



## BE/BME 447/547 Sensors & Controls (Fall 2021)

Lecture (live online wk 1-4; Social Sciences 100 wk 5 & beyond): WF 2-2:50 (all sections)  
Lab (in-person; Marley 218): M 1-3:30 (section A); M 3:30-6 (section B);  
W 11-1:30 (section C); W 3-5:30 (section D)

### Description of Course

Principles of electric circuits towards sensor and biosensor design and fabrication. Selection, interfacing and calibration of digital and analog sensors to measure physical, chemical, and biological variables. Optical and electrochemical biosensors. Advanced biosensors.

### Course Prerequisites or Co-requisites

Prerequisites: CHEM 151 & CHEM 152 (or equivalent)

### Instructor and Contact Information

Instructor: Jeong-Yeol Yoon, Professor, Marley 541J, [jyyoon@arizona.edu](mailto:jyyoon@arizona.edu)

TA's: Aditi Deshpande, [aditid@email.arizona.edu](mailto:aditid@email.arizona.edu) (section A)  
Avory Zhou, [4avoryz@email.arizona.edu](mailto:4avoryz@email.arizona.edu) (section B)  
Alexander Day, [alexanderday@email.arizona.edu](mailto:alexanderday@email.arizona.edu) (section C)  
Cassidy Mannier, [cmannier17@email.arizona.edu](mailto:cmannier17@email.arizona.edu) (section D)

Office hour of instructor and all TA's: F 3-3:50 (live online wk 1-4; Marley 541H wk 5 & beyond)

All course information can be found at D2L page.

### Course Format and Teaching Methods

Lecture (2 hours) + lab (3 hours). Group projects (term paper) towards the end of the semester. Lectures and office hours will be delivered live online via zoom for the first four weeks. This first four-week duration can be shortened or extended depending on the COVID-19 situation. Zoom links will be available at D2L. After this period, lectures and office hours will be back in person. Laboratories will be delivered in person throughout the semester.

### Mask Mandate

Face mask is REQUIRED for all in-person laboratories, lectures, and office hours, until further notice. See <https://covid19.arizona.edu/face-coverings> for details.

### Course Objectives

A typical sensor generates an electrical signal in response to a variable. Because of this, one needs to have some fundamental knowledge on electronics and circuitry in developing successful sensors. Modern sensors are now implementing DNA probes or antibodies to recognize other DNAs or antigens, which forms an exciting new area of biosensors. Topics related to advanced biological sciences also include optical fibers, fluorescence, pulse oximeter, immunosensors, lateral flow assays, glucose sensors, lab on a chip, and nano biosensors. Students will learn the principles of such sensors and biosensors through lectures and group activities. Hands-on laboratory exercises will also guide students to build such sensors and biosensors from the electric circuit level and to properly process sensor signals. 447H & 547 students will additionally learn the up-to-date research trends and advanced topics through additional activities described in the Assignments and Examinations section.

## **Expected Learning Outcomes**

Upon completion of the course, students will be able to: 1) set up career goals within biosystems- and biomedical-related professions; 2) gain professional skills (all students) and up-to-date research knowledge (447H & 547 only) to develop and apply a broad and cross-disciplinary approach to problem-solving; 3) gain skills to communicate effectively, function in teams, and develop social and ethical responsibility; 4) identify, formulate, and solve complex, and solve complex engineering problems by applying principles of engineering, science, and mathematics (all students) as well as up-to-date research (447H & 547 only); 5) apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors (all students), as well as needs from governmental funding agencies and industry (447H & 547 only); 6) develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions; 7) acquire and apply new knowledge as needed, using appropriate learning strategies (all students) and critical assessment of recent development (447H & 547 only).

## **Absence and Class Participation Policy**

A make-up exam or term paper presentation can be scheduled only when a student has a valid excuse and submits a written note made by a responsible person.

The UA's policy concerning Class Attendance, Participation, and Administrative Drops is available at: <http://catalog.arizona.edu/policy/class-attendance-participation-and-administrative-drop>

The UA policy regarding absences for any sincerely held religious belief, observance or practice will be accommodated where reasonable, <http://policy.arizona.edu/human-resources/religious-accommodation-policy>.

