BMED 3510 Biomedical Systems and Modeling

Credit: 3-2-4

Prerequisite(s): ECE 2025 and PHYS 2212 (w/minimum grade of "C") and MATH 2403 and BMED 3100

Catalog Description
Basic concepts, modeling tools and analysis techniques for the study of biochemical, bioelectrical and biomechanical systems.

Texts
Schaums's Outline: Signals and Systems, H.P. Hsu. McGraw Hill, 1995.

Schaums's Outline: Feedback and Control Systems, J.J. DiStefano, A.R. Stubberud, and I.J. Williams. McGraw Hill, 1995.

Objectives
This course introduces the student to the engineering approach to the quantitative modeling of physiological systems. The course lectures will focus on the basic approaches to modeling and a broad set of mathematical tools and domains that provide the foundation for the development of quantitative models. Weekly studio sessions will focus on the development of modeling skills and the application of mathematical tools in a team-based problem-solving setting.

Outcomes
By the end of the course the students will be able to:

1. Understand the basic strengths and limitations of quantitative modeling
2. Have a basic skill set for developing quantitative models of physiological systems
3. Understand steady-state and dynamical analysis techniques
4. Know the relationships between time, Laplace, and frequency domains
5. Understand how to apply tools from each of these domains - differential equations, Laplace transforms, and frequency response - to the analysis of dynamical systems

Topical Outline

1. Systems and Modeling (2 weeks)
   - linear systems basics
   - modeling process and types of models
   - conservation laws, energy, and ODEs
   - block diagrams and feedback
   - electrical/mechanical/chemical/fluidic/thermal equivalencies

2. Linear-Systems Analysis in the Time Domain (3 weeks)
   - first- and second-order systems
   - review of ODEs, complex variables
   - solutions of equations, convolution
   - damping, resonance, and stability
   - nonlinear systems

3. Linear-Systems Analysis in the Laplace Domain (4 weeks)
   - Laplace transform (comparison to Z Transform)
   - using Laplace to solve differential equations
   - impulse and step responses
   - system analysis, block diagrams, and transfer functions
   - effects and analysis of delay

4. Linear-Systems Analysis in the Frequency Domain (4 weeks)
   - introduction to the frequency domain, Fourier series
   - relationship between Laplace and frequency domains
   - frequency response, spectrum, and Bode plots
   - filtering, low-, high-, and band-pass filters
   - Fourier transform

5. Control Systems Design and Analysis (2 weeks)
   - feed-forward and feedback control
   - sensitivity and stability