

Exploring Concepts From Soft Robotics 2022

Course Description: The dirty, open secret of soft robotics is that no one has monetized it yet. Precisely because the full potential of the emerging field of soft systems, particularly soft actuators, is unrealized, there are countless opportunities for curious innovators to discover or develop novel soft systems. This course teaches hands-on fabrication techniques for constructing simple pneumatic actuators from cast silicone and heat-sealed mylar, and challenges participants to design and build their own. Lectures and discussion center on concepts from soft innovation history, the current state-of-the-art, and sister disciplines of bio-inspired and hybrid (soft/hard) robotics. Consideration of both brand new soft materials, from a class visit to Material ConneXion, and everyday overlooked soft mechanisms, found in average retail stores, will require participants to look at softness through a new lens. Final projects will be the development of an original soft/flexible/hybrid research concept presented with context, material swatches with justifications for choices, and physical or modeled proof-of-concept.

This course will discuss ideas from simulations and control systems, but will not be hands-on in these topics.

There are no required textbooks: Readings will be shared digitally

Thursdays 6:30pm - 9:00pm EST
(Jan 27 – Mar 10)

Instructor: Kari Love

Email: klove@nyu.edu

Guaranteed responses to email only once every 24 hours.

Grading: is based on successful completion of all assignments, class participation and attendance.

For a missed class, hands-on components can be delivered in-person, or as video or animated gifs

Missed presentations can be given during office hours or a designated make-up class

7 week class - 2 unexcused absences will result in automatic fail

Please email to discuss in advance if you need consideration of the possibility of an excused absence.

Updates: This syllabus will be updated week to week with new links and notes.

Office Hours: My office hours will be In-person at ITP by appointment Monday 11am-1pm morning as determined by the Doodle Poll

<http://bit.ly/softrobotofficehours>

Or additional times by email request for a video chat via Zoom

Week 1

- Class Recording -
https://nyu.zoom.us/rec/share/t88iQ6_kLbrtAFZgpEy-lkPAG33YU2qaHqeW910ASG1nkKNnJx2KSrdVSY-qvjb2.idJxrFogj0JG_EHa?startTime=1643327172000
- Introductions
- Intro to course
 - Syllabus and expectations
- Lecture: A Brief Intro to Soft Robotics
 - <https://docs.google.com/presentation/d/1-zOcmGPSlgJ2i19pL0Y8YO9YRSIjmeWliSe8EtUG5po/edit?usp=sharing>
- Discussion: What is softness? Why are you interested in softness?
 - Touch soft materials/mechanisms - Toys
 - Group Exercise: Make brainstorm some criteria for soft materials assessment
- Demo for hands-on work: Making simple flexible cabled models from straws, strings and beads.
- Lecture: The problem space of cable control, actuation and tension.

Week 1 Assignments:

- **#1** Response to Welcome Email (if you did not receive it, reach out at klove@nyu.edu)
 - Please confirm that it is the best email to reach you
 - Please email a link to your blog or where you intend to document
 - Please email a link to your favorite past project
 - This is a way for me to better understand you!
- **#2** “A Soft Robot That Excites You” Slide
 - Pick object or topic from soft robotics or other soft innovation
 - Please look around a lot before choosing
 - Prepare a 1-minute presentation slide
 - Place the slide here:
<https://docs.google.com/presentation/d/11U-n0HiB4uzVHUP-FwxsXGo0koZU9kGA4DzNzP1ZgX8/edit?usp=sharing>
 - Include:
 - Image or Animation or Embedded Video (30 seconds or shorter, queued to start point)
 - Your Name
 - Innovation name, date, who made it
 - What is it?
 - What excites you about it?
 - Link to where you can read more about it

