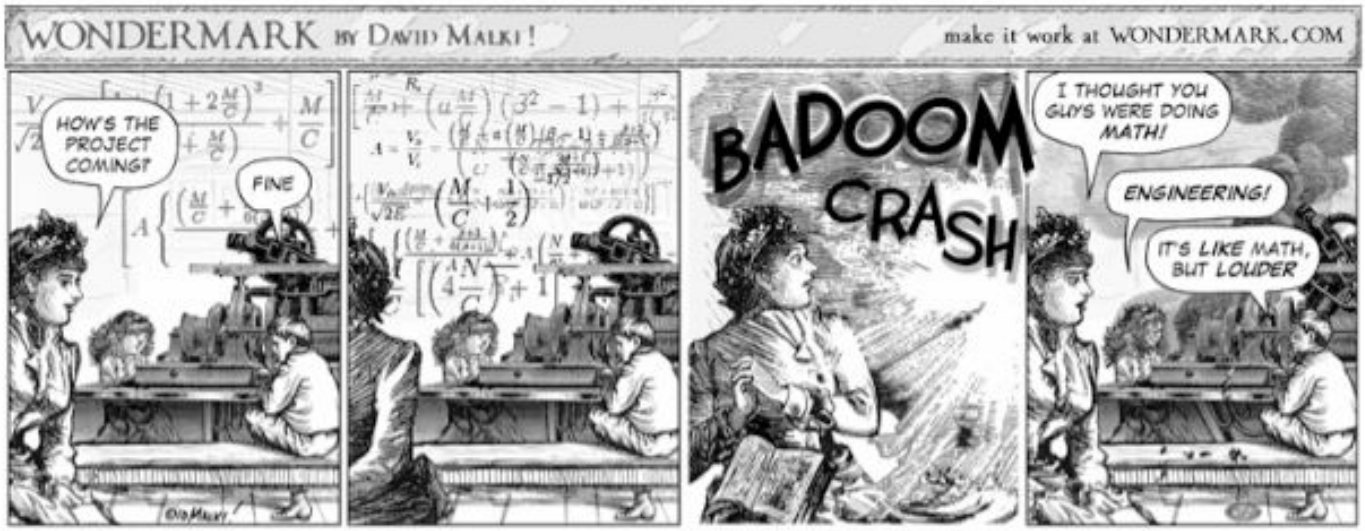
# BioE 10: Introduction to Biomedicine for Engineers

## *Department of Bioengineering, UC Berkeley*

"Many technological systems, when examined for context and overall design, are basically anti-people. People are seen as sources of problems while technology is seen as a source of solutions." - *Ursula Franklin*




Course Format:

- Tu and Th 3:40-4:25PM: remote live lecture (*will be recorded*)
- Tu and Th 4:30-5PM: remote team work engaging with bCourse modules & assignments
- Various days/times: 50 minute remote discussion section with attendance required (*will not be recorded*)

Important notes:

- **You will need to be signed into zoom with your berkeley.edu address to join the lectures and discussions.**
- **Class recordings and materials should not be shared with people outside of the class (though they may be shared with DSP). The copyright is held by the instructor.**
- There is no textbook for the course, but a number of online readings will be assigned.
- BioE 10 does ***not*** have a final exam. The final exam time slot is automatically given to us by the campus and will not be used.
- You will need to access journal articles for this class. If you are not using the campus network, you will need to follow these instructions for library access.

Instructor: Terry Johnson

GSIs:

- Kazuomori Lewis (Sections 102, 105, and 110)
- Brian Li (Sections 101, 103, 104, and 108)
- Dimitris Papadimitriou (Sections 106, 107, and 109)

Office Hours:

- Terry
  - W 2:40-3:30 - remote open office hours via Zoom
  - You can also sign up for a 10-minute one-on-one remote meeting using your berkeley.edu address. A Google Meet link will be added to the bCal invite.
    - Only sign up for slots titled "open appointment slots"
    - Don't sign up for multiple contiguous slots to embiggen your meeting
    - Include a brief description of what you'd like to talk about
    - If there are no slots available during a given week, check future weeks
- Kaz
  - T 9:10-10 AM remote office hours by Zoom
  - W 10-11 AM by appointment (sign up using this link)
- Brian
  - W 4:10-5PM - remote office hours via Zoom
  - Th 9-10AM by appointment (sign up using this link)
- Dimitris
  - F 9:10-10AM - remote office hours by Zoom
  - By appointment (sign up using this link)

# Course Description

This course is designed to introduce undergraduates to the types of problems that bioengineers solve and the concepts they apply to solve them. Various types of devices - from genetically engineered bacteria to biosensors - will be discussed, and we will explore the physics and biology necessary to understand and design each of these devices. In addition, students will learn how to work effectively in groups and to communicate their results in a professional manner.

While this syllabus is meant to be an accurate description of the course and its content, it may be modified at the instructor's discretion.

