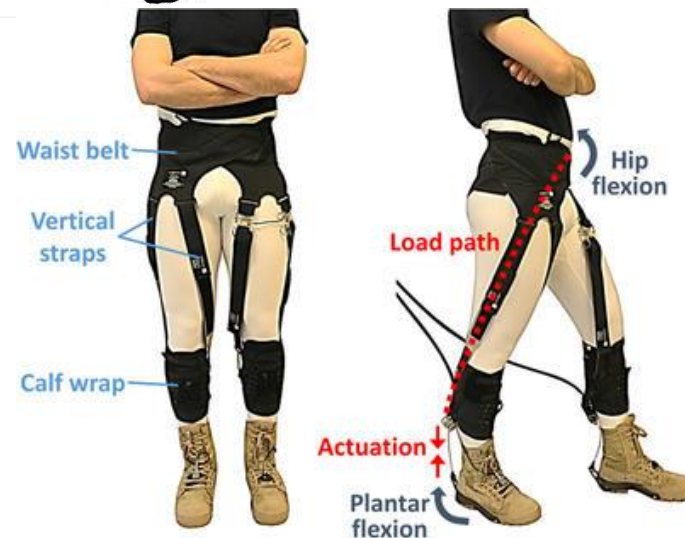
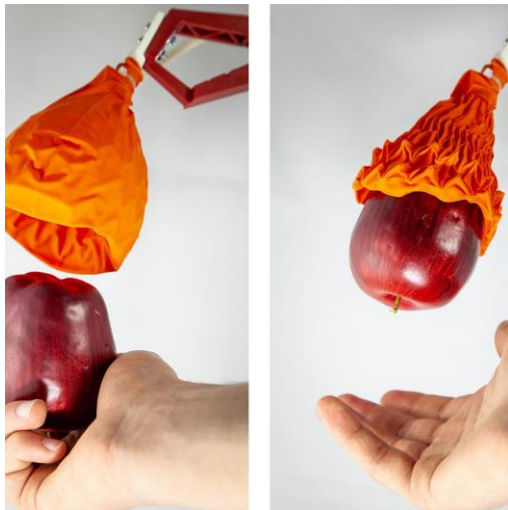
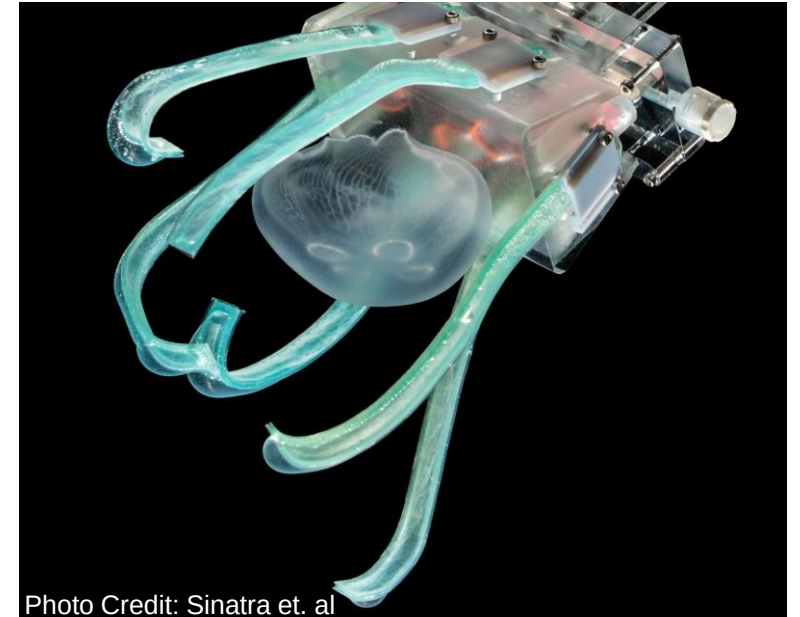
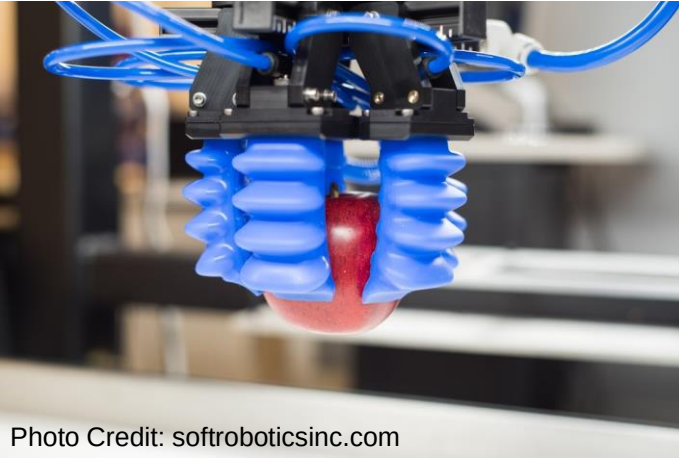


Soft Robotics Engineering Curriculum

What are soft robots?

