BIOEN 404-405 General Purpose SYLLABUS*

***Please refer to Canvas sites for BIOEN 404 and 405 for current course information.**

Course Title: BIOEN 404 – Bioengineering Team Design I

BIOEN 405 – Bioengineering Team Design II

Instructors: Chris Neils and Alyssa Taylor

Credits: BIOEN 404: 3

BIOEN 405: 4

UW General Catalog Course Description:
404: First course in team design project course sequence. Prerequisite: BIOEN 400.
405: Second course in team design project course sequence. Prerequisite: BIOEN 404.

Detailed Course Description:
The Department of Bioengineering offers two options for completing a senior capstone project. Students who choose the BIOEN 401-402 sequence conduct an individual design project. Students who choose the BIOEN 401-403-404-405 sequence conduct an individual research project and a team design project. The number of total credits in each sequence is equal.

BIOEN 404 and BIOEN 405 form a two-quarter design sequence for bioengineering majors, running through winter and spring quarters. BIOEN 404/405 students work in 2-5 person teams to design, create, and test a system, device, or process that addresses an unresolved medical or health-related problem. The faculty instructors will identify and develop projects prior to the start of BIOEN 404. Projects will be sought from the broader health care community, including School of Medicine, School of Nursing, College of Engineering, and local industry. Where possible, the faculty, clinicians, or industry representatives will provide in-kind funding and mentorship for the student groups. Projects without such dedicated sponsorship will be supported to a limited extent by departmental funds or education grants.

During BIOEN 404, the instructor team will present the project topics, assign teams, and provide guidance on project planning and execution. Lecture topics may include intellectual property issues, regulatory affairs, design for low-resource settings, design case studies, and prototyping techniques, although some of these items may be covered in BIOEN 400. Instruction with lab practice will be offered in technical drawing. Machine shop instruction will be provided on a space-available basis. During BIOEN 404 students will request assignment to project teams, develop and present design strategies for their assigned projects, and complete homework related to the various lecture and lab topics listed above. By the end of the quarter each student group should have a design concept, system specifications, a budget and a timeline that will be carried out during the following quarter.

BIOEN 405 is devoted primarily to the detailed design and production of the project deliverables. Students may work in Bioengineering student labs, UW instrument fabrication shops, or facilities provided by their project mentors, as space and student qualifications permit. Depending on the availability of funds and the complexity of the project, students may also pay professional instrument makers to build parts to the detailed specifications provided by the

student groups. The team capstone instructor will monitor student progress and provide both technical and strategic guidance as necessary. Students will submit progress reports and a final paper describing the design process and project outcome, with a presentation and demonstration of the final product. When time and funding permit, students will be invited to test each product in its intended location, for example in a hospital setting or in a rural community.

The team design project is intended to satisfy the ABET requirement for a culminating design experience. Please see the ABET Engineering Accreditation Commission General Criteria for Baccalaureate Programs. The design content should be consistent with the ASEE white paper, *Design versus Research: ABET Requirements for Design.*[1]

The BIOEN 404 grade is based on the following:

Patent review (individual)	5%
Progress presentations (individual)	10%
Draft proposal submission (team)	10%
Project proposal (team)	30%
Project proposal (individual section)	15%
Oral presentation of proposal (team)	20%
In-class participation & Cross-project critique (indiv.)	10%

The BIOEN 405 grade is based on the following:

Assignments (individual)	20%
Final written report (team)	30%
Final oral presentation (team) and exam (individual)	30%
Peer evaluation of group work performance	10%
Class Participation	10%

Prerequisites by Topic:

Circuit analysis, differential equations, physics (mechanics, E & M). Requires Fundamentals of Bioengineering Design (BI0EN 400).

Textbooks: None. Students will conduct project research and literature analysis using resources through UW Libraries.

Learning Objectives:

- Learn the strategic and technical skills needed to plan and conduct bioengineering projects.
- Develop design skills that may be applied to a variety of bioengineering devices.
- Integrate skills and knowledge learned throughout curriculum by completing an open-ended project with recognizable implications for healthcare.

[1] Gassert *et al*., 2006, accessed via http://soa.asee.org/paper/conference/paper-view.cfm?id=1341.

- Learn the importance of effective medical care through the process of addressing unresolved medical needs.
- Develop interpersonal skills that promote effective team design skills.
- Develop effective communication skills by conveying project proposal and final demonstration in both oral and written formats to a variety of audiences.

Topics Covered:

Design of experiments, tools, and devices. Composition of design proposals and project reports. Prototyping and design testing. Podium presentations. Specialized topics and techniques as appropriate.

