

# BENG 122A: BIOSYSTEMS AND CONTROL

Fall 2022

Class lectures Tue and Thu 9:30-10:50am, Ridge Walk Academic Complex 0121 and Zoom:

<https://ucsd.zoom.us/j/95305285764>

Discussions Wed 11am-11:50am and Wed 2pm-2:50pm, Powell-Focht Bioengineering Hall 161

Web site: <http://isn.ucsd.edu/courses/beng122a>

**Instructor:**

Prof. Gert Cauwenberghs  
Department of Bioengineering  
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Office hours: see web site

**TAs:**

Becky Chin, [rchinn@ucsd.edu](mailto:rchinn@ucsd.edu)  
Will Sharpless, [wsharpless@ucsd.edu](mailto:wsharpless@ucsd.edu)  
Consultations: see web site

- Overview:** This course will provide an overview of systems and control theory applied to bioengineering, from modeling and stability of linear time-invariant dynamical systems to design of closed-loop feedback control systems, with examples in sensorimotor control and neuromorphic engineering. A control systems design project and an oral presentation are required. There are guest lectures from experts in bioinspired control systems.  
The Tuesday and Thursday lectures will be formal presentations of course material, with further review and examples presented during the Wednesday and Friday discussions. Zoom recorded class lectures will be posted on Canvas for asynchronous access.
- Textbook:** Tranquillo VT. *Biomedical Signals and Systems*, Morgan & Claypool Publishers, Dec. 2013. <https://doi.org/10.2200/S00551ED1V01Y201311BME052>
- Homework:** There will be 5 homework assignments as indicated in the course outline. They are posted on the class web page and are due over Canvas. Homework assignments are the best way to learn engineering. You are expected to complete every homework problem on your own, but may consult with classmates before completing a problem. Please turn in your homework on time; late assignments will not be accepted. Each homework will have some form of a design problem. Solutions will be made available on Canvas.
- Tests:** There will be two quizzes weeks 5 and 8, covering all material up to the previous week. Quizzes are take-home, and are open-book and open-notes. No web browsing is allowed, nor is any form of communication, other than questions to the instructor and TAs, until submissions are due.
- Project:** The class culminates in a final project, in groups of five students each. Students define a biomedical control problem of their choice and apply systems and control concepts towards an effective solution, validated through simulation in Matlab/Simulink.
- Grades:** Final letter grades will be based on a combination of:  
Homework: 30% (6% each assignment);  
Quizzes: 40% (20% each quiz);  
Final project: 30% (10% in-class presentation; 20% final report).
- Reviews:** The TAs conduct reviews during the discussion sessions and take questions about grading during consultations.

## Course Outline—Fall 2022

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<b><u>Week</u></b>	<b><u>Topics</u></b>
Sep 22, 27-29	Introduction to biosystems and control. Linearized models and linear transforms. <i>Reading:</i> Tranquillo Ch. 1-4 <b>HW#1, Due Fri 10/7</b>
Oct 4-6	System response, transfer function, and block diagrams. Matlab and Simulink. <i>Reading:</i> Tranquillo Ch. 8 & 5 <b>HW #2, Due Fri 10/14</b>
Oct 11-13	Stability and feedback. <i>Reading:</i> Tranquillo Ch. 6-7 <b>HW #3, Due Fri 10/21</b>
Oct 18-20	Review. Control fundamentals. <i>Reading:</i> Tranquillo Ch. 1-8 (recap); Sec. 9.1-2
Oct 25	<b>Quiz #1, Due Wed 10/26</b>
Oct 27	Proportional, integral, and derivative (PID) control systems. <i>Reading:</i> Tranquillo Ch. 9 <b>HW #4, Due Fri 11/4</b>
Nov 1-3	Frequency response. Bode design and phase margin. <i>Reading:</i> Tranquillo Ch. 11 <b>HW #5, Due Mon 11/14</b>
Nov 8	Review. Features of biological control systems. Neuromorphic systems engineering. <i>Reading:</i> Tranquillo Ch. 9 & 11 (recap).
Nov 15	<b>Quiz #2, Due Wed 11/16</b>
Nov 17	Features of biological control systems. Neuromorphic systems engineering. <i>Reading:</i> Tranquillo Ch. 9.
Nov. 22	Guest lecture: <i>Rodolphe Sepulchre, Cambridge:</i> Neuromodulatory control systems.
Nov 29, Dec 1	<b>Final project presentations</b>
Dec 8	<b>Final project reports due</b>