What are soft robots?



SDM Objectives

Pneumatic textile back brace



Cable actuated prosthetic fingers



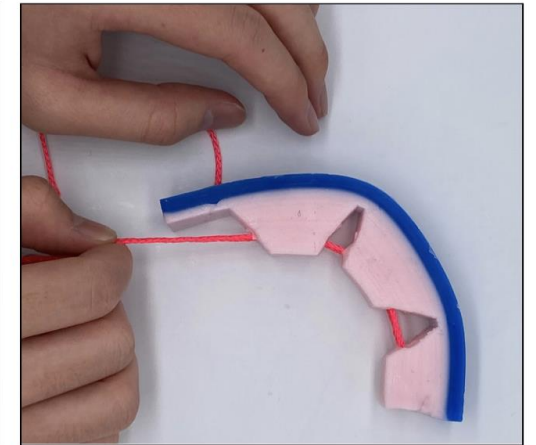
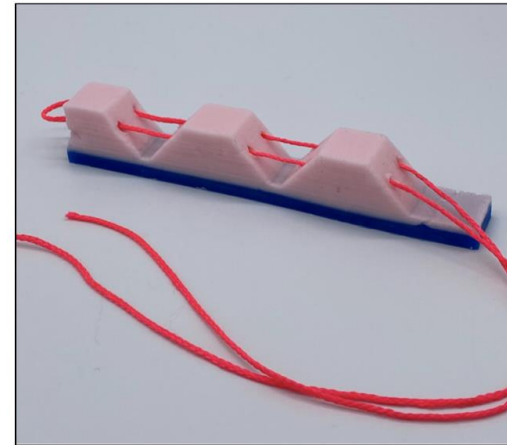
This week we will build three devices:



SIA Pneumatic Actuator



Mckibbens Muscle



SDM Cable Actuator

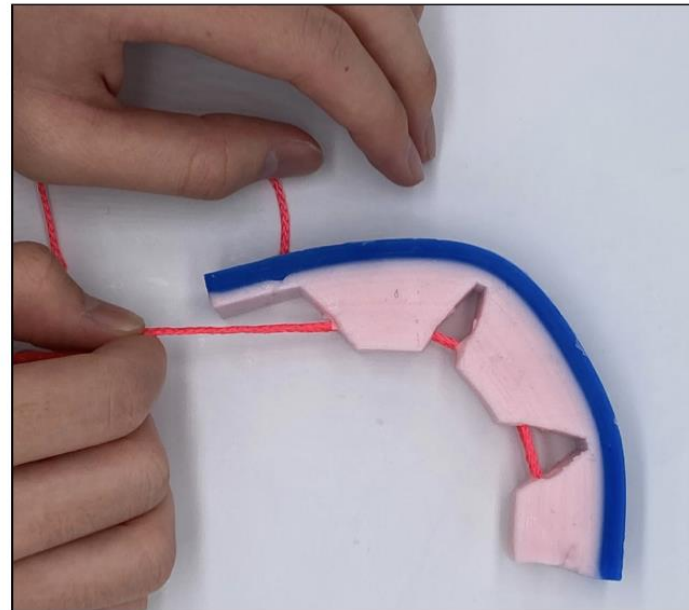
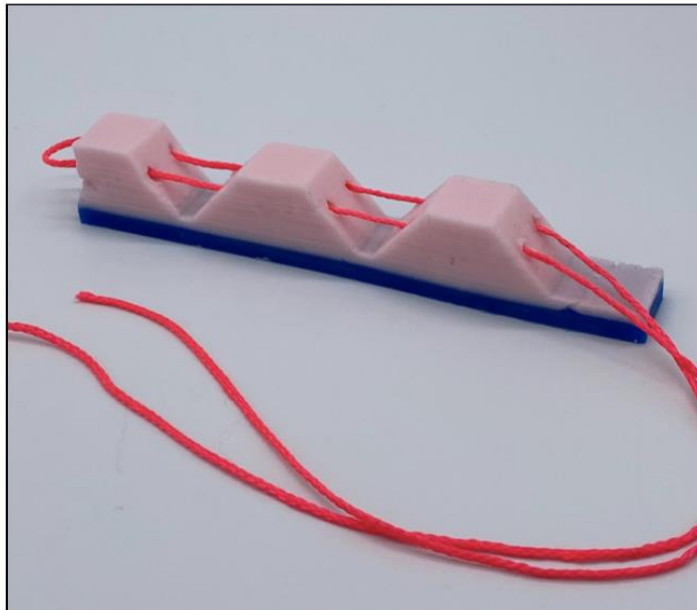
SDM Actuator (Day 1)



Today, we will use a 3D printed mold and various strengths of silicone to create a cable-operated actuator.