- **Due during Class 2 (Feb 3)**
- **#3 “Soft Opportunities In The Wild” Store**
 - Visit a Toy Store, Hardware Store, Craft Store, Home Store, Sporting Goods Store or other (single use store recommended)
 - Take a selfie in front of an identifying feature of the store
 - Make a list of items that feature softness that have potential for exploration
 - A short description on why it attracted your attention and some ideas on how it might be explored
 - Minimum 10 items
 - Submit blog link via email **at least 12 hours before class (6am Feb 3)**
- **#4 Make and Present Cable Experiments:** additional explorations of simple cabled systems. Try different materials (papers, plastics, fabric, bendy straws, boba tea straws) Try mixing soft and hard.
 - **Bring to experiments to Class #2 to share results.**
 - Minimal Blog Post Required - Just photos, animated image or video
 - Solo only if just hand pulled/twisted, Pairs okay if you want to automate

Week 2

- Class Recording
 - https://nyu.zoom.us/rec/share/cVUKVMtb7ig0NBr_hDWG_KTWDcAJa_9kTiXFF2B5ZSiOvD91FWDW_YeVNI2OZOpe.0fsHAhnfufleSEC
- Present: 1 minute slide from “A Soft Robot That Excites Me” Assignment #2. Discuss insights from “Soft Opportunities In The Wild” from Assignment #3. Present favorite simple cabled system exploration Assignment #4.
- Discuss Field Trip
- Lecture: Introduction to Pneumatics and Inflatables
 - <https://docs.google.com/presentation/d/1OJgon1Fj8KNkFbsSuv22vaiB5v7tSitSwfqnlQv5eY/edit?usp=sharing>
- Demo: Heat-Sealed Mylar film

Week 2 Assignments:

- **#5 Make and Present Inflatable Explorations:** additional explorations of simple flat-patterned inflatables
 - Please do not just repeat existing examples
 - Photos or video of process on your Blog
 - **Bring to Week 3 to share**
- Reading: <http://www.pbs.org/wgbh/nova/next/tech/evolution-of-bioinspired-robots/>
- Sign Up for Material Connexion Library
 - You must be on the campus network to make profile
 - On Campus or via VPN
 - Once you have an account, you can access from anywhere
 - <http://guides.nyu.edu/materialconnexion>

Week 3

- Class Recording
 - <https://nyu.zoom.us/rec/share/xiSgREgNcX5iEBx9iw8JzK1EGer7TREbeCJzYbk6BTQ5jiTeor5SrICB9mpppSQ6.A9GIU6nFp-U6MG96>
- Demo: Cast silicone with 3D printed molds
 - Finger Cot Actuator - Casting Notes
 - <http://bit.ly/softrobots-castingclassnotes>
 - bit.ly/softrobot2019class3
- Present: Explorations of simple flat-patterned inflatables from Assignment
- Outside Field Trip: Materials Connexion
 - 28 Liberty St 6th floor, New York, NY 10005
 - Bring Photo ID
 - Wednesday or Thursday at 5pm
 - <https://drive.google.com/open?id=0B2it7oS90TgYdU1WYXZVWkJDUeDqUGo1UEpGeENWbFNyUU9Z>
 - <https://drive.google.com/open?id=0B2it7oS90TgYczhheVE1UGRSMGYwakVNa0UzTzNLSHdWMjNF>
 - Look for items you can:
 - Get and use from manufacturer/distributor
 - Knock-off (make your own)
 - Use as inspiration to build on their product idea or take it in a new direction

Week 3 Assignments:

- #6 Materials ConneXion Blog: Post about your most useful or interesting Materials Connexion find.
 - a. Email link to klove@nyu.edu or add to spreadsheet at
 - <https://docs.google.com/spreadsheets/d/1MiUtlXkDe5PhGXqaYCd-pBI3eZoCIkvA2mxNGI-6sw/edit?usp=sharing>
 - b. Image of material
 - c. Link to Material Connexion page
 - d. How does it relate to your Soft Engineering interests?
 - e. Soft Durometer/Flexibility/Elasticity/Other - Which properties does it have?
 - f. Distributors - Where can you buy it? If no distributor, how do you get in touch with the manufacturer?
 - g. On label use?
 - h. Request/Acquire a material sample (please BCC: kari@teammammal.org on your initial request)
 - Some Tips and Sample Letters
 - <http://bit.ly/softrobots-acquiringmaterialsamples>
- #7 Simple Silicone casting lesson
 - a. Cast Bibenda Actuator

