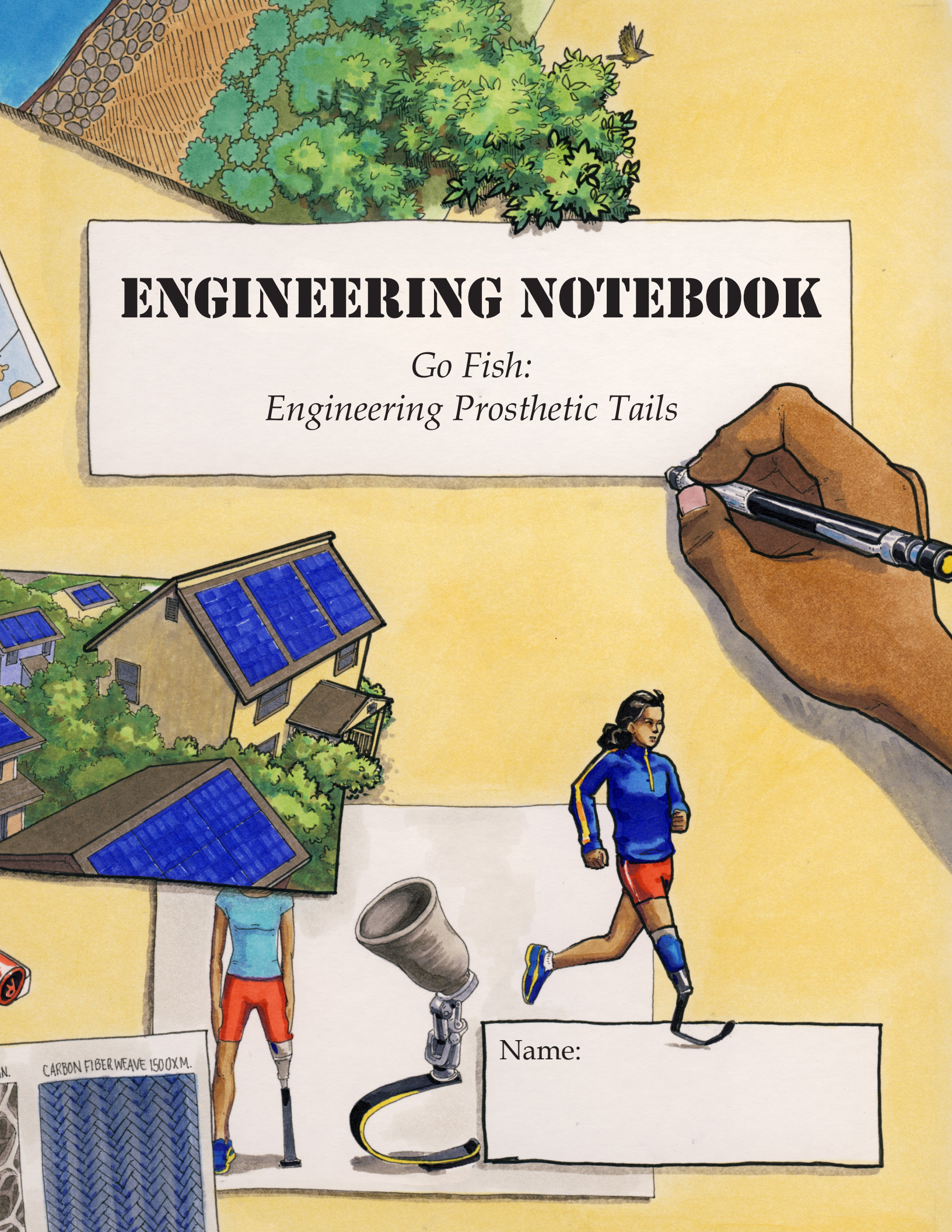
ENGINEERING NOTEBOOK

Go Fish:
Engineering Prosthetic Tails



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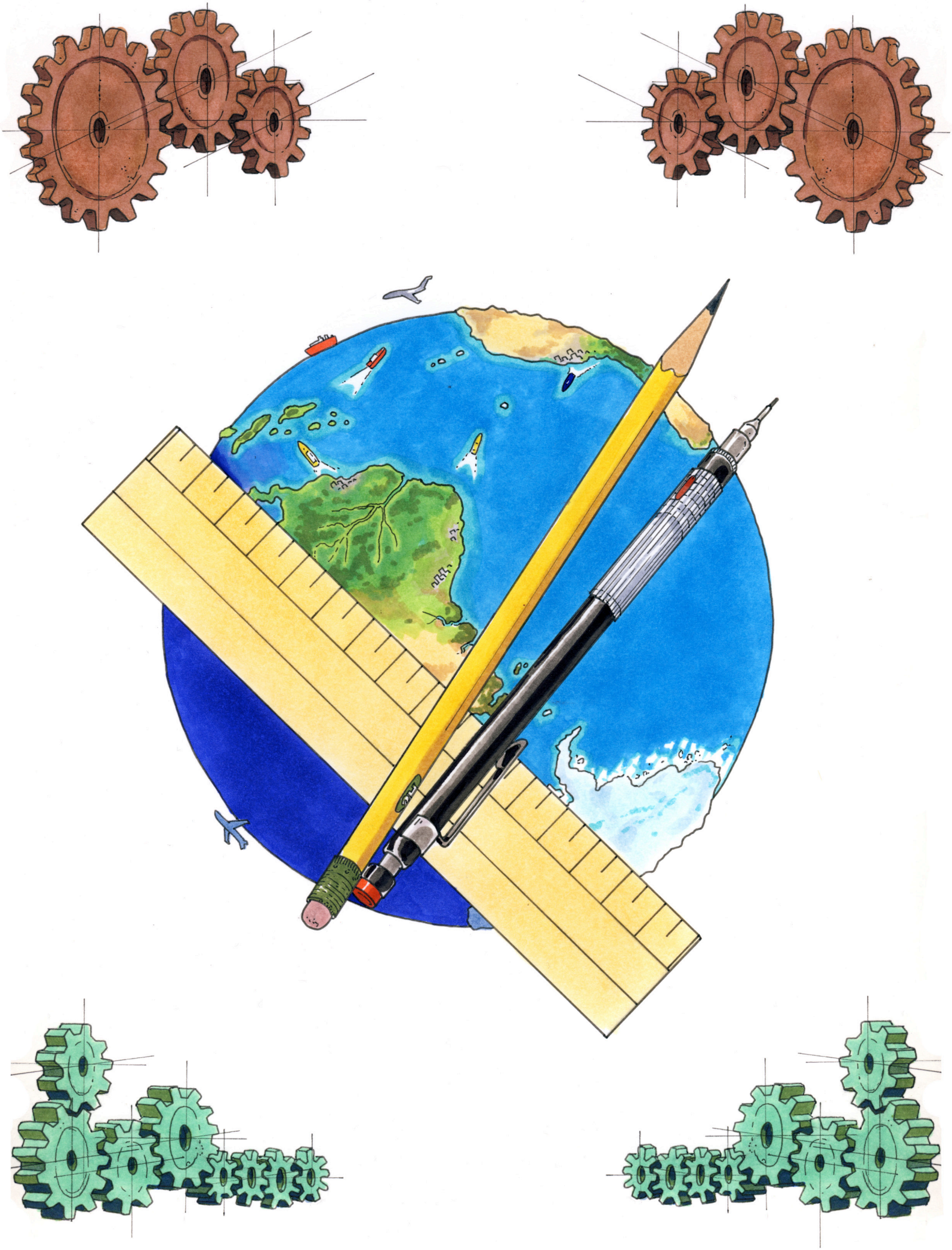


Criteria and Constraints

Prep Activity 1

Follow the **criteria** and **constraints** in the table below to engineer a life vest for Champ the corgi.

Criteria are things you or your design needs to accomplish.