SDM Actuator Design Objectives

- Analyze each component of the mold design.
- Understand why two types of silicone will be utilized.
- Implement mobility to the finalized mold with cables.



SDM Reminders

Follow all directions carefully, especially at the following steps...

- Make sure the tubing is sticking out enough for you to later grab and pull out (#1).
- Ensure all components of the mold are well coated in Mold Release spray (#2).
- If you wish to add color, add a few drops to part A only (#3).
- Mix parts A and B together for at least **5 minutes** (#3).
- Be sure only fill the mold to the lines since another layer of silicone will be added later (#4).



SIA Actuator (Day 2)

Today, we will use a 3D printed mold and with silicone and fabric to create a pneumatic powered actuator.

Recap from yesterday

Soft robots are:

- **made from soft materials**
- **able to interact with people and delicate objects**
- **bioinspired?**
- **are made from materials such as polymers, silicone, rubber**



Photo Credit: Shepard et al.



Photo Credit: softroboticsinc.com



Photo Credit: Rich et al.

Materials: What are metals and polymers?

Metals: Traditional robot parts



Photo Credit: Science.lu



Photo Credit: VEXRobots

Polymers: New soft robot parts

Hard Plastics



Photo Credit: NDRC

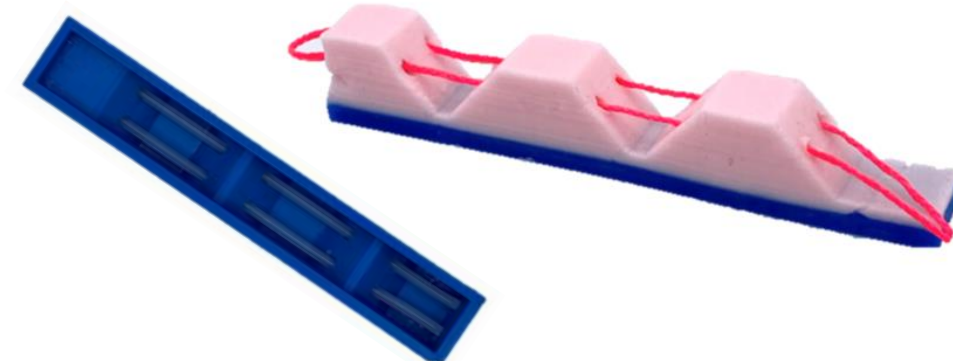
Rubbery Plastics



Photo Credit: Let's Talk Science



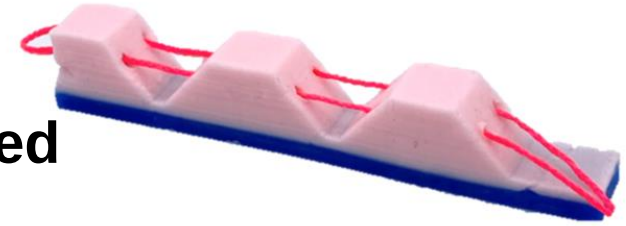
Photo Credit: Su et al.