Absences pre-approved by the UA Dean of Students (or Dean Designee) will be honored. See: <https://policy.arizona.edu/employment-human-resources/attendance>

Participating in the course and attending lectures and other course events are vital to the learning process. As such, attendance is required at all lectures and discussion section meetings. Students who miss class due to illness or emergency are required to bring documentation from their health-care provider or other relevant, professional third parties. Failure to submit third-party documentation will result in unexcused absences.

## **Course Communications**

Official UA e-mail addresses described in Instructor and Contact Information as well as D2L.

## **Required Texts or Readings**

Required: Introduction to Biosensors: From Electric Circuits to Immunosensors, Second Edition, By Jeong-Yeon Yoon (Springer). ISBN 978-3-319-27411-9 (print) 978-3-319-27413-3 (online).

## **Required or Special Materials**

Special tools or supplies needed: calculator (for exams) and lab coat (for labs).

## **Assignments and Examinations: Schedule/Due Dates**

Lab reports with homework questions (individual reports): 20% (447) or 17.5% (447H & 547) of grade. Students will conduct experiments in teams (usually of two to four, depending on the nature of experiments). Individual lab report is still expected. Introduction, theory, materials and methods should not be included in a lab report. It should contain only results and discussion. Students also need to attach the answers to the questions in the textbook. Data interpretation, discussion, and answers to homework questions must be different among team members. Lab report is due one week after each lab exercise. Late lab report will be accepted with penalty (25% for each day that is late). Note: 447H & 547 students will conduct advanced versions of laboratory exercises throughout the semester.

Term paper (team effort): 20% of grade. A team presentation and a written proposal of soliciting new investment in starting a new biotech venture company (447) or a research grant proposal (447H & 547). For 447, extensive theoretical background is not required, but the feasibility as a profitable business model should be addressed. For 447H & 547, the research grant proposal must deliver original, novel research idea. Oral presentations are scheduled on 12/6 (sections A & B) and 12/8 (sections C & D) during the regular lab hours. Written term paper is due at the time of presentations.

Journal critique: 447H & 547 only. 10% of grade. 5-minute oral presentation of journal critique. Each 547 student will make two presentations over a semester, given at the beginning of Friday lecture.

Exam I: 20% (447) or 17.5% (447H & 547) of grade: 1-hr in-person closed book (first half)

Exam II: 20% (447) or 17.5% (447H & 547) of grade: 1-hr in-person closed book (second half)

Final exam: 20% (447) or 17.5% (447H & 547) of grade: 1-hr in-person open book (cumulative – all topics). Note: 447H & 547 students will have a different version of final exam, incorporating the materials from journal critiques, research grant proposal, and advanced versions of laboratory exercises.

## Grading Scale and Policies

447: Lab reports with homework questions 20%; Term paper 20%; Exam I 20%; Exam II 20%; Final exam 20%.

447H & 547: Lab reports with homework questions 17.5%; Term paper 20%; Exam I 17.5%; Exam II 17.5%; Final exam 17.5%.

Grades will be assigned on a curve.

University policy regarding grades and grading systems is available at  
<http://catalog.arizona.edu/policy/grades-and-grading-system>

**Requests for incomplete (I) or withdrawal (W)** must be made in accordance with University policies, which are available at

<http://catalog.arizona.edu/policy/grades-and-grading-system#incomplete> and

<http://catalog.arizona.edu/policy/grades-and-grading-system#Withdrawal> respectively.

