BME 405L
Senior Projects: Measurements and Instrumentation
Application of instrumentation and measurement techniques to biomedical engineering involving measurement, replacement or augmentation of biomedical systems. (4.0 units).

Fall 2024.
Lecture.   Tuesdays AND Thursdays, DMC 211, 11 AM to 12:20 PM.
Lab.   Monday OR Tuesdays, DRB 351, 2 PM to 4:50 PM

Instructor: John Mai, PhD.
Contact: johnmai@usc.edu
Office: DRB 174
Office hours: I am available in the back of the classroom during the lab sessions (Monday & Tuesdays 2PM to 4:50PM). Also available by appointment on Tuesdays and Thursdays.

Teaching Assistant: Trent Benedick
Contact: benedick@usc.edu

Syllabus

BME 405L is about learning to design and build a prototype of a biomedical device or test system that others can use for assessing diseases and patients, monitoring living functions and wellness, or for therapy and rehabilitation. In doing so, you will learn to apply the engineering design process and practice coding in high-level modern apps and/or Arduino C/C++ to read data from external sensors, process the data, present them to users, and create archival records.

Learning Objectives

At the completion of BME 405L, you will be able to integrate knowledge and skills you acquired in your BME studies to conceive, design, and build a minimum viable prototype of a biomedical device following an approach similar to that used by engineers in industry. You will consider the needs of potential users and how the users interact with your device. You will design the device to match these needs and modes of interactions. After the device is designed, you will build a working prototype. Many students before you have used their BME 405 project as a sample of their work when applying for internships and jobs.

At the end of this course, you should be able to
1. Describe and explain the steps of the engineering design process
2. Apply the use case method to establish design requirements for an engineered system
3. Design software applications using standard programming techniques, clear documentation, and code validation
4. Design and document a biomedical prototype involving signal measurement, data analysis, and a human-computer interface, considering the needs of its users, and the application and implications of engineering standards
5. Function effectively in a team of student engineers during a semester-long project

6. Integrate knowledge and skills acquired in previous courses and through independent research for the development of your senior project

Course Organization

This class is structured in an inverted (flipped) instructional model. You will watch short videos outside of class that present essential concepts of high-level programming and of the engineering design process. In class, you will practice programming and experimenting with steps of engineering design to develop your skills and solidify your understanding of what you discover in the video lessons. You will gain the largest benefits from this course if you keep up with the video lessons, practice doing the exercises in class, and submit all the completed assignments on time.

All course materials (syllabus, lecture slides, homework assignments, etc.) will be available through Brightspace (https://brightspace.usc.edu/d2l/home). This includes copies of lecture slides. I will also include links to relevant technical videos.

Lab Organization

Lab 1 is a workshop on brainstorming about unmet biomedical needs, nucleating project ideas, and outlining a practical use-case storyboard.
Labs 2 – 4 help you become familiar with the Adafruit Feather microcontroller, which you program for data acquisition, digital I/O, digital control of sensors, and data transfer to a PC for analysis, display, and storage.
Thereafter, you will work on your project as part of a team of student engineers, designing, building, and testing a concept prototype of your device to demonstrate its usefulness to its users.

Course Policies

1. You are part of a project team. It is highly recommended to attend every lecture and lab in order to not let your team down. Furthermore, the final project report requires a table listing the contributions of each team member.
2. Attribute and document all non-original ideas or solutions. This course will mimic the commercial environment. In class you are encouraged to use digital resources to verify ideas and suggestions in real-time. However, if you decide to use a solution you find on the internet, you are expected to document and attribute the source.
3. You will receive credit for each homework assignment you turn in by the due date. For the labs, you can receive up to 50% credit even if you turn in the assignment late.
4. This course encourages practical experimentation. As such, mistakes will be made and this is part of the learning process.
5. Respect for your classmates and everyone else during the class discussions is very important for the team-building environment of this course. You will discuss how your project group will operate during the teamwork workshop to setup mutually-agreeable ground rules between everyone in your project team.

Policy on Use of Artificial Intelligence (AI) in this Course
In this course, you **are** permitted to use artificial intelligence (AI)-powered programs to help you with assignments and your project. <u>You MUST explicitly acknowledge when you use AI in course assignments</u>. However:

(1) You should also be aware that AI text generation tools may present incorrect information, biased responses, and incomplete analyses; thus these tools are not yet sufficiently advanced to produce text that meets the standards of this course. You are responsible for ensuring the accuracy and completeness of any materials that you submit for the course.
(2) To adhere to our university values, **you must cite any AI-generated material (e.g., text, images, and other content) included or referenced in your work and provide the prompts used to generate the content.** Using an AI tool to generate content without proper attribution will be treated as plagiarism and reported to the Office of Academic Integrity.

