Physical Bases of Biomedical Systems


Lecture Location: Nguyen Engineering Building 2608
Lecture Hours: Tuesdays and Thursdays, 9:00 – 10:15 am
Recitation Location: Nguyen Engineering Building 1103
Recitation Hours: Fridays, 10:30 -11:20 am (BENG 220-301)
Tuesdays, 12:30-1:20 am (BENG 220-302)
Credit Hours: 3
Instructor: Vasiliki Ikonomidou
E-mail: vikonomi@gmu.edu
Office: Long and Kimmy Nguyen Engineering Building, 3909
Office Hours: Tuesdays 3-4 pm, Thursdays 2-3 pm; other times by appointment
Teaching Assistant: Karthik Murthy
E-mail: kmurthy@gmu.edu
Office Hours: TBD

I will try to respond to e-mails within two business days of receiving them. Due to University regulations, you need to use your GMU e-mail account in all correspondence related to the course. Please put BENG 220 in the subject line!

Announcements and additional course materials will be posted on Blackboard. It is the student’s responsibility to regularly check it.

Prerequisites:

Introduction to Bioengineering (BENG 101) or equivalent, MATH 213 (Calculus III), PHYS 160 (University Physics I); or permission of instructor
It is highly recommended (even though NOT required) that students have taken, or are currently taking MATH 214 (Elementary Differential Equations)
Grading Policies

Your grade in BENG 220 will be a weighted average of your grades in homeworks, midterm and final exam as described below:

Homework (30%)

Homework constitutes a major component of the course. It should demonstrate an understanding of the background, and a clear and critical presentation of the procedure followed and the results obtained. “Critical” means questioning what was done and why such results were obtained.

There will be two types of homework assignments in the class: the first assignment in each course unit will be graded for effort only and is intended to give you an idea of what is expected in the course. The other two will be graded for performance.

Assignments should be delivered in Blackboard. It is your responsibility to make sure that you know how to use Blackboard, and that your account functions properly. Ideally, assignments should be typed, but in cases where there is too much math or sketches, scanned copies of hand-written solutions will be accepted. Please note that this refers to a scanned copy, NOT a photo of the solution – the latter are oftentimes not legible. Poor quality submissions in terms of legibility, including photos of handwritten assignments, will not be graded.

(If you don’t have access to a scanner, please check some smartphone apps that emulate a scanner, there are some good free ones)

In case of computer based assignments, please note that the homework consists of two parts: (a) the code and (b) the results and comments on the results of the code.

Submissions that contain only code will receive a grade of zero – we will not run your code to see if it works, or what sort of results it gives. Code needs to have comments and descriptive variable names so that it is easy to read. Computer code should be working; there will not be partial credit for non-working code.

Unless specified otherwise, the submitted homework should be ONE file only, preferably in pdf format. Submissions that split answers over multiple files, or that are submitted in image format (jpg, png, tif etc) will not be graded.

In order to maximize your grade, state all assumptions made in approaching a problem. Overall, all solutions should have enough comments to make the thinking process clear. Take care to use proper grammar and syntax.

Homework is due at the beginning of the class of the day stated, and will not be accepted afterwards. In case of a documented medical emergency that does not allow you to submit it on time, please notify the instructor as soon as possible. Also, if you are unable to submit an assignment due to observance of a religious holiday, please notify the instructor in advance.

As part of your homework, you will be asked to view short online videos before coming to the lecture, and write a short paragraph describing the content of these videos, in addition to answering a few short questions. The video assignments are
should be submitted on Blackboard, and are due before the start of the class immediately following the one they were assigned.

*Quizzes (10%)*

There will be a number of unannounced in-class quizzes throughout the semester, testing understanding of the class material on those days. The two quizzes with the lowest grades will be dropped. The average grade in these quizzes will constitute 10% of the total grade.

*Midterm (30%)*

There are two midterms for the class. Both will be open book / open note exams. Laptop computers will be allowed during the exam only for consulting with text provided as part of the e-reserves for the class; Internet connectivity must be turned off. Cellphones will not be allowed during any exam. It is advised that students own a calculator with trigonometric functions. The grade for the midterm will be 70% of the higher of the two scores and 30% of the lower one.

