***Late submission of homework within three days automatically receives a half grade*.**
  - Homework and reading assignments should be submitted electronically on Canvas/MHconnect.
  - No late submission will be accepted **after three days**. In rare cases such as medical/family emergency, late homework can be accepted after arranging with Instructor.

- **Midterm exam (15%)**
  - Midterm Exam - Tentative time: Oct 18th during lecture time
  - 50 minutes
  - Closed book, one page cheat sheet allowed, letter-size, front and back, hand-written only.

- **Attendance and Course Evaluation (5%)**
  - Each week there is a short survey to collect your feedback for the lecture and lab content. The completeness of these surveys consists of **3%** of total grade
  - The end-of-semester evaluation completeness will be counted towards grade, **2%**

- **Lab assignments (40%):**
  - This course has **weekly lab assignments**. The grade of lab assignments consists of **40% of the total score** for this course.
  - Groups of **two or three students** will work on the lab assignments together.
  - Attendance and participation of all lab assignments is required.
  - **If you miss three or more labs, you will automatically get an F for the course**
  - Missing labs for special reasons (sickness/emergency) must communicate with the instructor ahead of the time. No make up lab sessions will be held. Students in such circumstances may work on the lab alone without TA instructions and support.
  - All deliverables are to be submitted electronically via Canvas on the assigned due date.
  - Collaboration on lab activities and deliverables with other students is encouraged. However, all work submitted must be your own work – copying the work of others is considered to be academic dishonesty and will be dealt with accordingly.

- **Final Exam (20%)**:
  - Comprehensive final exam
  - 2 hours

- Open book, open note

- **Bonus point (5% max)**
  - In exams, there will be additional questions for bonus points. Correctly completing those problems earns you bonus points.
  - We will apply a “progress bonus” for in the final grading, mechanism TBD

- The final letter grade will be assigned using curved grading based on the grand average and standard deviation of the class (Note: the curving will not lower your grades)

| <60 | 60-70% | 70-75% | 75-80% | 80-87% | 87-94% | 94-100% |
|---|---|---|---|---|---|---|
| F | D | C | BC | B | AB | A |

**18. TENTATIVE COURSE SCHEDULE**

| Week | Monday (lecture) | Tuesday (lab) | Wednesday (lecture) | Thursday (lab) | Friday (lecture/discussion) |
|---|---|---|---|---|---|
| **1 9/6-9/8** | | | Lec 1: Introduction, KCL & KVL | Skip | Lec 2: resistive circuit analysis, node voltage |
| **2 9/11-9/15** | Lec 3: resistive circuit analysis continue: superposition/Thevenin | **Lab 1:** equipment lab | Lec 4: resistive network problems; introduction to sinusoidal steady state | Complete lab 1 | Lec 5: phasor and impedance |
| **3 9/18-9/22** | Lec 6: transfer functions, passive filter | **Lab 2:** resistive network | Lec 7: Bode plot | Complete lab 2 | Lec 8: operational amplifiers: model and amplifiers |
| **4 9/25-9/29** | Lec 9: more amplifier circuits, starting filters | **Lab 3:** passive filter lab | Lec 10: active filter continues | Complete lab 3 | Lec 11: Diodes (one-way valve) |
| **5 10/2-10/6** | Lec 12: Diode finishing; Intro to Transistors | **Lab 4:** Op-amp scaling/shifting | Lec 13: Transistor drive circuit | Complete lab 4 | Lec 14: Introduction to digital electronics |
| **6 10/9-10/13** | Lec 15: Introduction to Microcontrollers | **Lab 5:** Op-amp filtering | Lec 16: Discussion of micro controller, digital logic | Complete lab 5 | Lec 17: C-programming Fundamentals, data types |
| **7 10/16-10/20** | Lec 18: C-programing: functions | **Lab 6:** Transistor driving LED | Midterm Exam | complete lab 6 | Canceled due to advising day |

| | | | | | |
|---|---|---|---|---|---|
| **8 10/23-10/27** | Lec 20 In-circuit debugging on MCU | **Lab 7:** Digital latch | Lec 21: Ditigal IO, register, IO configuration | Complete lab 7 | Lec 22: discussion |
| **9 10/30-11/3** | Lec 23: Interupts, timers, counters, | **Lab 8:** In circuit debugging | Lec 24: Timing in programming application | Complete lab 8 | Lec 25: Data communications, serial/parallel |
| **10 11/6-11/10** | Lec 26: USART and SPI configurations | **Lab 9:** Digital I/O | Lec 27 Encoders, encoder counter, position sensors | Complete lab 9 | Lec 28 Communication Bus discussion, encoder discussion |
| **11 11/13-11/17** | ADC/DAC, Alliasing/Filtering | **Lab 10**: Interrupts & Timers Lab | PWM and H-bridges | Complete lab 10 | Read datasheet of ADC DAC |
| **12 11/20-11/24** | PWM problems, power electronics intro | **Lab 11**: USART & SPI lab | Discussions | Thanksgiving break | |
| **13 11/27-12/1** | Modeling of DC brushed motor | **Lab 12:** ADC/DAC Aliasing Lab | Intro to other electric machines | Complete lab 12 | Examples of motors |
| **14 12/4-12/8** | PID control and their physical meaning | **Lab 13:** Motor Velocity control lab | Digital realtime controller implementation | Complete lab 13 | State-of-the-art overview and further study/research opportunities |
| **15 12/11-12/13** | Final exam review | End-of-lab party | Last class day Final exam review | | |