Class Schedule:

BIOEN 404 (winter quarter) meets twice weekly with 1-hour periods for lecture and discussion, plus once weekly for a 2-hour lab period. BIOEN 405 (spring quarter) meets twice weekly with 1.5 hour periods for individual guidance and team meetings, lecture and discussion, or student presentations. Students are expected to contribute significant effort outside of class to the design and development, and the instructor is expected to provide significant office or lab hours to provide consultation.

Computer Use:

Coursework requires the use of computer-aided design (CAD) tools and test systems, including AutoCAD, LabView, and similar software environments. Engineering experimentation requires computer-based data analysis. Projects may require numerical simulations, signal and image processing, and advanced programming depending on the particular research projects. Standard desktop software is used for communication and report preparation.

Laboratory Projects:

Students work in 2-5 person teams to design, create, and test a system, device, or process that addresses an unresolved medical or health-related problem. Brief computer-aided drawing and fabrication projects may be assigned as learning exercises.

Course Outcomes and Assessment:

In this cumulative design experience, students will develop a variety of important engineering and professional skills. Students are graded on their ability to engage in the following activities, as demonstrated by their progress reports, design proposal, assignments, and final reports and quantified in the attached grading rubrics. Letters refer to ABET student learning outcomes, which apply to all students and projects. The bulleted items are BioE-specific program criteria; we seek to teach all of these topics to our students and give them experience with each of these, but given the real-world relevance and wide variety of project topics, any given Capstone project will emphasize some subset of the topics listed.

an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

In this course, students execute key steps of the engineering design process, including identification of the problem, exploration and formulation of the problem, and design of a solution. Students learn how to identify and conduct thorough research on current bioengineering problems, and work in teams to propose and design solutions to those identified

problems. Student competency will be assessed through the final oral project presentation and an individually-based final oral exam session.

- Many, but not all, projects will serve to grant students further experience in solving bio/biomedical engineering problems associated with the interaction between living and non-living systems.

an ability to 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

Throughout this project, students are working to design a system to meet a desired need within identified realistic constraints, including relevant engineering standards. Students work with their team and advisor to identify the constraints relevant to their design problem, and work for two quarters to design a solution to meet the need (identified through first-hand observations, interviews with users, etc.). Student competency will be assessed through the final oral project presentation and an individually-based final oral exam session.

- Students will gain experience with analyzing, modeling, designing, and realizing bio/biomedical engineering devices, systems, components, or processes.

an ability to communicate effectively with a range of audiences

Students develop effective communication skills by conveying project proposal and final demonstration in both oral and written formats to a variety of audiences. We have an annual Bioengineering Capstone Design Symposium, where students have the opportunity to present their projects to other students, faculty, clinicians, and industry partners.

an ability to 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

Students describe the ethical and professional responsibilities surrounding the design and regulatory matters in the proposal. The proposal also asks students to consider the impact of solution in global, economic, environmental and societal contexts. Student competency will be assessed through an individually-based section of the written proposal, in which students must discuss the following topics as appropriate for the proposed technology: the social and economic cost or consequence of not having (or having) the proposed technology, current ethical, legal, and regulatory standards, any public debate surrounding these standards or the implementation of this technology.

an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives

Student design teams work together to reach project objectives. Instructor check-ins help ensure students are collaborating, establishing goals, planning tasks, and creating an inclusive environment. Student competency will be assessed through individually-based oral progress reports, instructor observations, and peer evaluation of group work performance.

an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions

Students will test prototypes and analyze the test results, using those results to make informed design decisions and to iterate on their design solutions.

an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Students will show and describe continuous progress in the field prior to and during the Capstone project, by conducting literature searches. They also will develop skills to research prior art, by performing patent searches and analysis.

Team Capstone Projects contribute to these **Program Criteria** (curricular topics)–
W. apply principles of engineering, biology, human physiology, chemistry, calculus-based physics, mathematics (through differential equations), and statistics: Teams apply principles of engineering, science, and statistics to planning of proposed design
X. Solve bio/biomedical engineering problems, including those associated with the interaction between living and non-living systems: For relevant projects, teams will solve biomedical engineering problems, which are associated with the interaction between living and non-living systems.
Y. Analyze, model, design, and realize bio/biomedical engineering devices, systems, components, or processes: Students gain experience with these tasks throughout the project.
Z. Make measurements on and interpret data from living systems: For relevant projects, make measurements on and interpret data for living systems

