BIOEN 3202
Physiology for Engineers
Fall 2018
Version: 180814-1427-gac (or later)

LECTURE INSTRUCTORS
Gregory A. Clark, Ph.D. (GAC)
506 Biomedical Polymers Res. Bldg. (BPRB)
20 S 2030 E
(801) 585-9796
greg.clark@utah.edu
Office hours: Mon after class, or by appt.

Jessica R. Kramer, Ph.D. (JRK)
5209 Sorenson Molecular Biotech. Bldg.
36 S. Wasatch Dr.
(801) 213-2039
jessica.kramer@utah.edu
Office hours: Wed after class, or by appt.

LABORATORY INSTRUCTOR
David J. Warren, Ph. D. (DJW)
506E Biomedical Polymers Res. Bldg. (BPRB)
(801) 585-2697
david.warren@utah.edu
Lab Sessions: All
Office hours: Th 11-12 AM, Th 2-3 PM, or by appt.

See also www.bioen.utah.edu (directory, faculty directory) for more information about us.

TEACHING ASSISTANTS
John (Jack) Mize (JM)
532 Biomedical Polymers Res. Bldg.
(801) 581-3817
Jack.Mize@utah.edu
Lab Sessions: Tu AM, Th AM
Office hours: Tu 9-10 AM; 1480 MEB (on independent study lab weeks), or by appt.

Jacob Weston (JW)
194 Biomedical Polymers Res. Bldg.
No office phone
jacob.weston@utah.edu
Lab Sessions: Tu AM, Th AM
Office hours: Th 10-11 AM; 1480 MEB (on independent study lab weeks), or by appt.

Brett Davis (BD)
207 Wintrobe
No office phone
Brett.h.davis@utah.edu
Lab Sessions: Tu PM, We PM
Office hours: Tu 4-5 PM; 1480 MEB (on independent study lab weeks), or by appt.

Austin Schlirf (AS)
5020 SMBB
No office phone
Austin.Schlirf@utah.edu
Lab Sessions: Tu PM, Th PM
Office hours: Th 4-5 PM; 1480 MEB (on independent study lab weeks), or by appt.

Jiawei Dong (JD)
TBD
No office phone
j.dong@utah.edu
Lab Sessions: We PM, Th PM
Office hours: We 4-5 PM; 1480 MEB (on independent study lab weeks), or by appt.
DESIGNATION
Required course for BIOEN majors.

CATALOG DESCRIPTION (modified)
This course teaches students to apply knowledge of mathematics, science, and engineering to cellular and systems physiology, including function, dysfunction, and the mechanisms that underlie treatment. The course also addresses professional and ethical responsibility associated with the development, testing, and implementation (or withholding) of biomedical devices or treatments. Associated laboratory modules teach students to design, conduct, and analyze experiments, and to use the techniques, skills, and tools necessary for engineering practice. Topics this semester include the nervous system, striated and smooth muscle, and respiratory, renal, and cardiovascular systems. 4 credit hours.

TEXTS (REQUIRED)
- Selected readings and web materials to be assigned

LEARNING OBJECTIVES
To produce students and future engineers who:
- Have fundamental knowledge of physiological system function and dysfunction
- Can analyze physiological systems from a quantitative, engineering and experimental perspective
- Can perform experiments on, and collect and analyze experimental data from, physiological tissues, and can use and troubleshoot experimental equipment
- Can formulate practical engineering solutions to ameliorate biological disorders
- Understand how solutions manifested in biological systems may potentially be applied to the solution of traditional engineering problems—a “bio-based” approach
- Appreciate the ability of bioengineering to improve the quality of life
- Recognize the ethical issues associated with testing and implementation of biomedical devices and treatments
- Understand the need for life-long learning to maintain and enhance their technical skills, and to stay abreast of advances in understanding
- Have a strong work ethic and can work effectively in teams
- Have good written and oral communication skills
- Are independent, critical, and creative thinkers who seek out new points of view and who can effectively evaluate assumptions, evidence, and conclusions and can distinguish among them

TOPICS COVERED
Lecture Topics
- Cellular neuroscience (7 lectures)
- Systems neuroscience (8 lectures)
- Applied neuroscience/neuroengineering (2 lectures)
- Striated and smooth muscle (3 lectures)
- Respiratory systems (3 lectures)
- Renal systems (2 lectures)
- Cardiovascular system (9 lectures)
- Immune system (5 lectures)

