BME 484/485 Biomedical Engineering Capstone Design I & II

2019-2020

Credits and Contact Hours: 5 Credits (3 credits in the fall and 2 credits in the spring)
Fall semester schedule: Monday Lecture 1:00-1:50; Lab 2:00-4:45 pm
Place: BME Lab, Engineering 110, Kingston, RI 02881

Instructors:	Section 1: Ying Sun	<yingsun@uri.edu>	Eng 216	874-2515
	Section 2: Eugene Chabot	<eugenechabot@gmail.com>	Eng 218	
	Section 3: Jiang Wu	<house.jw@gmail.com>	Eng 218	
	BME Technician: Tanya Wang	<tanya_wang@uri.edu>	Eng 110C	

Textbook: None. Using materials from previous courses (particularly BME 361 Biomeasurement laboratory and BME 363 Biomedical Instrumentation Laboratory), documentations on relevant projects, data sheets, relevant journal and conference papers, and Internet resources.

Course Information: Applications of engineering skills; team projects in biomedical areas such as neuroengineering, assistive technology, cardiopulmonary measurements, medical imaging, and modeling of physiological systems. Two-course sequence. **Prerequisites:** BME 207 and BME 362.

ABET Student Learning Outcomes – BME 484: 4, 5; BME 485: 2, 5

2: 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.
4: 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.
5: 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 objective.

Course Assessment Methods

1. Project management & design process – 10%
2. Mid-year progress report – 10%
3. Oral presentation – 10%
4. Project prototype – 30%
5. Conference paper, grant proposal, & IRB application (if applicable) – 20%
6. Final Report and documentation – 20%

Grading Scale

A	94-100	B-	80-82	D+	67-69
A-	90-93	C+	77-79	D	60-66
B+	87-89	C	73-76	F	<60
B	83-86	C-	70-72		

General Education – Integrate & Apply
Course Outcomes and Rubric Elements

Rubric Element for Integrate and Apply Outcome	Specific Course Outcome for BME 484 and 484 Biomedical Engineering Capstone Design	Student work used to assess achievement of the outcome (Assessment)	How will this course provide content to address student outcomes? (Student practice)
1. Transfer Skills: Adapts and applies skills, abilities, theories or methodologies to substantial issues.	ABET 2: an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	1. project proposal, 2. engineering standards, 3. design process, 4. prototype demonstration, 5. conference paper, 6. final report.	1. helps students identify and specify a real-would design project, 2. advises students to integrate and apply pervious knowledge and skills for specific engineering tasks.
2. Connects Knowledge: Makes connections between experience and academic knowledge. AND Makes connections across disciplines.	ABET 5: 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 ABET 4: 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 ABET 2: see above (item 1)	1. project management, 2. proposal to URI UGI Awards, 3. two short oral presentations, 4. undergraduate design competition, 5. conference paper, 6. conference poster presentation, 7. IRB approval (if any), 8. invention disclosure (if any).	1. helps students form multi-disciplinary teams and obtain outside advisors from relevant fields, 2. guides students through processes of UGI grant, application, IRB, and conference.
3. Creates: Create a project* that combines knowledge and skills in a professional and responsible manner.	ABET 2: see above (item 1)	1. design process, 2. proof-of-concept prototype, 3. functional prototype, 4. engineering prototype, 5. conference paper, 6. technical documentation.	1. guides students through an iterative design process, 2. provides forums and opportunities for disseminating R&D results.

General Education – Integrate & Apply
Integrative Learning General Education Rubric

Element	Competent	Approaches Competency	Beginning Competency
1. Transfer Skills: Adapts and applies skills, abilities, theories or methodologies to substantial issues.	Independently transfers, adapts, and/or applies skills, abilities, and/or methodologies gained in previous courses to a real-world problem leading to an original biomedical device and/or system.	Transfers, adapts, and/or applies skills, abilities, and/or methodologies gained in previous courses to a real-world problem leading to a biomedical device and/or system extended from other models with some originality.	When prompted, uses skills, abilities, or methodologies gained in previous courses to a real-world problem leading to a biomedical device and/or system with limited functionality and originality.
2. Connects Knowledge: Makes connections between experience and academic knowledge. AND Makes connections across disciplines.	Experience: Independently and successfully extends the project to additional experiences including IRB approval, grant application, invention disclosure, conference paper, and design competition. Disciplines: Independently manages the different discipline requirements of the project by assigning unique functional roles to team members and demonstrates excellent teamwork.	Experience: Extends the project to additional experiences including IRB approval, grant application, invention disclosure, conference paper, and design competition with some success. Disciplines: Manages the different discipline requirements of the project by assigning unique functional roles to team members and demonstrates good teamwork.	Experience: When guided, extends the project to additional experiences including IRB approval, grant application, invention disclosure, conference paper, and design competition with limited success. Disciplines: Approaches the different discipline requirements of the project by assigning unique functional roles to team members.
3. Creates: Create a project* that combines knowledge and skills in a professional and responsible manner.	Independently and successfully solves a real-world biomedical engineering problem through a sound design design process and/or develops an engineering prototype.	Solves a real-world biomedical engineering problem through a sound design design process and/or develops an functional prototype.	When guided, solves a real-world biomedical engineering problem through a design design process and/or develops a proof-of-concept prototype.

