

HandGineering

Design, Create, Iterate

Bioengineers use the engineering process to help make living things work better. One example is designing, testing, and refining prosthetic devices for people with limb loss or a limb difference.

Bioengineering works best when engineers listen carefully to what users need and keep those needs in mind through the whole design process. This is called user-centered design.

When designing a prosthetic, for example, an engineer needs to understand many different needs. What tasks does the user need the prosthetic to do? How does the user's limb difference affect them physically, emotionally, and socially? Does the prosthetic move naturally and easily? Is the design comfortable to wear?

Successful user-centered design leads to a product that makes people's lives better.

Why not try your hand at designing a hand? In this activity, you will use materials your teacher provides to create a prosthetic hand to meet the needs of a possible user.

To accomplish this, you will go through the steps shown in the diagram at the right. They are described in more detail on the following pages but here is a quick overview.

The first step, **Design**, has 3 parts

- Define
- Imagine
- Plan

The second step, **Create**, includes

- Build
- Test

Iterate will send you through the entire cycle again so that you can improve upon what you created. You can and should do this last step multiple times.

Let's start with Design!



Step 1: Design



As you start designing your solution, there are things that you need to determine, or define. These will help you understand the requirements and limits so that you can create a successful prototype.



- **User needs.** When designing an engineering solution, you should always consider what the end user really needs from it. This list of things your solution needs is often called the **criteria**.
- **Constraints** are things that limit what you can do, such as a certain budget or a short timeline.

Your teacher will help you decide upon these things for this project. Record them in the table below.

Table 1: Considerations

User needs (Criteria)	Constraints

1. What do you think are the 3 most important user needs to meet with your hand prototype?
2. List (or circle in your answer to question 1) the need(s) you will attempt to address.



Brainstorm potential solutions. You can use your imagination and write down whatever ideas come to mind. Don't edit your ideas at this stage.

NAME _____ DATE _____



Now it's time to narrow down your ideas and **devise a concrete plan**. Look carefully at each potential solution. Discard any that don't fulfill the considerations listed above in Table 1. Choose one to try, then do the following.

Draw your prototype. Be very detailed and include all measurements.

Create a list of materials you will need (mind your constraints!).

Step 2: Create



Build your prototype. Use the provided materials and stay as close to your drawing as possible. Document any changes that you make on your drawing and materials list.



Test your prototype. When designing a solution, it is critical to conduct tests to see if your idea will work. Interestingly, the best way to do that is to design tests that do everything you can to make it fail! Only then can you see how to improve.



Below are tests for Gestures and Grasping. If you’re attempting to address a different need, create your own procedure and data table on a separate paper.

Gesture Test Test how long your prototype can hold each gesture (the goal is at least 10 seconds!)

- 1. Choose 2 gestures of your own and list them below in the first column.
- 2. You will attempt each gesture 3 times. Record how many seconds the prototype can hold each gesture in the “Trial 1, 2, and 3” columns of the table below.
 - If you couldn’t make the gesture at all, put 0 in the column.
 - If you held the gesture at least 10 seconds (but could have held it longer), enter 10 in the column.
- 3. Calculate the average time for each gesture and enter into the column labeled “Average”.
- 4. Graph on a separate paper.
- 5. Use the last column to record observations, notes about any failures, and anything else you might want to remember later.

Table 2: Gesture Test

Gesture	Number of seconds (out of 10)				Observations/Failure notes
	Trial 1	Trial 2	Trial 3	Average	
Thumbs up					
Peace sign					

Grasping Test

Now let’s test your prototype’s ability to pick things up. Choose 4 objects that you think will test the limits of your design. Remember that finding ways your design fails is the only way to learn how to improve!

- 1. Record the names of your chosen objects in the first column.
- 2. Attempt to grip and lift each object 30 centimeters. Repeat the test 3 times for each object.
- 3. Record the height in centimeters for each attempt in the “Trial 1, 2, and 3” columns of the table below.
 - If you couldn’t grab it or lift it at all, put 0 in the column.
 - If you could have lifted it more than 30 centimeters, just enter 30 in the column.
- 4. Calculate the average distance for each object and enter into column labeled “Average”
- 5. Graph on a separate paper.
- 6. Use the last column to record observations, notes about any failures, and anything else you might want to remember later.

Table 3: Grasping Test

Object	Height lifted in cm (out of 30)				Observations/Failure notes
	Trial 1	Trial 2	Trial 3	Average	

Step 3: Iterate

1. What does it mean to iterate?

You likely found some ways that your prototype failed (if not, put it through more vigorous tests!). Now you know what doesn't work and can try new things that might. Good solutions don't happen on the first try! You must go around the cycle again and again, improving your prototype each time. So how many times do you iterate? At what point should you stop? When you find something that works well enough to fit the needs of your user. So let's get started on the iterating!



Analyze your prototype. Think about 3 things you could do to improve your model and list the changes below along with your reasoning. Talk to 2 other classmates and get their feedback on your choices.

Table 4: Improvements

Change	Why make this change?	Peer feedback

2. List the user need(s) you will attempt to meet.

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Review the user needs and constraints you listed before (In Table 1). List new ones here.



Brainstorm potential solutions. Remember to consider the user needs and constraints from the last step.



Draw your new prototype (or edit your previous drawing).

Create a list of additional needed materials (mind your constraints!).



Build your prototype.



Test your prototype. Create a data table like the ones your filled out in Step 2. Record your results.

Analyze your prototype. Think about 3 things you could do to improve your model and list the changes below along with your reasoning.

Table 5: Further improvements

Change	Why make this change?

3. What else could you do to improve your hand model if time and cost of materials were not a constraint?