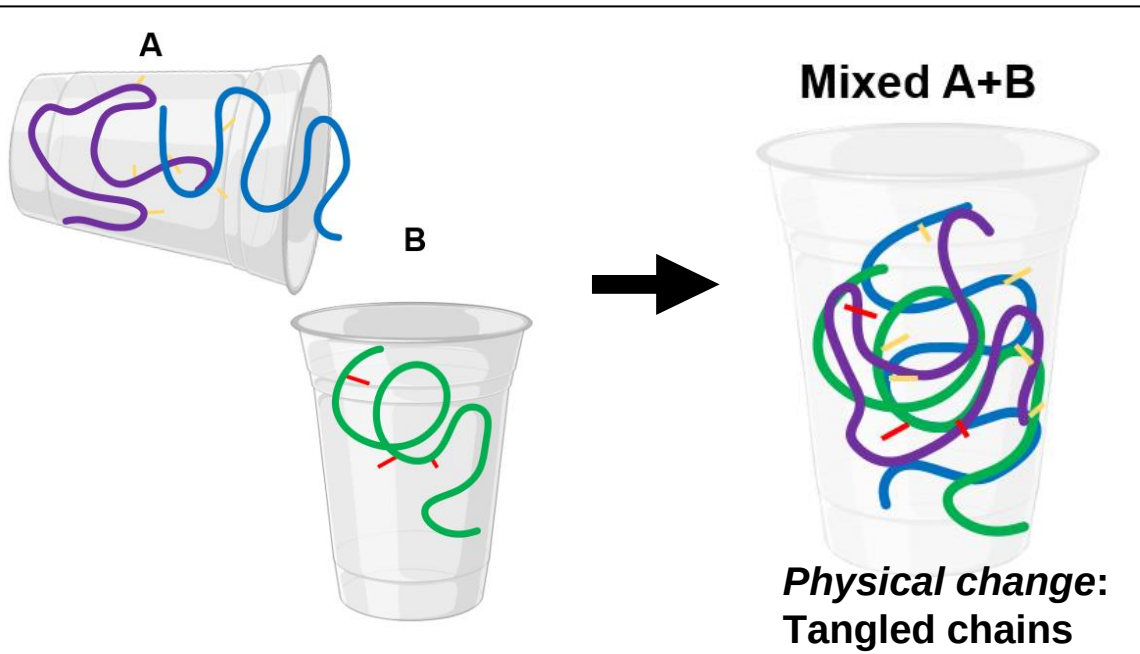
Materials: What happened in our molds overnight?

Polymers:

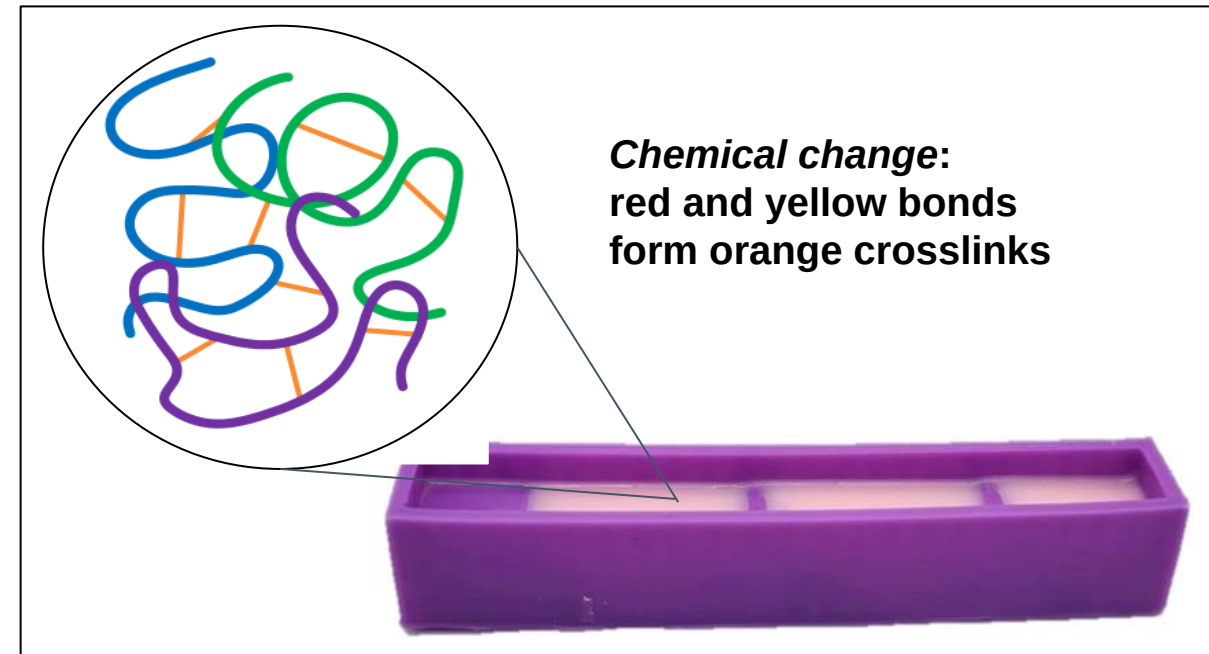
- Under a microscope, look like longs chains of spaghetti
- Are liquid until they are crosslinked
- When polymers become solid, they are firm but can be stretched
- Silicone is one type of rubbery polymer



