BENG 320: Bioengineering Signals and Systems

Fall 2015
Credits 3
MW 10:30 am -11:45 am, Nguyen Engineering Building, 2608

Instructor:
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Associate Professor
Department of Bioengineering
Office: Krasnow Institute for Advanced Study, Room 141
Email: ssikdar@gmu.edu
Phone: 703-993-1539
Office hours: Monday/Wednesday 12:00-1:00 pm and by appointment

Teaching Assistant:
J. Lucas G. Olavo
Email: jgomesol@masonlive.gmu.edu

Prerequisite(s): Grade C or better in
1. Calculus including Differential Equations (MATH 214 or equivalent)
2. Introduction to Bioengineering (BENG 101 or equivalent)

Textbook (Required):
Signals and Systems for Bioengineers, Second Edition
By: John Semmlow
Academic Press

Course Description
The course builds on concepts introduced in BENG 101 and BENG 220. Concepts include (1) signal analysis and (2) system analysis, design and implementation. In this course analytical tools and methods including convolution and transforms will be introduced to analysis continuous-time (CT) and discrete-time (DT) physiological signals and systems. Major topics include properties of linear time-invariant signals and systems, convolution, Fourier series, Fourier transforms, Laplace Transforms and applications to biomedical problems. This course will make use of Matlab/Simulink in homework assignments and projects. Applications to biological and physiological signals and systems will be emphasized throughout the class.

Course Objectives
• This course is designed to enable students to be able to identify basic continuous time and discrete time signals (e.g. unit step functions, ramps, and impulses) and manipulate them with basic operations (e.g. shift, fold). Students will be able apply the concepts stated above to basic physiological signals.
• Students will be able to characterize systems based on basic system properties (e.g. linearity, time invariant, causality, stability)
• Students will be able to compute energy and power of CT and DT signals.
• For a given signal, students will be able to convert from the time domain to the frequency domain, and visa-versa.
• Students will be able to write and orally present a research project that relates directly to the processing of biological signals with applications in health care.

**Course structure**
The course will consist of two weekly lectures, one weekly recitation, homework assignments, in-class quizzes, two written exams and a final project. Some of the homework assignments and the course project will involve programming in MATLAB. The exams will be closed book and closed notes.

**GRADING POLICIES**
*Your grade in BENG 320 will be a weighted average of your grades in homeworks, projects, tests, and final exam as described below;*

**Homework (15%)**
There will be a homework assignment almost every week. Homework is due at the beginning of class, except when indicated otherwise. Late homework will not be excepted unless prior arrangements with the instructor have been made. A reasonable amount of collaboration on homework assignments is expected and encouraged. However, each student must write up his/her own solution. You are required to follow GMU’s policies on academic dishonesty [http://academicintegrity.gmu.edu/honorcode/]. If you are collaborating with other students on homework assignments you must state with whom you collaborated.

**Course Project (20%)**
The students are expected to complete an individual project in this class. The project will involve formulating a problem of biomedical/clinical significance related to biomedical signals and systems, implementing a set of signal processing/analysis steps to address the problem, and interpreting the findings critically. Detailed instructions for the completion and assessment of these projects will be made available and discussed as indicated on the course calendar. The student will be expected to seek out and define a biomedical or clinical problem or disease that involves a particular biomedical signal and system and define what type of measurements or information would need to be extracted from the signal to answer a diagnostic, therapeutic or basic science question about the problem. The student will then implement a chosen processing strategy on real data to yield information on the problem identified. The final project report should be formatted as a 4-page, 2-column, IEEE conference paper in 12-point Times New Roman font, with appropriate references in IEEE format. The project report is expected to consist of four sections: (1) Introduction and Background, (2) Methods and Materials, (3) Results and Discussion (4) Conclusion.