BME 484 Activities

In the fall there are 1 lecture hour plus a 3-hour lab section. There is a multitude of activities that need to be initiated and organized in the fall semester, which include:

- Forming a multidisciplinary team and assigning job functions
- Project topic identification and specifications
- Project proposal and design process specifications
- Prototype development and research
- IRB approval (for some teams)
- Undergraduate Research Initiative grant proposal development (usually due in October)
- 2-page paper for Northeast Bioengineering Conference (usually in February)

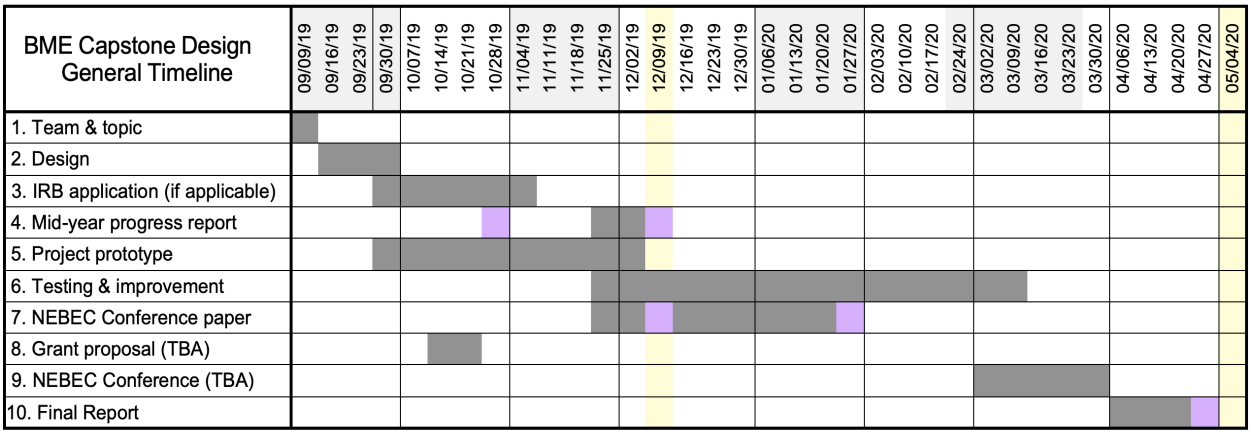
Topics Covered

- Design Process
- Defining the Customer's Design Problem
- Performance Specifications, Functional Requirements
- Evaluating Design Alternatives
- Design Implementation and Project Timeline
- FDA Guidelines, the Design History File
- IRB approval for human study
- Engineering Ethics and Obligations
- Innovation, patent application, entrepreneurship
- Presentations professional conferences

Project Topics – Project topics vary from year to year. They are recommended to students and address one or more of the following ABET criteria for BME:

- Solving the problems at the interface of engineering and biology.
- Developing the ability to make measurements on and interpret data from living systems.
- Addressing the problems associated with the interaction between living and non-living materials and systems.

General Timeline



1. Team & topic – team formation, job assignment, preliminary specifications, resources.
2. Design – engineering standards, functional block diagram, detailed specifications, timeline.
3. IRB application – applicable to projects having a human study component.
4. Mid-year progress report – due December 4, 2019.
5. Project prototype – hardware, software, mechanical parts, packaging.
6. Testing & improvement – preliminary data collection, evaluation, improvement.
7. NEBEC Conference paper – deadline for submission around 2/1/2020.
8. Grant proposal (Undergraduate Research Initiative Awards) – TBA, likely in October 2019
9. NEBEC Conference – TBA, usually in May/April 2020 <www.nebec.org>.
10. Final Report – technical documentation and discussion on ABET outcomes (2, 4, 5).