Laboratory Topics
- Bioinstrumentation and R-C modeling of neurons
• Stimulating and recording from nerve
• Neuromuscular systems
• Respiratory systems
• Cardiovascular structure and function
• Cardiovascular monitoring and signal analysis

CLASS SCHEDULE
Lecture: M, W, F: 9:40-10:30 AM, WEB L103
Laboratory: MEB 1480, 4-h laboratory on selected weeks (see later in syllabus). 5 sections: Tue 8:15 AM-12:15 PM; Tue 2:00 PM-6:00 PM; Wed 2:00 PM-6:00 PM; Thu 8:15 AM-12:15 PM; Thu 2:00 PM-6:00 PM

ASSESSMENT TOOLS
• Homework assignments
• Two in-class exams, plus possible quizzes
• One final exam
• Written lab reports, quizzes; observation and questioning of students during experiments
• In-class presentations
• Student evaluation of teaching
• Student evaluation of course

Lecture: ~75% of overall course grade split between exams and possible quizzes (~60-65%) and homework assignments (~10%). Formal didactic lectures may be complemented by discussion/problem-solving sessions that may have special assignments. Students will be expected to have completed the assignments and be prepared to participate in the topic discussion or problem solving.

Laboratory: ~25% of overall course grade. Laboratory participation, laboratory reports and presentations, and laboratory quizzes or exams. Attendance is required.

Standards: Curves may be applied to improve letter grades if appropriate, but will not be applied to decrease grades. Hence, it can be both beneficial and more enjoyable for you to help each other learn the material, and we encourage you to do so. Note, however, comments below on plagiarism regarding written assignments.

Assignments: Reading and other assignments are listed on the class schedule. Additional assignments not listed on the syllabus may be given throughout the semester.

Exams: There will be two exams during the semester and one final exam at semester's end. Each exam including the final will not be comprehensive and will cover only material presented since the previous exam. Exams cannot be rescheduled except in cases of documented emergencies.

Quizzes: Occasional announced or unannounced quizzes may be given throughout the semester in order to provide more frequent feedback and additional incentive for students to keep pace with course materials. Quizzes may be given in addition to, or at times different from, those presently scheduled on syllabus.

INSTRUCTOR AVAILABILITY
Instructors and TAs will be available during their scheduled office hours (see above), after most lecture/laboratory sessions, and by appointment. We realize that many students’ schedules are highly constrained and may not allow students to meet during our “scheduled” office hours. We encourage you to arrange alternative times to meet with us to discuss any questions or issues associated with the course, or beyond.

STUDENT CONTACT INFORMATION
So that we are able to contact you, please
1) Set your UU e-mail account so that it is the account that you actually use and check, or so that it forwards emails to the account that you actually use and check.

2) Set the options in your Canvas account to forward the Canvas emails and announcements to whatever email account you normally use and check.

Contacting instructors and TAs directly (instead of through Canvas) is usually more efficient for time-sensitive responses.

WEB POSTINGS OF COURSE MATERIALS
Most course materials will be posted on the web, at either the University’s Canvas site, or elsewhere as indicated.

GAC file-naming conventions for Canvas:
AaaBb_yymmm_dd_Cc_Dd_vyyymmd-hhmm-author_Ee.*
Example: <Lec01_180820_LS_Intro_v180819-2319-gac_Example.pdf> translates into:
“Meeting type, Number: Lecture01_Meeting date: 2018-Aug-20_File type: Lecture Slides_Abbreviated Title: ’Intro’_Version: 2018 Aug 19, 11:19 PM, Gregory A. Clark_MisInfo: Example”

COURSE GUIDELINES
The course will be conducted according to the policies and procedures of the College of Engineering, which can be found on the College of Engineering websites:
https://www.coe.utah.edu/students/academic-affairs -> (Academic Affairs web page)

ATTENDANCE
Attendance at lectures and especially laboratory sessions is required except for absences explicitly excused by a faculty course instructor (preferably in writing) or for officially sanctioned University activities or other circumstance indicated by University Policy (e.g., University Policy 6-100, Section O; https://regulations.utah.edu/academics/6-100.php). Unexcused absences may be penalized via grade reductions, particularly for labs. Unless explicitly indicated by a faculty instructor (preferably in writing) or University Policy, all assignments remain due according to the standard schedule, even in the event of excused absences.

