Quality and quantity of work in lab – 40%

The capstone advisor(s) have the flexibility to judge – as objectively as possible – the performance of the student on a day-to-day basis. This judgment should consider progress on the project itself, as well as the student's ability to function effectively as a member of a research lab group. Specific items to be considered include planning tasks, record keeping, adherence to safety guidelines, following experimental procedures and good lab practice, communication with advisors and group members, follow-through on agreements, and time spent on the project or in lab.

Table 1 provides a rubric for evaluating a student's performance on the practical aspects of conducting the design project.

Table 1. Each BS BIOE graduate will conduct a design **project** that shows his/her ability to…

ABET Outcome	Ability	4 Exemplary	3 Proficient	2 Apprentice	1 Novice	Score
A1	**Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics:** 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.	Medical or scientific need is clearly understood as student tells mentors how results and next steps related to scientific or medical need; current costs (health, economic, social, etc.) were used to justify project; device or process was shown to be an effective solution, or student clearly understood the outcome of efficacy testing.	Medical or scientific need is understood; current costs (health, economic, social, etc.) were considered; problem was cast as engineering challenge; device or process was shown to be an effective solution, or student at least understood the effectiveness of the attempted solutions.	Student understands how results and next steps relate to medical or scientific need only when told; current costs were considered; engineering design may be inappropriate for challenge; demonstrated some understanding of the effectiveness (or lack thereof) of attempted solution.	Student did not show understanding of need for project, problem was not addressable by engineering solutions, and/or the student did not understand clearly why the attempted solution did not satisfy the stated needs.	
A2	**Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors:** Apply design plans developed in BIOEN 401 while considering multiple design options and realistic constraints (such as cultural, social, economic, and engineering standards); modify and improve the design based on experimental results to meet specified needs (iterate on design); consider risks and trade-offs during design process.	Realistic design constraints, including appropriate engineering and experimental standards, were considered thoroughly during the design process. Student completely considered public health, safety, and welfare, global, cultural, social, environmental and economic factors and thoughtfully incorporated the relevant factors into design decisions. Risks were considered and thoughtful trade-offs were made during design process. Design adaptations based on acquired results were considered to better adapt the design to the desired needs. More than one option was considered and tested and the best option was utilized.	Multiple realistic constraints (including any relevant engineering standards) were identified and incorporated into the design process. Student considered public health, safety, and welfare, global, cultural, social, environmental and economic factors and incorporated the relevant factors into design decisions. Satisfactory consideration of risk throughout design process. Design adaptations based on acquired results were considered to better adapt the design to the desired needs. At least one design adaptation (based on acquired results) was considered and tested.	Realistic constraints were integrated into the design process but some obvious ones may be missing. Student considered and incorporated public health, safety, and welfare, and global, cultural, social, environmental and economic factors only to a marginal degree. Some risks relevant to the project were considered and addressed, but this may be incomplete. One design adaptation based on acquired results was considered but not tested.	Failure to identify and/or incorporate relevant realistic constraints into design process. Student did not consider public health, safety, and welfare, nor global, cultural, social, environmental and economic factors and/or failed to incorporate those relevant factors into design decisions. Student does not display consideration of risk during design project. Original design followed without considering modifications.	