Tentative Weekly Lecture and Lab Schedule.

Week	Topics	Labs/Readings/Prep	Deliverables
1	Intro. Overview. Unmet Needs; Engineering Design Process.	Lab 1. Getting to know each other.	1. Class brainstorming about unmet needs.
2	Unmet Needs. From Problem Definition to Product Requirements. Minimum Viable Prototype (MVP).	Lab 2. Arduino 1. Guest Expert 1 Q&A Guest Expert 2 Q&A	HW1 Assigned. Interests and skills survey to assign teams.
3	Example 1. Unmet Needs to Features to Product Specifications to MVP.	Lab 3. Arduino 2.	HW1. Due and teams assigned. HW2. Assigned.
4	Product Tear Down 1. FDA Regulatory Overview. 510(k) predicate device.	Lab 4. Particle Argon 1.	HW2. Team presentations of unmet needs and use case scenario.
5	Product Tear Down 2. Engineering Standards, Design Controls and ISO 13485	Checking in with Experts	Team Project Task 1. MVP specifications and bill-of-materials.
6	Group Projects. Use Case Scenarios and MVPs. Sensors Part 1		Team Project Task 2. Assigned. Preliminary Design Review
7	Group Projects. PDR overview. Sensors + Integration.		Team Project Task 3. PDR presentations.
8	Project Management	Midterm Exam (tentative)	
9	Team troubleshooting 1. Electronics and noise		
10	Team troubleshooting 2. Signal processing		
11	Feedback from PDRs, Part 1		
12	Feedback from PDRs, Part 2.		
13	Extra Lab time 1		Team Project Task 3. Video update on status of MVP.
14	Extra Lab time 2		
15	Final Presentations		Team Project Task 4 and 5. Final Oral Presentations. Final Written Report.
FINAL			

Note. Due to University holidays or scheduling of Guest, this schedule may be modified during the semester. Changes to the schedule will be posted on Brightspace as early as possible.

Grading Breakdown and Summary

Assignment	Points	Percent of Grade
Labs (3 activities)	100	10
Exams	200	20
Project	600	60
Homework and in-class quizzes	100	10
Total		100%

Addendum
HW1 = 10 points
HW 2 individual = 50 points
HW 2 group = 40 points.

Description and Assessment of Assignments

<u>Homework</u> (100 points total):

The purpose of the homework is to keep your projects on track. You can use more detailed revisions of your homework for your final project report. Homework will be periodically assigned and the grading rubric will be included with the instructions for the homework.

Assignments are due on the specified date at the beginning of class.

<u>Labs</u> (100 points total):

Exam (200 points) There is a midterm OR final exam for this course.

<u>Project</u> (600 points total):

For your project, your team will submit two detailed written reports and give two oral presentations over the semester. The team submission will be graded using a detailed rubric which I will share with you. Project-related parts will be purchased for each team.

<u>Final exam</u>
A final exam will cover the lecture topics covered throughout the semester and will be assigned and due in the designated timeslot of the final week. If there is a documented illness or emergency, the student can request some accommodation.

<u>Additional Policies</u>

Late homework will only be accepted in cases of documented illness or emergency, and permission should be obtained from the instructor **before** the deadline. Otherwise, points will be <u>reduced by 25% per day past the deadline</u>.
All inquiries regarding graded homework or exams are due within one week of their return to the students. The requester must type or write clearly an explanation for the regrade and submit it to instructor with the original assignment.

Course Schedule.

An updated course schedule will be posted on Blackboard by the 3rd week of this semester.
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 and 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. The university prohibits discrimination or harassment based on the following *protected characteristics*: race, color, national origin, ancestry, religion, sex, gender, gender identity, gender expression, sexual orientation, age, physical disability, medical condition, mental disability, marital status, pregnancy, veteran status, genetic information, and any other characteristic which may be specified in applicable laws and governmental regulations. The university also prohibits sexual assault, non-consensual sexual contact, sexual misconduct, intimate partner violence, stalking, malicious dissuasion, retaliation, and violation of interim measures.

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 Support and Advocacy - (213) 821-4710
uscsa.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.