Grasping with Straws: Make a Robot Hand Using Drinking Straws

Kit Contents

QTY	ITEM DESCRIPTION
20	Drinking straws
42	Rubber washers
1	Upholstery thread
3	Polymer clay
1	Sewing needle
1	Glue, 4 oz
1	Cardboard cutting surface
3	Nitrile gloves, pair
3	Rubber bands
1	Ping pong ball
1	Lab notebook

You will also need from home:

- Craft knife
- Fine-tipped permanent marker
- Scissors

Summary

Prerequisites	None
Safety	Adult supervision is suggested for parts of this project. Use caution with sharp knives and glue.

Abstract

Imagine how cool it would be to build a robot hand that could grasp a ball or pick up a toy. In this robotics engineering project, you will learn how to use drinking straws, sewing thread, and a little glue to make a remarkably lifelike and useful robot hand. What will you design your robot hand to do? Pick up a can? Move around a ping pong ball? It is up to you! With these starting instructions, you can design any type of hand. You will simulate human finger anatomy as the basis for a fully functional robot hand that is easy to build and does not require complicated tools.

Objective

To build a working hand/gripper out of common, inexpensive materials that demonstrates how a real robot hand/gripper might work.

Introduction

Your hands are amazing. With them you can play the violin, cook a meal with your parents, or design a robot. When people design robots, one of the parts they spend the most time on is the hand, or whatever other "grabber" the robot might have. Robots do useful and important work, and unless they can grab and move things, they cannot get the job done.

Watch this video to see how a three-fingered robot hand handles a wide range of objects.

In this project you will study the physiology of the hand to see how human fingers work and design a robot hand that uses human-like fingers to perform a task. Best of all, you are going to make your robot hand from everyday drinking straws. By simply applying some creativity and your engineering knowhow, you can make a useful robot hand.

The straw-hand design shown in this project mimics the way that **tendons** bend your fingers even though the **muscles** that control the action are actually in your forearm. To make your finger bend, a muscle pulls on a long string of **collagen** called a tendon. The tendon connects the muscle to the bone in your finger. It is kind of like remote control: When the muscle pulls, the finger bends at the **joint**. You will use a drinking straw as both bone and skin, sewing thread as a tendon, and you will provide the muscle. When you have finished this engineering project, you will have made a working robot hand, with multiple fingers that you control just by pulling threads. (See Figure 10 below for an example.)

Terms and Concepts

- Tendons
- Muscles
- Collagen
- Joints
- Physiology of the hand
- Shim

Questions

- How does a human finger bend?
- How are fingers arranged and connected in a human hand?
- Give examples of tools that are used for picking up and/or grabbing things. How many finger-like projections do they have?
- Give examples of different animal hands and/or feet. What do those animals do with their hands and feet?
- Based on the tool and animal examples, how might you design a hand for grabbing a ball? How about for holding a fork?

Bibliography

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Experimental Procedure

Note: This engineering project is best described by the **engineering design process,** as opposed to the **scientific method.** You might want to ask your teacher whether it's acceptable to follow the engineering design process for your project before you begin. You can learn more about the engineering design process in the Science Buddies Engineering Design Process Guide (http://www.sciencebuddies.org/engineering-design-process/engineering-design-process-steps.shtml).

These instructions will help you build a robot finger from an everyday drinking straw. They will also provide some ideas on how to hook several straw fingers together to make a hand. As the robotics engineer, you will need to figure out what you want your hand to do and play around with the design to make the best hand possible for that job.

Each finger in your robot hand will be made up of a drinking straw with one or more notches cut in it to make joints. Upholstery thread or dental floss will be threaded through the finger and knotted at the joint(s) then attached to a ring. Tugging on the ring will pull on the thread and cause the straw to bend at the joint(s). This is how the finger will flex.

Note: In the photographs for this project you will see several different colors and types of straws from our testing. Any color straw will work as long as it is wide enough, and flexes well without breaking. See the Materials section for more details.

Deciding How to Cut Straw Joints

Before making your final design, you need to find the best way to cut joints in the drinking straw. How big should the notch be? How close should you come to cutting all the way through the straw? Use one of your straws to find out. If you have straws from different sources, try a few notches in all the different types of straws to see which straws work the best.

