



BME 499: Introduction to Biosensors and Diagnostics Devices for Healthcare Applications

Units: 4

Spring 2022—TBD two 110-minute sessions per week

Location: To be determined

Instructor: Maral Mousavi

Office: DRB 170

Office Hours: To be determined

Contact Info: Email: mousavi.maral@usc.edu;

Phone: (213) 821-1066; Emails will be replied to within 36 hours.

Class TA: TBD

Catalogue Description

With the current COVID19 pandemic, importance of efficient and accessible testing biosensing platforms is well-recognized. Indeed, biosensors are an integral part of healthcare, precision medicine, and personal health monitoring. The purpose of the course is to provide a broad introduction to biosensor technology, and describe working principles and fundamentals of biosensors. The class will review: (i) Biosensors classification, (ii) Bio-recognition elements in biosensors, (iii) integration of engineering and biology for design of biosensors, (iv) design of point-of-care biosensors. This course has emphasis on practical and translational knowledge and will utilize demonstrations and discussions to provide hands-on skills and critical thinking skills as well as theoretical knowledge (this is not a lab class, but we will meet in the lab for a few sessions to observe demonstrations and discuss experimental design). Students should be prepared to read journal articles and engage in discussions in class.

Learning Objectives, Specific Outcomes of Instruction, and Relationship to Program Outcomes

1. Learning objectives

- Be able to identify different classes of biosensors and describe their functioning principles
- Be able to recognize limitations of biosensors in real-life applications
- Be able to extend engineering principles to biosensor development
- Be able to extend engineering principles to design point-of-care biosensors
- Understand the principles and concepts of transducers and their application in biosensor design
- Understand fundamentals of diagnostic devices and biomarker testing in biological fluids
- Understanding the technical and societal factors involved in point-of-care diagnostics and wearable sensors
- Develop communication and team-working skills to be able to work in interdisciplinary biomedical teams

2. Course outcomes

- Outcome 1: Apply principles and concepts of biology and engineering to design biosensors
- Outcome 2: Apply principles and concepts of electronics and electrochemistry to design electrochemical biosensors
- Outcome 3: Recognize different types of transducers, and their application in biosensor design
- Outcome 4: Apply principles and concepts of sensing and engineering to (i) design biosensors for detection of markers in biofluids, and (ii) be able to evaluate quality of biosensors

- Outcome 5: Apply engineering tools to evaluate parameters needed for point-of-care health screening and mobile-health, and design of appropriate point-of-care diagnostic devices
- Outcome 6: Work in a team to design biosensors and identify applications

Prerequisite(s): None

Co-Requisite(s): None

Concurrent Enrollment: None

Recommended Preparation: Basic knowledge of biology (BISC220L or equivalent courses), physics (PHYS 152L or equivalent courses), and chemistry (CHEM 105 A or equivalent courses) required. Class open to second year, junior, and senior undergraduate students from BME, Chemical Engineering, Chemistry, and equivalent majors. Freshmen students should obtain instructor's permission before registering, and their registration will be permitted if they have the basic knowledge of chemistry and biology.

Textbook: None, lecture notes and assigned reading only.

Course Notes: This course is designed to introduce you to different aspects of biosensor design. Through homework assignments, exams, critical reading of primary literature, class presentations, and a collaborative project, students will learn design of biosensors. The timeline on which the material will be covered is provided below and is subject to change, at the instructor's discretion and the class progress.

Web page: A class website will be setup on Blackboard containing information about the course: syllabus, reading handouts, homework assignments, grades, information about class activities, solutions to the homework sets, and an email directory of all students in the class. Use it as much as you find it useful. The web page can be accessed at: <https://Blackboard.usc.edu>.

Office Hours: Time and location for office hours will be identified at the beginning of first session of the class. Students are encouraged to take advantage of office hours

Class Format and Grading Policy:

The final grade will be based on the following:

(1) Weekly Take-home Quizzes (50%)

After each session of class, a short quiz (consisting of 1–3 questions) will be posted to Blackboard. The quiz will gauge student's learning on content covered in the corresponding session of class (or sessions prior). The quizzes can ask conceptual questions, questions on assigned reading, or design/calculation questions. Each quiz is worth 10 points. Quizzes will be graded shortly after, and answer key will be posted. The class has no exams, and no homework separate from quizzes. Students should expect 25–30 quizzes.