Yesterday



Last night

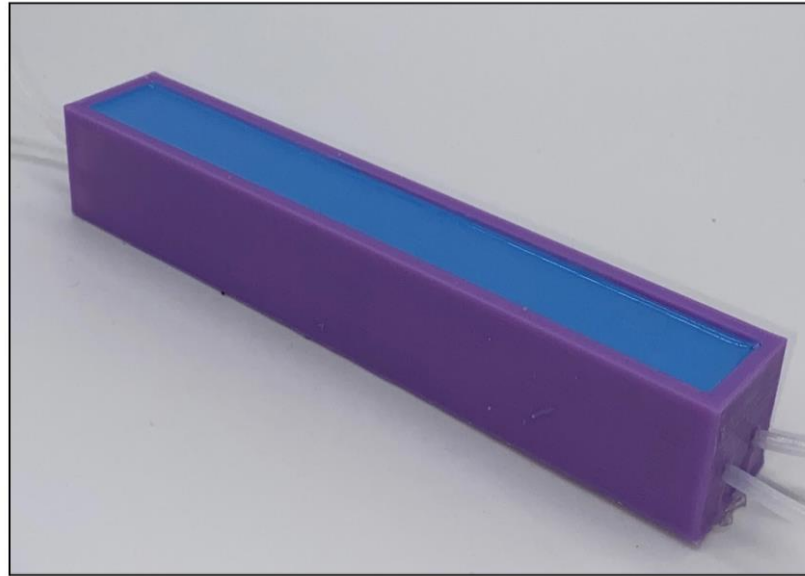


Soft Robot Examples: Glove



SDM Finalization

- Refer back to the instructions to start at step #5-7...
 - be sure to fill the mold completely with the new layer of silicone!



- Once your final layer is poured, return mold to the curing area.

SIA Actuator Design Objectives

- Understand why both silicone and fabric will be utilized.
- Implement mobility to the finalized mold with air pressure.



Follow all directions carefully, especially at the following steps...

- Ensure all components of the mold are well coated in Mold Release spray (#1-3).
- If you wish to add color, add a few drops to part A only (#4).
- Mix parts A and B together for at least **5 minutes** (#4).
- Be sure to gently push the fabric into the silicone (#7).
- Carefully coat the fabric with a thin layer a silicone to ensure it is well secured in the mold (#8).



McKibbens Muscle (Day 3)



Today, we will build a pneumatic powered system that mimics the motion of a muscle.

Watch:

<https://www.rolex.org/rolex-awards/video/applied-technology/conor-walsh>

As you watch the video, write out a question you have about:

- the video
- soft robotics
- activities we are doing together
- engineering

Who works on these robotic exosuits?