LATE POLICY
Except in cases of legitimate, compelling extenuating circumstances, the late policy for assignments, including but not necessarily limited to homework assignments, lab reports, any papers, etc., will be as follows:
• “On time”:
  Electronic submissions: Most or all lecture homework assignments, lab assignments and reports should be turned in via Canvas by the specified time.
  o Electronic homework assignments: typically will be due 15 min before the start of the lecture period indicated.
  o Electronic lab assignments: typically will be due on Sunday 11:59 PM, ~1-1/2 weeks after the data collection; or as specified.
  o Electronic lab quizzes: typically will be due on Sunday 11:59 PM, of the weekend prior to data collection; or as specified.
  o Other electronic or other submissions: As specified.
• “Late”: 10% grade penalty (one letter grade).
  o Lecture homework submissions. 15 min before start of next normally scheduled meeting for lecture.
  o Lab assignments: One additional calendar week.
Lab Quizzes: One additional calendar week.

Other electronic or other submissions. As specified.

Not accepted: Assignments not turned in by the late period will not be accepted except under extraordinary extenuating circumstances.

ACADEMIC MISCONDUCT AND PLAGIARISM
All work for this course, including exams, assignments, and presentations, must be completed in keeping with the University of Utah Policy 6-400: Code of Student Rights and Responsibilities (“Student Code”), available at http://regulations.utah.edu/academics/6-400.php.

As defined in the Student Code (section I.B.),

“‘Academic misconduct’ includes, but is not limited to, cheating, misrepresenting one’s work, inappropriately collaborating, plagiarism, and fabrication or falsification of information, as defined further below [see Student Code]. It also includes facilitating academic misconduct by intentionally helping or attempting to help another student to commit an act of academic misconduct.”

A primary example of academic misconduct is plagiarism: submitting as one’s own, work that is copied from an outside source. Other examples include cheating, such as copying from another student’s examination, or sharing or studying from past exams that were not meant for public distribution; and fabrication or falsification of information, such as fabricating data for a laboratory report.

Science and engineering strive to uncover truth, discover new approaches, and create novel inventions and works. Academic misconduct is antithetical to these goals, and to the goal of mastering new materials and skills. Academic misconduct will not be tolerated in this course.

Students may be required to indicate that assignments have been completed in accord with the student code. Additional measures to reduce academic misconduct may be implemented.

Academic misconduct may result in reduced grades and/or disciplinary action and written notification to the Department and College, as well as dismissal from the Biomedical Engineering program, particularly in cases of repeat occurrences. For a more complete description of what does and does not constitute academic misconduct, consult the University of Utah Student Code and policies.

Studying. You can study together for upcoming exams and quizzes, or to learn material. This is often the best way to learn, and we encourage you to do so.

Lecture Homework Assignments. In contrast, you should work independently for any lecture homework assignments that you turn in for credit, unless you are explicitly informed otherwise in writing. Feel free to contact instructors or a TA for assistance.

Laboratory Reports Assignments. Lab partners necessarily will work together and collect data together during laboratory sessions. Subsequent data analyses, interpretation, and figure generation can also be performed jointly with your explicit lab partner(s). However, in contrast, the writing, reporting, and discussion of your results should represent your own work. Any selected exceptions to this expectation for group assignments will be communicated in writing by the course instructors to the students. Use of data collected by other students is not allowed except by written permission from a course instructor. Unless given explicit instruction allowing such by a course instructor, TAs cannot provide such permission.
ACCOMMODATION POLICY
The University Accommodation Policy can be found here:
Accommodation Policy (Section Q): [http://regulations.utah.edu/academics/6-100.php](http://regulations.utah.edu/academics/6-100.php).

Further information and background regarding the policy can be found here:

The University’s Office of General Counsel recommends use of a disclaimer if a faculty member has reason to believe an accommodation request might arise. Accordingly, please note the following:

“Some of the writings, lectures, films, readings, activities, presentations, or other content in this course may include material that conflicts with the core beliefs of some students. Please review the syllabus carefully to see if the course is one that you are committed to taking. If you have a concern, please discuss it with the relevant faculty instructor at your earliest convenience.”

Not all changes to course content trigger the use of the Accommodations Policy. Only student requests for accommodations based on conflict with sincerely-held core beliefs trigger the use of this policy. Thus, for example, instructors can continue to be able to make modifications to course content for pedagogical reasons, such as adding or substituting a new reading.