**Midterm Exams (20% each, total 40%)**
Two written midterm exams will be administered during the semester. Exams will be closed book and electronics will not be allowed. Instructor supplied formula sheets will be made available. Absence from exams must be notified ahead of time and alternative
arrangements made with the instructor. The topics covered in the exams will not be cumulative, i.e., the second midterm exam will only cover material discussed after the first midterm.

Test #1 – October 5th                         Test #2 – November 9th

Final Exam (20%)
The final exam will be cumulative. It will be closed books and notes. Instructor supplied formula sheets will be made available. The final exam is on December 16th from 10:30 am – 1:15 pm.

In-class Quizzes (5%)
Active participation in class has been shown to improve learning and retention. Each lecture will include in-class exercises to facilitate active engagement. The exercises will focus on the material covered in the lecture, in the assigned reading and on homework. They will range from simple exercises based on a single topic, to more complex exercises that require you to assimilate multiple concepts. You are expected to attend and prepare for each class. This includes reviewing previously covered material, as well as completing the assigned reading. You are responsible for all material covered in class and in the assigned reading.

Scoring for in-class exercises:

<table>
<thead>
<tr>
<th>Score</th>
<th>Response</th>
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<tbody>
<tr>
<td>0</td>
<td>None</td>
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<tr>
<td>1</td>
<td>Incorrect</td>
</tr>
<tr>
<td>2</td>
<td>Correct</td>
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I>Clickers
This course will use I>clickers, a classroom response system, to facilitate the in-class exercises. The system provides immediate feedback about overall class understanding, which can lead to class discussion to clarify misconceptions and common mistakes. You are expected to purchase, or have purchased, an I>clicker device for use in this course. The devices that you can choose from include I>clicker, I>clicker2, and Web>clicker. To learn about each of these devices please visit the I>clicker website at http://www.iclicker.com.

You must register your I>clicker device online at http://www.iclicker.com/support registeryourclicker/.

Important information when registering your I>clicker:
• GMU uses a Learning Management System (Blackboard)
• Your student ID is the prefix of your email address.

