

BME 333

Biomedical Signals and Systems



The Department of
Biomedical Engineering

CLASS HOURS

Tuesday 2:30pm-3:50pm (Fenster 640)
Friday 10:00am – 2:20am (Fenster 640)

OFFICE HOURS (Fenster 610)

F 12:00pm – 1:00pm
Or by appointment
(973) 596 3193 joelsd@njit.edu

TEXT

An Introduction to Signals and Systems, Stuller, Thomson
ISBN: 0495073016
Supplemental handouts are found on <http://web.njit.edu/~joelsd>

COURSE DESCRIPTION

Prerequisites: BME 310 and Math 222. BME Tools such as the Laplace and Fourier Transforms, time-frequency analysis are introduced. Applications include signals and noise, processing of the ECG, mathematics of imaging and derivation of useful physiological parameters from input signals.

LEARNING OUTCOMES

By the end of the course you should be able to do the following:

- **Signal Processing:** Understand the mathematical principles of continuous and digital signal processing. In particular, gain knowledge in ODE, Convolution, Signal Approximation, Fourier Series, Fourier Transforms, Modulation, Sampling, Laplace Transforms, and Z-transforms. Apply knowledge of math, engineering and science to identify, formulate, and solve problems in these areas.
- **Biomedical Signal Processing:** Apply knowledge of math, engineering and science to understand the principle of biomedical signal processing. Understand how to apply specific mathematical techniques to solve problems in the areas of biomedical signals (e.g., calculation of an ECG spectrum using Fourier Series and calculation of Heart Rate Variability using Fourier Transforms).

COURSE OUTLINE*

Date	Topic/Lecture		Material	Class work	Reading/Problem Assignment
09/06	Some Review of Signals and Systems	1	1.1 – 1.3, See notes	In-class discussion;	See Notes + CT.1.2.1,CT.1.2,3 DT.1.2.1,DT.1.2.3
09/09	Unit Impulse Function	2	2CT.2,4, 3CT.2 Appendix A See notes	In-class discussion; Review exercises	See Notes + Appendix A.4, A.7 2CT.2.4
09/13	Linear Systems Analysis with Biomedical Engineering Applications	3	1.3 See notes	In-class discussion; Review exercises	See Notes + CT.1.3.1
09/16	Engineering Systems Analysis using Linear Ordinary Differential Equations	4	See Notes	In-class discussion; Review exercises	See Notes
09/20	Sinusoidal Response and Discrete Systems	5	3CT.2 See Notes	In-class discussion; Review exercises	See Notes + 3CT.3.1, 3CT.3.2, 3CT.3.4
09/23	Convolution and Stability of Systems	6	2CT.3 – 8 See Notes	In-class discussion; Review exercises	See Notes + 2CT.3.1, 2CT.3.2 LAB
09/27	Review			Review exercises and Homework	
09/30	Exam #1				
10/4	Approximation of Signals – Fourier Series	7	5CT.1-2,4 See Notes	In-class discussion; Review exercises	See Notes + 5CT.1.1, 5CT.1.2
10/07	Fourier Series for Periodic Functions	8	5CT3,4,6,7 See Notes	In-class discussion; Review exercises	See Notes + 5CT.7.1
10/11	Calculation the Spectrum of BioMedical Signals Using Fourier Series	8a	Handout	Applying Fourier Series to determine the spectrum of a ECG	LAB
10/14	Fourier Transforms	9	4CT.1-4 See Notes	In-class discussion; Review exercises	See Notes + 4CT.2.2 4CT.2.3
10/18	Properties of Fourier Transforms	10	4CT.5 3CT.3-5,7,8 See Notes	In-class discussion; Review exercises	See Notes + 4CT.5.1, 4CT.5.2 3CT.5.1, 3CT.5.2, 3CT.5.3
10/21	Discrete Fourier	11	See Notes	In-class	See Notes