Engineers use math and science to solve problems and design solutions

Fabric Assembly:
Tailor/Fashion Designer



Interaction of human body with exo-suit:
Bioengineers



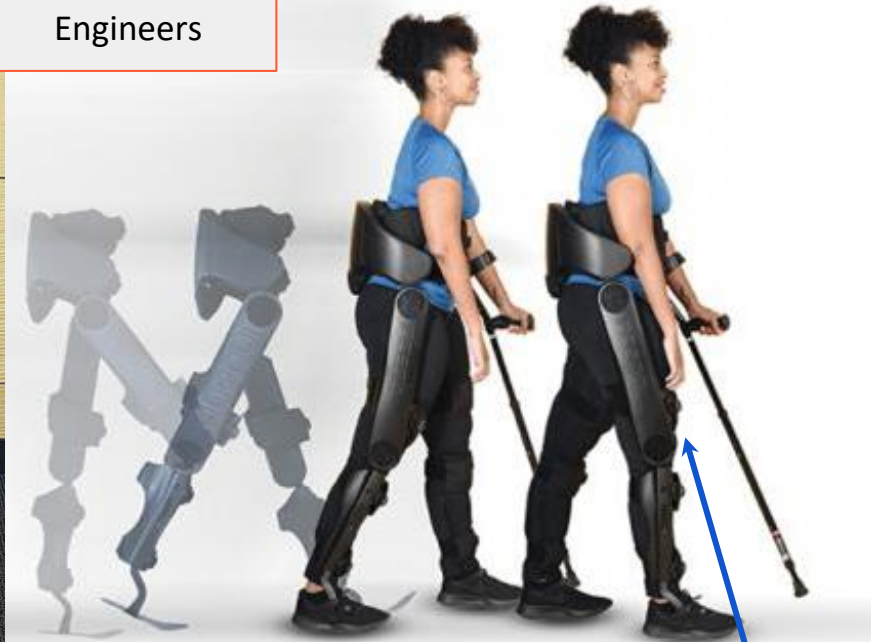
Buildings and Bridges:
Civil Engineers



Sensor System and Circuits:
Electrical Engineers



Programs: Computer Science

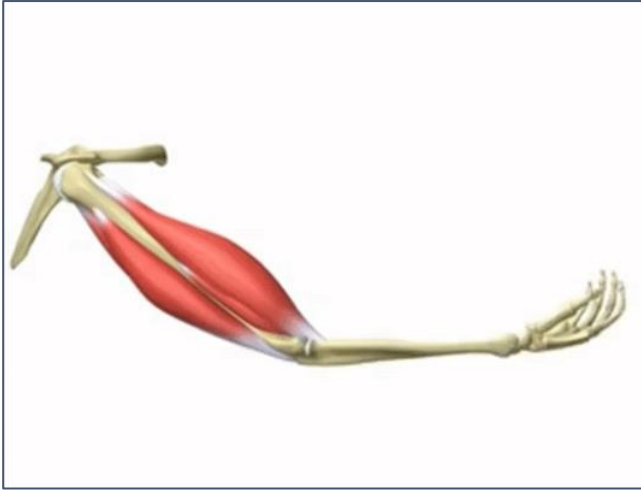


Robot Structure and Joints:
Mechanical Engineers

Photo Credit: Polygerinos et al.

Photo Credit: Indego.com

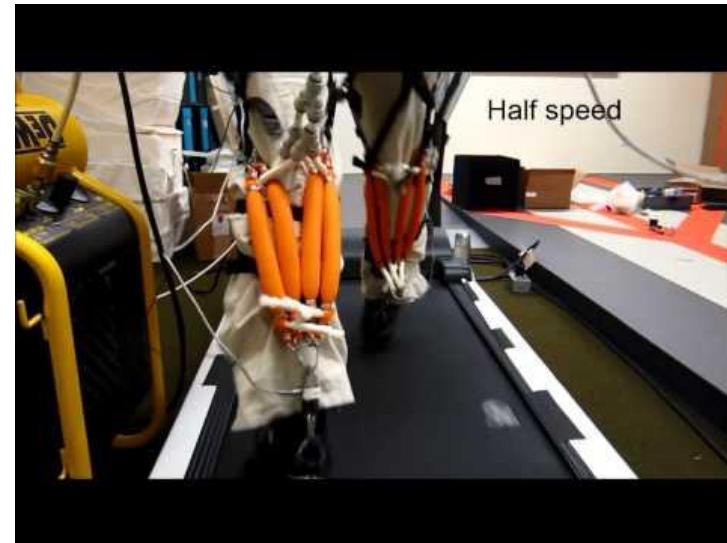
McKibbens Muscle



Video Credit: [Ciaran Cassiday](#)



Video Credit: [Yong-Lae Park](#)