Constraints are ways that you or your design are limited.

GOAL: Engineer a life vest that keeps the model dog's head above the water.

CRITERIA	CONSTRAINTS
• Your life vest must allow the model dog to float with his head above the water for 10 seconds. • Your life vest must attach and detach from the model dog as quickly as possible.	• You can only use up to two plastic bags, two sheets of foam, three rubber bands, one measuring tape, and one pair of scissors. • The scissors and measuring tape cannot be used as a part of the life vest. • You cannot *test* the life vest on the model dog until the designated *testing* time. • You have 20 minutes to engineer your design.

Prep Activity 1

Engineering a Life Vest

Take a look at the example life vest for pets.
What do you notice about its design?

Draw a *plan* for your design of Champ's life vest in the space below.

What materials or methods worked best for keeping Champ afloat?

What materials or methods worked best for quickly attaching and detaching the life vest to Champ?

My Engineering Profile

Prep Activity 2

You will be working as biomechanical engineer. What skills are you already an expert at? What skills would you like to develop further?

✓ Check off your engineering strengths.
◯ Circle any engineering skills you would like to practice getting better at throughout the rest of this engineering unit.

- ☐ *communicating*
- ☐ building things
- ☐ *imagining*
- ☐ being creative
- ☐ drawing
- ☐ working on a team
- ☐ leading a team
- ☐ analyzing data
- ☐ making a *plan*
- ☐ offering critical feedback on others work
- ☐ receiving feedback on your own work
- ☐ moving forward after something does not work
- ☐ thinking of different ways to do something
- ☐ solving problems
- ☐ troubleshooting problems

What are some other skills that you consider strengths? What else would you like to get better at? Write or draw your thoughts in the space below.

Activity 1

Chhouk's Prosthetic Leg

In 2007, a young elephant in need of help was discovered in a remote region of northeastern Cambodia. The elephant was alone and having trouble moving around because the bottom portion of his right front leg had been lost. The injury was likely caused by a hunter's snare trap.

Human volunteers cared for the elephant and nursed him back to health. They named him "Chhouk," meaning "Lotus Flower," and arranged for him to be transported to a wildlife rescue center where veterinarians and animal specialists could help him.

It soon became clear that Chhouk needed a prosthetic device to keep him healthy and restore his ability to walk. A team of biomechanical engineers *created* a prosthetic leg that was designed to function just like his original one. They chose materials that were strong enough to support his massive weight and durable enough to last. They also used soft padding and straps to ensure the device was comfortable to wear and easy to attach.

The design was a success! Upon receiving his new prosthetic device, Chhouk's medical issues and spirit improved rapidly. Even so, the engineers have continued to *improve* upon their original design, *creating* several new versions of the device that match Chhouk's growing size and boundless energy!

Article adapted from: Wildlife Alliance, *Chhouk, the Elephant with a Prosthetic Foot*

Designing a Prosthetic Elephant Leg

Activity 1

A model is a representation that helps us understand an object or concept.

GOAL: Engineer a model prosthetic elephant leg.

CRITERIA:

Your model prosthetic elephant leg must:

- support your weight
- attach to your actual leg at the knee
- stay together when used
- be comfortable to wear

Be sure to review the testing procedures on the next page!

What will your design look like? Draw a plan in the space below.

Elephants are heavy! Adult Asiatic elephants can weigh up to 11,000 pounds!

The bottoms of elephants' feet are covered in a thick tissue layer that acts like a cushion.

Activity 1

Testing the Prosthetic Elephant Leg

Carefully place your knee onto the top of your model prosthetic elephant leg and secure any attachments you have designed. Hold onto a friend or a steady piece of furniture to prevent yourself from losing your balance. Follow the testing procedures below.

Function

Place your weight on the prosthetic leg.

Does the device feel stable?

