Course Title: BIOEN 482 – Bioengineering Capstone Project

Instructor: Neils, C. M. and Bioengineering faculty. Each student registers with an individual Bioengineering faculty advisor. Writing progress and other issues are supervised by a single instructor.

Credits: 8 total, divided among 2-4 consecutive quarters, with 2-6 credits per quarter.

UW General Catalog Course Description: Independent senior design project with final paper and poster.

Course Description:
BIOEN 482 places seniors in Bioengineering faculty laboratories to conduct individual design projects related to real medical problems. Students may initiate projects or choose projects suggested by the faculty host. A senior project may be part of a larger project, but it must have definable design goals and be sufficiently novel that its successful completion would merit publication in a science or engineering journal. The design content should be consistent with the ASEE white paper, *Design versus Research: ABET Requirements for Design* (Gassert *et al*., 2006), which may be viewed via http://depts.washington.edu/bioe/programs/bachelors/bs.html.

During the project, seniors are members of a laboratory group, attending group meetings and sharing lab maintenance duties in addition to planning and executing the senior project. In larger lab groups, seniors are typically assigned a graduate student or post-doctoral fellow as mentor.

Students register for 8 credits, divided among 2-4 sequential quarters with 2-6 credits per quarter. Autumn quarter typically includes planning, equipment acquisition, and training, winter quarter includes fabrication and/or experimentation, and spring quarter emphasizes analysis and reporting. This schedule is flexible to accommodate students' progress and graduation plans. The grade for all quarters of BIOEN 482 is determined upon completion of the course and project. The grade is based primarily on a written project report and poster submitted in the last quarter of the class, and secondarily on the advisor's quarterly progress evaluations.

Each student is encouraged to choose a host lab before starting BIOEN 481 in spring of the junior year, and must select a project topic early in BIOEN 481. The BIOEN 482 project proposal is developed during BIOEN 481, and the nature of the project is examined twice by the Student Affairs Committee and/or BIOEN 481 instructor. An initial review early in BIOEN 481 confirms that each project will be a culminating Bioengineering design experience, recommending changes when necessary. The second review is based on the project plan written in BIOEN 481, and may occur during the spring or summer quarter.

Prerequisites by Topic:

Bioengineering Design and Capstone Principles (BIOEN 481), Molecular Bioengineering (BIOEN 357), Probability and Engineering Statistics.

Textbooks: None

Course Objectives:

Allow students to observe and practice the detailed tasks needed to plan and conduct Bioengineering projects and to maintain an R& D lab. Provide independent bioengineering design experience with educational support and advice. Promote the transition from student to engineer by assigning professional responsibilities. Provide experience working in a group.

Topics Covered:

Design of experiments, tools, and devices. Statistical basis for the design and analysis of experiments. Composition of design project reports. Podium and poster presentations. Specialized topics and techniques as appropriate.

Class Schedule:

Students work in lab on a schedule agreed between each advisor and student (8-24 hours/week). All students convene one hour per week to discuss their progress and course requirements.

Computer Use:

Requires on-line access to search literature and to communicate via email. Requires computer-based data analysis, report generation, and overhead slide preparation. May require numerical simulations, signal and image processing, and advanced programming depending on the individual research projects.

Laboratory Projects:

Students conduct cutting-edge design projects alongside graduate students in faculty laboratories. Projects may be proposed by the students or advisors, according to the interests of both. Topics of past senior projects have included: Schlieren imaging system to monitor ultrasound therapy; computer model of brain tumor growth; pH-sensitive gels for timed release of antibodies; low-cost, portable tests for STDs; implantable materials with enhanced biocompatibility.

Course Outcomes and Assessment:

Students' success in BIOEN 482 depends on their ability to perform the tasks described below, and to synthesize these tasks into a coherent effort. Individual students are assessed by their senior project advisor(s), weighted as follows: 40% technical content of report, 20% writing & presentation of report, 20% poster, and 20% advisor's evaluation of planning, progress, record keeping, and ability. In addition, the course is assessed annually by a committee of faculty who review 9 representative senior project reports and posters (3 with high grades, 3 with low grades, and 3 with average grades).

Students' ability to perform each of the tasks listed below is assessed based on their senior project reports and posters, according to the attached grading rubric.

[b] Design and conduct experiments as well as analyze and interpret data

[c] Design a system, component, or process to meet desired needs.

[e] Identify, formulate, and solve Bioengineering problems.

[g] Communicate effectively.

[i] Recognize the need for, and ability to engage in, life-long learning.

[j] Demonstrate knowledge of contemporary issues.

[m] Apply advanced mathematics (including differential equations and statistics), science, and engineering to solve the problems at the interface of engineering and biology.

[n] Make measurements on and interpret data from living systems, addressing the problems associated with the interaction between living and non-living materials and systems.