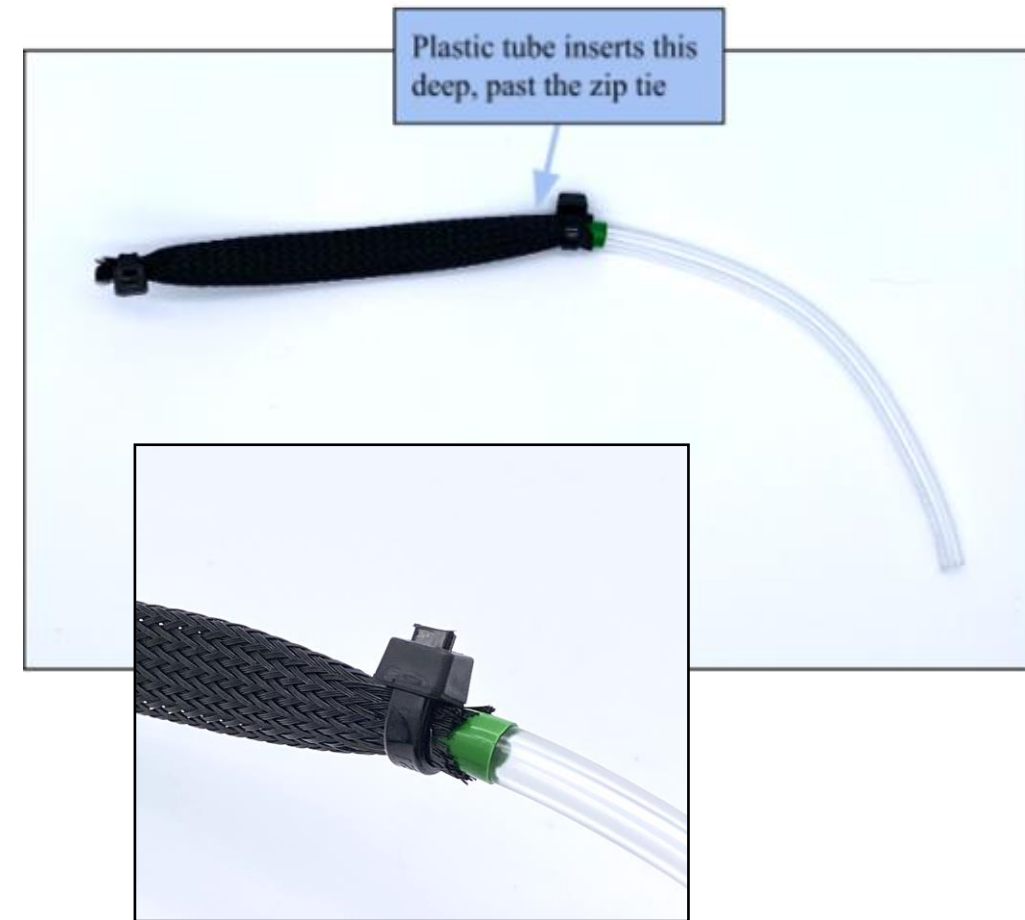
McKibben's Muscle Design Objectives

- Analyze the properties of the material that determine the muscle's function.
- Understand why the air pressure alter's the shape and function.



Follow all directions carefully, especially at the following steps...

- Make sure the balloon is far enough over the tubing so it will not slide off (#3).
- Use a zip-tie to secure the sleeving and balloon around the tubing. Pull it at tight as it can be.
- Part of the balloon can be outside of the zip-tie but the tubing needs to be inside the secured sleeve (#4).



Applications

[The King Actuator: Haverford Soft Robotics Club Wins Harvard University Competition on Vimeo](#)



Demolding & Analysis (Day 3)

We will now demold both the SDM and SIA actuators and explore their abilities and limitations

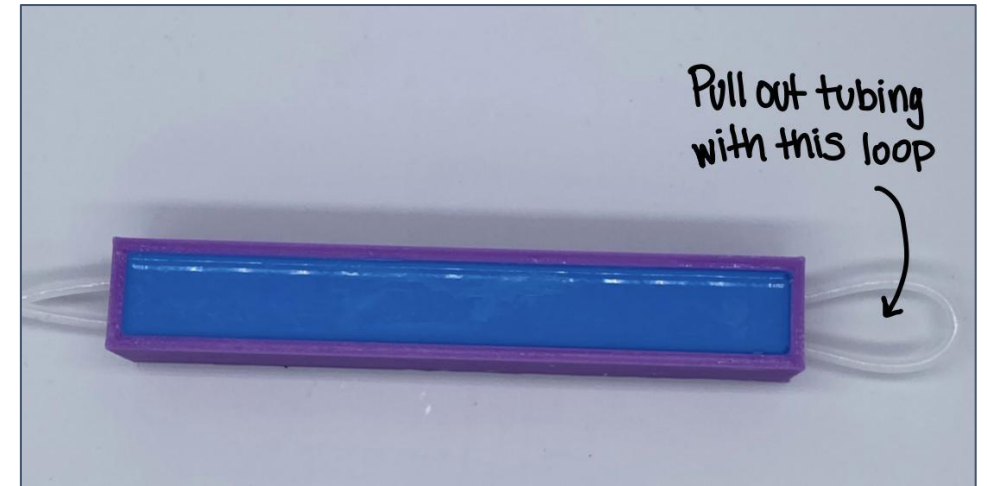
Demolding Instructions

SDM Demolding: follow step #8

- Pull the tubing out from the looped end.
- Slowly remove the silicone
 - if pulled too quickly, silicone may rip.

SIA Demolding: follow steps #10

- Lift and pull up on the spine holder
 - pliers may be needed for more force
- Carefully pull spine out with pliers.
- Trim excess fabric if desired
 - be sure to not puncture the silicone



Improvements:

- Which step(s) were the most difficult to execute?
- Is there a way we can improve the ease of the design process?
- Did the design successfully perform its desired function?

Favorite Design:

- Which design (SDM actuator, wrist brace, SIA actuator) was your favorite and why? What are some applications of this design?

