College of Engineering and Applied Science

Introduction to Sensors

EECE 5151/6051

Instructors:

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Fall 2024

August 26, 2024

Course Coordinators

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TA: TBD

Communication Policy:
You are encouraged to communicate with instructors in person, via email, or on Canvas throughout the course. Coordinating faculty and TA can be reached by email any time of the semester for general questions about the course including course policies, grading, learning progress, and any technical problems you may have on Canvas. Instructors will hold weekly office hours via *Zoom* during their instructional weeks. Please join the Zoom meetings and ask questions about course materials to the instructors. Individual in-person discussions are also available upon email appointment with instructors.

Course Welcome
Welcome to EECE-5151/6151 Introduction to Sensors, Fall 2024. This course is designed for graduate students and senior undergraduate students in engineering, as well as Industry 4.0/5.0 students who are interested in sensors and sensor technologies. It is offered as an asynchronous online course on Canvas this semester. In this course, we will provide a comprehensive overview of sensors and their applications for smart systems, internet of things (IoT), mobile networks, and healthcare. Fundamental principles and technologies for a variety of sensors will be introduced and discussed in this course, which includes design, analysis, implementation, signal conditioning, and instrumentation of sensors in engineering practices. Applications of electrical, physical, chemical and biomedical sensors for environmental monitoring, automobiles, aerospace, healthcare, IoT, etc. will be covered.

Due to the breadth of course content, this course is taught by multiple instructors on their topics of expertise. Please see the course schedule for more information.

Syllabus

Course Title: Introduction to Sensors

Course Number: EECE 5151/6051 **Semester**: Fall 2024

Course Description:
Introduction to sensor principles, design and implementation, signal conditioning, instrumentation and networking, and applications in engineering practice. Designed for CEAS students and students with STEM backgrounds.

Prerequisites: None

Course Credits: 3 credits

Office Hours (Online):
5:00 ~ 6:00 PM, every Thursday in *Zoom* (the meeting links will be provided later)

Special Needs Policy:
If you have a disability (e.g., visual impairment, hearing impairment, physical impairment, communication disorder, and/or specific learning disability, etc.) which may influence your performance in this course, you must meet with the Accessibility Resources Office to arrange for reasonable accommodations to ensure an equitable opportunity to meet all the requirements of this course. If you require accommodation due to your disability, please contact Accessibility Resources at 513-556-6823, Campus Location: 210 University Pavilion.

Textbook:
None. Use lecture notes uploaded on Canvas

Optional Materials:
- John Vetelino and Aravind Reghu, *Introduction to Sensors*, CRC press, 2017.
- Gerard Meijer, Kofi Makinwa, and Michiel Pertijs, *Smart Sensor Systems: Emerging Technologies and Applications*, Wiley, 2014.
- C. Karunakaran, et. al., *Biosensors and Bioelectronics*, Elsevier, 2015.

Course Objectives:
Students who successfully complete this course will be able to:
1. Illustrate the fundamental principles and concepts of sensor devices, technologies and systems.
2. Model the principles and concepts of sensors to healthcare, environmental monitoring, automobiles, aerospace, wireless communication, IoT applications.
3. Adapt mathematical and analytical tools for design and analysis of sensors.

Quizzes & Exams

Instructions: In Module 1, you are asked to write a short essay on a specific type of sensors you are interested in. From Module 2 to Module 6, you are required to complete short online quizzes in the middle of each Module. They are multiple-choice questions that can be quickly answered on Canvas about the concepts and principles of the sensors learned. At the end of each Module, there will be an exam that may require application of analytical tools and calculations to solve problems. Finally, there will be a final exam at the end of the semester.

