ME 568: Soft Robotic Technologies – Fall 2024

Instructor:
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I consider this classroom to be a place where you will be treated with respect, and I welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability – and other visible and nonvisible differences. All members of this class are expected to contribute to a respectful, welcoming and inclusive environment for every other member of the class.

Course schedule:
Lectures: Monday and Wednesday 10:10-11:55 (EPC B05)

Labs: EPC B05 (see schedule below)

Teaching Assistant: Grace Matthews (gamatt@bu.edu)

COVID 19 & BU Community Health Expectations:
All students are expected to follow all university guidelines. For a detailed description of official BU policies regarding COVID, please visit: *http://www.bu.edu/dos/policies/lifebook/covid-19-policies-for-students/*

Office hours: Please email *tranzani@bu.edu* to schedule office hours.

Textbook: No textbook is required; the instructor will provide all course materials.

Blackboard quizzes: we will use Quizzes regularly to evaluate participation.

Course web page: Blackboard

Prerequisites: CAD, Instrumentation (electronic boards - reading/acquiring signal), structural mechanics, fluid mechanics, Matlab programming, calculus, linear algebra, differential equations, mechanics of materials, engineering. mechanics, first class on robotics, mechatronics (basic knowledge of what a sensors and actuators are), Measurements and Instrumentation.

Course learning objectives:
- Understanding potential and limitation of soft robotic technologies
- Understand how to model, design, and characterize materials for soft robotics
- Learn how to design, model, build, and characterize soft robot components (i.e. actuators, sensors, and stiffening components)
- Learn how to design and manufacture a soft robot
- Understand current trends and unsolved challenges in the field
- Learn how to use soft robotic technologies to address unsolved challenges in robotics

Policy on hands-on projects:
- Each student will be given materials for the realization of their hands-on projects. The materials will be available in EPC B05 and you should coordinate with the TA to access that.
- The materials will be used to pursue the labs. Detailed instructions for each lab will be provided ahead of time by the TA. Any question related to the labs should be addressed to the TA.
- The materials will also be used to pursue the final project, based on the contents presented in class. No additional materials and/or components will be provided by the instructor and/or the Department.

- Each hands-on project will be done in teams.
- The class will not require work in EPIC, but you are welcome to use EPIC for your projects.
- The class will not require work in RASTIC, but you are welcome to use RASTIC for your projects.

Policy on quizzes:

- If you fail to remember that you need to complete the quiz in 24 hours after the assignment, you can send an email to Prof. Ranzani to ask if you can take the quiz at another time. You will be notified when the quiz will reopen for you and will be given a window of time to complete it.
    - If it is the first time, you will not be penalized.
    - If it is the second time, 10 points will be subtracted from your total score.
    - If it is the third time, 20 points will be subtracted from your total score.
    - If it is the fourth time, 30 points will be subtracted from your total score.
    - After the fourth time, you will not be given the possibility to take the quiz at another time.

Grading:

	Grade %	Instructions
Labs	35	for each lab: • write report (1" margin, Times New Roman 11) • upload 1 video (1 minute, can be sped up). The video needs to be shared as a YouTube or Google Drive link. Late submission policy: 5% less for each day after deadline if submitted up to 3 days after deadline. No credit if submitted after then.
Competition + homework	15	• Complete the assigned homework to develop the robot for the competition. • Showcase a working robot at the competition. Grading will consider design and execution of the soft robotic design, thoughtfulness and creativity of the design, and proper implementation of concepts presented in class.
Quizzes	15	20% discussion in class and quizzes after the end of every module as well as periodic check points for the final project
Final Project Presentation (Due Dec 4th at 9am)	15	• You will present your final project with a short PowerPoint/Keynote presentation. • The presentation must include videos with demos of your working prototype. (See additional guidelines on the slides)
Final Project Report (Due by Dec 10th at 11:55pm)	20	The **project report** needs to have the following three sections: • **Intellectual Merit** (see following slides for guidelines) • **Broader Impact** (see following slides for guidelines) • **References** (between 10 and 30 research articles - from journals or conferences - and patents) The report should include a description of the proposed research project, including preliminary supporting data, specific objectives, methods and procedures used, and expected significance of the results. (See additional guidelines on the slides)

Each exam will take place over an entire class period. Each exam will cover a block of lectures as noted in the schedule. ***Boston University Academic Conduct Code****:* Honesty is a core value of Boston University. Any violations of BU academic honesty and integrity standards ***will be pursued*** through appropriate University channels.

This includes, but is not limited to: cheating, plagiarism and misrepresentation. If you have any questions as to what constitutes an honor code violation, please ask. ***Ignorance is not an excuse for cheating***. You may access the BU Academic Conduct Code at: http://www.bu.edu/academics/policies/academic-conduct-code/

Course Schedule:
Below are listed the modules that will be covered in this class.

Module 1: introduction	Introduction to soft robotics: definitions and applications
	Morphological computation and Bioinspired design
Module 2: materials for soft robotics (fundamentals of mechanics of polymers)	Elastomers: polymer mechanics and hyperelastic modeling
	Thermoplastics and textiles
	Advanced materials
(Sep 18) Lab 1: Mechanics of Elastomers	Hyperelastic Material experimental characterization and modeling
Module 3: soft actuation (design, modeling, manufacturing, and characterization)	Cable driven soft robots
	Fluidic actuation
	Shape memory alloys
	Brief overview of additional actuation strategies
(Sep 25) Lab 2: cable driven actuation	Cable driven actuation and constant curvature modeling
Lab 3: Soft elastomeric fluidic actuators	a) **(Oct 2)** McKibben actuator design, characterization, and modeling b) **(Oct 9)** PneuNet actuator design, characterization, and modeling c) **(Oct 15)** Fiber reinforced soft actuator design, characterization, and modeling
(Oct 16) Lab 4: Soft inflatable robots	Design and fabrication of inflatable and growing robots
(Oct 23) Lab 5: FEM modeling	Finite Element Modeling (FEM) of soft fluidic actuators
(Nov 6) Lab 6: SMA	SMA fabrication and testing
Module 4: soft electronics and soft sensing	How to embed sensing capabilities and conductive elements in soft structures
	Soft resistive, capacitive, and inductive sensing
	Soft optical and ionic sensing
(Nov 13) Lab 7: Sensing	Capacitive and ionic sensing
Module 5: Variable Stiffness mechanisms for soft robotics	Introduction to variable stiffness structures
	Jamming mechanisms
(Nov 18) Lab 8: Stiffening	Layer and granular jamming design, fabrication, and testing
(Nov 20) Lab work for final project	

(Nov 25) Lab work for final project
(Nov 27) Lab work for final project
(Dec 2) Lab work for final project
(Dec 4) Final Project presentations
(Dec 9) Competition