Relationship of course to Departmental Objectives:

This course allows students to apply the Bioengineering fundamentals they have learned, and to learn advanced topics and techniques, in a manner consistent with graduate and professional training in medicine and biology. The student projects are typically part of externally funded programs, and therefore address immediate or long-term issues that are of considerable importance to human health. Students may encounter problems that require knowledge from any or all of their prior courses or that may require them to master concepts that they have not previously explored. Students must communicate their progress to their advisors, collaborators, and peers, who may encompass a broad range of academic and professional backgrounds.

Thus, students in BIOEN 482 progress toward our departmental objectives by:

- Integrating engineering concepts with mathematics, physics, chemistry, computing, and biology to solve biomedical problems. (assessment via the senior project report)
- Deriving design principles from nature to create biomedical devices and materials. (assessment via the senior project report)
- Communicating problems and their solutions effectively with physicians, biologists and other engineers. (assessment via the senior project report and poster)
- Taking ethical and social issues into consideration (assessment via the senior report)
- Continuing to develop technical knowledge and awareness to maintain leadership in human health issues (assessment via the senior project report)

References:

Gassert, J., Enderle, J.D., Lerner, A., Richerson, S. and Katona, P., Design versus Research; ABET Requirements for Design and Why Research Cannot Substitute for Design, *Proceedings of the ASEE Annual Conference and Exposition,* June 18-21, 2006, Chicago, Illinois, Session 2006-1139.
Accessed May 10, 2007, http://www.asee.org/acPapers/code/getPaper.cfm?paperID=10634

BIOEN 482 Project Report

The final report is to be submitted to the primary advisor, to the co-advisor, if there is one, and to the academic counselor (in electronic form only in the latter case). The document will be in 12-point Times or an equivalent font, double-spaced, with 1” margins, for a recommended total length of 35-50 pages, not including references and appendices. It will take the form of a thesis with the following format and suggested section length:

Title

Abstract (~250 words)

Introduction, 16 pages

Concise definition of the project, 1 page
Significance (medical and/or scientific), 1-2 pages
Social, Ethical and Economic Issues, 1-2 pages
Technical Background
Theory, 2 pages
Review of Literature (>30 relevant references concisely narrated), 5 pages
Previous relevant work in the advisor’s laboratory, 2 pages
Outstanding technical issues at the outset of the project, 2 pages

Design of Tools, Devices, and Experiments, 5-6 pages

Overview of design and research plan as proposed in BIOEN 481, 1 page
Overview of revised design process (if significantly different from proposal), 1 page
Materials and Methods, 1 page
Costs (e.g., equipment, services and supplies purchased for the project in Excel-style table), 1 page
Details of design process, including statistical basis for design of experiments, 2 pages

Results, 22 pages

Final timeline (using MS Project Gant chart or equivalent), 1 page
Data, including a chronological narrative, tables, figures, and statistical analysis, 15 pages
Experimental/design decisions made by the student during the course of the project, 1 page
Analysis and Conclusions, 4 pages
Suggestions for future work, 1 page

Acknowledgements

Credit to all others who gave assistance or financial support in the performance of the project), 1 paragraph

References

(>30, as noted above)

Appendices

Includes optional additional figures, data, programs, CAD files, etc., in electronic form made available on a web site

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

The final thesis is to be graded by the primary advisor. Grading for the paper and poster will be based on the criteria in the table below. Full credit for the poster is half of the “communicates effectively” criterion below. Full credit for BIOEN 482 will be on the basis of 32 points, as shown below. The numerical grade will be scaled accordingly ((points/8) = grade).

Bioengineering Senior Project Rubric

Student: ______________________ Advisor: ___________________ Academic Year: _____________