The Department of Biomedical Engineering (formerly “Bioengineering”) has adopted the following:

“None of the following, either singularly or in combination, is sufficient grounds for requesting a content accommodation:

a. personal disagreement with legitimate course content or its implications;
b. conflict between a student’s beliefs and legitimate course content or its implications;
c. any burden imposed on a student’s beliefs by legitimate course content or its implications.

Accommodations requested on such grounds, either singularly or in combination, will not be granted.”

Drs. Clark and Warren will not provide content accommodations. Dr. Kramer will consider content accommodation requests on a case-by-case basis.

Students’ requests for a content accommodation shall follow the procedures indicated in the University’s Accommodation Policy (e.g., Q.3.c. et al.):

“It is the student's obligation to determine, before the last day to drop courses without penalty, when course requirements conflict with the student's sincerely-held core beliefs. If there is such a conflict, the student should consider dropping the class. A student who finds this solution impracticable may request a content accommodation from the instructor. Though the University provides, through this policy, a process by which a student may make such a request, the policy does not oblige the instructor to grant the request, except in those cases when a denial would be arbitrary and capricious or illegal. This request must be made to the instructor in writing, and the student must deliver a copy of the request to the office of the department Chair, or, in the case of a single-department college, to the office of the Dean. The student's request must articulate the burden the requirement would place on the student's beliefs.”

Instructors also shall follow the procedures and criteria outlined in the Policy (e.g. section Q.3.d. et al.).
ADA STATEMENT
The University of Utah seeks to provide equal access to its programs, services and activities for people with disabilities. If you will need accommodations in the class, reasonable prior notice needs to be given to the Center for Disability Services 162 Olpin Union Building, 801-581-5020 (V/TDD). CDS will work with you and the instructor to make arrangements for accommodations. All information in this course can be made available in alternative format with prior notification to the Center for Disability Services. (http://www.oeo.utah.edu/ada/guide/faculty/)

ADDRESSING SEXUAL MISCONDUCT
Title IX makes it clear that violence and harassment based on sex and gender (which includes sexual orientation and gender identity/expression) is a civil rights offense subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories such as race, national origin, color, religion, age, status as a person with a disability, veteran’s status or genetic information. If you or someone you know has been harassed or assaulted, you are encouraged to report it to the Title IX Coordinator in the Office of Equal Opportunity and Affirmative Action, 135 Park Building, 801-581-8365, or the Office of the Dean of Students, 270 Union Building, 801-581-7066. For support and confidential consultation, contact the Center for Student Wellness, 426 SSB, 801-581-7776. To report to the police, contact the Department of Public Safety, 801-585-2677(COPS).

WELLNESS STATEMENT
Personal concerns such as stress, anxiety, relationship difficulties, depression, cross-cultural differences, etc., can interfere with a student’s ability to succeed and thrive at the University of Utah. For helpful resources, you should contact the Center for Student Wellness at www.wellness.utah.edu, 801-581-7776.

CHANGES TO SYLLABUS
The enclosed information represents a plan, not a contract. Topics, dates, and assignments and other content are subject to change at instructors’ discretion.
## LECTURE SYLLABUS