Module	Assessment	Open in Canvas	Closes in Canvas
Module 1 (Cahay)	Essay writing	Beginning of Week 1 (Aug. 26, Mon.)	End of Week 2 (Sep. 8, Sun.)
Module 2 (Bahk)	Quiz #1	Beginning of Week 2 (Sep. 2, Mon.)	End of Week 2 (Sep. 8, Sun.)
	Quiz #2	Beginning of Week 3 (Sep. 9, Mon.)	End of Week 3, (Sep. 15, Sun.)
	Exam	Friday of Week 4 (Sep. 20)	End of Week 4 (Sep. 22, Sun.)
Module 3 (Li)	Quiz #1	Beginning of Week 5 (Sep. 23, Mon.)	End of Week 5 (Sep. 29, Sun.)
	Quiz #2	Beginning of Week 6 (Sep. 30, Mon.)	End of Week 6, (Oct. 6, Sun.)
	Exam	Friday of Week 7 (Oct. 11)	End of Week 7 (Oct. 13, Sun.)
Module 4 (Kim)	Quiz #1	Beginning of Week 8 (Oct. 14, Mon.)	End of Week 8 (Oct. 20, Sun.)
	Quiz #2	Beginning of Week 9 (Oct. 21, Mon.)	End of Week 9, (Oct. 27, Sun.)
	Exam	Friday of Week 10 (Nov. 1)	End of Week 10 (Nov. 3, Sun.)
Module 5 (Ahn)	Quiz #1	Beginning of Week 11 (Nov. 4, Mon.)	End of Week 11 (Nov. 17, Sun.)
	Exam	Friday of Week 12 (Nov. 1)	End of Week 12 (Nov. 3, Sun.)
Module 6 (Han)	Quiz #1	Beginning of Week 13 (Nov. 18, Mon.)	End of Week 13 (Nov. 24, Sun.)
	Exam	Friday of Week 15 (Dec. 6)	End of Week 15 (Dec. 8, Sun.)
	Final Exam	Beginning of Final Exam Week (Dec. 9, Mon.)	End of Final Exam Week (Dec. 14, Sat.)

Grading Policy

Method for Calculation of Course Grade

Assignment	Module 1	Module 2	Module 3	Module 4	Module 5	Module 6	Total
Essay Writing	10						10 (5%)
Quizzes/Exams		20 (5+5+10)	20 (5+5+10)	20 (5+5+10)	15 (5+10)	15 (5+10)	90 (45%)
Final Exam		20	20	20	20	20	100 (50%)
Total Points (Percentage)	**10 (5%)**	**40 (20%)**	**40 (20%)**	**40 (20%)**	**35 (17.5%)**	**35 (17.5%)**	**200 (100%)**

Grading Scale

Grade Center: All grades will be maintained in Canvas' online Grade Center. Students are responsible to track their progress by referring to the online grade book. Email me with any questions on this.

Grading will be curved as necessary for final grades.

Course Policies

Participation Policies: Students are expected to actively participate in the Canvas learning environment and to complete all assignments in a timely manner. Infrequent and inconsistent participation and work completion will reduce the benefits that may be obtained from the course as well as lead to a lower grade.

Make-Up Policy: Assignments are due by 11:59 PM of each due date**.** All quizzes and exams will be **automatically graded** on Canvas and the essay for Module 1 will be graded and returned **within 30 days**. If you have a SERIOUS problem that keeps you from participating on time and that can be documented and verified, please contact me immediately. I will determine if the seriousness of your problem warrants an exception to the late assignment rule. If you are not passing the class at any point due to missing work, you might be asked to drop the class.

You are responsible for timely assignment submission. Should your personal computer system or network go down, you must still turn in your work in a timely manner. Don't wait until the last minute. Plan ahead by seeking alternative means for submitting your work before you need to. Local libraries and the University of Cincinnati campuses can

serve as alternative resources. Not having access to the required software on your home or work computer is NOT a legitimate excuse for turning in assignments late.

Religious Accommodations Policy: As an asynchronous course, there are no required meeting times and thus, you should be able to schedule your work around religious holidays. However, the Ohio law and the University's Student Religious Accommodations for Courses Policy 1.3.7 permits a student, upon request, to be absent for reasons of faith or religious or spiritual belief system or participate in organized activities conducted under the auspices of a religious denomination, church, or other religious or spiritual organization and/or to receive alternative accommodations with regard to examinations and other course requirements due to an absence permitted for the above-described reasons. Not later than fourteen days after the first day of instruction in the course, you should provide me with written notice of the specific dates for which you request alternative accommodations. For additional information about this policy, please contact the Executive Director of the Office of Equal Opportunity and Access at (513) 556-5503 or oeohelp@UCMAIL.UC.EDU.

Academic Integrity Policy: The University Rules, including the Student Code of Conduct, and other policies of the department, college, and university related to academic integrity will be enforced. Any violation of these regulations, including acts of plagiarism, cheating, or falsifying field work will be dealt with according to the severity of the misconduct. Dishonesty in any form may result in a failing grade in a course and/or suspension or dismissal from a program (e.g., graduate or undergraduate).

Electronic Communication / Email Policy: Instructors can be reached via email and will try to respond to all emails within **12 hours**. If something is urgent, you can call the coordinating instructors at the numbers listed.