# Objectives

To introduce students to the field of bioengineering and, in general, to thinking about problems and solutions in the field ethically and effectively.

# Grading Policy

There are a variety of assignments for the course available on bCourses, where you can find their point values and due dates. Most of these assignments are due at the end of the month, so that they can be engaged in flexibly. Students are strongly encouraged to work ahead when possible, because they will receive no credit for late work. Last minute extensions, barring extraordinary circumstances, will not be granted. If there is a power outage or similar situation, all due dates will be pushed back, and details will be communicated via bCourses announcement.

**There are a total of 300 points that can be earned in BioE 10**. The final grading is not curved, and the breakdown is as follows.

| Grade | Score |
|---|---|
| A | 270 |
| A- | 260 |
| B+ | 250 |
| B | 240 |
| B- | 230 |
| C+ | 220 |
| C | 210 |
| C- / P | 200 |
| D+ | 190 |
| D | 180 |
| D- | 170 |

**We expect you to work with others in this class**. While copying on individual assignments is not allowed, collaboration on these assignments is very much encouraged. You will be assigned a project group and they - or another group of students in the class - should be a regular part of your week as you work together to understand the material and complete assignments.

There will also be assignments that are turned in as a group. **The instructor reserves the right to assign different grades to various members of the group, or to remove a member from a group to work on an ad hoc individual assignment, if the workload on a group assignment is not distributed and carried out evenly.** Students who are taking the class on a Pass/Fail basis should take special note of this policy.

Assignments fall into a few different categories:

- **Module quizzes** - these are really homeworks. Some are completely graded automatically, and others are a combination of automatic and personally graded. They are not timed like a quiz, they are simply due on their due date, so feel free to open and read them as early as you like. Students will have **seven** (and *only* seven) attempts at submitting each quiz, so they will have opportunities to receive feedback on the automatically graded portions and improve. These tend to be challenging, and your version of the quiz will typically be different from other student's versions.
- **Section work** - the due dates for these assignments will fluctuate. Some of the due dates will be assigned in your section.
- **Final project paper** - see below. This is due on Dec 18 at 7PM.

**This model gives you more authority over your workflow than weekly assignments do, but with that comes the responsibility to keep up with the material.** If you wait until the last week to attempt to complete a month's worth of work, and find it difficult to get all the help that you need in the time remaining, that's on you.

If a power outage causes the cancelation of a lecture, find a time to meet with your group and work ahead on modules, if possible. We'll make up the lost lecture time later, if necessary, by using some of the 4:30-5PM Tu/Th time (usually reserved for group work) for lecture.

If you would like to contest a grade, you must send Dimitris Papadimitriou an email briefly describing the issue **within 1 week of the grade being posted**. You should not expect that the instructor or the GSI will regrade anything while in conversation with you - that would not be fair to the other students in the class, whose homeworks have been graded without them present. Regrade requests should be based on an error on our part (e.g., adding up the points incorrectly) or what you suspect is a misunderstanding of your work (e.g., arriving at the correct answer using an unexpected technique). Regrade requests that argue with the rubric (e.g., "this is wrong, but you took too many points off") will not be considered.

Your homeworks should stand alone. If a homework is disorganized or ambiguous, and requires an extensive explanation to the grader, you will likely still lose points. The homeworks are not only evaluating your understanding of the material, they are also meant to evaluate your ability to communicate that understanding clearly and concisely.

Also, be aware of UC Berkeley's Code of Student Conduct. Plagiarism or cheating will not be tolerated. Plagiarism includes appropriation of whole passages with or without credit, appropriation of words and phrases without credit, appropriation of both main and supporting ideas without credit, and paraphrasing without credit. Plagiarism also includes submitting a paper written by someone else.

Finally: dealing with unavoidable circumstances is part of my job. **If something is preventing you from a satisfactory engagement with this course, consult the Academic Accommodations Hub** to determine if there is a campus resource that can guide you. If there is, we will work together to accommodate you. Otherwise, please contact me directly.

# Course Content

## Introduction

- Structure of the course
- What is bioengineering?
- Professional ethics and standards
- Working in groups
- Effective communication

References:

- Advice for graduate and undergraduate students in science and engineering

## Device 1 - Genetically engineered yeast

Theory: *Molecular biology; genetic engineering*
- Central dogma
- Transcriptional regulation
- Genetic modification

Practice: *Intellectual Property*
- Copyright
- Patents
- Trade secrets

Reading: Production of the antimalarial drug precursor artemisinic acid in engineered yeast

Reference (not required): Primer for synthetic biology - part 1

## Device 2 - DermaGraft

Theory: *Physiology; biomaterials*
- Organ structure and function
- Biocompatibility
- Compartmental modeling
- Mass transfer

Practice: *Regulatory concerns; hypothesis testing*
- FDA regulation for drugs, medical devices, biologics, and combination products
- Clinical trials
- Experimental design
- Statistics and hypothesis testing