☐ Yes ☐ No

Comfort

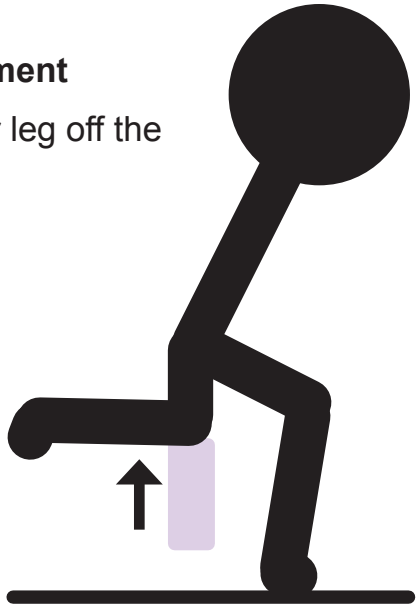
Place your weight on the prosthetic leg.

Does the device feel comfortable?

☐ Yes ☐ No

Attachment

Lift your leg off the ground.



Does the device stay attached to your knee?

☐ Yes ☐ No

Durability

Walk in place for five steps.

Does the device stay together?

☐ Yes ☐ No

Beauty's Prosthetic Beak

Activity 2

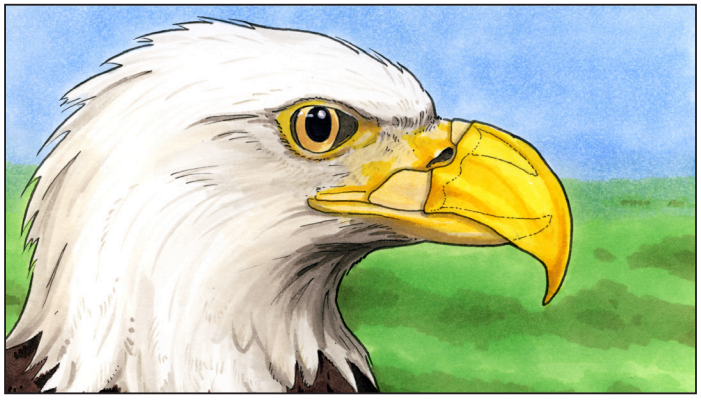
In 2005, a bald eagle was discovered injured and scavenging for food at a landfill in Alaska. Sadly, the upper part of the bird's beak had been shattered by a poacher. The injury made it incredibly difficult for the bird to catch and eat food. For an eagle, trying to eat with half of a beak is like trying to pick something up with a single chopstick.

Eating is only one of the many important functions of a bird's beak. Birds use their beaks to preen themselves (clean and straighten their feathers) and gather materials to make nests. With a damaged beak, it would be very hard for a bird to survive in the wild.

The eagle was named "Beauty" and was relocated to a raptor rehabilitation center in Idaho where she was nursed back to health by a team of volunteers. They worked with scientists, medical specialists, and engineers to design and *create* a prosthetic upper-beak that would restore Beauty's ability to eat and take care of herself.

When the design was complete, the team enlisted the help of a dentist to attach the prosthetic device to the end of Beauty's injured beak. After the procedure was over, Beauty's recovery continued and she was soon able to feed herself and preen her feathers.

As Beauty and her injured beak continue to grow, the team will consider *improvements* to prosthetic device to make sure that she remains happy and healthy.

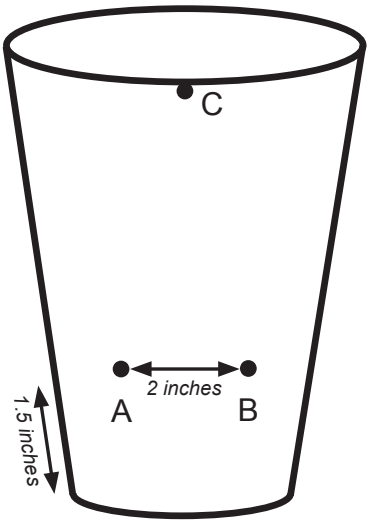


Article adapted from: Birds of Prey Northwest, *The Story of Beauty* and The Guardian, *Restoring Beauty*