*Final Exam (30%)*

The final exam will be cumulative, open book / open note.

**Academic Integrity**

All George Mason University students have agreed to abide by the letter and the spirit of the Honor Code. You can find a copy of the Honor Code at academicintegrity.gmu.edu. All violations of the Honor Code will be reported to the Honor Committee for review.

If for an assignment you use material from other sources, like books, articles or the web, such sources must be cited appropriately. All assignments and exams must contain a signed honor pledge: “On my honor, I have not given nor received any help on this assignment/exam”, otherwise they will not be graded.

For all assignments and exams, code submitted and write-ups are expected to be your own. While discussing an assignment with a classmate is a normal part of the learning process, sharing code and write-ups is not permitted. Likewise, copying text and/or code from books or the Internet constitutes plagiarism. Limited citing should be clearly marked as such, and appropriately referenced.

**Disability statement**

If you have a documented learning disability or other condition that may affect academic performance you should: 1) make sure this documentation is on file with the Office of Disability Services (SUB I, Rm. 222; 993-2474; http://www.gmu.edu/student/drc/) to determine the accommodations you need; and 2) talk with me to discuss your accommodation needs.
**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/
Eric Heath, Chief of Police  Phone: (703) 993-3840  E-mail: eheath2@gmu.edu

Academic courtesy

You can help make this a better experience by:
• Arriving in time for the class
• Silencing your cell phone and not using any electronic devices other than your laptop (but, no web surfing or e-mailing!).
• No electronic devices are allowed in class during exams.
• Not eating or drinking in class
• Not preparing to leave until the instructor indicates that the lecture is over

Detailed Course Information

Course Objectives: This course aims to introduce the student to the physical basis of biomedical systems and signals. It introduces basic concepts in biomechanics, electrophysiology, as each pertain to biomedical signals. Specific examples of biomedical signals include the electrocardiogram and the electroencephalogram. At the end of the class, students should be able to:

• explain how the laws of physics can be used to describe biomedical systems
• describe some of the main problems in biophysics, and how they relate to biology and the generation of biomedical signals
• explain how the physical description of a biomedical system results in basic notions of signals and systems theory, like linearity, superposition, frequency and transfer functions
• apply knowledge from mechanics to calculate forces in the human body
• identify biophysical processes in a living system to enable measurements
• explain how the laws of biophysics apply to molecular interactions and biomolecules

As you will see in the course calendar, the course is divided in 5 units. For each unit, there will be a rubric with learning objectives posted on Blackboard. These rubrics describe the aims of each unit separately, and are intended to clarify what you need to know for each part of the course. Please make sure to consult them while studying!
Recitation Section

The class includes a zero-credit recitation section, to be held on Fridays 11:30 am - 12:20 pm. The purpose of the recitation section is twofold: (a) to provide additional practice for problems in-class and (b) to provide practice in using MATLAB for solving problems.

It is expected that students have gained some familiarity with MATLAB in BENG 101 (or equivalent). This class further builds on this knowledge. Students are strongly encouraged to review MATLAB basics as needed from the online tutorials on the Mathworks website.

MATLAB is available to students at all computer labs at the Volgenau School of Engineering; however, students are strongly encouraged to purchase a student version of MATLAB for their use. Also, students are strongly encouraged to bring their own laptop computers to the recitation session; any computer able to run MATLAB (Windows/Mac OS/Linux) is fine.

Textbook


Signals and Systems (2nd edition) by Alan V. Oppenheim and Alan S. Willsky (this is the textbook for BENG 320)

Please note that some reading material for the class is available through the e-reserves system of the GMU library.

Note: A lot of the reading material, including notes and links to other online resources, will be available through Blackboard.
Calendar (All dates and topics are tentative and subject to change – all readings are from the Hobbie book unless otherwise noted)

<table>
<thead>
<tr>
<th>Lecture</th>
<th>Readings</th>
<th>Tentative Date</th>
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<tbody>
<tr>
<td>1</td>
<td>Introduction to the class</td>
<td>1/19</td>
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**Unit 1: Molecular Biophysics / Introduction to Digital Signals (MB)**
Covers introductory concepts of signals in biological molecules