<table>
<thead>
<tr>
<th>Session</th>
<th>Topic</th>
<th>Reading &amp; Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unit 1. Nervous &amp; Muscular Systems. Greg Clark.</strong></td>
<td><strong>1.1. Introduction: Neurons &amp; Neural Signaling</strong></td>
<td></td>
</tr>
<tr>
<td>01. M 08/20</td>
<td>Overview of Physiology &amp; Neural Function</td>
<td>S9:282-293, 300-302, (303-306); review syllabus; &amp; TBA††.</td>
</tr>
</tbody>
</table>
| 02. W 08/22 | Neuroengineering: Restoration and Repair              | HW 1.0a due before lecture.*  
S10:338-351.                                          |
| 03. F 08/24 | Neurons and Neuronal Signaling                        | S8:223-235.                                              |
| 04. M 08/27 | Ion Channels and Resting Membrane Potentials           | HW 1.0b due before lecture.  
S5:124-136, 152-158, (160-163, as relevant); S8:234-237. |
| 05. W 08/29 | R-C Circuits and the Resting Membrane Potential       | S8:237-228. Appendix B.                                  |
| 06. F 08/31 | R-C Circuits and the Passive Propagation of Electrical Signals | HW1.1a, due before lecture. Additional assigned readings. |
| --- M 09/03 | Labor Day Holiday                                      | None                                                     |
| 07. W 09/05 | Action Potentials and Active Conductances 1            | HW1.1b, due before lecture.  
S8:239-249 (to be cont’d).                             |
| 08. F 09/07 | Action Potentials and Active Conductances 2            | Continued                                                 |
| 09. M 09/10 | Synaptic Potentials and Intercellular Communication   | HW1.1c, due before lecture.  
S6:165-179; S8:249-265 (266-270).                      |
| **1.2. Sensory Systems**                               |                                                                                          |
| 10. W 09/12 | Overview of CNS, PNS, and Sensory Systems; Somatosensory 1 | HW1.1d, due before lecture.  
S10:308-322.                                         |
| 11. F 09/14 | Somatosensory Systems 2                                  | Continued                                                 |
| 12. M 09/17 | Audition 1                                              | S10:328-335, (352-354)                                    |
| 13. W 09/19 | Audition 2                                              | Continued                                                 |
| 14. F 09/21 | EXAM 1 (Units 1.1 & 1.2)                                |                                                          |
| **1.3. Somatic Neuromuscular Systems**                 |                                                                                          |
| 15. M 09/24 | Skeletal Muscle 1                                        | HW1.2, due before lecture.  
S11:368-370, (371-373); S12:374-400, (410-413)         |
| 16. W 09/26 | Skeletal Muscle 2                                       | Continued                                                 |
| 17. F 09/28 | Neural Control of Movement 1: Overview, Spinal Reflexes | S13:414-422                                               |
| 18. M 10/01 | Neural Control of Movement 2                           | Continued                                                 |
| 19. W 10/03 | Neural Control of Movement 3                           | S13:426-428; (429-431)                                   |
| **1.4. Autonomic, Regulatory, and Modulatory Systems**  |                                                                                          |
| 20. F 10/05 | Smooth Muscle                                           | HW1.3, due before lecture.  
S12:400-409, (410-413)                                  |
<p>| 10/7 - 10/15 | Fall Break                                             | None                                                     |</p>
<table>
<thead>
<tr>
<th>Date</th>
<th>Activity</th>
<th>Reading Assignments</th>
</tr>
</thead>
<tbody>
<tr>
<td>22. W 10/17</td>
<td>ANS 2: Control of Target Tissues: To Pee or Not to Pee.</td>
<td>S10:339-340; S15:489, 492-495; S19:612-613</td>
</tr>
<tr>
<td><strong>Unit 2. Respiratory System. Greg Clark.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Unit 3. Renal (Kidney) System. Greg Clark.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26. F 10/26</td>
<td>Kidneys 1: Overview; Filtration</td>
<td>HW 2.1, due before lecture. S19:587-600</td>
</tr>
<tr>
<td>28. W 10/31</td>
<td>EXAM 2 (Units 1.3, 1.4, 2, 3)</td>
<td>HW 3.1 due before lecture</td>
</tr>
<tr>
<td><strong>Unit 4. Cardiovascular System. Jessica Kramer.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29. F 11/02</td>
<td>CV01: Heart Anatomy and CV overview</td>
<td>S14: 433-436; 440-445 HW 3.1 due before lecture</td>
</tr>
<tr>
<td>30. M 11/05</td>
<td>CV02: Electrophysiology of cardiac cells and excitation-contraction coupling</td>
<td>S14: 446-449</td>
</tr>
<tr>
<td>31. W 11/07</td>
<td>CV03: Action potentials in cardiac cells</td>
<td>S14: 449-452</td>
</tr>
<tr>
<td>32. F 11/09</td>
<td>CV04: Electrical propagation in cardiac tissues, cardiac cycle</td>
<td>S14: 452-454, 460-462</td>
</tr>
<tr>
<td>33. M 11/12</td>
<td>CV05: Cardiac cycle and the electrocardiogram (ECG)</td>
<td>S14: 455-459, 463-464</td>
</tr>
<tr>
<td>34. W 11/14</td>
<td>CV06: Regulation of heart rate and cardiac function</td>
<td>S14: 464-470</td>
</tr>
<tr>
<td>36. M 11/19</td>
<td>CV08: Blood flow and pressure</td>
<td>S15: 487-496 HW 4.1 due before lecture</td>
</tr>
<tr>
<td>37. W 11/21</td>
<td>CV09: Exchange in the capillaries, CV review</td>
<td>S15: 495-498</td>
</tr>
<tr>
<td>--- F 11/23</td>
<td>Thanksgiving Break</td>
<td>None</td>
</tr>
<tr>
<td><strong>Unit 5. Immune System. Jessica Kramer.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>41. M 12/03</td>
<td>Immune 4: Acquired immunity</td>
<td>S24: 764-765, 768-772 HW 5.1 due before lecture</td>
</tr>
<tr>
<td>42. W 12/05</td>
<td>Immune 5: Immunoengineering, review</td>
<td>S24: Supplements, TBA</td>
</tr>
<tr>
<td><strong>43. W 12/12</strong></td>
<td>8:00-10:00. FINAL EXAM (Exam 3). Units 4-5 (CV, Immune). Exam time is different from regular class meeting time. Same classroom.</td>
<td>Review</td>
</tr>
</tbody>
</table>

