

**Lesson Three: Prosthetic Fingers**  
**Center for Sensorimotor Neural Engineering**  
Lesson Plan Author: Phelana Pang



**LESSON OVERVIEW**

**Activity Time:** 80 minutes (over two days).

**Lesson Plan Summary:**

Students will create and observe a silicone model of their finger to consider constraints in engineering a prosthetic device.

**STUDENT UNDERSTANDINGS**

**Big Idea & Enduring Understanding:**

- Models can be made and examined to consider design criteria and constraints.

**Essential Question:**

- What factors need to be considered when designing a prosthetic device?

**Learning Objectives:**

*Students will know...*

- Models have limitations.
- Models can be used to consider the criteria and constraints in a design process.

*Students will be able to...*

- Come up with similarities and differences between their prosthetic finger and their real finger.

**Vocabulary:**

- **Engineering design:** criteria, constraints.

**Standards Alignment:** This lesson addresses the following middle school Next Generation Science Standards (NGSS).

**NGSS Middle School Disciplinary Core Ideas**

- **MS-ETS1.A Defining and Delimiting Engineering Problems:** The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specifications of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.

### NGSS Cross-Cutting Concepts

- **Structure and Function**

### NGSS Science & Engineering Practices

- **SEP:** Asking Questions and Defining Problems
- **CCC:** Influence of SET on Society and Natural World
- **NoS:** Science is a Human Endeavor
- **NoS:** Science Addresses Questions about the Natural and Material World

### MATERIALS

Material	Description	Quantity
<i>Student Handout 3.1: Making a Prosthetic Finger</i>	Guides students through the process of making prosthetics and includes reflection questions	1 copy per student
Dow Corning silicone rubber curing agent	Ellsworth Adhesives Part # 3-6559 CURE ACCEL .45KG BT, <a href="https://www.ellsworth.com/">https://www.ellsworth.com/</a>	1 bottle
Silastic E curing agent and accelerator	Ellsworth Adhesives Part # RTV-4230-E KIT 4.4KG KIT, <a href="https://www.ellsworth.com/">https://www.ellsworth.com/</a>	1 bottle each (comes as a set)
Alginate powder Alja-Safe	Smooth-on, <a href="http://www.smooth-on.com/Life-Casting-Alja-/c3_1185/index.html">http://www.smooth-on.com/Life-Casting-Alja-/c3_1185/index.html</a>	3lb should be plenty
100 mL Graduated cylinders	For measuring water	1 per group
10 mL Graduated cylinders or large disposable pipettes	For measuring curing agent and accelerator; very difficult to clean afterwards	2 for class (teacher use)
Small disposable cups (Dixie bathroom cups)	For mixing alginate	1+ per student
Popsicle sticks or tongue depressors	For mixing and applying alginate	1+ per student
Film canisters or other rack/apparatus	For holding molds/casts while curing	1+ slots per student
Paper towels	Should be dry for removing any silicone on hands	1+ roll per class

Scissors	For trimming silicone after curing	1+ per group
Lab bench underpads (optional)	To protect tables and for easy clean-up	1 per group
Permanent markers	For decorating prosthetic fingers	5+ colors per group

### TEACHER PREPARATION

1. Try making the prosthetic finger on your own ahead of time. Use dry paper towels to remove any silicone that gets on your hands before washing with soap.
2. Pre-measure alginate into small cups so students only have to measure water.
3. Prior to Day 2: check to make sure the fingers are cured (should only take 24 hours)

### PROCEDURE

#### Day 1

##### Engage: Brainstorm (10 minutes)

1. In groups, partners, or individually, brainstorm responses to the questions listed in the Brainstorm section of *Student Handout 3.1: Making a Prosthetic Finger*. Possible answers are listed in *Teacher Resource 3.1*.

##### Explore: Make a Prosthetic Finger (30+ minutes)

2. Use alginate and silicone to make mold and cast of finger (these will need to cure overnight).
  - Instructions are provided on Day 1 section of *Student Handout 3.1: Prosthetic Fingers*.
  - Save time for cleaning up. Students should wipe off silicone with DRY paper towels before washing their hands with soap.
  - Allow fingers to cure for 24-72 hours.



## Day 2

### Explain and Evaluate: Examining Prosthetic Fingers (40+ minutes)

3. After prosthetic fingers have cured overnight:
  - a. Remove mold (can be discarded) and use scissors to trim excess silicone.
  - b. Examine and sketch prosthetic fingers.
  - c. Complete Day 2 section of *Student Handout 3.2: Prosthetic Fingers*.
    - i. Discuss similarities/differences compared to actual finger in terms of structure, function.
    - ii. Discuss modifications to this finger to make it an optimally functional prosthetic component.
    - iii. Discuss with students whether aesthetics may be important to an end-user.
  
4. *Optional*: Decorate prosthetic finger with permanent markers.



### STUDENT ASSESSMENT

**Assessment Opportunities:** Student knowledge, skills, and concepts for this lesson will be assessed in a number of ways.

