Course Description: A key aspect of Bioengineering involves making measurements from living systems, including the human body, both for basic science research as well as for diagnosis and treatment of disease. This course will introduce the basic concepts and tools for making biomedical measurements, describe instrumentation design and analysis considerations, and discuss several practical applications. Students will gain hands-on experience with bioinstrumentation and signal analysis techniques that are fundamental in Bioengineering. Students will make use of a wireless physiologic monitor that allows biomedical signals to be recorded safely and for experimental subjects to move freely. Co-requisite: BENG 301 or with approval from instructor.

Course Objectives: After successfully completing this course, a student will be able to:

- Collect, analyze, and interpret common biomedical measurements.
- Describe sources of signal artifacts that contaminate biomedical signal acquisition and complicate interpretation.
- Explain the source of biomedical signals.
- Apply statistical methods for characterization of biomedical measurements and their variation.
- Prepare a laboratory reports detailing rationale, methods, results, and conclusions.

Relationship to Bioengineering Program Outcomes: It is expected that this course will help students achieve the following outcomes:

b) An ability to design and conduct experiments, as well as to obtain, analyze and interpret data from living systems

- students can design experiments, taking into account variability when planning measurements from living systems
• students can conduct experiments safely and effectively
• students can analyze and interpret data thoughtfully and critically, taking into account variability of living systems

**k) An ability to use techniques, skills, and modern engineering tools necessary for engineering practice**

• students understand and can use techniques and skills, such as sensor development, telemetering, search algorithms, to obtain data from living systems
• graduates can use computational tools, such as signal analysis, modeling, pattern recognition, to understand living systems
• graduates can integrate information, such as obtained from measurements and computational approaches, to design, apply, or test systems that are of potential societal benefit

Course Organization: Students will work in groups of two or three to undertake each of the laboratory exercises. For several of the laboratory exercises, one student will serve as the biomedical signal source where the partners will be responsible for the data acquisition. The role of experimental subject should be shared equally.

Schedule:

<table>
<thead>
<tr>
<th>Section 202 (Wed) Date</th>
<th>Lab #</th>
<th>Topic</th>
<th>Notes:</th>
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<tbody>
<tr>
<td>January 23</td>
<td></td>
<td>Orientation and Wet Lab Safety Training Assessment</td>
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<tr>
<td>January 30</td>
<td>1</td>
<td>Data Acquisition Basics</td>
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<tr>
<td>February 6</td>
<td>2</td>
<td>Statistics</td>
<td>Lab #1 report due</td>
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<tr>
<td>February 13</td>
<td>3</td>
<td>Electrocardiography</td>
<td>Lab #2 report due</td>
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<td>February 20</td>
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<td>Electrocardiography (continued) and Final Project Proposal</td>
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<td>February 27</td>
<td>5</td>
<td>Electro-oculography</td>
<td>Lab #3 report due</td>
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<td>March 6</td>
<td>6</td>
<td>Electromyography</td>
<td>Lab #4 report due</td>
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<td>March 13</td>
<td>7</td>
<td>Spring Break</td>
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<td>March 20</td>
<td>8</td>
<td>Electromyography</td>
<td>Lab #5 report due</td>
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<td>March 27</td>
<td>9</td>
<td>Thermal Sensor</td>
<td>Lab #6 report is due</td>
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<td>April 3</td>
<td>10</td>
<td>Electroencephalography</td>
<td>Lab #7 report is due</td>
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<td>April 10</td>
<td>11</td>
<td>Electroencephalography II</td>
<td>Lab #9 report is due</td>
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<td>April 17</td>
<td>12</td>
<td>Blood Pressure</td>
<td>Lab #10 report is due</td>
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<td>April 24</td>
<td>13</td>
<td>Blood Glucose</td>
<td>Lab #11 report is due</td>
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<tr>
<td>May 1</td>
<td>14</td>
<td>Biofeedback</td>
<td>Lab 12 report is due</td>
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<tr>
<td>May 8 TO 15</td>
<td>Final</td>
<td>Presentations on Student Design Lab TBD</td>
<td>PowerPoint, Room 3802</td>
</tr>
</tbody>
</table>
Laboratory Reports: Only one laboratory report from each laboratory group is required to be submitted. All submissions should be in hardcopy. The laboratory reports should include the following:

- Title of the laboratory exercise
- Laboratory group names, dates experiment performed
- Introduction (20%):
  - Biomedical measurement description
  - Clinical significance of the biomedical measurement
  - Experiment objectives
- Methods (10%):
  - Amplifier configuration, filter settings, data acquisition rates
- Data and Analysis (30%):
  - Screen/Data captures with captions:
    - Describe what is being shown in the figure. Use language such as “this figure shows that brain focus increases alpha wave activity”.
    - Provide an interpretation of the data
  - Summary of what the data demonstrate.
- Conclusions (20%)
  - Start your conclusion section with “In this experiment, we observed the ....” – make it consistent with the objectives of the experiment.
  - What did this experiment demonstrate? What did you observe?
  - Analyze and interpret data thoughtfully
  - Identify sources of error in measurements or variability associated with measurements from living systems
- Each student in every group must submit his / her answer to the discussion questions at the end of each laboratory exercise (20%)

Laboratory reports should be submitted in hardcopy format no later than 1 week after the laboratory exercise. It is critical that you do not copy data/conclusions from other student groups or from other references including the internet. Lab reports that have been plagiarized will be sent to the Honor Committee.