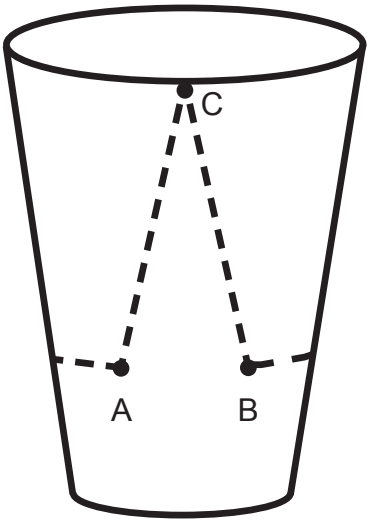
Activity 2

Making the Model Damaged Beak

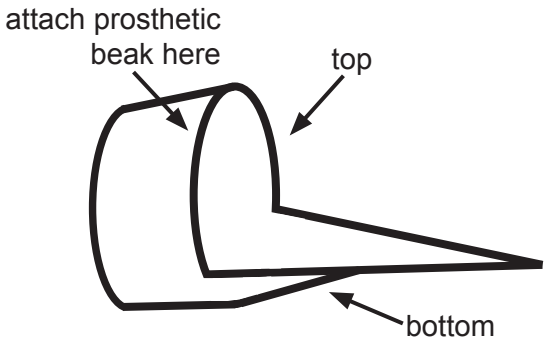
Follow the instructions below to make a model damaged beak, which you can use to *test* your prosthetic beak designs. You will need a small paper cup, a marker, a measuring tape, and a pair of scissors.



- Draw **Dot A** 1.5 inches from the bottom of the cup.
- Draw **Dot B** 2 inches to the right of **Dot A**.
- Draw **Dot C** on the rim of the cup in-between **Dot A** and **Dot B**.



- Draw a straight line connecting **Dot A** and **Dot C**.
- Draw a straight line connecting **Dot B** and **Dot C**.
- Draw a straight line connecting **Dot A** and **Dot B** around the back of the cup. Keep the line parallel to the bottom of the cup.



- Cut along the lines and keep the bottom portion of the cup. This will serve as your model damaged beak.
- Note the area on the top of the model damaged beak where you will attach the prosthetic beak that you design.

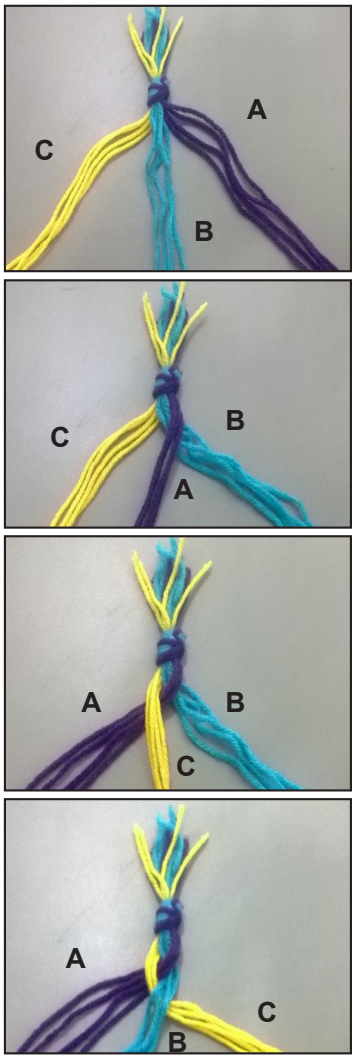
Testing Your Beak: Preening

Activity 2

To see if your prosthetic beak can preen, you will need to undo and straighten strings that have been braided.

Make Your Braid

1. Cut 12 pieces of string, each about 10 inches long.
2. Tie a knot at one end of all the strings.
3. Divide the string into three groups (four pieces of string each).
4. Take A (the string on the right) and cross it over B.
5. A should now be in the middle.
6. Take C (the string on the left) and cross it over A.
7. C should now be in the middle.
8. Take B (the string now on the left) and cross it over C, so it is in the middle.
9. Continue this pattern until you've braided the whole length of the strings.