† Reading assignments: S = Silverthorn Chapter/pages. For example, S9:285-296 = Silverthorn, Chapter 9: pg. 285-296. The associated review pages at the end of the chapter are also assigned in conjunction with all Silverthorn readings. These are typically demarcated in parentheses; for example, Chap. 9 Running Problem Conclusions, plus Chapter Summary, Questions, and Answers. In cases where only portions of the chapter are assigned, only the review material associated with the assigned readings is required, irrespective of the review pages indicated herein. “Explorations” exercises are not required unless explicitly assigned. HINT: Occasionally, questions or variations thereof may be taken from these review pages for exams or quizzes.
††Additional readings or homeworks beyond those indicated in the syllabus may be assigned throughout the course.
* If the class falls behind the projected syllabus timeline, then homework due dates may be shifted accordingly.
# LABORATORY SYLLABUS

<table>
<thead>
<tr>
<th>Session (Week)</th>
<th>Topic</th>
<th>Reading/Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Tu 8/21 W 8/22 Th 8/23</td>
<td>• Independent study, plus office hours(^1)</td>
<td>Independent Study</td>
</tr>
<tr>
<td>2. Tu 8/28 W 8/29 Th 8/30</td>
<td>• Module 1. R-C Modeling of Neurons</td>
<td>Canvas(^2)</td>
</tr>
</tbody>
</table>
| 3. Tu 9/04 W 9/05 Th 9/06 | • Data analysis and independent study, plus office hours  
• Turn in Module 1 (R-C Modeling) assignment as instructed | Data Analysis |
| 4. Tu 9/11 W 9/12 Th 9/13 | • Module 2. Stimulating and Recording from Frog Sciatic Nerve | Canvas |
| 5. Tu 9/18 W 9/19 Th 9/20 | • Data Analysis and independent study, plus office hours  
• Turn in Module 2 (Sciatic N.) assignment as instructed | Data Analysis |
| 6. Tu 9/25 W 9/26 Th 09/27 | • Independent study, plus office hours | Independent Study |
| 7. Tu 10/02 W 10/03 Th 10/04 | • Module 3. Surface Electromyography (EMG) and Muscle Activation | Canvas |
| -- Tu 10/09 W 10/10 Th 10/11 | \(\text{Fall Break}\) | n/a |
| 8. Tu 10/16 W 10/17 Th 10/18 | • Data analysis and independent study, plus office hours  
• Turn in Module 3 (EMG) assignment as instructed | Data Analysis |
| 10. Tu 10/30 W 10/31 Th 11/01 | • Data analysis and independent study, plus office hours  
• Turn in Module 4 (Respiration) assignment as instructed | Data Analysis |
| 11. Tu 11/06 W 11/07 Th 11/08 | • Module 5. Frog Heart Lab: Structure, Function & Regulation  
• | Canvas |
| 12. Tu 11/13 W 11/14 Th 11/15 | • Data analysis and independent study, plus office hours  
• Turn in Module 5 (Frog Heart) assignment as instructed | Data Analysis |
| 13. Tu 11/20 W 11/21 Th 11/22 | • Independent study, plus office hours  
• (Note: Thanksgiving week.) | Independent Study |
| 15. Tu 12/04 W 12/05 Th 12/06 | • Data analysis and independent study, plus office hours  
• Turn in Module 6 (ECG and Exercise) assignment as instructed | Data Analysis |