Relationship of Course to Program Educational 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 typically originate as suggestions from clinicians or industry experts, 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 instructors, collaborators, and peers, who may encompass a broad range of academic and professional backgrounds. Students in BIOEN 404-405 progress toward our departmental objectives because they are required to manage a team design project with real-world relevance. They develop written and oral communication skills, technical expertise, and engineering design knowledge. Completion of their project allows students to gain key professional and research skills that they will need to obtain employment in bioengineering-related fields. Working with an advisor from medicine or industry, students must be responsible and guide the progress of their own projects. They gain experience in project management, working in an interdisciplinary team, and conveying their ideas to their peers and supervisors. Students gain practice in transferrable professional tasks such as proposal writing and oral presentations. As such, this

experience will give students many tools needed to reach the program educational objectives of the Bioengineering undergraduate program:

- Earn advanced degrees and/or obtain employment in bioengineering-related fields, such as medicine, device development, or biotechnology.
- Advance their careers by obtaining appropriate educational and professional qualifications.
- Serve their profession and community.
- Contribute to responsible development of new technical knowledge.
- Take leadership roles as individuals or in teams to address domestic or global bioengineering-related issues.

Week	Topic	Assignment due
1	Course introduction, project goals, team status	--
	Informal lecture on documentation and project-specific IP issues or technology. Using a lab notebook.	
	Free work time, ideally meeting with mentors.	Resource request
2	Lecture on redundancy, reliability, and safety margins; perhaps national and local design competitions.	
	Student project lab setup, basic equipment use, lockers.	Draft time line
	Project team work time	
3	Groups present results of their literature and patent searches.	Patent search
	Project team work time	
4	Preparing design proposals / progress reports	
	Progress presentations I (individual, one per group)	
	Project team work time	
5	Design software: LabView	
	Lecture: Software regulation and documentation	Proposal outline
	Project team work time	
6	Lecture: Materials selection Design software workshop: Solidworks	
	Progress presentations II (individual, one per group)	
	Project team work time	
7	Design for high-resource settings: profit & marketing	
	Project team work time	
8	Design software: Solidworks+COMSOL	
	Design for low-resource settings	Draft proposal
	Project team work time	
9	Attend BIOEN 402 / 403 presentations	
	Progress presentations III (individual, one per group).	
	Group work time: prepare for presentations	
10	Student proposal presentations (team)	
	Discussion: Maintaining project continuity over spring break	Critique of presentations (i)
	Individual work time: BIOEN 404 proposal or BIOEN 403 research report.	Final proposal
11	*Final exam period* *(alternative time for student presentations)*	

During scheduled team work time, instructors will be available in rooms N119 or N133. This schedule assumes that project teams have been determined during autumn quarter.

BIOEN 405 Class schedule* (Spring quarter)

Day	Topic	Assignment due
1	Welcome, syllabus review, project status report	Informal project status reports (team)
2	Documenting device designs	
3	Team work day: Instructor check-in meetings with teams	
4	Generating a testing plan	
5	Market analysis and economic considerations	
6	FDA Experiences in Industry (guest speaker)	
7	Human Factors in Design (guest speaker from IND E)	Notebook check
8	-Design for manufacturing (lecture + in-class activity) -Discussion of engineering standards	
9	Design solutions workshop; Progress status report	Written progress report
10	Team work day: Instructor check-in meetings with teams	
11	Mid-quarter formative assessment	
12	Oral presentation guidelines	Report draft (team)
13	Team work day	
14	Current events in IP, technology, and regulation -Current events in Patent Law (2013)	Notebook check
15	Team work day: Instructor check-in meetings with teams	
16	Team work day (return report draft comments)	
17	Center for Teaching and Learning: BIOE program evaluation with the seniors	
18	Your project as a job-seeking tool/interviewing	
19	Team work day	
20	Wrap-up; Course evaluations/survey	
21	Final Oral Presentations at the BIOE Capstone Design Symposium, including Prototype demonstrations (team) and Exam (individual)	Final Oral Presentations and Oral Exam
22	*Finals Week*	Final written report (team) & Test Data component (individual), Peer Evals

*Topics may be adjusted per student interest and project relevance.

Instructors will be available during team work days to provide assistance and will hold frequent office hours.

BIOEN 404-405 assignments

Meet with Mentors: Use time outside of class to discuss project with outside mentors, and lay out time line.

Resource request: Anticipated needs for computation, storage, fabrication, time, advising, and funding. Groups should propose sources for each of these resources.

Patent/literature search: Each team member should choose one patent or patent application that is relevant to the design project. Include the number and title, at least one figure (which can be taken from the patent), a summary of the patent's claims, and a commentary on its implications for your project. To the extent possible given the available materials, analyze the design procedure, composition of the design team, human factors constraints, regulatory issues including standards, reliability concerns, and resource related constraints. If the device is commercially available, address its profitability. If you have found other patents of interest include their numbers and titles only. Please submit one combined document per team.