- <http://bit.ly/softrobots-castingclassnotes>
 - 3D Print inner mold core part for Cast Silicone lesson
 - <https://www.thingiverse.com/thing:2085246>
 - Print orientation standing upright with the 3 prongs down on the plate
 - Print yourself or use print services (print takes approximately 1 hour 44 minutes)
 - <http://www.nyu.edu/life/information-technology/locations-and-facilities/laguardia-studio/laguardia-studio-resources.html>
 - Complete outer mold (PVC cut at 75mm)
 - Complete sewn tube (length cut at 80mm, slits cut at 15mm, 25mm, 35mm, 45mm)
 - Cast
 - Test
- b. Blog photos of process, and about lessons-learned

Week 4:

- Class Recording:
 - https://nyu.zoom.us/rec/share/2wmh-z6mIMIE5F6PRCMOsMkGxneEXz_ZDVnx4GNCLIHZ1EKxaHVC3floC7_E5tUb.y9SNKQFX3T4NjH4m
- Silicone cast actuators from Assignment #7 troubleshoot
- Introduction to Silicone Mold Design for Soft Robotics
 - https://docs.google.com/presentation/d/1AXuOHncCWkDFcHJifK_cMs1xPDeh2sRB7-M_tjcxjyg/edit?usp=sharing
- Final Project Information: Heilmeier's Catechism and Quad Charts
 - <https://docs.google.com/presentation/d/1wZs8ry4IDExd-BUqYEyzQta-luVUa3-OQ3Bqtp2dqB0/edit?usp=sharing>
- Lecture: Bio-Inspiration
 - <http://bit.ly/softrobot-class2-bioinspirationslides>
 - Activity: Bio-Inspired Matrix Cards
- Demo: Programmable Air - Amitabh Shrivastava

Week 4 Assignment

- #8 Silicone Casting Blog: Design Your Own Mold
 - Design an original/variation mold concept
 - Can be digitally designed or physically designed
 - 3D modeled/printed, Laser Cut, Cardboard
 - Simple or as complex as you like
 - Try to use less than 100g of silicone to conserve materials for classmates
 - Make a test cast
 - Photograph your finished mold and cast and write up a “lessons-learned” statement on your blog

- Email your link or drop in [spreadsheet](#) and bring your physical prototype to class
- ~~#9 Blog Post on Bio-Inspiration: Look to nature for Bio-Inspiration~~
 - ~~Write a blog post about an interesting plant, animal, body feature, etc~~
 - ~~Send email link to post by noon the night before class~~
 - ~~Include at least 1 picture/photo~~
 - ~~Include what you find interesting about this thing from nature~~
 - ~~Include what how you wish its features could be used in technology~~
 - ~~DO NOT write about an existing technology or robot~~
-
- #10 Make Quad Chart of Final Project 1st Idea Proposal
 - Ask yourself the Heilmeier's Catechism questions about your idea
 - quick link- <http://www.darpa.mil/work-with-us/heilmeier-catechism>
 - Make a Quad Chart
 - https://docs.google.com/presentation/d/1_sajlfEd8ooh0jBvZm1GiLupqK9ppZyFE_s2_Ak7VSg/edit?usp=sharing
- Optional Reading: Soft Robotics Commercialization: Jamming Grippers from Research to Product
 - <http://bit.ly/softrobot-commercializationcasestudy>
 - Rare technical Case-Study on hardware start-up (and ultimate closing)

Week 5:

- Class Recording (Sorry I forgot to screen share! You'll need to check out the linked slide decks from the syllabus):
 - https://nyu.zoom.us/rec/play/b8kDLWpyd0H_ZgCFTAK6fVZq27fYAYJ1Z_OBGGi_nYRBoxpLUhtu7KiYXZFhNmUPJHGzf08O--K-OHD7g.PcY1_Py-QkIACDwL?startTime=1645745455000
- Announce Guest Lecturer next week: Cindy Harnett University of Louisville J. B. Speed School of Engineering
 - Cool Video of Magnetic Soft Actuator
 - <http://harnettlab.org/2018/02/19/fabric-linear-motor/>
 - Presenting Soft Optical Sensors
- Present: Assignment #7 cast silicone from your own mold
- Candy Soft Robotics - Materials Driven Process for Emerging Technology
 - <http://bit.ly/softrobot-candyrobotslides>
- Present and Feedback: #8 Quad Chart Final Project Idea
 - https://docs.google.com/presentation/d/1_sajlfEd8ooh0jBvZm1GiLupqK9ppZyFE_s2_Ak7VSg/edit?usp=sharing
 - bit.ly/softrobotprojectfeedback

Week 5 Assignments:

- **Parameters for FINAL:** Choose Concept for Final Project - Due May 13th
 - a. **Develop and present early concept for soft innovation or exploration as 5 minute presentation (+ 3 minutes for questions and critique)**
 - Must be soft for a defensible reason
 - Must follow an innovation process and demonstrate that process
 - It works (to at least a limited extent you can justify)
 - Must be clearly communicated in presentation
 - **Presentation Criteria**
 - Rehearsed and timed
 - Identify Project and Value Proposition
 - Remember your Heilmeier's Catechism
 - History and State-of-the-Art
 - Experts Consulted, and their insights/contributions
 - Personal Specifications for Success
 - Iteration Process Description
 - Demo Proof-of-Concept
 - In person, if possible
 - If not, well documented
 - Do you have an ask of your audience? (Always consider when giving a talk)
 - Final Slide must be in Quad Chart format - You do not need to read this out loud!
- Assignment #9 prep for Design Pathway for Final Project

Write these up for your blog

- a. **Update Heilmeier Questions as needed**
- b. **Research History & State-of-the-Art**
- c. **Generate a list of Experts to invite to talk with you by category**
 - Broaden your idea of who an expert is
 - Identify specific individuals who fit
 - Mix of high level of expertise and low level
 - Don't put too many "dream" experts on the list, it is worth asking, but low rate of return
 - Short time-frame, who do you already know?
 - Send out emails or in-person invitations to talk with them
 - Ask if there is anyone else they would recommend speaking to
- d. **Generate a list of relevant soft or flexible materials.**
 - Make a list, hard copy
 - Consider similar materials, and at least one drastically different material

- Assess via materials assessment class thought lines
 - Properties
 - How can they fail/be damaged?
- Turn into a shopping list
 - **Purchase supplies**
 - Most critical items for prototyping
 - Small enough volumes to eat the cost or change course within your budget
- e. **Define specs**
 - How do you know when it works?
- f. **Start Materials Explorations/1st Iterations**

Week 6:

- Class Recording:
 - https://nyu.zoom.us/rec/share/eT6E8j9YK0RPFqJQxFPcvEwR8P0twZbwdFngXrbmQ-Gljl8xv_HGkbbKJAYSkBdb.SZPjN_d1M3wYBzJw
- Guest Lecture: Cindy Harnett from
 - Cool Video of Magnetic Soft Actuator
 - <http://harnettlab.org/2018/02/19/fabric-linear-motor/>
- Final Project Questions and Troubleshooting
- Lecture: Soft Simulation
 - <https://docs.google.com/presentation/d/1rCTXfUsTL9NDJg199deMivY5fy3AN483qhT05X08YE4/edit?usp=sharing>

Week 6 Assignment:

- Presentation Prep: Final Project
- Submit Slides via email by 5pm day of the final (I will pre-load slide decks where possible to reduce time between presentations)