	Transforms		5DT	discussion; Review exercises	LAB
10/25	Filtering	12	3CT.5 – 6 See Notes	In-class discussion; Review exercises	See Notes LAB
10/28	Calculation the Spectrum of BioMedical Signals Using Fourier Transforms	12a	Handout	Applying Fourier Transforms to calculate Heart Rate Variability	LAB
11/01	Modulation	13	4CT.5 See Notes	In-class discussion; Review exercises	See Notes
11/04	Review			Review exercises and Homework	
11/08	Exam #2				
11/11	Sampling Theorem	14	4CT.6 See Notes	In-class discussion; Review exercises	See Notes
11/15	Angle Modulation Pulse Code Modulation	15, 16	See Notes	In-class discussion; Review exercises	See Notes
11/18	Laplace Transforms	18	6CT.1-4 See Notes	In-class discussion; Review exercises	See Notes + 6CT.2.1 6CT.2.2
11/23	Solving Systems using Laplace Transforms	19	6CT.5-7 See Notes	In-class discussion; Review exercises	See Notes
11/28	Review			Review exercises and Homework	
12/02	Exam #3				
12/06	Z-Transforms	20	See Notes 6DT	In-class discussion; Review exercises	See Notes
12/09	Z-Transforms	20	See Notes 6DT	In-class discussion; Review exercises	
12/13	Review			Review exercises and Homework	
TBA	Final Exam				

***The Course Outline may be modified at the discretion of the instructor or in the event of extenuating circumstances. Students will be notified in class of any changes to the Course outline.**

GRADING

- Homework and Matlab Programming: 15%
- Class participation: 10%
- Exam 1: 15%
- Exam 2: 15%
- Exam 3: 15%
- Final Exam 30%

Attendance is mandatory. Failure to attend class regularly will result in a failing grade. No makeup examinations will be administered. If a valid, documented excuse for a missed exam is provided, the weight of the Final Exam will increase to compensate for the missed grade.

Honor Code Violations/Disruptive Behavior:

NJIT has a zero-tolerance policy regarding cheating of any kind and student behavior that is disruptive to a learning environment. Any incidents will be immediately reported to the Dean of Students. In the cases the Honor Code violations are detected, the punishments range from a minimum of failure in the course plus disciplinary probation up to expulsion from NJIT with notations on students' permanent record. Avoid situations where honorable behavior could be misinterpreted.

No eating or drinking is allowed at the lectures, recitations, workshops, and laboratories. Cellular phones must be turned off during the class hours.

BME 333: Learning Outcome Summary

Strategies and Actions	Student Learning Outcomes	Outcomes (a-m)	Prog. Object.	Assessment Methods/Metrics
Course Objective 1: Signal Processing: Understand the mathematical principles of continuous and digital signal processing. In particular, gain knowledge in ODE, Convolution, Signal Approximation, Fourier Series, Fourier Transforms, Modulation, Sampling, Laplace Transforms, and Z-transforms. Apply knowledge of math, engineering and science to identify, formulate, and solve problems in these areas.				
Signal processing with applications are covered in class lectures, and homework	Understand basic signal processing to apply and analyze biomedical signals.	A, E, K,M	1, 2	Tests and homework are graded.
Course Objective 2: Biomedical Signal Processing: Apply knowledge of math, engineering and science to understand the principle of biomedical signal processing. Understand how to apply specific mathematical techniques to solve problems in the areas of biomedical signals (e.g., calculation of an ECG spectrum using Fourier Series and calculation of Heart Rate Variability using Fourier Transforms).				
Lectures, discussions and laboratories will cover theoretical models; will challenge students to process biomedical signals.	Apply signal processing to analyze biomedical signals	A, E, K,M,N	1, 2	Tests and homework are graded

ABET Outcomes expected of graduates of BME BS program by the time that they graduate:

- (A) an ability to apply knowledge of mathematics, science, and engineering
- (B) an ability to design and conduct experiments, as well as to analyze and interpret data
- (C) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- (D) an ability to function on multi-disciplinary teams
- (E) an ability to identify, formulate, and solve engineering problems
- (F) an understanding of professional and ethical responsibility
- (G) an ability to communicate effectively
- (H) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- (I) a recognition of the need for, and an ability to engage in life-long learning
- (J) a knowledge of contemporary issues
- (K) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
- (L) an understanding of biology and physiology
- (M) the capability to apply advanced mathematics (including differential equations and statistics), science, and engineering to solve problems at the interface of engineering and biology
- (N) an ability to make measurements on and interpret data from living systems
- (O) an ability to address problems associated with the interaction between living and non-living materials and systems