Drawing homework: Produce design drawing using AutoCAD or SolidWorks (for mechanical designs) or other appropriate package (for biomaterials designs). Specifications will be provided during the class lecture time.

Preliminary proposal: Device overview, including specifications, available technology, technology to be used, test methods, and design timeline. 3-4 pages of text plus 2+ pages of figures plus one-page timeline.

High/Low-resource homework: How the proposed project earns profits or fills global health needs.

Formal proposal: similar to design proposal in BIOEN 401. See subsequent detailed outline.

Critique of presentations: 1-page commentary on technical and communication aspects of two of the design proposal presentations.

Notebook: Twice during the spring quarter, each student will submit the design notebook to the instructor for review. Multiple turn-in dates will be given to fit students' schedules.

Peer review: 1-page review of the contribution of each of the team members to the device design and prototyping process. Each student will receive a score based on the completeness and professionalism of the critique, and a score based on the opinions of the other team members.

Report draft: Draft of final report. Provides opportunity for instructor to gauge student understanding and provide feedback.

Test data assignment: Individually-executed assignment on generation of testing plan and resultant test data.

Final report: see separate detailed format & outline.

BIOEN 405 Project Report

Please see detailed requirements, description, and grading rubric posted on the course website. Briefly, the final report will be a technical document describing the need for the project, its design constraints, the design process, the selected design, the implementation of that design, and the results of testing. The document should be in 12-point Times or an equivalent font, 1.5-spaced, with 1" margins. The number of pages proposed is merely a guideline and is neither a minimum nor maximum. (Grading will be based on content, not length.) All writing is to be in formal technical English.

The team design final report should include the following content:

Cover Page (1 page)

- Title of the project, course name, names of all team members.
- Briefly describe each team member's contributions and roles in the project.

Abstract (.5 page)

Problem Statement and Description (.5 - 1 page)

Market Analysis (.5 - 1 page)

Prior Art (1 - 2 pages)

Design Specifications (1 page)

Solution Generation and Selection (2 pages)

Results: Design Description (2 - 3 pages)

Results: Test Data (Submitted separately by each team member, 2 - 3 pages)

- Describe generation of testing plan and the resultant test data analysis; see separate assignment description and rubric.

Ethical and Societal Considerations (.5 - 1 page)

Global and Societal Impact (1 page)

Regulatory Issues, including a discussion of relevant standards (.5 page)

Conclusions (1 page)

Future Work (.5 page)

References

Acknowledgements

Appendix (2 pages)

- Gantt Chart
- Costs Table

Grading Rubric for Bioengineering Capstone Team Design Project

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:** Identify and formulate a problem in the 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 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.	
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 404 while considering multiple design options and realistic constraints (including cultural, social, and economic); modify and improve the design 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. 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. Solution meets a specified need with consideration of public health, safety, welfare, as well as global, cultural, social, environmental, and economic factors	Multiple realistic constraints (including any relevant engineering standards) were identified and incorporated into the design process. Design adaptations based on acquired results were considered to better adapt the design to the desired needs. At least one option was considered and tested.	Some realistic constraints were integrated into the design process but some may be missing. A design adaptation based on acquired results was considered to better adapt the design to the desired needs. One option was considered but not tested.	Failure to identify and/or incorporate relevant realistic constraints into design process. Original design followed without considering modifications.	

Grading Rubric for Bioengineering Capstone Team Design Project

A3	**Communicate effectively with a range of audiences:** Communicate the capstone project proposal in written form; Prepare detailed written report; demonstrate device or process to range of audience members during BioE Capstone Symposium. Maintain professional and consistent communication with mentors.	Written report is virtually error-free, logically presents project, is well organized and easy to read, contains high quality data/graphics, and draws conclusions supported by presented data. Product demonstration oral presentation is well organized, clear, and informative. Could be counted on to communicate professionally with outside collaborators.	Report is logically presented, well organized, easy to read, contains high quality data/graphics, and contains few minor grammatical and/or rhetorical errors. Conclusions drawn from presented data. Product demonstration, oral presentation is adequately organized and informative. Usually could be counted on to communicate professionally with outside collaborators.	Report is generally well written but contains some grammatical, rhetorical and/or organizational errors; project is not well explained and not fully discussed. Questionable conclusions made based on presented data. Product demonstration, oral presentation is not well organized and confusing. Sometimes lacking in communication with collaborators.	Report does not present project clearly, is poorly organized and/or contains major grammatical and/or rhetorical errors. Data does not support conclusions, or conclusions not presented. Product does not perform desired task and oral presentation is not informative or is painful to watch. Communication with collaborators was noticeably lacking and/or unprofessional.	
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.	