Test Your Prosthetic Beak

On the line below, rate how well your prosthetic beak separates the strands of the braid.

10	5	1
It easily separates the whole braid	It can separate some strands	It cannot separate any strands

Improve Your Prosthetic Beak

What *improvements* might you make in order to better separate the braid?

Activity 2

Testing Your Beak: Picking Up

To see if your prosthetic beak can help a bird eat, you will need to be able to pick up small items.

Test Your Prosthetic Beak

Try picking up many different items with your prosthetic beak and list your findings below.

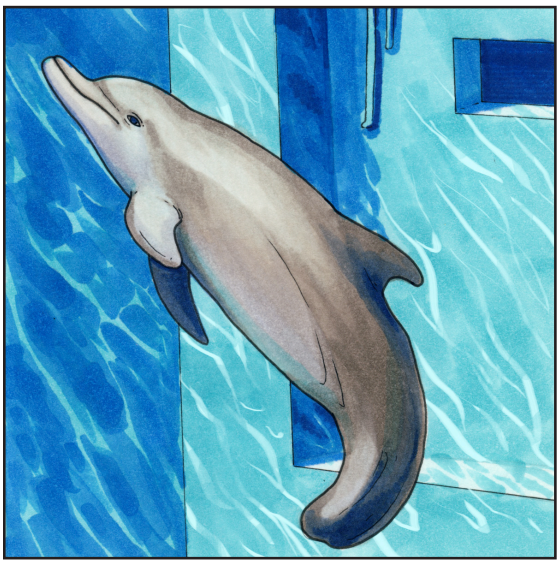
Item	Can you pick it up?	Notes
	☐ Yes ☐ No	
	☐ Yes ☐ No	
	☐ Yes ☐ No	
	☐ Yes ☐ No	
	☐ Yes ☐ No	
	☐ Yes ☐ No	
	☐ Yes ☐ No	
	☐ Yes ☐ No	

Improve Your Prosthetic Beak

What improvements might you make to your prosthetic beak design to better pick up various objects?

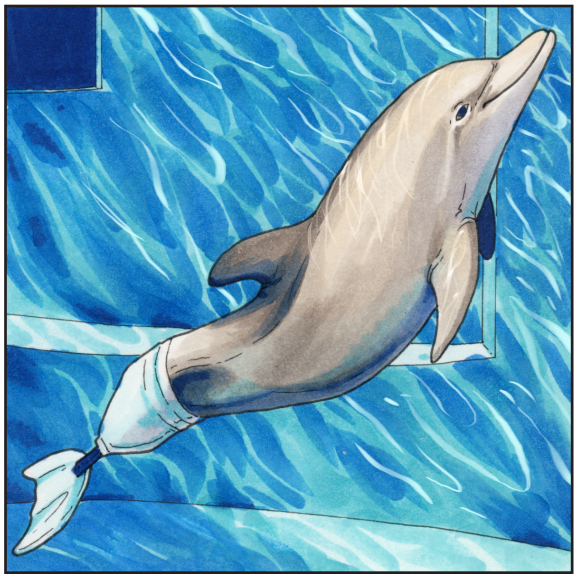
Winter's Prosthetic Tail

Activity 3



In 2005, a stranded dolphin was found in Mosquito Lagoon, near Cape Canaveral, Florida, with a serious medical problem. Her body had become caught in the rope of a fisherman's crab trap, which cut off circulation to her tail. Medical experts from a local aquarium did everything they could to save the fin, but the damage was too great and Winter lost her tail.