Collaboration is permitted on quizzes; however copying is not. Collaboration is highly encouraged and includes discussions of concepts, exchange of information, and working together. Each student is responsible for individually preparing and fully understanding the work they submit. Review the university and course Integrity Policies (links below). They will be strictly enforced. This class has a no-tolerance policy on academic integrity violations – copying is a form of cheating.

All assignments should be submitted online through the Blackboard system. Submission via email will not be accepted.

Class has no late policy. Late submissions (even if it is by a minute) is not accepted under any circumstances, and will result in zero points received for that assignment. Students are responsible to allow sufficient time for uploading the files and submission. We recommend starting early and not leaving submission to the last minute. All cutoff time for submissions on 11:30 pm of the announced day.

All questions on homework should be posted to the appropriate discussion board on D2L. In submissions, show all work. All derivations must be included with symbols before numbers are “plugged in.” Units must accompany numerical results when applicable. Submission should cite all references used in the work. Failure to do so will result in losing points in the assignment.

Each student can void two quiz grades from the final grade calculations. It is recommended to leave this opportunity for emergencies.

(2) Journal Presentations (5%)

Each student will be asked to present a journal article relevant to class topics throughout the semester. Depending on number of students in class, journal presentations can be completed in pairs. There will be a 10 presentation, followed by 5 minutes of discussions in class. Articles will be posted to Blackboard and will be announced in class. Students will be offered opportunities to volunteer to present articles.

(3) Final Exam (25%)

(4) Class participation (5%)

Class participation includes attendance in lecture sessions and engagement in discussions class and answering of questions.

(5) Final project (15%)

- a. The goal of this final project is to cultivate team-working skills of the students, and provide an opportunity to exercise the theoretical knowledge gained in the classroom towards real-life medical problems. The project entails identifying an unmet medical need and designing a biosensor to address this need (using the knowledge gained in the classroom). Examples of such projects include: (i) Biosensor for monitoring liver injury at the point-of-care, (ii) Smart-phone compatible biosensor for management of food intake in patient’s suffering from chronic kidney disease
- b. Students will be asked to work in teams of 2-4 to complete the final project.
- c. The team should submit a written document (template will be provided) with appropriate citations, motivation of the work, proposed design, control experiments, and discussion about regulatory process for testing of the device. Each team will present the work in the classroom (10-15 minutes duration of presentation, no limitation on number of slides). One grade will be assigned to all the team members for their written report and oral presentation. All students are expected to contribute equally towards the final project. A one-page document stating individual contributions from each team-member should be submitted after the in-class presentations. A rubric for grading of final written report and oral presentation is provided (please see the Addendum).

Grading Breakdown

Grades will be based on the individual homework assignments and exams.

The weighting scheme for the final grade is below:

Quizzes	50%
Journal Presentation	5%
Class Participation	5%
Final Exam	25%
Final Project	15%

Total: 100%

Homework/Academic Integrity Policy

Students are expected to spend approximately six hours per week on readings and assignments. Students are expected to do their own homework assignments and should completely understand everything that they submit as their own. It is anticipated and expected that students consult one another for clarification of concepts, advice, to compare the final numerical homework solution, etc. It is not acceptable to show someone else your written homework, even if it is easier than explaining a concept verbally. You may also use whatever materials you find on the web, in other texts, or other sources to assist in preparing your homework. Also, copying homework prepared by another student and plagiarizing are strictly prohibited. Violations of this policy will result in an **automatic F** in the class and filing of an academic misconduct report to the Office of Student Conduct. All students are expected to adhere to the USC standards of Academic Integrity (<http://www.usc.edu/student-affairs/SJACS/docs/AcademicIntegrityOverview.pdf> and <http://www.usc.edu/student-affairs/SJACS/docs/GradIntegrity.pdf>).

Course Schedule: A Weekly Breakdown (this schedule is tentative and subject to change)

