



EE599: Flexible and Stretchable Bioelectronics

Units: 4

Fall 2022 – Mon/Wed: 12:00-1:50 PM

Location: TBA

Instructor: Yasser Khan

Office: MCB270D

Office Hours: Mon/Wed: 2:00 PM - 3:00 PM

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Course Description

Bioelectronics is the discipline resulting from the convergence of biology and electronics. Exciting developments in the field of soft electronics and miniaturized integrated circuits in the past three decades have added a new dimension to bioelectronics -- we now can design sensor and actuator systems that are as soft as the biological matter, and as small as the size of human fingertips.

In this graduate-level introductory class, students will learn about the exciting new developments in the field of flexible and stretchable wearables, implantable, and ingestible medical devices. Starting from biochemical and biophysical concepts and methods, materials, fabrication, device, and sensor design for bioelectronics will be presented. Materials/form factor design will be addressed from the perspective of new concepts in bioelectronics for multimodal wearable patches and implanted probes for diagnostic and therapeutic applications. The course will include two problem sets, a final exam, and a group project on current leading-edge research topics in bioelectronics.

Learning Objectives

By the end of this semester, students should be able to:

- Understand biophysical and biochemical concepts in bioelectronics.
- Specifications for the design of sensor instrumentation and electrochemical sensor interfaces.
- Design simple bioelectric systems such as amplifier and filtering systems.
- Familiar with the core concepts associated with materials design and fabrication of flexible and stretchable bioelectronics.
- Design and implement a bioelectronic system for given specifications.

Prerequisite(s): Electronic device and circuit concepts and basic understanding of biomaterials or physiology is helpful.

Co-Requisite(s): None

Recommended Preparation: Recommended, but not needed. EE202L, EE338, EE109L.

Course Notes

All lecture notes, assignments, and any suggested additional reading for this class, will be posted on the Blackboard site.

Technological Proficiency and Hardware/Software Required

Should have programming experience in Python or C/C++, also a familiarity with PCB designing software such as Eagle or KiCad, or Altium is preferred.

Required Readings and Supplementary Materials

There are no required textbooks for this class, although the following are recommended references:

- Willner, Itamar, and Eugenio Katz, eds. *Bioelectronics: From Theory to Applications*. John Wiley & Sons, 2006.
- Webster, John G., ed. *Medical Instrumentation: Application and Design*. John Wiley & Sons, 2009.
- Rogers, John A., Roozbeh Ghaffari, and Dae-Hyeong Kim, eds. *Stretchable Bioelectronics for Medical Devices and Systems*. Switzerland: Springer, 2016.

Description and Assessment of Assignments

There will be 2 problem sets. These will assess the basic concepts covered in class. Problem sets will be mostly math, chemistry, and design problems. Assignments should be handed in before the lecture on the day they are due. Late assignments will be penalized at a 10% credit reduction per day except with a medical excuse. The bulk of the assessment will be done through a design project and the final exam. In the design project, students in teams will work on designing and implementing a bioelectronic wearable, implantable, or ingestible medical device. Student teams of 4 students should discuss the project with the instructor starting in week 1. One example project can be a set of sensors that classify objects using a robotics arm. A project proposal and mid-presentation are due on week 7. The final project presentation and report will be due on week 15. A comprehensive final will be held at the end of the semester.

Grading Breakdown

Assessment Tool (assignments)	% of Grade
Problem Sets	20
Project	40
Final	40
TOTAL	100

Course Schedule: A Weekly Breakdown

Course website: <https://khan.usc.edu/protected/bioelectronics/>

Password:

	Readings/Preparation		Deliverables
Week 1 8/22 and 8/24	Introduction to the class and projects		
Week 2 8/29 and 8/31	Design of bioelectronic systems Flexible and stretchable materials 1		Project proposal part a: mention team members and their skillset.
Week 3 9/7	Flexible and stretchable materials 2		Project proposal part b: 2-page literature review on the proposed project.
Week 4 9/12 and 9/14	Fabrication of bioelectronics		Project proposal part c: Design considerations for the proposed bioelectronic device or system. 2-page report that includes system design.
Week 5 9/19 and 9/21	Printing of bioelectronics		
Week 6 9/26 and 9/28	Principles of biosensing		Project proposal part d: Schematic design, bill of materials, and design file submission for PCB fabrication.
Week 7 10/3 and 10/5	Sensor instrumentation		Project proposal presentations. Each team will present 15 mins on the proposed topic.
Week 8 10/10 and 10/12	Lab: stretchable capacitive sensor array fabrication	PS1 out	
Week 9 10/17 and 10/19	State-of-the-are bioelectronics		PS1 due
Week 10 10/24 and 10/26	Cell and chemical concepts Biophysics 1		Project update report: 2-page on the current status of the project.

Week 11 10/31 and 11/2	Biophysics 2 Spectroscopy		
Week 12 11/7 and 11/9	Electrochemistry Microfluidics	PS2 out	
Week 13 11/14 and 11/16	Power and packaging		PS2 due Project update report: 4-page summary on design validation and data collection.
Week 14 11/21	FDA and ethical consideration		
Week 15 11/28 and 11/30	Project presentations and demos		Final project report (10-page) and 30-min presentations from each group
FINAL			Refer to the final exam schedule in the USC Schedule of Classes at classes.usc.edu .

All reports should be single spaced, with 1" margins. Please include necessary charts and diagrams in the reports.

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 [Research and Scholarship Misconduct](#).

Students and Disability Accommodations:

USC welcomes students with disabilities into all of the University’s educational programs. The Office of Student Accessibility Services (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as

accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu.

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 for Equity, Equal Opportunity, and Title IX (EEO-TIX) - (213) 740-5086

eeotix.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.symplcity.com/care_report

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

The Office of Student Accessibility Services (OSAS) - (213) 740-0776

osas.usc.edu

OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

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, Equity and Inclusion - (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.

Office of the Ombuds - (213) 821-9556 (UPC) / (323-442-0382 (HSC)
ombuds.usc.edu

A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

Occupational Therapy Faculty Practice - (323) 442-3340 or otfp@med.usc.edu
chan.usc.edu/otfp

Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.