Week 7:

- Present Final Project: 5 minute presentation with 3 minute Q&A
 - Sammy Nelson
 - Jane Meng
 - Nick Parisi
 - Wendy Wang
 - Lauren Lumbra
 - Sean Zhu
 - Pedro Sodre
 - BREAK
 - Aike Akhigbe
 - Erin Tao

- Daniel Ryan Johnston
- Akshita Bawa
- Kevin Peter He & Vivian Ngiam
- Chloe Choi
- Evaluations: [ITPG-GT 2125 - Exploring Concepts From Soft Robotics \(Kari Love\)](#)

New material

Magnetic and Light Powered - Hydrogel

<https://techcrunch.com/2020/12/09/tiny-water-based-robot-is-powered-by-light-and-can-walk-move-cargo-and-even-dance/>

<https://www.advancedsciencenews.com/a-magnetically-controlled-hydrogel-for-octopus-like-robots/>

Flexible Battery -

<https://www.inceptivemind.com/new-flexible-battery-10-time-more-energy/16619/>

<https://www.chemeurope.com/en/news/1169048/this-flexible-and-rechargeable-battery-is-10-times-more-powerful-than-state-of-the-art.html>

Edible Soft Robotics update - elephant trunk

<https://www.newscientist.com/article/2246165-we-can-make-robots-from-gelatine-and-other-edible-ingredients/>

Smart Pasta

<https://newsela.com/read/smart-pasta-fun-shapes/id/2001022934/>

STATEMENT OF ACADEMIC INTEGRITY

Plagiarism is presenting someone else's work as though it were your own. More specifically, plagiarism is to present as your own: A sequence of words quoted without quotation marks from another writer or a paraphrased passage from another writer's work or facts, ideas or images composed by someone else.

STATEMENT OF PRINCIPLE

The core of the educational experience at the Tisch School of the Arts is the creation of original academic and artistic work by students for the critical review of faculty members. It is therefore of the utmost importance that students at all times provide their instructors with an accurate sense of their current abilities and knowledge in order to receive appropriate constructive criticism and advice. Any attempt to evade that essential, transparent transaction between instructor and student through plagiarism or cheating is educationally self-defeating and a grave violation of Tisch School of the Arts community standards. For all the details on plagiarism, please refer to page 10 of the Tisch School of the Arts, Policies and Procedures Handbook, which can be found online at:

<http://students.tisch.nyu.edu/page/home.html>

STATEMENT ON ACCESSIBILITY

Please feel free to make suggestions to your instructor about ways in which this class could become more accessible to you. Academic accommodations are available for students with documented disabilities. Please contact the Moses Center for Students with Disabilities at 212 998-4980 for further information.

STATEMENT ON COUNSELING AND WELLNESS

Your health and safety are a priority at NYU. If you experience any health or mental health issues during this course, we encourage you to utilize the support services of the 24/7 NYU Wellness Exchange [212-443-9999](tel:212-443-9999). Also, all students who may require an academic accommodation due to a qualified disability, physical or mental, please register with the Moses Center [212-998-4980](tel:212-998-4980). Please let your instructor know if you need help connecting to these resources.

STATEMENT ON USE OF ELECTRONIC DEVICES

Laptops will be an essential part of the course and may be used in class during workshops and for taking notes in lecture. Laptops must be closed during class discussions and student presentations. Phone use in class is strictly prohibited unless directly related to a presentation of your own work or if you are asked to do so as part of the curriculum.

STATEMENT ON TITLE IX

Tisch School of the Arts is dedicated to providing its students with a learning environment that is rigorous, respectful, supportive and nurturing so that they can engage in the free exchange of ideas and commit themselves fully to the study of their discipline. To that end Tisch is committed to enforcing University policies prohibiting all forms of sexual misconduct as well as discrimination on the basis of sex and gender. Detailed information regarding these policies and the resources that are available to students through the Title IX office can be found by using the following link: [Title IX at NYU](#).