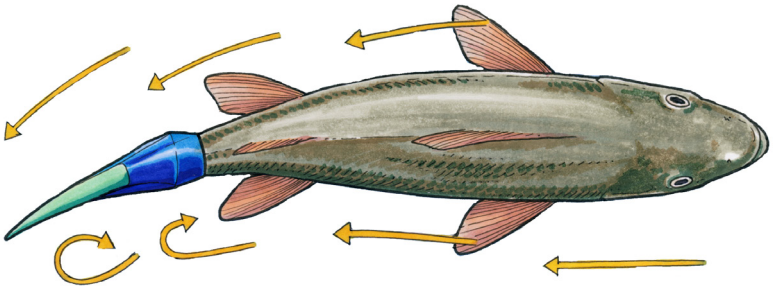
Engineers and veterinarians worked together to design a prosthetic tail that could help restore Winter's ability to swim naturally. They started by developing a plastic sleeve that would stay attached to her body as she moved through the water. It was important that the sleeve was comfortable for Winter because dolphins have very sensitive skin that can be easily damaged. They then created a new tail fin that was the same size and shape as the one she had lost. They made sure to use waterproof materials so the design could be used in the water. Finally, they designed a method of attaching and detaching the prosthetic device so Winter does not have to wait long when the device is attached and removed.



The new tail was a success and Winter soon learned to use the device to swim around her new home at the aquarium. Her story has become an inspiration for many humans who use prosthetic devices and a film called *Dolphin Tale* was released in 2011 that was inspired by many of the events of her story.

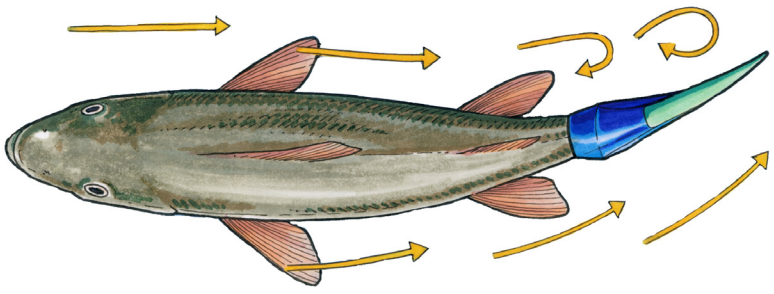
Article adapted from: Clearwater Marine Aquarium, *Winter: The Dolphin That Could*

Criteria and Constraints



GOAL: Engineer a prosthetic tail for a model fish.

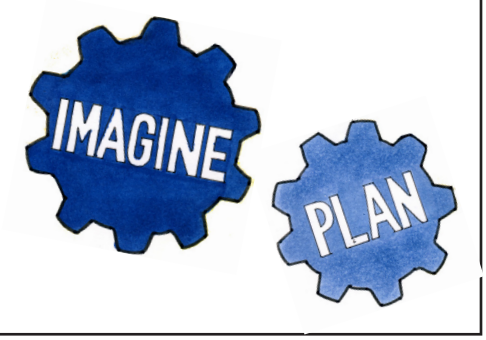
CRITERIA	CONSTRAINTS
• The model prosthetic tail must remain attached to the model fish while in use. • The model prosthetic tail must be comfortable to wear and not leave indentations in the play dough. • The model prosthetic tail must be waterproof. • The model prosthetic tail must be durable enough to be attached and removed at least two times. • The model prosthetic tail must be able to be attached and removed in 10 seconds or less.	• No tape may be used on the model prosthetic tail.



Imagine and Plan

Activity 3

Make a *plan* for the prosthetic tail, labeling the materials you will use.



Activity 3

Test Results

Test the model prosthetic tail on the model fish and record results below.

Comfort

Does the model prosthetic tail leave any indentations in the play dough?

☐ Yes ☐ No

Attachment

How long does it take to attach and remove the model prosthetic tail?

☐ Less than 10 seconds ☐ More than 10 seconds

Durability

Can the model prosthetic tail be attached and removed at least two times?

☐ Yes ☐ No

Function

Does the model prosthetic tail stay on while the model fish is moving through the water?

☐ Yes ☐ No

Can the materials be used in the water?