Schedule – Fall 2019

Wk	Date	Activity	Deliverable
1	09/09/19	Introduction, project selection, team forming	
2	09/16/19	Top-down design, engineering standards, literature search	Order requests
3	09/23/19	Bottom-up design, technical requirements	IRB if applicable
4	09/30/19	Demonstration of hardware/software systems	Proof-of-concept prototype
5	10/07/19	Development of the URI^2 grant proposal (due 10/18)	
6	10/15/19	(Tuesday) Construction of the prototype	UGI grant proposal
7	10/21/19	Construction of the prototype	
8	10/28/19	Mid-term progress report	
9	11/04/19	Improvement of the prototype	Functional prototype
10	11/11/19	Research and/or testing	
11	11/18/19	Continuous improvement and data collection BME capstone presentations (11/21/19 Thursday)	Oral presentation
12	11/25/19	NEBEC 2-page paper	NEBEC paper draft
13	12/02/19	Improvement of the paper, mid-year report	Mid-year report
14	12/09/19	Improvements and documentations	

Students with Disabilities

Any student with a documented disability is welcome to contact me as early in the semester as possible so that we may arrange reasonable accommodations. As part of this process, please be in touch with Disability Services for Students Office in Memorial Union, room 330 or phone 874-2098.

Schedule – Spring 2020

Wk	Date	Activity	Deliverable
1	01/27/20	Refinement of the NEBEC paper, additional research	
2	02/03/20	Refinement of the NEBEC paper, additional research	NEBEC paper
3	02/10/20	Specifications for the engineering prototype	
4	02/17/20	Development of the engineering prototype	
5	02/24/20	Development of the engineering prototype	Engineering prototype
6	03/03/20	Poster preparations	Poster
7	03/10/20	No class (Spring break)	
8	03/17/20	Preparation for a one-slide, 5-min oral presentation	BME in-house presentation
9	03/24/20	Attending NEBEC at NJIT	NEBEC Conference
10	03/30/20	Technical documentation: schematics, source code	
11	04/06/20	Electronic documentation; UGI report, if funded	UGI report
12	04/13/20	Complete and turn in the project package	Final project package
13	04/20/20	Development of the final report	Final report
14	04/27/20	Conclusions	Google drive upload

45th Annual Northeast Bioengineering Conference (NEBEC) <www.nebec.org>
Place: Pennsylvania State University
Time: TBA (usually early April 2020)

Suggested Projects

1. **Self-braking Walker:** A self braking system to detect when something was in close proximity, or the walker is not in use, or the person is seated. Current walkers on the market have poor braking systems that may be misused or ineffective. (*Collaboration with RI Geriatric Education Center, Alexandra Morelli, Corinne Russo)*

2. **Assistive device for wearing stockings:** Expandable compression hose stockings that are able to expand (this would make it easier for the individual to wear them. Once the stockings are on they would tighten and fit to the appropriate fitting. (*Collaboration with RI Geriatric Education Center, Alexandra Morelli, Corinne Russo)*

3. **Adaptive game controller:** A young man is paralyzed on his left side, ataxic on his right. He needs an adaptive controller to play Xbox type of games with his left hand. A joystick type of controller has been acquired, but is not quite compatible with the Xbox controller. Thus, an engineering solution needs to be developed to make this adaptation possible. *(A request from the Rhode Island community)*

4. **Machine learning for an eye blinking switch:** With two electrodes around the eye, the eye blinking signals can be recorded. A neural network based (or similar) algorithm will differentiate intentional blinks from spontaneous blinks.

5. **Voice-activated home automation:** Using the voice recognition function on a smartphone, simple voice commands can activate household applications. The smartphone could be linked to the X10 home automation system.

6. **Limb accelerometer for stroke patients:** Wearable sensors are attached to all four limbs in order to measure movements in X, Y, and Z planes for patients in hospital beds who cannot stand. If successfully developed, this device will be used in a clinical trial on stroke patients. *(Co-advised by Dr. Brian Silver, Neurology, UMass Medical School, Worcester)*

7. **Body temperature sensing and cooling blanket:** A blanket of plastic cover containing a sensor or sensors for measuring the body temperature of menopausal women during sleep. The blanket also has a cooling mechanism to lower the temperature. *(Co-advised by Dr. Brian Silver, Neurology, UMass Medical School, Worcester)*

