# BE 402: Control Systems in Biomedical Engineering

Course Syllabus, Spring 2018

## Instructor

Dr. Mary Dunlop
Email: mjdunlop@bu.edu

## Graduate Teaching Fellows (GTFs)

| **Name** | Megan Griebel | Ali Lashkaripour | Bahar Rahsepar | Smrithi Sunil |
|---|---|---|---|---|
| **Email** | mgriebel@bu.edu | lashkari@bu.edu | baharr@bu.edu | ssunil@bu.edu |
| **Section Time** | F 12:20-1:10 pm | F 1:25-2:15 pm | F 3:35-4:25 pm | F 9:05-9:55 am |
| **Section Location** | PSY B53 | PSY B53 | PHO 201 | PHO 201 |

## Summary

Mathematical analysis of dynamic and linear feedback control systems. Emphasis on application to physiological systems, physiological transport, pharmacokinetics, glucose/insulin control, and respiratory control. Performance criteria. Root locus, Nyquist, and other stability criteria. State space analysis with state variable feedback control. Design and compensation.

## Course Schedule

Tu/Th 9:00-10:45am, PHO 206

## Office Hours

- Sundays 3-4pm, ERA B11 (Megan)
- Mondays 11-12:30pm, 36 Cummington, 2nd floor conference room (Smrithi)
- Mondays 3:30-5:30pm, 36 Cummington, 2nd floor conference room (Ali / Bahar)
- Thursdays 10:45-11:45am, 36 Cummington, Room 307 (Dr. Dunlop)
- Or by appointment, email any GTF or Dr. Dunlop to arrange

## Textbook

Norman S. Nise. *Control Systems Engineering*, Wiley, 7th Edition.
This textbook is required, however you may use previous editions of the book. If you use an older edition, you are responsible for making sure that any problems assigned from the book match the current edition.

## Grading, Exams, Dates

| | **Weight** | **Date** |
|---|---|---|
| Homework | 15% | due weekly in class |
| Exam 1 | 25% | Thurs February 22 (in class) |
| Exam 2 | 25% | Tues April 10 (in class) |
| Final Exam | 35% | Tues May 8 (9-11am) |

## Homework

Homework will be assigned weekly. Full solutions to all problems will be posted on Blackboard the day the homework is returned. Code used for numerical simulations is part of the solution and must be turned in. Course instruction will use Matlab, however you are welcome to use any programming language on homework assignments as long as you include the code.

Late homework is not accepted without prior approval and will receive a score of zero.

All questions regarding homework grades should be addressed to the GTF serving as the homework grading liaison: Megan Griebel, `mgriebel@bu.edu`.

## Exams

There will be three exams, two in class and one final exam. The focus of the material for the first and second exams will be on the content from that period, while the final exam will be cumulative.

Exam dates are included on this syllabus and are not negotiable.

## Academic Integrity / Collaboration

*Homework*: You are encouraged to collaborate with other students on the homework, but the write up must be your own, in your own words. Identical assignments will receive a score of zero. For Matlab problems you can share ideas, but code must be written individually. You are not permitted to use solutions from any source. Any questions about what constitutes an acceptable level of collaboration should be addressed to the instructor.
*Exams*: No collaboration, calculators, books, or outside materials are allowed. You will be allowed to bring one page (front and back) of handwritten notes with you to the exam.

I encourage you to review the University's policy on Academic Conduct:
https://www.bu.edu/academics/policies/academic-conduct-code/

## Cell Phone and Computer Use

Cell phones, laptops, and other electronic devices may not be used in class except for the purposes of taking notes.

## Webpage and Email

The course webpage is available through Blackboard.
Course announcements will be sent via email to your BU email address.

## Prerequisites

BE 401 Signals and Systems in Biomedical Engineering

## Expected Outcomes

At the end of the course students should know how to do the following:

- Identify open and closed loop systems
- Write scripts in Matlab to solve engineering design problems
- Understand and calculate key concepts such as stability, tracking, and performance measures
- Design feedback control laws for single input, single output systems
- Use design tools such as root locus and Nyquist plots
- Use mathematical models to describe dynamic processes
- Use frequency response plots to design control algorithms
- Understand tradeoffs and limitations in feedback control design

## Course Topic List

Please note that this order and list of topics is tentative and subject to change.

- Models of dynamical biomedical systems, Laplace transform review, transfer functions
- Poles, zeros, stability, response vs. pole location, step, impulse, and arbitrary inputs
- Open loop vs. closed loop, block diagrams
- PID control, lead-lag compensation, and other controllers
- Routh-Hurwitz criterion, root locus method
- Root locus design
- Frequency response, Bode plots
- Gain margin, phase margin, performance specifications
- Design given performance specifications
- Nyquist plots, time delays
- State space design
- Controllability
- Observability and observers
- Optimal control