**RULES, RIGHTS & RESPONSIBILITIES**

· See the Guide's to Rules, Rights and Responsibilities

**ACADEMIC CALENDAR & RELIGIOUS OBSERVANCES**

Academic Calendar & Religious Observances

Establishment of the academic calendar for the University of Wisconsin-Madison falls within the authority of the faculty as set forth in Faculty Policies and Procedures. Construction of the academic calendar is subject to various rules and laws prescribed by the Board of Regents, the Faculty Senate, State of Wisconsin and the federal government. For additional dates and deadlines for students, see the Office of the Registrar's pages. Students are responsible for notifying instructors within the first two weeks of classes about any need for flexibility due to religious observances.

## ACADEMIC INTEGRITY STATEMENT

By virtue of enrollment, each student agrees to uphold the high academic standards of the University of Wisconsin-Madison; academic misconduct is behavior that negatively impacts the integrity of the institution. Cheating, fabrication, plagiarism, unauthorized collaboration, and helping others commit these previously listed acts are examples of misconduct which may result in disciplinary action. Examples of disciplinary sanctions include, but are not limited to, failure on the assignment/course, written reprimand, disciplinary probation, suspension, or expulsion.

## ACCOMMODATIONS FOR STUDENTS WITH DISABILITIES

The University of Wisconsin-Madison supports the right of all enrolled students to a full and equal educational opportunity. The Americans with Disabilities Act (ADA), Wisconsin State Statute (36.12), and UW-Madison policy (UW-855) require the university to provide reasonable accommodations to students with disabilities to access and participate in its academic programs and educational services. Faculty and students share responsibility in the accommodation process. Students are expected to inform faculty of their need for instructional accommodations during the beginning of the semester, or as soon as possible after being approved for accommodations. Faculty will work either directly with the student or in coordination with the McBurney Center to provide reasonable instructional and course-related accommodations. Disability information, including instructional accommodations as part of a student's educational record, is confidential and protected under FERPA. (See: McBurney Disability Resource Center)

## COURSE EVALUATIONS

Students will be provided with an opportunity to evaluate their enrolled courses and their learning experience. Most instructors use AEFIS a digital course evaluation survey tool. In most instances, students receive an official email two weeks prior to the end of the semester, notifying them that anonymous course evaluations are available. Student participation is an integral component of course development, and confidential feedback is important. UW-Madison strongly encourages student participation in course evaluations.

## DIVERSITY & INCLUSION STATEMENT

Diversity is a source of strength, creativity, and innovation for UW-Madison. We value the contributions of each person and respect the profound ways their identity, culture, background, experience, status, abilities, and opinion enrich the university community. We commit ourselves to the pursuit of excellence in teaching, research, outreach, and diversity as inextricably linked goals. The University of Wisconsin-Madison fulfills its public mission by creating a welcoming and inclusive community for people from every background – people who as students, faculty, and staff serve Wisconsin and the world.

## MENTAL HEALTH AND WELL-BEING STATEMENT

Students often experience stressors that can impact both their academic experience and personal well-being. These may include mental health concerns, substance misuse, sexual or relationship violence, family circumstances, campus climate, financial matters, among others.

Students are encouraged to learn about and utilize UW-Madison's mental health services and/or other resources as needed. Visit uhs.wisc.edu or call University Health Services at (608) 265-5600 to learn more.

## PRIVACY OF STUDENT RECORDS & THE USE OF AUDIO RECORDED LECTURES STATEMENT

View more information about FERPA.

Lecture materials and recordings for this course are protected intellectual property at UW-Madison. Students in courses may use the materials and recordings for their personal use related to participation in class. Students may also take notes solely for their personal use. If a lecture is not already recorded, students are not authorized to record lectures without permission unless they are considered by the university to be a qualified student with a disability who has an approved accommodation that includes recording. [Regent Policy Document 4-1] Students may not copy or have lecture materials and recordings outside of class, including posting on internet sites or selling to commercial entities, with the exception of sharing copies of personal notes as a notetaker through the McBurney Disability Resource Center. Students are otherwise prohibited from providing or selling their personal notes to anyone else or being paid for taking notes by any person or commercial firm without the instructor's express written permission. Unauthorized use of these copyrighted lecture materials and recordings constitutes copyright infringement and may be addressed under the university's policies, UWS Chapters 14 and 17, governing student academic and non-academic misconduct.

## STUDENTS' RULES, RIGHTS & RESPONSIBILITIES

Rights & Responsibilities

## TEACHING & LEARNING DATA TRANSPARENCY STATEMENT

The privacy and security of faculty, staff and students' personal information is a top priority for UW-Madison. The university carefully reviews and vets all campus-supported digital tools used to support teaching and learning, to help support success through learning analytics, and to enable proctoring capabilities. View the university's full teaching and learning data transparency statement.