Soft Robotics Common Questions (End of Day 4)

Education

- How many years are required in college to study soft robotics?
 - Undergraduate degree
 - Bachelor's degree - 4 years
 - Core Courses: math, chemistry, physics, biology.
 - Research groups and labs
- Who/how are they funding their projects?
 - National Science Foundation
 - University grants
 - Company funding: Honeywell, Tyson Foods



Honeywell

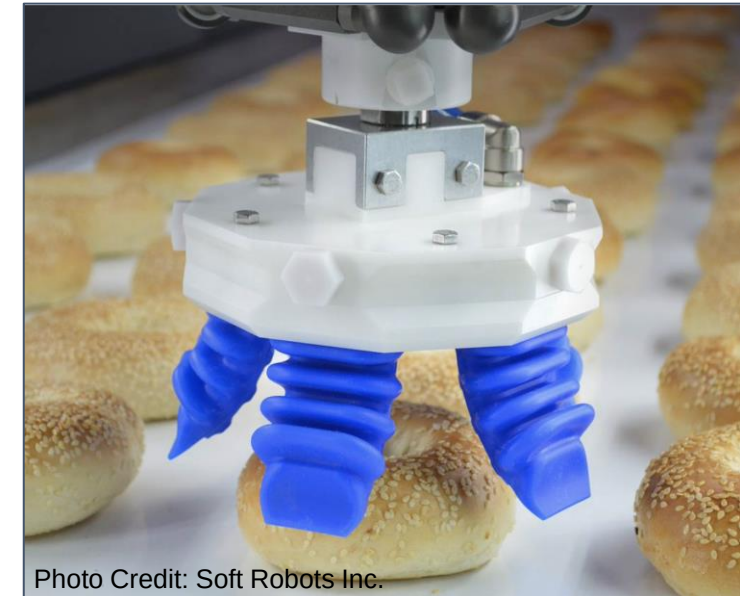


Photo Credit: Soft Robots Inc.

Design Process

- What are the certain steps to build soft robots?
 - Identity the main function/task you want the robot to perform.
 - Organize materials
 - Build prototype = first model
 - Test prototype and take notes on problems
 - Edit model with improvements and modifications
 - Build second model
 - Test, edit, build again until version is successful.
- How does science or math change depending on the body part?
 - Different measurements based on size of arms, legs, etc.
 - Age and fitness levels alters how much force one can withstand.
 - Material properties (soft, hard, stretchy) are required for different parts of the body.



Exosuit Functions

- What are they powered by?
 - Electricity, Air, Batteries, human powered (by walking, running).
- Are the suits painless?
 - The suits are made of materials that are comfortable and fit well to the body.
 - Rigid components are typically covered in a softer material.
- How does your body know that you have the robot thing on?
 - A sensor system uses stickers to detect changes in electrical signals.
 - Electrical signals change as a muscle is moved.
 - Wires connect the stickers to a device that powers the exo-suit.

Soft Robot Fun Facts

- When was the first soft robotic thing created and what was it used for?
 - 1950: McKibbens Muscle
 - Designed for polio patients: support the patient's legs to aid in mobility.
- How big can soft robots get?

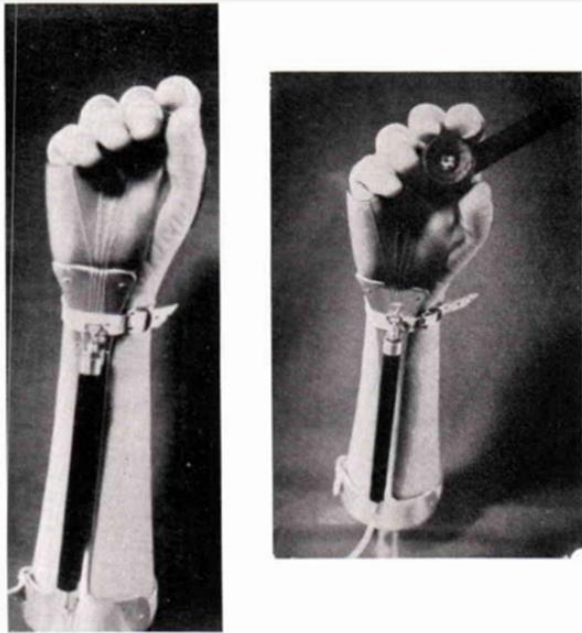


FIGURE 3, A and B

Flexor tendons pass through channels imbedded in the plastic portion of the hand orthosis so that the power distribution to the digits will be as much like natural anatomical movements as is possible and more mechanically efficient.





The Grainger College of Engineering

UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

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