- Oral discussion of criteria, constraints, and modifications to prosthetic finger
- Written and oral reflection on limitations of prosthetic model
- Written reflections on student handout or lab notebook.

**Student Metacognition:**

- Provide students opportunities to come up with questions, reflect on their initial ideas about what they know and understand, and write them down in their lab notebook. They can add new/changing ideas to their lab notebook.

**Scoring Guide:**

- *Teacher Resource 3.1.* provides a scoring key for *Student Handout 3.1.*

## EXTENSION ACTIVITIES

**Extension Activities:**

- Students can make a prosthetic of other body parts (for example: nose, ear, or toe). If doing nose or ear, use cotton to plug openings before making alginate mold.
- Students can research the challenges of creating prosthetic limbs and how engineers have addressed various criteria and constraints in their solutions.

## TEACHER BACKGROUND & RESOURCES

**Background Information:**

Written by Dianne Hendricks (see citation below):

“The material used for the mold is produced from reaction of water with algiform. The alginate is a gelating polysaccharide that makes up a large part of the cell wall of giant brown seaweed, horsetail kelp, and sugar kelp. It is often used as a creamer in ice cream, a suspending agent in soft drinks, and in various medical applications such as dental impressions and capsule coatings for pharmaceuticals.

“The casting material, Silastic E RTV Silicone Rubber, contains polydimethylsiloxane (PDMSO) and an organo-platinum complex catalyst. The curing agent contains the crucial crosslinking ingredient that is activated by the catalyst to join the polymer chains in the base (casting) material. The crosslinking process attaches chains of polymer together to form a network and eventually a solid material.

“An accelerator, which consists of additional platinum catalyst, is sometimes required to cure the rubber when surfaces such as masking tape or latex inhibit the catalyst already in the base. It is used here to ensure formation of a firm, well set prosthetic.”

**Citations:**

Prosthetics finger lab is based on an activity developed by Dr. Dianne Hendricks, Lecturer and Faculty Lead for Outreach, Department of Bioengineering, University of Washington, [dgh5@uw.edu](mailto:dgh5@uw.edu), <https://bioe.uw.edu/outreach>.

Photographs taken by Phelana Pang.



## Student Handout 3.1: Prosthetic Fingers

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: \_\_\_\_\_

### Day 1: Making a Prosthetic Finger

#### Brainstorm

What are different types of functions a hand can perform? If you didn't have a hand, what could you not do? Describe/diagram.

If you were to design a prosthetic hand, what considerations would you prioritize? What would it look like? What would it do?

#### Procedures

1. Combine 100 mL of alginate powder and 90 mL of warm water in a small Dixie cup.
2. Stir with popsicle stick.
3. Use popsicle stick to apply alginate over one whole finger. Be sure to cover all holes and apply an even layer about 1.0-1.5 cm thick.
4. Allow to dry for a few minutes, then carefully remove finger.
5. Place mold in film canister.
6. Obtain silicone mixture from your teacher (2.0 mL Cure Accelerator, 5.0 mL Curing Agent, 40 mL Silastic Rubber Base).
7. Pour silicone into mold. Allow to sit overnight.
8. Use a dry paper towel to wipe off your finger, then wash with soap and water.
9. The next day, peel off alginate mold to reveal the cast of your finger!

## Day 2: Observations of Prosthetic Finger

**Sketch** and **label** and/or **describe** your prosthetic.

How is your prosthetic **similar** to your real finger?

How is your prosthetic **different** from your real finger?

Brainstorm some **modifications** that would make this prosthetic finger more “real.” Think of both **functional** and **structural** modifications.





## Teacher Resource 3.1: Prosthetic Fingers Answer Key

### Day 1: Making a Prosthetic Finger Answer Key

#### Brainstorm

What are different types of functions a hand can perform? If you didn't have a hand, what could you not do? Describe/diagram.

Possible answers: gripping, grabbing, bending, pushing, pinching, twisting, holding, typing, writing, pointing

If you were to design a prosthetic hand, what considerations would you prioritize? What would it look like? What would it do?

Possible answers: looks like a hand, feels like a hand, has fingers, has opposable digit, has joints that can bend, has ability to revert back to its original shape (not stay bent), skin tone matches user, can be controlled easily, lasts a long time, can be taken off,

### Day 2: Observations of Prosthetic Finger Answer Key

**Sketch** and **label** and/or **describe** your prosthetic.

Possible answers: has details of lines on skin, might be dented based on how finger was positioned while curing, bubbles can exist if the silicone was thick and quickly poured in

How is your prosthetic **similar** to your real finger?

Possible answers: details of skin and nail present, size is same

How is your prosthetic **different** from your real finger?

Possible answers: color is white, doesn't bend in the same way, flexible/malleable, has a better grip due to silicone

Brainstorm some **modifications** that would make this prosthetic finger more "real." Think of both **functional** and **structural** modifications.

Possible answers: skin tone can match person, can bend at joint