Grading Rubric for Bioengineering Capstone Team Design Project

A5	**Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives:** Work effectively in teams to complete project goals through behaviors such as contributing to team discussions and work effort, communicating with team members, colleagues, and advisors, establishing team goals and planning tasks, providing leadership to teammates and helping foster an inclusive and collaborative environment	Team member fulfills assigned roles during execution of team design project without having to be reminded, assists others, consistently does what he/she was supposed to or went beyond obligations; very well prepared, respectful, inclusive and cooperative.	Team member performs duties that are assigned, listens to teammates most of the time, usually cooperative and prepared for meetings.	Inconsistently performs duties that are assigned, may not allow others to speak or share ideas; cooperation with teammates is lacking.	Always relies on others to do the work, never listens to other teammates, does not perform duties of assigned team role.	
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 404; correctly analyze results; compile/interpret results, and use engineering judgement to draw conclusions and improve design.	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. Testing data was correctly analyzed and interpreted to draw conclusions for prototype refinement. *laboratory or prototyping facility	Analytical methods were appropriately designed and correctly implemented and interpreted and testing results were utilized to improve design. 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. Testing data may be incorrectly analyzed or interpreted or data may not have been used to draw useful conclusions about design performance or iteration.	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:** Show/describe the continuous progress in the field prior to and during Capstone project via literature search and analysis.	Current literature is monitored. Student exhibits proficiency in researching prior art, including patents. Key advances relevant to the project are identified and considered as motivation for changes in the project.	Literature is monitored, and key advances and current technology 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 or new related technological developments with mentors.	

The final Capstone Project Proposal defines the work to be done to design, build, and test a prototype, as well as the motivation for the project. The project proposal obviously incorporates design, but may include description of any research that is necessary to accomplish the design build project.

Required Elements for the Team Capstone Proposal

Cover page

- *Title*
- *Names of Students*
- *Name of primary mentor (not 404-5 instructors)*
- *Date*
- *Project summary (1 paragraph)*

Background and Significance (probably 4 pages + graphics)

- *Statement of Problem*
- *Review of methods or devices currently in use*
- *Review of intellectual property / patents*
- *Review of relevant industry and governmental standards*
- *Review of ongoing design work elsewhere; if none, state so*

Individually-based part of B & S (turn in one section per person):

- *Critical evaluation of existing approaches and design work*
- *The current cost or consequence of not having this technology*
- *Other benefits or consequences of success, if any*
- *Barriers to implementing the technology*
    - *Technological challenges*
    - *Economic, Ethical, Social, Legal and Regulatory Issues*
    - *Briefly touch on all; describe the most applicable in depth*

Plan of Work (4 pages + graphics)

- *Specific design goal (more applicable if you have a lot of leeway in your goals)*
- *Design overview*
- *Materials, methods, and specific tasks to be performed*
- *Deliverables (devices, processes, systems, software, or reports, as appropriate)*

  - *Phase 1 (necessary product)*
  - *Phase 2 (desired product)*
- *Anticipated decision points, risks and problems, and planned workarounds*
- *Methods to evaluate product, including statistical basis and analysis strategy*
- *Resources (funds, equipment, supplies, animals, patients, samples, information, software, etc.) available, used so far, and needed in the future to carry out work*

Timeline: Table or Gantt chart (1 page)
Key personnel (may be put in another section if it fits better)
References

Format: The preferred format is 1.5-spaced 12 point Lucida Fax, Cambria, Verdana, Leelawadee, Trebuchet, Arial, Calibri, Candara, Rockwell, or Tahoma, left (or inside) margins of 1.25 inches, and other margins of 1 inch or less. It should be submitted as a Word document so it can be edited and commented in electronic format. It is to be written in formal scientific English; style, formatting and proofreading count.

Final Capstone project proposal

The team must also have their advisor submit an e-mail stating that the advisor has read and approved the plan (or a draft thereof), to be received by the same due date as the final proposal.

Cover page, refs, time line†	10
Background and significance†	15
Design†	20
Design strategy*	15
Identify and formulate problems*	15
Quality of writing &proofreading*	15
Explanation of current issues*	10
Total	*100*

†Score primarily for completeness

*See additional detail in rubric table.

In-class oral presentation of capstone proposal (10 + 5 minutes for questions)

Completeness of spoken part	5
Logical sequence and transitions	5
Oral communication skills	5
Completeness of slides or other visual/tactile aids	5
Quality of presentation slides (visual interest, readability)	5
Ability to answer questions from audience	5
Total	*35*