8. **Bicycle helmet turning signals:** Existing bicycle helmets with turning signals are relatively expensive due to the use of wireless remote controls. Using accelerometers embedded in the helmet, the turning signals can be activated with a jerk of the head toward the right or left. *(Co-advised by Dr. Brian Silver, Neurology, UMass Medical School, Worcester)*

9. **MagnetPeutics**: To develop a light-weight helmet with rotating magnets for stroke rehabilitation. If successfully developed, this device will be used in a clinical trial on stroke patients. *(Co-advised by Dr. Brian Silver, Neurology, UMass Medical School, Worcester)*

10. **Smart 3D-Printed Prosthetics:** Develop various models of 3D Printed Prosthetics for lower-limb amputees. The prosthetics will be integrated with pressure sensors and vibro-tactile modules for a close-loop system. After the design, the project will involve the validation of the prosthetics in amputees through a pilot study. *(Sponsored by Prof. Kunal Mankodiya and his team)*

11. **Biofeedback for emotional dysregulation** – Create a biofeedback type program to raise awareness of an individual when they are starting to become dysregulated; bring the user back to a control state;

support teaching regulation by learning to control some aspects of the autonomic nervous system during an dysregulated state such as anger. (*Collaboration with Seven Hills RI, Marie Capobianco)*

12. **Pain detector** – for persons with limited ability to speak/communicate. Spasms or cramping for folks with certain muscle disorders/CP cause a tremendous amount of discomfort for many folks. But them may not be able to inform the caregivers effectively and timely. (*Collaboration with Seven Hills RI, Marie Capobianco)*

13. **Smartphone based Augmentative and Alternative Communication (AAC)** – Develop affordable Communication devices for individuals with limited mobility and inability to speak or sign, always a challenge. (*Collaboration with Seven Hills RI, Marie Capobianco)*

14. **Model house for assistive living**: Develop a scaled-down model house to demonstrate a) home modification for persons with disabilities or the older adults, b) assisted technology devices that are more difficult to implement in full scale such as wheel-chair lifter, self-descending cabinets, personnel transfer/lifting device, garage modification, etc. (*Collaboration with Ocean State Center for Independent Living, Lorna Ricci)*

15. **Adaptive sports equipment - golf**: Create adaptive sports equipment for disabled Veterans to relearn golf with their disability. VA Providence is interested specifically in designing golf balls that provide auditory feedback for blind Veterans. *(Sponsored by Providence VA Medical Center, Jordan Anderson)*

16. **Infusion pump safe transport**: Create safe covers that meet hospital standards to help protect infusion pumps and other IV pole transported equipment from damage. *(Sponsored by Providence VA Medical Center, Jordan Anderson)*

17. **UV disinfection solutions**: Create UV disinfection wand or storage solution to safely kill surface bacteria on medical equipment. *(Sponsored by Providence VA Medical Center, Jordan Anderson)*

18. **Online hearing loss test**: Develop a web-based test for hearing loss using a series of “Yanny or Laurel” type of questions.

19. **Neuroscience – neuron emulator**: Develop an experimental setup for microelectrode recording of live neuron; Improve the design of a neuron emulator.

20. **Neuroscience – digital voltage clamp**: Develop an experimental setup for microelectrode recording of live neuron; Perform testing with the Universal Clamp system.

21. **Pulse amplitude ratio (PAR) for assessing heart failure**: Using photoplethysmogram to measure PAR during the Valsalva maneuvor, a forced exhalation against a closed glottis (throat). A large PAR is associated with a healthy heart with a responsive baroreflex control of the autonomic nerve system. This ratio is likely decreased in heart failure patients and thus can serve as a useful marker.

22. **Pulse oximetry on PIC**: To develop a pulse oximeter for measuring arterial oxygen saturation based on our PIC microprocessor system.

23. **Visual-tactile sensory substitution**: Use a miniatured camera to detect moving objects and relate the motion information via an array of vibrators embedded in a waist belt for persons with visual impairments. The image analysis will be done on a smartphone. The focus will be on the implementation on a Raspberry Pi or equivalent. Explore the possibility of using an artificial retina

(way to limit the field of view) to provide additional flexibility to the individual with a basic motion tracking algorithm (like the AIMS). Examine technologies that try to construct 3D information (possibly in real-time) and how to relay it to an individual.

24. **Intelligent balance board for rehabilitation:** Develop a sensor-embedded wobble board for rehabilitation of ankle or knee injuries with a focus on adding a stress sensor to determine pressure applied by different parts of the foot and improving real-time feedback/calculation. (Collaboration with physical therapist Craig Simpson).