<table>
<thead>
<tr>
<th>ABET Outcome</th>
<th>Capability</th>
<th>4 Exemplary</th>
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<th>2 Apprentice</th>
<th>1 Novice</th>
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<tr>
<td>b</td>
<td>Design and conduct experiments as well as analyze and interpret data: Utilize BioE skills to test experimental hypotheses developed in BIOEN 401; correctly analyze results; compile/interpret results in a permanent record such as lab notebook or written reports. Conduct experiments consistent with relevant standards.</td>
<td>Appropriate analytical methods were selected and correctly implemented. Quality laboratory conduct was followed, including experimentation consistent with all relevant standards, and compilation of results in a professional manner in a lab notebook or written reports.</td>
<td>Analytical methods were appropriate and correctly implemented. Basic laboratory conduct was followed including adherence to relevant experimental standards and maintenance of a lab notebook, detailed notes or written reports.</td>
<td>Analytical methods were appropriate, but implementation may be questionable. Basic laboratory conduct was followed including lab notebook or detailed notes and reports. Student may need reminding to consider and follow experimental guidelines and standards.</td>
<td>Analytical tools applied were inappropriate and/or not implemented correctly. Basic laboratory conduct was only partially followed (including neglecting experimental standards, infrequent reports or inadequate details in lab notebook).</td>
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<td>e</td>
<td>Identify, formulate, and solve BioE problems: Recognize need in medical or bioscience community; evaluate its relative and absolute importance; cast need as engineering challenge; demonstrate device or process that addresses the problem.</td>
<td>Medical or scientific need is clearly understood; current costs (health, economic, social, etc.) were used to justify project.</td>
<td>Medical or scientific need is understood; current costs (health, economic, social, etc.) were considered; problem was cast as engineering challenge.</td>
<td>Medical or scientific need is understood; current costs were considered; engineering design may be inappropriate for challenge.</td>
<td>Student did not show understanding of need for project, the project did not satisfy the stated needs.</td>
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<td>g</td>
<td>Communicate effectively: Maintain active, effective communication with lab members and advisors. Scheduling and form of communication depends on the lab group and agreements with the advisor.</td>
<td>Student maintained frequent, productive communication with lab members and advisor. Provided high-quality written reports or group presentations. Could be counted on to communicate professionally with outside collaborators.</td>
<td>Student maintained adequate, communication with lab members and advisor. Provided written reports on time and was prepared for group meetings. Could be counted on to communicate effectively with outside collaborators.</td>
<td>Student maintained intermittent, communication when required. Written reports were submitted eventually, and participation in group meetings was minimal. Advisor needs to oversee communication with collaborators.</td>
<td>Student seldom responds to email. Attendance at group meetings was minimal. Advisor reluctant to let student communicate with collaborators.</td>
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<td>l</td>
<td>Recognize the need for, and have the ability to engage in, life-long learning: Shows an ability to keep up with continuous progress in the field during project. See note (1) below.</td>
<td>Current literature is monitored. Key advances relevant to the project were identified and considered as motivation for changes in the project. Student welcomes opportunities to attend conferences, if available.</td>
<td>Literature is monitored, and key advances relevant to the project were identified but impact on project was not recognized.</td>
<td>Student reads relevant current literature when its existence is pointed out. Student is not interested in interpersonal communication as means to advance knowledge.</td>
<td>Either ability or motivation to engage with current literature is lacking.</td>
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</table>
(1) Assessing recognition of the need for life-long learning is similar to assessing students’ understanding of scientific and technological progress and potential. Students should be able to relate: A brief history of their technical field, starting from a point that predates their advisors’ entry into the field; Recent and ongoing advances in the field, especially those that change the goals, methods, and analysis of their projects; A set of new skills or knowledge that must be learned before the next major step in this project or research can be taken; How the education of others outside this institution might change after the results of their project (or the advisor’s larger research effort) are publicized.

Suggested criteria for assessing a student’s ability to engage in life-long learning are: An ability to gain access to available academic resources – including texts, specialized periodicals, and technical databases – after the student has graduated; An ability to seek out and communicate with persons who possess knowledge that cannot be learned effectively from impersonal means; An ability to assimilate newly acquired knowledge into one’s existing understanding of technology; An ability to assess which endeavors are worthy of pursuit, in order to apply time and energy effectively.
The BIOEN 403 Research Paper – 50%

The final report is to be prepared in the form of an engineering research paper following the manuscript format for one of the journals relevant to the field. The document should be in 12-point Times, Cambria, or equivalent font, 1.5- or double-spaced, with 1” margins. The recommended length is 10-15 pages, not including figures or appendices. It is not necessary for the paper to have the same appearance (columns, type face, figure placement) as would appear in the final published version of the paper.

At a minimum, the paper should include the following sections:

- Title page
- Abstract
- Introduction
- Methods and Materials (including adherence to relevant experimental standards and guidelines, such as IACUC and BSL-2)
- Results
- Discussion (may be combined with Results)
- Acknowledgements
- References
- Appendix with the following information:
  - Costs (equipment, services and supplies) in a spreadsheet or table,
  - Description of any significant changes from the initial research plan
  - Experimental/design decisions made by the student during the course of the project, as a measure of the level of independence exercised by the student.

- Additional figures, data, programs, CAD files, etc., that do not fit in the paper may be made available in electronic form made available on a web site as supplemental information.