\(^1\)Office hours held during off-weeks are subject to change; times as indicated earlier in syllabus.  
\(^2\)Students are required to read the lab manual before coming to lab. This will greatly facilitate their ability to understand and complete the exercises.  
Announced or unannounced quizzes on the lab manual are possible.
ACCREDITING BOARD OF ENGINEERING AND TECHNOLOGY (ABET): RELATIONSHIP OF THE COURSE TO THE PROGRAM OUTCOMES

What students actually learn is more important than what teachers try to teach. Long-term educational objectives can be evaluated in terms of specific, measureable outcomes. ABET is a professional organization that provides accreditation of the Bioengineering Department undergraduate educational program as well as engineering programs throughout the world, based on what students actually achieve. Employers often consider graduation from accredited programs as part of their hiring decisions.

The following information provides target levels of competence for student outcomes and capabilities (according to Bloom's Taxonomy of Educational Objectives) for BIOEN 3202. In short, these represent measurable goals of the course for student achievement.

**ABET Outcomes A-L**

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Description</th>
<th>Target Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Ability to apply knowledge of mathematics</td>
<td>4</td>
</tr>
<tr>
<td>A2</td>
<td>Ability to apply knowledge of science</td>
<td>4</td>
</tr>
<tr>
<td>A3</td>
<td>Ability to apply knowledge of engineering</td>
<td>4</td>
</tr>
<tr>
<td>B1</td>
<td>Ability to design experiments</td>
<td>3</td>
</tr>
<tr>
<td>B2</td>
<td>Ability to conduct experiments</td>
<td>3</td>
</tr>
<tr>
<td>B3</td>
<td>Ability to analyze and interpret data</td>
<td>3</td>
</tr>
<tr>
<td>C</td>
<td>Ability to design a system, component, or process to meet desired needs and within realistic constraints</td>
<td>3</td>
</tr>
<tr>
<td>D</td>
<td>Ability to function on multi-disciplinary teams</td>
<td>2</td>
</tr>
<tr>
<td>E</td>
<td>Ability to identify, formulate, and solve engineering problems</td>
<td>2</td>
</tr>
<tr>
<td>F</td>
<td>Understanding of professional and ethical responsibility</td>
<td>1</td>
</tr>
<tr>
<td>G1</td>
<td>Ability to communicate effectively in an oral format</td>
<td>2</td>
</tr>
<tr>
<td>G2</td>
<td>Ability to communicate effectively in a written format</td>
<td>3</td>
</tr>
<tr>
<td>H</td>
<td>Understanding of the impact of engineering solutions in a global and societal context</td>
<td>2</td>
</tr>
<tr>
<td>I1</td>
<td>Recognition of the need for life-long learning</td>
<td>1</td>
</tr>
<tr>
<td>I2</td>
<td>Ability to engage in life-long learning</td>
<td>1</td>
</tr>
<tr>
<td>J</td>
<td>Understanding of contemporary issues</td>
<td>2</td>
</tr>
<tr>
<td>K1</td>
<td>Ability to use the techniques and skills necessary for engineering practice</td>
<td>3</td>
</tr>
<tr>
<td>K2</td>
<td>Ability to use modern engineering tools necessary for engineering practice</td>
<td>3</td>
</tr>
<tr>
<td>L</td>
<td>Other Areas</td>
<td>2</td>
</tr>
</tbody>
</table>
A1 - Ability to apply knowledge of mathematics
A major focus of the course is analyzing physiological systems from mathematical, scientific, and engineering principles in an integrated manner. For example, many physiological systems are examined from the perspective of feedback control.

A2 - Ability to apply knowledge of science
As indicated in A1, knowledge is integrated across these three domains.

A3 - Ability to apply knowledge of engineering
As indicated in A1, knowledge is integrated across these three domains.

B1 - Ability to design experiments
Lectures pose and design thought-experiments to distinguish among interpretations of observations or mechanisms. In laboratory exercise, students conduct experiments, and analyze and interpret data, with a modest experimental design component.

B2 - Ability to conduct experiments
As in B1.

B3 - Ability to analyze and interpret data
As in B1.

C - Ability to design a system, component, or process to meet desired needs and within realistic constraints
Much of the systems-level physiology is taught from a bio-based design perspective. Given physiological constraints, how would the student design a system to serve, repair or replace the function of the system or tissue being studied? What is the system "designed" to do, and how?