Project Title: ____

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

ABET Ref#	Objective	4 Exemplary	3 Proficient	2 Apprentice	1 Novice	Score
b	**Design and conduct experiments as well as analyze and interpret data**: Utilize BioE skills to test experimental hypotheses or prototypes from design plans developed in BIOEN 481; correctly analyze results; compile results in a permanent record such as lab notebook or written reports.	Analysis is complete, correct and conclusions consistent with results. Appropriate analytical methods are selected and correctly implemented. Quality laboratory conduct is followed including: results compiled in a professional manner in lab notebook or written reports.	Analysis is complete but contains 1 or 2 minor errors. Analytical methods are appropriate and correctly implemented. Basic laboratory conduct is followed including lab notebook, detailed notes or written reports.	Analysis is satisfactory, but contains 1 or more conceptual and/or procedural errors. Analytical methods are appropriate and correctly implemented. Basic laboratory conduct is followed including lab notebook or detailed notes and reports.	Analysis contains major conceptual and/or procedural errors. Analytical tools applied are inappropriate and/or not implemented correctly. Basic laboratory conduct is only partially followed (inadequate details in lab notebook or infrequent reports).	
c	**Design a system, component, or process to meet desired needs:** Apply design plans developed in BIOEN 481; modify and improve based on experimental results.	Design adaptations based on acquired results are considered to better adapt the design to the desired needs. More than one option is considered and tested and the best option is utilized.	Design adaptations based on acquired results are considered to better adapt the design to the desired needs. At least one option is considered and tested.	A design adaptation based on acquired results is considered to better adapt the design to the desired needs. One option is considered but not tested.	Original design followed without considering modifications.	
e	**Identify, formulate, and solve BioE problems**: Recognize need in medical or bioscience community; Evaluate its relative and absolute importance; cast problem as an engineering challenge; demonstrate device or process that addresses the problem.	Medical or scientific need is clearly explained; current costs (health, economic, social, etc.) are used to justify project; problem is cast as engineering challenge; device or process is shown to be an effective solution.	Medical or scientific need is clearly stated; current costs (health, economic, social, etc.) are mentioned; problem is cast as engineering challenge; device or process is shown to be an effective solution.	Medical or scientific need is clearly stated; some current costs are mentioned; engineering design may be inappropriate for challenge; device or process is implemented but is only partially effective.	Need is not clear, problem is not addressable by engineering solutions, and/or the project does not satisfy the stated needs.	
g	**Communicate effectively:** Prepare detailed written report that addresses engineering, economic, and societal issues as shown in report outline (attached). Prepare a poster suitable for display at a national meeting.	Written report is virtually error-free, logically presents project, is well organized and easy to read, and contains high quality data/graphics. Printed poster is well organized, clearly defines problem, presents data clearly, presents data clearly with quality data/graphics, and draws conclusions supported by presented data.	Report is logically presented, well organized, easy to read, contains high quality data/graphics, and contains few minor grammatical and/or rhetorical errors. Printed poster is adequately organized; problem clearly defined; data presented with only minor graphic or grammatical errors; conclusions drawn from presented data.	Report is generally well written but contains some grammatical, rhetorical and/or organizational errors; project is not well explained and not fully discussed. Printed poster not clearly organized; problem not well defined; data has grammatical or graphics errors; conclusions made based on presented data.	Does not present project clearly, is poorly organized and/or contains major grammatical and/or rhetorical errors. Printed poster poorly organized; problem not well defined; data has major grammatical and/or graphics errors. Data does not support conclusions, or conclusions not presented.	

Bioengineering Senior Project Rubric

Student: ______________________ Advisor: ___________________ Academic Year: _____________

Project Title: ____

i	**Recognize the need for, and have the ability to engage in, life-long learning**: Show/describe the continuous progress in the field prior to and during project. See note (1) below.	Current and seminal literature is discussed in relation to the project and key advances relevant to the project are identified. Proper referencing shows that the literature was thoroughly searched and analyzed.	The number and quality of citations indicates a thorough literature search. Literature is discussed in relation to the project. Information sources are cited throughout paper where required.	The current literature is mentioned/listed, indicating an adequate literature search. Information sources are cited throughout paper where required.	Number and brevity of citations indicates only a minimal literature search. Statements are made without citing information source.	
j	**Demonstrate knowledge of contemporary issues** surrounding the design, such as environmental, social, legal, ethical, geopolitical consequences.	Identifies a number of important E, S, L, E, G considerations; evaluates strengths & weaknesses of each category, including present and future ramifications.	Identifies a number of important E, S, L, E, G considerations; includes limited discussion of the strengths & weaknesses of each category, including present ramifications.	Identifies only a few of the obvious E, S, L, E, G considerations with shallow discussion of the ramifications.	Lists E, S, L, E, G considerations with no discussion of the ramifications.	
m	**Apply advanced mathematics, science, and engineering to solve Bioengineering problems.** Assessment should emphasize statistical analysis.	Applies graduate-level engineering mathematics in theoretical analysis; addresses all hypotheses posed in experimental design; supports conclusions with thorough statistical analysis using appropriate methods, large sample sizes and thorough control experiments.	Correctly applies undergraduate engineering mathematics in theoretical analysis; addresses hypotheses posed in experimental design; includes statistical analysis, with appropriate methods, adequate sample sizes and some control experiments; uses statistics to support conclusions.	Applies basic engineering mathematics in theoretical analysis; includes statistical analysis, but with inappropriate methods, inadequate sample sizes and few control experiments.	Omits or incorrectly applies engineering mathematics in theoretical analysis; does not address hypotheses posed in experimental design; does not include statistical evaluation of the data.	
n	**Make measurements on and interpret data from living systems, addressing the problems associated with the interaction between living and non-living materials and systems**	Student clearly knows what parameters need to be measured and is proficient at more than one type of measurement to address the problem. Student is familiar with the advantages and disadvantages of all the methods.	Student is aware of what parameters need to be measured and is proficient at least one type of measurement. Student is familiar with the advantages and disadvantages of this type of measurement	Student is aware of how to make at least one type of measurement and interpret the data. Student does not clearly understand the advantages and disadvantages of this measurement or how it addresses the interaction between living and non-living materials and systems.	Student unclear on how to make measurements or interpret the data. Report does not address problems involved with interaction between living and non-living systems	

(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 topics are worthy of pursuit, in order to apply time and energy effectively; The intellectual energy and acuity to learn effectively as age increases, thus requiring an understanding of the factors that promote physical and mental health (and the will power to implement them).