Guidelines for I>clicker use:
• You must register your I>clicker in order to use it in this course.
• You must bring your I>clicker to every class. If you do not bring your I>clicker to class you cannot get credit for the in-class exercises.
• You may use ONLY your I>clicker and no one else's. If you are caught using more than one I>clicker, all of them will be confiscated for the duration of class and you will receive a 0 for all in-class exercises. Only your I>clicker will be returned at the end of class.
<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Lecture Topic</th>
<th>Reference Chapter</th>
<th>Assignments and Deadlines</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Aug 31 (M)</td>
<td>Introduction to CT and DT signals.</td>
<td>Chapter 1</td>
<td></td>
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<tr>
<td></td>
<td>Sep 2 (W)</td>
<td>Signal properties and basic measurements</td>
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<td>2</td>
<td>Sept 7 (M)</td>
<td>Labor Day No Class</td>
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<td></td>
<td>Sept 9 (W)</td>
<td>Basic concepts in signal processing: Basic signals, comparisons, transformations</td>
<td>Chapter 2</td>
<td></td>
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| 3    | Sept 14 (M)| Introduction to the Fourier Transform: Fourier series                        | Chapter 3.1-3.4   | Supplemental material posted on blackboard
|      | Sept 16 (W)| Introduction to the Fourier Transform: Continuous and Discrete Fourier Transform | Chapter 3.5-3.8   | Project Proposal due. |
| 4    | Sept 21 (M)| Applications of the Fourier Transform Sampling, Spectral resolution         | Chapter 4.1       |                                                                |
|      | Sept 23 (W)| Applications of the Fourier Transform Power Spectrum and Signal Bandwidth     | Chapter 4.2-4.6   |                                                                |
| 5    | Sept 28 (M)| Linear Time-Invariant Systems: Basic properties, differential/difference systems, transfer function | Chapter 5.1-5.3   |                                                                |
|      | Sept 30 (W)| In class exercises/ Exam #1 Review                                           | Supplemental material posted on blackboard | Project Report: Introduction and Literature Review draft due. |
| 6    | Oct 5 (M)  | Exam #1                                                                       | Chapters 1.1-5.3  | and supplemental material                                      |
|      | Oct 7 (W)  | Response of LTI systems to complex exponentials                               | Chapter 5.4       |                                                                |
| 7    | Oct 13 **(T)| Analysis of LTI systems in the frequency domain [note, class meets on Tuesday] | Chapter           |                                                                |
|      | Oct 14 (W) | Introduction to Bode plots                                                   | Chapter 5.4       |                                                                |
| 8    | Oct 19 (M) | Construction of Bode plots using asymptotes                                  | Chapter 5.5       | Supplemental material posted on blackboard                      |
|      | Oct 21 (W) | Frequency and phase response of systems                                       | 3.9-3.10          |                                                                |
| 9    | Oct 26 (M) | Introduction to the Laplace transform                                         | Chapter 6.1       |                                                                |
|      | Oct 28 (W) | Laplace Transforms applied to solutions of differential systems, transfer function | Chapter 6.2       |                                                                |
| 10   | Nov 2 (M)  | In class exercises, practice problems                                         | Supplementary material | Project Report: Updated draft with Methods section due. |
|      | Nov 4 (W)  | In class exercises/ Exam #2 Review                                            |                   |                                                                |
| 11   | Nov 9 (M)  | Exam #2                                                                       | Chapters 5.4-6.2  |                                                                |
|      | Nov 11 (W) | LTI systems: Convolution                                                     | Chapter 7.1       |                                                                |
| 12   | Nov 16 (M) | System simulations with Simulink                                              |                   |                                                                |
|      | Nov 18 (W) | System simulations with Simulink                                              | 10.0-10.3         |                                                                |
| 13   | Nov 23 (M) | Linear filters: design and implementation                                     | 10.4-10.6         | Project Report: Updated draft with Results section due.       |
|      | Nov 25 (W) | Thanksgiving Break No Class                                                  |                   |                                                                |
| 14   | Nov 30 (M) | Z-transform applied to solution of difference systems and digital filtering  | 10.7-10.8         |                                                                |
|      | Dec 2 (M)  | Sampling                                                                      |                   | Final Project Report Due                                       |
| 15   | Dec 7 (M)  | Review of material covered in the course and in class exercises              |                   |                                                                |
|      | Dec 9 (W)  |                                                                                |                   |                                                                |
| 16   | Dec 16 (W) | FINAL EXAM (10:30 am -1:15 pm)                                               | Chapters 1-8      |                                                                |
Participation in discussion forums:

This term we will be using Piazza for class discussion. The system is highly catered to getting you help fast and efficiently from classmates, and myself. Rather than emailing questions to me, or asking me during office hours, I encourage you to post your questions on Piazza. If you have any problems or feedback for the developers, email team@piazza.com.
Find our class page at: https://piazza.com/gmu/fall2015/beng320/home

Academic Honesty and Collaboration:

The integrity of the University community is affected by the individual choices made by each of us. GMU has an Honor Code with clear guidelines regarding academic integrity. Three fundamental and rather simple principles to follow at all times are that: (1) all work submitted be your own; (2) when using the work or ideas of others, including fellow students, give full credit through accurate citations; and (3) if you are uncertain about the ground rules on a particular assignment, ask for clarification. No grade is important enough to justify academic misconduct.

With collaborative work, names of all the participants should appear on the work. Homework problems are designed to be undertaken independently. You may discuss your ideas with others and conference with peers; however, it is not appropriate to give your work to someone else to review. You are responsible for making certain that there is no question that the work you hand in is your own. If only your name appears on an assignment, your professor has the right to expect that you have done the work yourself, fully and independently.