	Topics Covered
Week 1	Discussions on class structure, grading, exams, final project Introduction to biosensors Biosensor classification, Main elements in biosensors Characteristics of signals
Week 2	Review of chemical structure Biomolecules in biosensors: DNA, enzyme, antibody, antigen, protein, peptide, aptamer of biomolecules and their characteristics in biosensors Biomolecules in biosensors continued, Amplification Techniques (PCR), ELISA (enzyme-linked immunosorbent assay)
Week 3	Overview on basics of detection methods: Fluorescence Spectroscopy, UV-Vis Absorption and Emission, Surface Plasmon Resonance, Magnetic labeling Introduction to electrochemical detection methods, redox processes, and electron transfer
Week 4	Electrochemical cells for measurements, processes at electrode surface, and mass transport of material to the electrode surface Active DC electrochemical techniques: voltammetry and amperometry, Journal club presentation by students, In Lab demonstration of techniques
Week 5	Active DC electrochemical techniques, immobilized enzyme-electrodes Review on Enzyme Kinetics, Journal Club Presentation In lab demonstration of enzymatic biosensor
Week 6	Potentiometry for small molecule and ion detection Impedimetric detection, Journal Review Nanowires in electrochemical detection
Week 7	Basics of microfluidics, journal club presentations Integration of microfluidics with healthcare applications
Week 8	Paper-based microfluidics Point-of-care sensing
Week 9	In lab demonstration of paper-based microfluidics Enzymatic colorimetric biosensors and lateral flow assays
Week 10	Fluorescence biosensors Colorimetric biosensors, Journal Review

Week 11	Magnetic Sensors and labeling, Journal presentation In-lab demonstration of colorimetric and fluorescence biosensors
Week 12	Detection of viruses Detection of bacteria
Week 13	COVID-19 point-of-care testing, review on technologies Regulation of medical devices and entrepreneurship
Week 14	Wearable devices, design considerations, detection methods, medical applications
Week 15	Presentations of Final Project by Students and in class discussion Class Evaluation
Final's Week	Exam II (Cumulative)

Statement on Academic Conduct and Support Systems

Academic Conduct:

Plagiarism – presenting someone else’s ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, “Behavior Violating University Standards” policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, policy.usc.edu/scientific-misconduct.

Support Systems:

Counseling and Mental Health - (213) 740-9355 – 24/7 on call

studenthealth.usc.edu/counseling

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call

suicidepreventionlifeline.org

Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-9355(WELL), press “0” after hours – 24/7 on call

studenthealth.usc.edu/sexual-assault

Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED) - (213) 740-5086 | Title IX – (213) 821-8298

equity.usc.edu, titleix.usc.edu

Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

Reporting Incidents of Bias or Harassment - (213) 740-5086 or (213) 821-8298

usc-advocate.symplicity.com/care_report

Avenue to report incidents of bias, hate crimes, and microaggressions to the Office of Equity and Diversity | Title IX for appropriate investigation, supportive measures, and response.

The Office of Disability Services and Programs - (213) 740-0776

dsp.usc.edu

Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

USC Campus Support and Intervention - (213) 821-4710

campussupport.usc.edu

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity at USC - (213) 740-2101

diversity.usc.edu

Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call

dps.usc.edu, emergency.usc.edu

Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call

dps.usc.edu

Non-emergency assistance or information.

Addendum

Scoring Rubric for Oral Presentations

Category	Scoring Criteria	Total Points	Score
Organization (15 points)	Information is presented in a logical sequence.	10	
	Presentation appropriately cites requisite number of references.	5	
Content (65 points)	The motivation of the work is clearly explained.	15	
	Technical terms are well-defined.	5	
	Presentation contains accurate information.	10	
	Material included is relevant to the overall goal of the project.	5	
	Methodology is clearly explained.	15	
	Conclusion summarizes the key point of the work.	5	
	Length of presentation is within the assigned time limits.	10	
Presentation (20 points)	Speaker maintains good eye contact with the audience and is appropriately animated (e.g., gestures, moving around, etc.).	5	
	Speaker uses a clear, audible voice.	5	
	Visual aids are well prepared, informative, effective, and not distracting.	10	
Score	Total Points	100	

Scoring Rubric for Written Report

Category	Scoring Criteria	Total Points	Score
Introduction (45 points)	Motivation of the work is presented clearly.	10	
	Prior work is clearly explained and cited.	15	
	Gaps in the literature are explained.	10	
	Proposed method and element of novelty is explained clearly.	10	
Discussions (30 points)	Details of proposed method is explained.	10	
	Control experiments are discussed.	5	
	Design and fabrication are depicted using illustrations and figures.	10	
	Appropriateness of the proposed approach and to the medical need is discussed.	5	
Conclusion (10 points)	The key findings in the proposed approach are summarized.	5	
	Advantages and disadvantages of the proposed approach are discussed.	5	
Grammar and Writing (15 points)	Writing is grammatically correct.	5	
	Words have correct spelling.	5	
	Writing is simple and understandable and avoids use of unnecessary jargon and complicated wording.	5	
Score	Total Points	100	