- A statistical evaluation of the results must be included in the appropriate section.

- All writing is to be in formal technical English, using EndNote or equivalent for references (with appropriate in-text citations).

**Final Report Submission**

The report is to be submitted to the primary advisor and any co-advisor(s) in whichever form (paper or electronic) the adviser requests. The official due date is the last day of classes during the second quarter of BIOEN 403. The report should also be submitted to the academic counselor as a PDF or Word document.

**Final Report Grading**

The final paper is to be graded by the primary advisor, with input or guidance by any co-advisers, as appropriate. Grading for the paper will be based on the criteria in Table 2. Full credit for each item is 4 points, and the cumulative grade will be the average of the scores for the listed criteria. Items that are omitted entirely should receive zero.
## Bioengineering Senior Project Rubric

**Student:** ____________________  **Advisor:** ________________  **Academic Year:** ____________

**Project Title:** _____________________________________________

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**Table 2. BIOEN 403 Report grading rubric. The report grade is the average of scores from the five criteria below.**

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<td>b</td>
<td><strong>Design and conduct experiments as well as analyze and interpret data:</strong> Utilize BioE skills to test experimental hypotheses or prototypes from design plans developed in BIOEN 401; correctly analyze results.</td>
<td>Analysis is complete, correct and conclusions are consistent with results. Appropriate analytical methods are selected and correctly implemented. Experimental design considers all appropriate and required standards and guidelines.</td>
<td>Analysis is complete but contains 1 or 2 minor errors. Analytical methods are appropriate and correctly implemented. Experimental design considers appropriate standards and guidelines.</td>
<td>Analysis is satisfactory, but contains 1 or more conceptual and/or procedural errors. Analytical methods are appropriate and correctly implemented. Some relevant standards and guidelines are mentioned but may be incomplete.</td>
<td>Analysis contains major conceptual and/or procedural errors. Analytical tools applied are inappropriate and/or not implemented correctly. Lack of description of how experiments are consistent with relevant standards and guidelines.</td>
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<td><strong>Identify, formulate, and solve BioE problems:</strong> Recognize need in medical or bioscience community; evaluate its relative and absolute importance; cast need as engineering research challenge; perform experiments that address the need.</td>
<td>Medical or scientific need is clearly explained; current costs (health, economic, social, etc.) are used to justify project; problem is cast as engineering challenge; report shows that the research provided the desired knowledge or discovery.</td>
<td>Medical or scientific need is clearly stated; current costs (health, economic, social, etc.) are mentioned; problem is cast as engineering challenge; report shows that research met experimental goals.</td>
<td>Medical or scientific need is clearly stated; some current costs are mentioned; engineering design may be inappropriate for challenge; successful or not, the report explains the experimental outcomes.</td>
<td>Need is not clear, problem is not addressable by engineering solutions, and/or the report does not explain the impact of the experimental outcomes.</td>
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<td>g</td>
<td><strong>Communicate effectively:</strong> Prepare detailed written report that addresses engineering, economic, and societal issues as shown in report outline.</td>
<td>Written report is virtually error-free, logically presents project, is well organized and easy to read, and contains high quality data/graphics.</td>
<td>Report is logically presented, well organized, easy to read, contains high quality data &amp; graphics, with few minor grammatical or rhetorical errors.</td>
<td>Report is generally well written but contains some grammatical, rhetorical and/or organizational errors; project is not well explained and not fully discussed.</td>
<td>Does not present project clearly, is poorly organized and/or contains major grammatical and/or rhetorical errors.</td>
<td></td>
</tr>
<tr>
<td>i</td>
<td><strong>Recognize the need for, and have the ability to engage in, life-long learning</strong> Show/describe the continuous progress in the field prior to and during project.</td>
<td>Current and seminal literature is discussed in relation to the project; key advances relevant to the project are identified. Proper referencing shows that the literature was thoroughly searched and analyzed.</td>
<td>The number and quality of citations indicates a thorough literature search. Literature is discussed in relation to the project. Sources are cited throughout paper where needed.</td>
<td>The current literature is mentioned/listed, indicating an adequate literature search. Information sources are cited throughout paper where required.</td>
<td>Number and brevity of citations indicates only a minimal literature search. Statements are made without citing information source.</td>
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# Bioengineering Senior Project Rubric

Student: ____________________  Advisor: _______________  Academic Year: ________

**Project Title:** ________________________________________________________________

| Advanced math in BioE (Program Criterion) | Apply advanced mathematics (including differential equations and statistics), science, and engineering to solve the problems at the interface of engineering and biology. Demonstration of preparation should emphasize statistical analysis. | Provides a theoretical analysis using appropriate engineering mathematics; addresses all hypotheses posed in experimental design; supports conclusions with thorough statistical analysis using appropriate methods, large sample sizes and thorough control experiments. | Provides a theoretical analysis using appropriate engineering mathematics; addresses hypotheses posed in experimental design; includes statistical analysis, with appropriate methods, adequate sample sizes and some control experiments; uses statistics to support conclusions. | Explains theory using basic engineering mathematics; includes statistical analysis, but with inappropriate methods, inadequate sample sizes and few control experiments. | Incorrectly applies engineering mathematics in theoretical analysis; does not quantitatively address hypotheses posed in experimental design; mentions statistical evaluation without evaluating the data. |