D - Ability to function on multi-disciplinary teams
Students occasionally break into small problem-solving groups in lecture, and work in teams of two in the lab for data collection and analysis.

E - Ability to identify, formulate, and solve engineering problems
Some forms of physiological dysfunctions are more readily addressed by certain types of engineering approaches than others. How does one determine what types of problems are tractable to which types of engineering approaches?

F - Understanding of professional and ethical responsibility
Potential engineering solutions for medical problems must also address professional or ethical issues. For example, decisions regarding implants of a cochlear prosthesis for the congenitally deaf must be made when people are too young to decide for themselves.

G1 - Ability to communicate effectively in an oral format
Lecture meetings may have occasional prepared presentations and oral reports from small, directed problem-solving groups.

G2 - Ability to communicate effectively in a written format
Formal lab reports vary in length and depth but include some complete reports (with Abstract, Introduction, Methods, Results, Discussion). Exams and homeworks include essay questions.

H - Understanding of the impact of engineering solutions in a global and societal context
Bioengineering and physiology in particular address medical and quality-of-life in practical as well as conceptual terms.

I1 - Recognition of the need for life-long learning  
The course emphasizes fundamental underlying physiological and engineering principles that subsequently may be applied to the analysis of a variety of organ systems using similar thought processes and approaches learned here.

I2 - Ability to engage in life-long learning  
As in I1.

J - Understanding of contemporary issues  
Rapid advances in medical and engineering technologies applied to biomedical problems allow consideration of contemporary technological and societal issues.

K1 - Ability to use the techniques and skills necessary for engineering practice  
This ability is manifested in variety of laboratory modules, both for using the instrumentation and for data collection and analysis.

K2 - Ability to use modern engineering tools necessary for engineering practice  
As in K1.

ABET Capabilities 1-8

<table>
<thead>
<tr>
<th>Cap-ability</th>
<th>Description</th>
<th>Target Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Understanding of Biology</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Understanding of Physiology</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Make measurements and interpret data from living systems</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>Can address problems associated with the interaction between living and nonliving materials and systems</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>Capability to solve the problems at the interface of engineering and biology by applying ADVANCED MATH including differential equations</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>Capability to solve the problems at the interface of engineering and biology by applying STATISTICS</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>Capability to solve the problems at the interface of engineering and biology by applying SCIENCE (hypothesis driven research)</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>Capability to solve the problems at the interface of engineering and biology by applying ENGINEERING (design and analysis)</td>
<td>3</td>
</tr>
</tbody>
</table>

1 - Understanding of Biology 
Understanding biological principles and mechanisms is essential for understanding physiology

2 - Understanding of Physiology 
Understanding physiology with an emphasis on integrating ways of thinking from physiological and engineering perspectives, rather than rote memorization.
3 - Make measurements and interpret data from living systems
Several laboratory exercises measure and interpret animal and human physiological data, including compound action potentials from nerve, muscle length-force and force-velocity curves, and cardiovascular responses in frogs, and EMG and pulmonary responses in humans.

4 - Can address problems associated with the interaction between living and nonliving materials and systems
The course considers the use of artificial organs and interfaces for restoration of function, and hence also addresses biocompatibility and device-tissue interactions.

5 - Capability to solve the problems at the interface of engineering and biology by applying ADVANCED MATH including differential equations
Simple and some advanced mathematics is used for understanding biological (e.g., Hodgkin-Huxley) and electric-circuit equivalent models of neuronal and cardiovascular function.

6 - Capability to solve the problems at the interface of engineering and biology by applying STATISTICS
Students use extensive descriptive statistics (e.g., means, standard deviations) as well as modest inferential statistics for analysis of data in the laboratory exercises.

7 - Capability to solve the problems at the interface of engineering and biology by applying SCIENCE (hypothesis driven research)
In lecture, students are challenged to design thought-experiments whose potential outcomes might discriminate among various possible interpretations or mechanisms. In laboratory, students pose and subsequently test hypotheses in the real-world environment.

8 - Capability to solve the problems at the interface of engineering and biology by applying ENGINEERING (design and analysis)
Examples include brain-storming sessions for designing stimulus protocols for effective stimulation of bladder voiding, an artificial kidney, stimulating electrodes and stimulus paradigms to allow selective recruitment of small-diameter nerve fibers.