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<th>Lecture</th>
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<tbody>
<tr>
<td>2</td>
<td>Molecular biophysics: Biological Molecules and sequences, information content</td>
<td>E-reserves: Biochemistry &amp; Notes</td>
<td>1/21</td>
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<tr>
<td>3</td>
<td>Molecular biophysics: Sequencing</td>
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<td>1/26</td>
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<tr>
<td>4</td>
<td>Molecular biophysics: Sequence Matching</td>
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<td>1/28</td>
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<tr>
<td>5</td>
<td>Molecular biophysics: Sequence Matching, continued</td>
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<td>2/2</td>
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<tr>
<td>6</td>
<td>Unit 1: Review</td>
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<td>2/4</td>
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**Unit 2: Biomedical signals / Introduction to Analog Signals (BMS)**
Introduces basic concepts of generation, measurement and processing of biomedical signals

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<tbody>
<tr>
<td>7</td>
<td>Action potential, the recording chain</td>
<td>Notes, Chapter 6</td>
<td>2/9</td>
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<tr>
<td>8</td>
<td>EKG, sampling</td>
<td></td>
<td>2/11</td>
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<tr>
<td>9</td>
<td>Sampling / Frequency</td>
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<td>2/16</td>
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<tr>
<td>10</td>
<td>Fast Fourier Transform</td>
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<td>2/18</td>
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<tr>
<td>11</td>
<td>Fast Fourier Transform, continued</td>
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<td>2/23</td>
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<tr>
<td>12</td>
<td>Review</td>
<td></td>
<td>2/25</td>
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<tr>
<td>13</td>
<td>Review</td>
<td></td>
<td>3/1</td>
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<tr>
<td>14</td>
<td>Midterm exam 1 (covers units 1+2)</td>
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**Unit 3: Biomechanical systems and signals / Zero-order systems (BME)**
Covers material properties, stress analysis, kinematics

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<th>Lecture</th>
<th>Readings</th>
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<tr>
<td>15</td>
<td>Biomechanics 1: Forces and equilibrium</td>
<td>1.1-1.4</td>
<td>3/15</td>
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<tr>
<td>16</td>
<td>Biomechanics 2: Equilibrium and design</td>
<td>1.5-1.7</td>
<td>3/17</td>
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<tr>
<td>17</td>
<td>Biomechanics 3: Stress and strain</td>
<td>1.8-1.10</td>
<td>3/22</td>
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<tr>
<td>18</td>
<td>Biomechanics 4: Kinematics</td>
<td>Notes</td>
<td>3/24</td>
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<tr>
<td>19</td>
<td>Unit 3 review</td>
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<td>3/29</td>
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<td>20</td>
<td>Midterm exam 3 (covers units 1-3)</td>
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**Unit 4: Biophysical basis of therapeutic dosing / First order systems (BTD)**
Covers Pharmacokinetics, Laplace Transform

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<td>21</td>
<td>Exponential Growth and Decay</td>
<td>Chapter 2</td>
<td>4/5</td>
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<tr>
<td>22</td>
<td>Introduction to pharmacokinetics</td>
<td>Notes</td>
<td>4/7</td>
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<tr>
<td>23</td>
<td>Introduction to pharmacokinetics - Compartmental Modeling, Laplace Transform</td>
<td>Laplace transform</td>
<td>4/12</td>
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<tr>
<td>23</td>
<td>Introduction to pharmacokinetics, Laplace Transform</td>
<td>Laplace transform</td>
<td>4/14</td>
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<tr>
<td>25</td>
<td>Introduction to pharmacokinetics, Laplace Transform</td>
<td>Laplace transform</td>
<td>4/19</td>
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<tr>
<td>26</td>
<td>Unit 4 review</td>
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<td>4/21</td>
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<tr>
<td>27</td>
<td>Review</td>
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<td>4/26</td>
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<tr>
<td>28</td>
<td>Review</td>
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<td>4/28</td>
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<tr>
<td>5/9</td>
<td>Final Exam (7:30-10:15 am)</td>
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**Important Dates:**

First day of classes: 1/19  
Last day to add / drop classes without penalty: 1/26  
Final drop deadline (67% tuition penalty): 2/19  
Spring Break: 3/7-3/13  
Last Day of Classes: 5/2  
Final Exam: 5/9, please note the time, 7:30 am – 10:15 am