Readings:
- The Efficacy and Safety of Dermagraft in Improving the Healing of Chronic Diabetic Foot Ulcers

References (not required):
- Handbook of Biological Statistics
- *Primer of Biostatistics*, Glantz, 6th edition
- *How to Lie with Statistics*, Huff

## Device 3 - Home pregnancy test

Theory: *Immunochemistry, Fluid dynamics*
- Immunoassays
- Causes of flow
- Laminar vs. turbulent flow (Reynolds number)
- Bernoulli's principle
- Hagen–Poiseuille flow
- Washburn's equation
- Dimensional analysis

Practice: *Identifying needs and solutions*

- Needs finding
- Target specifications
- Concept generation
- Concept selection

Reading:

- Bernoulli's principle
- Hagen–Poiseuille flow
- Washburn's equation

References:

- *Product Design and Development*, Ulrich and Eppinger, 4th edition (recommended, not required - this book is a required text for BioE 192, the senior Capstone design course)

## Device 4 - Electrocardiograph

Theory: *Signals*

- Continuous functions vs. discrete data
- Sampling
- Aliasing
- Noise
- Analog to digital conversion
- Dynamic Range

Practice: *Street-fighting mathematics*

- Dimensions (Chapter 1)
- Estimating integrals and derivatives (Ch 3)
- Pictorial proofs (Chapter 2)
- Buckingham pi (Chapters 2 and 4)

Readings:

- Street-fighting mathematics (note the open access download link)

# Final Project

Each group of five students will be jointly responsible for the final product as a whole, and though you may split the work up amongst yourselves, all of you will be expected to comprehend and be able to explain any part of the final product.

If any member of the group is unable to do their share of the work due to unforeseen and extraordinary circumstances, it is that student's responsibility to inform the instructor *as soon as possible* so that alternate arrangements can be made. **The instructor reserves the right to assign different grades to various members of the group if the workload is not distributed and carried out evenly.** Students who are taking the class on a Pass/Fail basis should take special note of this policy.

There is a required format for your final paper. If all of this formatting stuff below seems picky, the goal is to make the grading more fair. I want everyone's paper to look the same so our brains are evaluating the content, not being unconsciously affected by the layout or font choice.

The final project consists of a six page *maximum* (not including Works Cited, Appendix I, II, and the project contract) paper. This paper should be in a 2-column format consistent with IEEE submissions (Times New Roman, font size 10 for main text, 14 for the title, 12 for subheadings, single spaced, 1 inch top/bottom margins, 0.7 inch left/right margins). Please note that larger charts, diagrams, tables, etc. *should* break from the 2-column format and take the entire width of the page. All tables and figures should be numbered and have a descriptive legend.

> **I. Introduction** - A description of the device, its function, and its operating principles. A brief history of the device's development. Finally, a description of the problem that the device solves. Some devices may be applied to more than one problem; if so, choose one and focus on it.
>
> **II. Alternatives** - A list of alternate solutions, including a weighted selection matrix. It is perfectly acceptable to conclude that your device is not the best device!
>
> **III. Key Challenges** - This should include a focus on at least one other practical concern (efficacy testing, the regulatory process, etc.) discussed in the course.
>
> **IV. Ethical Issues** - Consider at least one ethical issue associated with your device. This issue could be associated, for example, with the construction, application, or economics of your device.
>
> **V. Conclusions** - Indicate what you think the best solution(s) to the problem are. If your device or any of your solutions are speculative (e.g., not yet available), indicate which of the available options is best, and also which of all of the devices you expect would be best, were all to become available. Discuss aspects of your analysis that you find troubling or inconclusive.

The Works Cited below should be in the same formatting as the above, but does not count towards the 6-page maximum.

> **Works Cited** - your citations should consist primarily (though not necessarily exclusively) of peer reviewed journal articles. If you aren't sure if something is a peer reviewed journal - ask! Citations from the peer reviewed literature usually have a DOI number. Citations should be in the IEEE format.

The appendices and project contract do not count towards the 6 page maximum, and they may be formatted however the team chooses, so long as it is readable.

> **Appendix I** - minutes from weekly group meetings. These should include: the date and time of each meeting, a list of participants, the agenda, minutes (brief notes of what was discussed), and the action items generated.
>
> **Appendix II** - a copy of the personal goals statement for each team member detailing what that student wants to get out of the project experience along with a brief (250 words or fewer) statement from each team member discussing what steps that member took during the project to meet those goals.
>
> **A signed project contract**

A sample LaTeX template (on bCourses) and Google doc template are available for you, though you may use another document editor (e.g., Microsoft Word) to produce your document if you wish. If you decide to go with LaTeX, there are many free options available. I have TeXworks installed as an editor with TeXLive on my laptop, and if you'd prefer to work collaboratively online, OverLeaf is an editor that you can use directly in a browser.