A3	**Communicate effectively with a range of audiences:** Maintain active, effective communication with lab members and advisors. Scheduling and form of communication depends on the lab group and agreements with the advisor.	Student maintained frequent, productive communication with lab members and advisor. Provided high-quality written reports, symposia presentations, or lab group presentations. Could be counted on to communicate professionally with outside collaborators.	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 and deliver clear, effective presentations.	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. Clarity of oral presentations may be lacking.	Student seldom responds to email, Attendance at group meetings was minimal. Advisor reluctant to let student communicate with collaborators. Oral presentations need work.	
A4	**Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts:** Display knowledge of ethical and professional responsibilities surrounding the design, such as regulatory matters including standards, and environmental, social, legal, ethical, geopolitical consequences. Describe impact of solution in global, economic, environmental, and societal contexts.	Displays knowledge of ethical and professional responsibilities surrounding the design, such as regulatory matters including standards, and environmental, social, legal, ethical, geopolitical consequences and uses that knowledge to make informed judgements during the design process. Can describe impact of solution in global, economic, environmental, and societal contexts.	Identifies a number of important global, economic, environmental, and societal considerations relevant to project and utilizes knowledge to make informed design judgements; identifies regulatory matters including current relevant standards; may include limited discussion of each category, including present ramifications.	Identifies only a few of the obvious global, economic, environmental, and societal considerations surrounding the engineering design solution, with shallow discussion of the ramifications.	Identifies only a few of the obvious global, economic, environmental, and societal considerations surrounding the engineering design solution, with no discussion of the ramifications.	
A5	**Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives:** Function effectively as a member of a research team as defined by the PI, through behaviors such as integrating lab resources, objectives, and expectations into project planning and execution. Solicit and integrate feedback from mentors.	Student actively and obviously worked to understand and execute the team-working and leadership expectations set by the PI. Student was effective at working with their team to establish project goals, plan tasks, and meet objectives. Student was proactive about soliciting feedback from mentors and always followed through in incorporating that feedback. Student consistently contributed to a collaborative and inclusive research environment.	Student worked to understand and execute the team-working and leadership expectations set by the PI. Student was effective at working with their team to establish project goals, plan tasks, and meet objectives. Student solicited feedback from mentors and usually followed through in incorporating that feedback. Student usually contributed to a collaborative and inclusive research environment.	Student exhibited developing team-working abilities and may have not met the expectations set by the PI. Student was somewhat effective at working with their team to establish project goals, plan tasks, and meet objectives but may have needed more guidance and prompting than expected. Student did not solicit feedback from mentors during the Capstone process, and/or failed to incorporate that feedback. Student did not usually contribute to a collaborative and inclusive environment.	Student's team-working abilities were not effective. Student did not exhibit behaviors set by lab norms. Student did not ask for feedback and did not work effectively with research team to establish project goals, plan tasks, and/or meet objectives. Student may have been incommunicative or inaccessible, and did not contribute to a collaborative and inclusive environment.	

A6	**Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions**: Utilize BioE skills to test experimental hypotheses or prototypes from design plans developed in BIOEN 401; correctly analyze results; compile/interpret results in a permanent record such as lab notebook or written reports.	Appropriate analytical methods were selected and correctly implemented and interpreted. Quality laboratory conduct was followed including: results compiled in a professional manner in lab notebook or written reports. Exhibits independence in selecting next steps.	Analytical methods were appropriately designed and correctly implemented and interpreted. Basic laboratory conduct was followed including lab notebook, detailed notes or written reports.	Analytical methods were appropriate, but implementation and/or interpretation may be questionable. Basic laboratory conduct was followed including lab notebook or detailed notes and reports.	Analytical tools applied were inappropriate and/or not implemented correctly. Basic laboratory conduct was only partially followed (inadequate details in lab notebook or infrequent reports).	
A7	**Acquire and apply new knowledge as needed, using appropriate learning strategies:** Shows an ability to keep up with continuous progress in the field during project. See note (1) below.	Current literature is monitored. Key advances relevant to the project are identified and considered as motivation for changes in the project. Student welcomes opportunities to attend conferences, if available.	Literature is monitored, and key advances relevant to the project are identified but impact on project may not be recognized.	Student reads relevant current literature when its existence is pointed out by mentors. Student is not interested in interpersonal communication as means to advance knowledge.	Either ability or motivation to engage with current literature is lacking. Never discusses literature with mentors.	
Apply math (Program Criterion W)	**Apply mathematics (including statistics) and engineering to solve bio/biomedical engineering problems.** Preparation on this topic via Capstone should emphasize statistical analysis when appropriate to support conclusions.	Masters appropriate mathematical techniques or extended math capabilities appropriate for undergraduate curriculum; addresses each hypothesis posed in experimental design; performs statistical analysis using appropriate methods, large sample sizes and thorough control experiments.	Correctly applies undergraduate-level engineering mathematics in theoretical analysis; addresses hypotheses posed in experimental design; performs statistical analysis to assess statistical significance of conclusions, with appropriate methods, adequate sample sizes and some control experiments.	Applies basic mathematics to theoretical analysis; performs statistical analysis to assess statistical significance of conclusions, but may use inappropriate methods, analysis may be insufficient or has errors	Incorrectly applies engineering mathematics; does not quantitatively address hypotheses posed in experimental design.	

(1) Assessing the ability to **acquire and apply new knowledge as needed, using appropriate learning strategies**: 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. Suggested criteria for assessing a student's ability to acquire and apply new knowledge, using appropriate learning strategies are: An ability to gain access to available academic resources and to navigate them to obtain information needed for the project – including texts, specialized periodicals, and technical databases; 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.