## Scheduled Topics/Activities

Mon lab (sect. A/B)	Wed lab (sect. C/D)	Wed lecture (all)	Fri lecture (all)
08/23 No lab	08/25 No lab	08/25 Introduction	08/27 Circuit basics
08/30 Resistor	09/01 Resistor	09/01 Resistor	09/03 Diode/transistor
09/06 Labor day	09/08 Diode	09/08 Diode/transistor	09/10 Temp. sensor
09/13 Diode	09/15 Temp. sensor	09/15 Temp. sensor	09/17 Wheatstone
09/20 Temp. sensor	09/22 Wheatstone	09/22 Op-amp	09/24 Op-amp
09/27 Wheatstone	09/29 Op-amp	09/29 Light sensor	10/01 Light sensor
10/04 Op-amp	10/06 Photodiode	10/06 Spectrometry	10/08 Review
10/11 Photodiode	10/13 No lab	10/13 <b>Exam I</b>	10/15 Spectrometry
10/18 Spectrometry	10/20 Spectrometry	10/20 Fluorescence	10/22 Fluorescence
10/25 Fluorescence	10/27 Fluorescence	10/27 Electrochemical	10/29 Electrochemical
11/01 pH/ISE	11/03 pH/ISE	11/03 Glucose	11/05 Glucose
11/08 Glucose	11/10 Glucose	11/10 Immunosensor	11/12 Immunosensor
11/15 ELISA	11/17 ELISA	11/17 Lab on a chip	11/19 Lab on a chip
11/22 No lab	11/24 Thanksgiving	11/24 Thanksgiving	11/26 Thanksgiving
11/29 Paper LOC	12/01 Paper LOC	12/01 <b>Exam II</b>	12/03 Nanobiosensor
12/06 Term paper	12/08 Term paper	12/08 Advanced topics	12/10 <b>Final</b> (1pm)

## **Classroom Behavior Policy**

To foster a positive learning environment, students and instructors have a shared responsibility. We want a safe, welcoming, and inclusive environment where all of us feel comfortable with each other and where we can challenge ourselves to succeed. To that end, our focus is on the tasks at hand and not on extraneous activities (e.g., texting, chatting, reading a newspaper, making phone calls, web surfing, etc.).

Students are asked to refrain from disruptive conversations with people sitting around them during lecture. Students observed engaging in disruptive activity will be asked to cease this behavior. Those who continue to disrupt the class will be asked to leave lecture or discussion and may be reported to the Dean of Students.

## **Threatening Behavior Policy**

The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, including to oneself. See

<http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students>.

## **Accessibility and Accommodations**

Our goal in this classroom is that learning experiences be as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, please let me know immediately so that we can discuss options. You are also welcome to contact the Disability Resource Center (520-621-3268) to establish reasonable accommodations. For additional information on the Disability Resource Center and reasonable accommodations, please visit <http://drc.arizona.edu>.

If you have reasonable accommodations, please plan to meet with me by appointment or during office hours to discuss accommodations and how my course requirements and activities may impact your ability to fully participate.

Please be aware that the accessible table and chairs in this room should remain available for students who find that standard classroom seating is not usable.

## **Code of Academic Integrity**

Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work/exercises must be the product of independent effort unless otherwise instructed. Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog. See:

<http://deanofstudents.arizona.edu/academic-integrity/students/academic-integrity>.

The University Libraries have some excellent tips for avoiding plagiarism, available at <http://new.library.arizona.edu/research/citing/plagiarism>.

*Selling class notes and/or other course materials to other students or to a third party for resale is not permitted without the instructor's express written consent.* Violations to this and other course rules are subject to the Code of Academic Integrity and may result in course sanctions.

Additionally, students who use D2L or UA e-mail to sell or buy these copyrighted materials are subject to Code of Conduct Violations for misuse of student e-mail addresses. This conduct may also constitute copyright infringement.

## **UA Nondiscrimination and Anti-harassment Policy**

The University is committed to creating and maintaining an environment free of discrimination; see <http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy>

Our classroom is a place where everyone is encouraged to express well-formed opinions and their reasons for those opinions. We also want to create a tolerant and open environment where such opinions can be expressed without resorting to bullying or discrimination of others.

## **Additional Resources for Students**

UA Academic policies and procedures: <http://catalog.arizona.edu/policies>

Student Assistance and Advocacy information: <https://www.arizona.edu/academic-support>

## **Confidentiality of Student Records**

<https://www.registrar.arizona.edu/personal-information/family-educational-rights-and-privacy-act-1974-ferpa>

## **Subject to Change Statement**

Information contained in the course syllabus, other than the grade and absence policy, may be subject to change with advance notice, as deemed appropriate by the instructor.