Note: The *Science Buddies Kit* comes with a single type of straw with the right flexibility. It also includes scissors that work well for cutting notches. No other cutting implements are included but you should feel free to look around your house and see if you find a better tool for making the joint notches. With the *Science Buddies Kit* you will still want to try notches of different sizes to see what works best.

1. To protect your work surface, place a piece of cardboard on the table (or ask an adult if you can borrow a cutting board from the kitchen).
2. With the help of a parent, use the X-ACTO® knife, scissors or punch to cut several notches of different shapes and sizes. Each notch should be at least 2 centimeters (cm) apart. For safety's sake, always place the straw down on your cutting surface and point the knife blade away from you (as shown in Figure 2).
   a. Put your finger on the back of the straw and bend it as shown in Figure 3. Is it easy to bend? Does it spring back nicely or does it stay bent after you let go?
   b. Try making the cut less deep and leave more straw. Does this make it easier or harder to bend? Is it more or less springy?
   c. You can also try using a scrapbooking punch on half of the straw to punch out a section (as shown in Figure 4) rather than using the knife or scissors.
   d. Keep track of your observations in a table, like Table 1 below, in your lab notebook.

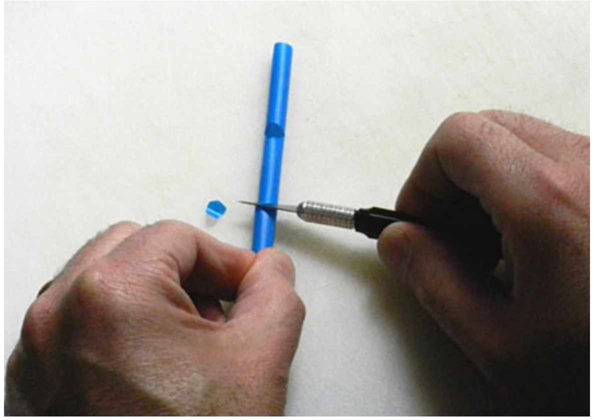


Figure 2. When cutting notches in the straw with a craft knife, always cut away from you for safety.

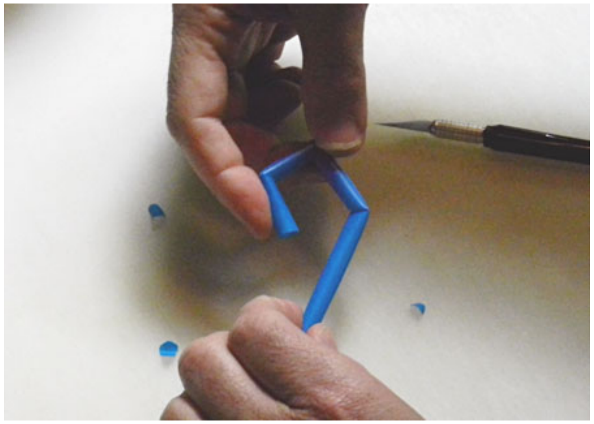


Figure 3. Press the cut straw into a curve to see whether the notches you cut make good joints.

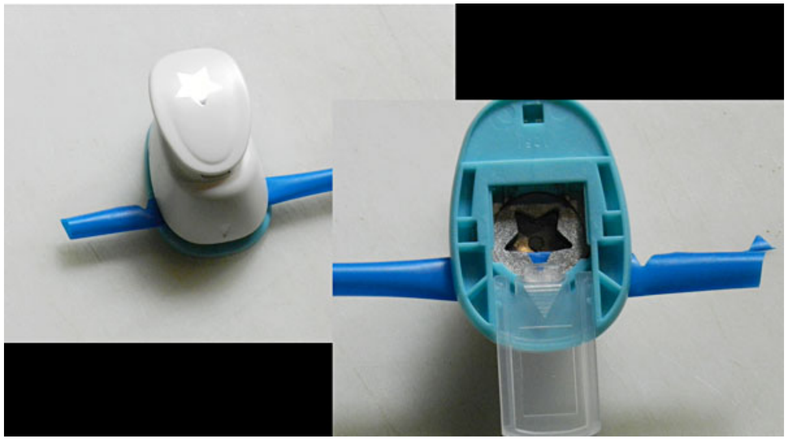


Figure 4. As a safer alternative to using a craft knife, squeeze the straw into the scrapbooking punch about halfway and punch out a notch. One point of a star-shaped punch does a great job.