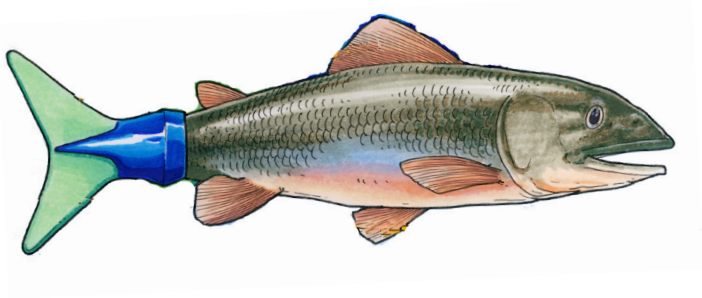
☐ Yes ☐ No

What parts of your design are working well? What improvements do you want to try next time?

Advice Exchange

Activity 4

Engineers often work in teams. Being able to *communicate* what is working well and what needs improvement in your design is an important part of the Engineering Design Process. Share your design with another group and write down or draw any ideas that they offer.



Activity 4

Additional Test Results

Test the model prosthetic tail on the model fish and record results below.

Comfort

Does the model prosthetic tail leave any indentations in the play dough?

☐ Yes ☐ No

Attachment

How long does it take to attach and remove the model prosthetic tail?

☐ Less than 10 seconds ☐ More than 10 seconds

Durability

Can the model prosthetic tail be attached and removed at least two times?

☐ Yes ☐ No

Function

Does the model prosthetic tail stay on while the model fish is moving through the water?

☐ Yes ☐ No

Can the materials be used in the water?

☐ Yes ☐ No

What parts of your design are working well? What improvements would you make if you had more time?

Create Your Own Fish

Activity 5

Create your own species of fish. What characteristics make this fish unique?

Species name:

Appearance: color, size, etc.

Habitat:

Diet:

Other (predators, behavior, etc.):

Activity 6

Communicate

During the showcase, you will get to share information about your engineering challenge with people who are not familiar with the problem. What are some things you might want to tell them about engineering prosthetic tails?

My Engineering Profile

Activity 6

Think about yourself as an engineer.

✓ Check off your engineering strengths.
◯ Circle any engineering skills you would like to practice getting better at throughout the rest of this engineering unit.

- ☐ *communicating*
- ☐ building things
- ☐ *imagining*
- ☐ being creative
- ☐ drawing
- ☐ working on a team
- ☐ leading a team
- ☐ analyzing data
- ☐ making a *plan*
- ☐ offering critical feedback on others work
- ☐ receiving feedback on your own work
- ☐ moving forward after something does not work
- ☐ thinking of different ways to do something
- ☐ solving problems
- ☐ troubleshooting problems

Compare your list above to the list you made during the first activity. What engineering skill do you think you have *improved* upon the most?

What would you like to engineer next?


IDENTIFY
INVESTIGATE
IMAGINE
PLAN
CREATE
TEST
IMPROVE
COMMUNICATE

Understand the engineering problem

- Define the problem in your own words

Gather details

- Learn about what others have done
- Explore possible materials or processes you could use for your design
- Conduct science experiments to gather data

Come up with different ways to solve the problem

- Use your creativity to think of lots of ideas that could work
- Evaluate the pros and cons of each idea
- Pick one idea that is a good starting point

Figure out the details of your design

- Discuss how it will work
- Draw diagrams and list materials
- Decide how you will test and evaluate

Build your design

- Follow your plan
- Fix small problems
- Record any changes to your plan

Evaluate how well your design works

- Test multiple times
- Record your observations and findings
- Figure out which parts are working well and which parts are not

Make changes to your design based on testing

- Decide what to change
- Put your changes into a new plan
- Build your improved design and test again

Share your solution with others

- Explain strengths and weaknesses of your solution
- Share how you used the Engineering Design Process
- Ask people for feedback


lines for streamlining and shock absorption
frontal view
lateral view
padding
center of
ventilation holes
28° from top to
Wind Power Turbine
Gear box
Rotor blade
Nacelle
Hub
Brake
GERULON MICROFIBER