Students are required to use a University of Cincinnati email address for all academic activities. The purpose of this policy relates to issues of confidentiality and security and to ensure receipt of information from the University of Cincinnati and your individual college. Failure to check your UC email will not constitute a failure of communication on the part of the university, this college, or this program.

When posting on the discussion boards and using other communication tools such as chat it is important to understand how to interact with one another online, sometimes called

netiquette. A good rule of thumb is to write nothing online that you wouldn't be willing to say in person. You can read more about using proper netiquette here.

Diversity, Equity, and Inclusion Statement:
The University of Cincinnati is committed to an environment (on campus and online) of inclusive excellence. We are a community of diverse backgrounds and perspectives. We value your experiences and want to leverage them. We strive to provide an environment where everyone can explore, learn, engage, and be empowered without barriers, all while being treated with dignity and respect.
(Adapted from Equity, Inclusion, & Community Impact & College of Law Diversity Statement)

Notice of Non-Discrimination:
The University of Cincinnati does not discriminate on the basis of disability, race, color, religion, national origin, ancestry, medical condition, genetic information, marital status, parental status (including status as a foster parent), sex, age, sexual orientation, veteran status, military status (past, present, or future), or gender identity and expression in its programs and activities.

The university does not tolerate discrimination, harassment, or retaliation on these bases and takes steps to ensure that students, employees, and third parties are not subject to a hostile environment in University programs or activities.

Please review the UC Notice of Non-Discrimination for more information or to file a grievance.

Course Schedule, Fall 2024

Modules/Dates	Instructor	Topics
Module 1 Week 1 (08/26 – 08/30)	Marc Cahay	**A New Look at the Electromagnetic Spectrum / An Introduction to Quantum Dots and Infrared Photodetectors** • Intro to the Electromagnetic Spectrum • Quantum Dots • IR photodetectors using quantum dots • All Electric Spintronics using Quantum Point Contacts
Module 2 Weeks 2 – 4 (3 weeks) 09/02 – 09/20	Je-Hyeong Bahk	**Temperature and Electro-Optical Sensors** • Basics of sensors, smart sensors, and interface electronics • Contact and non-contact-based Temperature sensors • Electro-optical sensors/image sensors
Module 3 Weeks 5 – 7 (3 weeks) 09/23 – 10/11	Tao Li	**Physical Sensors and MEMS** • Introduction to physical sensors, parameters and characteristics • Principles of capacitive, piezoresistive, piezoelectric, and resonant transduction-based sensors • Pressure sensors / strain gauges and case studies: Capacitive / piezoresistive / other types, readout interfaces, etc. • Resonant mass sensors and case studies • Inertial sensors and case studies: Accelerometers and gyroscopes • Magnetic sensors

Module 4
 	
Weeks 8-10
(3 weeks)
10/14 – 11/01
	Yeongin Kim	**Sensors Based on Optics/Photonics**
		• Optical sensors based on intensity modulation:
		  ○ Nondispersive infrared gas sensors
		  ○ Photoplethysmogram for pulse sensors
		• Optical sensors based on phase modulation
		  ○ Fabry-Perot interferometers for distance sensors
		  ○ Sagnac interferometers for gyroscopes
		• Other mechanisms of optical sensors
		  ○ Bragg gratings for strain sensors
		  ○ Polarimeters for biochemical sensors
		  ○ Fluorescence for biosensors
		  ○ Surface plasmon resonance for biosensors

Module 5 Weeks 11-12 (2 weeks) 11/04 – 11/15	Chong Ahn	**Biosensors and Lab Chips** • Introduction to biosensors and lab chips • Biosensors and lab chips for immunodiagnostics (Protein analysis) • Lab chips for polymer chain reaction (PCR) (DNA analysis) • Healthcare system using smartphone with biosensors and lab chips

Modules/Dates	Instructor	Topics
Module 6 Weeks 13-15 11/18 – 12/06	Daewoo Han	**Module 6: Human Sensors** • Biofluids: Blood, Urine, Saliva, Sweat • Whole Blood, Plasma, Serum, RBC/WBC, Coagulation Process • Hormones & Neurotransmitters • Point-of-Care Testing o Lateral Flow Assays o Immunoassays w. Antibodies o Aptamer-based Assays o Commercial Examples
Final Exam Final exam week 12/09 – 12/14		Covers Modules 2 – 6.

****Unless otherwise specified, all assignments, quizzes, discussion board postings due by 11:59 PM (EDT) of specified date.**