Plagiarism means using the exact words, opinions, or factual information from another person without giving the person credit. Writers give credit through accepted documentation styles, such as parenthetical citation, footnotes, or endnotes. Paraphrased material must also be properly cited. A simple listing of books or articles is not sufficient. Plagiarism is the equivalent of intellectual robbery and cannot be tolerated in the academic setting.

There will be a zero tolerance policy in this course for plagiarism in the written project report and in homework submissions. Every instance of plagiarism will be reported to the GMU Honor Committee. No excuses. No exceptions. If you have any doubts about what constitutes plagiarism, please see the instructor.

Email Policy:

You must use your Mason email account for all email correspondence having anything to do with your work at Mason. Federal laws protecting your privacy rights require that we only communicate student information directly to students – and use of the university
email system is our only way to validate your identity. You may forward your campus email elsewhere, but we can respond only to a Mason email account.

**Relevant Campus and Academic Resources**

**Disability Services**

Any student with documented learning disabilities or other conditions that may affect academic performance should: 1) make sure this documentation is on file with the Office of Disability Services (SUB I, Rm. 2500; 703-993-2474; http://ods.gmu.edu) to determine the accommodations you might need; and 2) talk with the instructor to discuss reasonable accommodations.

**Office of Diversity, Inclusion and Multicultural Education**

SUB I, Rm. 2400; 703-993-2700; https://odime.gmu.edu

**Writing Center**

Robinson 114A; 703-993-1200; http://writingcenter.gmu.edu

**WAVES: Wellness, Alcohol and Violence Education and Services**

WAVES promotes wellness within the Mason community through health education, alcohol/drug assessment and education, and violence awareness, prevention and sexual assault response. We help students make healthy, safe choices and encourage lifelong, thoughtful healthy decision-making through individualized support, creative programming, and evidence-based education and outreach.

**WAVES office 703-993-9999**

**SUB I, Suite 3200**

**24-Hour Sexual and Intimate Partner Violence Crisis Line 703-380-1434**

waves.gmu.edu

- 703-360-7273 (Fairfax County Office for Women and Domestic and Sexual Violence Services 25 hotline)
- 703-228-4848 (Arlington County Domestic Violence Services Hotline)
- 703-368-4141 (Prince William County Sexual Assault Victims Advocacy Services (SAVAS) hotline)
- 1-800-838-8238 (Virginia Family Violence and Sexual Assault Hotline)
- 1-800-656-HOPE (Rape, Abuse and Incest National Network)

https://ohl.rainn.org/online/

**CAPS: Counseling and Psychological Services**

Counseling and Psychological Services (CAPS) provides a wide range of free confidential services to students, faculty, and staff. Services are provided by a staff of professional clinical psychologists, social workers, counselors, learning specialists, and
psychiatric providers. CAPS individual and group counseling, workshops, and outreach programs are designed to enhance students’ personal experience and academic performance. Visit us at caps.gmu.edu for additional resources.

- For consultation or emergency assistance during office hours call 703-993-2380.
- For assistance during non-office hours, call University Police at 703-993-4357.
- 703-527-4077 (CrisisLink)
- 1-800-273-8255 (National Suicide Prevention Lifeline)
- 1-877-838-2838 (Veterans' Crisis Hotline)

**Student Health Services (SHS)** — Provides confidential health care to enrolled students in emergency and non-emergency circumstances on the Fairfax, Arlington and Prince William campuses. If there is a medical emergency and Student Health Services (SHS) is closed, please contact the free after-hours nurse ((703) 993-2831), a hospital emergency room, an urgent care facility, or call 911.

**SUB 1, Suite 2300**
**703-993-2831**

**University Police:**
Emergency: 911  Non-Emergency: (703) 993-2810
Reporting a Crime (Crime Solvers Anonymous Tip Hot-Line): (703) 993-4111
Mason Police Website: [http://police.gmu.edu/](http://police.gmu.edu/)
Eric Heath, Chief of Police  Phone: (703) 993-3840  E-mail: eheath2@gmu.edu