# BME 333
## Biomedical Signals and Systsms

The Department of Biomedical Engineering

**CLASS HOURS**
Tuesday, Friday
4:00pm – 5:25pm (Fenster 636)

**OFFICE HOURS (Fenster 610)**
M R 1:00pm – 2:00pm
Or by appointment
(973) 596 3193 joelsd@njit.edu

**TEXT**
Signals and Systems Analysis in Biomedical Engineering, Northrop
ISBN: 0849315573
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 |
|---|---|---|---|---|---|
| 09/02/08 | Some Review of Signals and Systems | 1 | Sections: 1.1.1-1.1.5 | In-class discussion; | See Notes |
| 09/05/08 | Unit Impulse Function | 2 | Section 2.4.1 | In-class discussion; Review exercises | See Notes |
| 09/09/08 | Linear Systems Analysis with Biomedical Engineering Applications | 3 | Sections 2.1, 2.2, 2.3.1-2, 2.3.1, 2.4.4 | In-class discussion; Review exercises | See Notes |
| 09/12/08 | Engineering Systems Analysis using Linear Ordinary Differential Equations | 4 | Sections 2.1, 2.2, 2.3.1-2, 2.3.1, 2.4.4 | In-class discussion; Review exercises | See Notes |
| 09/16/08 | Sinusoidal Response and Discrete Systems | 5 | Sections 2.2.2, 2.4.5-6 | In-class discussion; Review exercises | See Notes |
| 09/19/08 | Convolution and Stability of Systems | 6 | Sections 2.4.1-3, 2.6 | In-class discussion; Review exercises | See Notes |
| 09/23/08 | Review | | | Review exercises and Homework | |
| 09/26/08 | Exam #1 | | | | |
| 09/30/08 | Approximation of Signals – Fourier Series | 7 | Section 4.1 | In-class discussion; Review exercises | See Notes |
| 10/03/08 | Fourier Series for Periodic Functions | 8 | Sections 4.2-3 | In-class discussion; Review exercises | See Notes |
| 10/07/08 | Calculation the Spectrum of BioMedical Signals Using Fourier Series | 8a | Handout | Applying Fourier Series to determine the spectrum of a ECG | |
| 10/10/08 | Fourier Transforms | 9 | Sections 5.1-2 | In-class discussion; Review exercises | See Notes |
| 10/14/08 | Properties of Fourier Transforms | 10 | Section 5.3 | In-class discussion; Review exercises | See Notes |

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| 10/17/08 | Discrete Fourier Transforms | 11 | Sections 6.1-2 | In-class discussion; Review exercises | 6.2-4,6 |
| 10/21/08 | Filtering | 12 | Handouts | In-class discussion; Review exercises | See Notes |
| 10/24/08 | Calculation the Spectrum of BioMedical Signals Using Fourier Transforms | 12a | Handout | Applying Fourier Transforms to calculate Heart Rate Variability | |
| 10/28/08 | Modulation | 13 | Section 1.1.6 | In-class discussion; Review exercises | See Notes |
| 10/31/08 | Review | | | Review exercises and Homework | |
| 11/04/08 | Exam #2 | | | | |
| 11/07/08 | Sampling Theorem | 14 | Section 5.3.3 | In-class discussion; Review exercises | See Notes |
| 11/11/08 | Angle Modulation Pulse Code Modulation | 15, 16 | | In-class discussion; Review exercises | See Notes |
| 11/14/08 | Laplace Transforms | 18 | Section 1.1.6 | In-class discussion; Review exercises | See Notes |
| 11/18/08 | Solving Systems using Laplace Transforms | 19 | Section 3.5.1-3 | In-class discussion; Review exercises | See Notes |
| 11/21/08 | Z-Transforms | 20 | Section 2.5 | In-class discussion; Review exercises | See Notes |
| 11/26/08 | Review | | | Review exercises and Homework | |
| 12/02/08 | Exam #3 | | | | |
| 12/05/08 | Z-Transforms | 20 | Section 2.5 | In-class discussion; Review exercises | |
| 12/09/08 | 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: 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