GRADING POLICY:

Individual Student Answer for the discussion questions 30

This includes (discussion questions for each Lab and individual questions which will be given first week of March and will be due on the day of final presentation 15 points each)

Group Reports 30

This will includes the group Report Grade and the group questions which will be given on first week of March and due on the day of the final presentation, 15 points each)

Final Presentation 40

The final presentation grade has two parts grade as follows:

Group Presentation grade 20
**Individual Student presentation Grade**   20

**Notes:**

- Failure to attend each of the lab course sessions will result in significant penalties. Laboratory reports from students who do not attend the lab session or do not conduct the laboratory exercise will not be accepted. If you must miss a session, notify the instructor by e-mail as soon as possible stating the reason for your absence. If you must miss more than one session for medical reasons, please contact the instructor for alternative arrangements.

- Successful attendance to the lab comprises of being in the lab on time, being prepared and actively participating to the experiments. A successful presentation of the experiment includes a presentation of the experimental setup, the code and the measurements, and an understanding of the nature of the measurements.

- Laboratory reports should be submitted in hardcopy format no later than 1 week after the laboratory exercise. There will be a 10% penalty for every day delay after that. In case of a documented medical emergency that doesn’t allow you to submit the report on time, please notify the instructor.

**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. In this lab, you will work in groups of two or three. It is expected that you will collaborate in conducting the experiments, and that you will discuss problems that arise with your partner(s). It is also expected that you will present the same lab results as your partner. However, it is not acceptable that one partner conducts all the experiment; all students within the lab group should share the work in the experimental procedure and in the preparation and submission of the lab report.

**Academic Courtesy / Lab Rules:**

- No food or drinks are allowed in the lab
- Students are not allowed in the lab without a Lab Instructor or Lab Monitor present
- Handle equipment with care. If you suspect there is a problem with the equipment, notify the Lab Instructor, the TA or the Lab Monitor.
- You are responsible for leaving your working area clean and in good condition when you leave.
- Smoking is not allowed in the building
- Use of cell phones or mp3 players is not allowed during class
- Make sure you dress appropriately for the lab. Wear shoes with insulating soles, and avoid jewelry. Practice the general rules of electronics safety.

**Mason Email Accounts:** Students must use their MasonLIVE email account to receive important University information, including messages related to this class. See http://masonlive.gmu.edu for more information.
Office of Disability Services: If you are a student with a disability and you need academic accommodations, please see the instructor and contact the Office of Disability Services (ODS) at 993-2474. All academic accommodations must be arranged through the ODS. [http://ods.gmu.edu](http://ods.gmu.edu)

**Student Design Lab**

This course is designed to provide students with hands-on experience with biomedical signals and provide training in statistical analysis through a set of instructional laboratory exercises. For the final laboratory exercise, students will design and conduct their own pilot experiment, making use of one or more biomedical signals and analyzing results. Based on variation observed and acquired knowledge in statistics, students will describe what sample size is necessary for conducting a more definitive experiment. This Student Design Lab will be worth 30% of the grade. The exercise will be evaluated based on a final laboratory presentation which will substitute for the final exam for the course. Students will work in groups and deliver the final PowerPoint presentation together (20 min + 5 min for questions).

**Objectives:** An objective of BENG 302 is to teach students to design and conduct experiments, as well as to obtain, analyze and interpret data from living systems. This exercise will examine the ability of students to:

- design experiments, taking into account variability when planning measurements from living systems
- conduct experiments safely and effectively
- analyze and interpret data thoughtfully and critically, taking into account variability of living systems

**Final Laboratory Presentation:** The presentation must address the following in each of these sections in the following order:

1. Title of your experiment, with your name, your lab partners’ name, and date (1 slide)
2. Introduction (1-2 slides):
   - a. The biomedical question that is being addressed
   - b. Why the biomedical question is significant
   - c. Relevance of the selected biomedical signal(s) to address the question
3. Methods and Materials (1-2 slides):
   - a. How measurements were made including telemetry settings, data acquisition rates, and filtering.
   - b. Safety precautions
   - c. A hypothesis
4. Results (1-4 slides):
   - a. Summary data presented in numerical form as mean ± standard deviation.
   - b. Labeled and captioned graphs and figures with accompanying text explaining the what the data show
5. Discussion:
   - a. Interpretation of your results relative to the hypothesis
   - b. Unexpected observations
   - c. Compare your results to the published literature (find at least two published papers that you found relevant to your pilot experiment).
   - d. Are your results consistent with prior work? Anything different – if so – ideas why there are differences?
   - e. Sources of error
6. Beyond the Pilot Experiment (1-2 slides)
   a. Using your data and/or data from literature, describe a statistically valid study. Include a clear hypothesis and a power analyses to give number of subjects necessary.