Brand of Straw (if using more than one)	Tool Used to Make Notch	Notch Depth (shallow/medium/deep)	Does It Spring Back When Bent? (Yes/No)	Other Notes:

Table 1. Make a table like this one to keep track of how different notching techniques work. In the end, choose the brand of straw, tool, and notch depth that is easiest to work with *and* results in a notch that quickly springs back when bent.

3. Look at the data you have collected. Choose the straw type and notching technique that make the joint nice and springy but not too hard to bend.

Planning the Robot Hand

1. Before building the robot hand you must decide *what* it needs to be able to do. The Science Buddies Engineering Design Process guide has a page on how to Specify Requirements (http://www.sciencebuddies.org/engineering-design-process/engineering-design-requirements.shtml) that can help you think about how to do this. A few questions you might want to ask yourself :
    a. What will my robot hand do? Does it pick up items? What are some of the items it can grab?
        i. Suggestions: empty soda cans, paper cups, ping pong balls, paper towel cores.
        ii. Note: The straws are not strong enough to support heavy items.
    b. What special features should my robot hand have? Look at *your own* hand and think about how you grab things. If you could have as many or as few fingers as you needed, what is the very best way to grab these items?
    c. Can I arrange the fingers on my robot hand to make it better at picking things up?
2. Once you have answered the questions, sketch what your robot hand will look like.
3. Decide how you will test your hand.
    a. Do you want to attach it to an arm of some kind to make the testing easier?
    b. What item(s) will you have it pick up?
    c. How many tries will the robot hand get with each item?

Preparing the Straws

1. Here is a tip we found when testing this project. In order for the fingers to bend nice and straight, it is helpful to make sure there is a straight line running down the length of the straw. Cut the notches centered on this line. If the brand of straw you chose already has a straight line or lines as part of its design, skip this section and go on to Making the First Finger. Otherwise, mark each straw with a straight line.
2. Find a straightedge at least as long as the straw that is half as high as the straw is wide. For example, if you found straws 8 mm in diameter, your straight edge should be 4 mm thick. Your ruler may have a nice metal edge. If you place it flat on the table, is the edge 4 mm off the surface? You may be able to cut a thin piece of cardboard (a **shim**) to raise that metal edge up until it is 4 mm from the table.
3. Place the ruler and the cardboard shim on the table. Have a friend help you hold it firmly to the table or tape it down. You don't want it to move during this step.
4. Place one of your straws up against the edge of the ruler. Use your fine-tip marker and run a line down the length of the straw as shown in Figure 5. Hold the straw up to your eye like a telescope and look down the length. The line should be straight. Repeat this step with your remaining straws.

Figure 5. Marking a straight line down the length of the straw helps keep the joints lined up so the finger bends more naturally.

Making the First Finger

1. How did you draw up your plan? Did you make a sketch of how the robot hand will look? You should include that sketch in your final presentation. However you planned your final robot hand, it is time to make the first working drinking-straw finger.
2. From your experiment earlier, you have an idea of how much material to cut out of the straw for each joint. Look at your index finger. It has three sections. Whether your final design has a finger like this or not, use one of your straws to try making a finger that bends like yours. Hold the straw up next to your finger. With the other hand (you can also have a friend help you), mark the straw where the joints should go (generally about 2 cm apart). Somewhere in the middle of your hand, mark the straw so you know where to cut it to length.
3. Keep the straw at its full length for now. Starting at the finger tip, measure from the end and make a mark where the first joint will go. You will be cutting out the section from the side where you drew the line earlier. Make your mark on that side. Continue from there, measuring and marking the joints.
4. Place the straw flat on the surface with the line facing up. Make the cuts for each notch according to the technique you developed earlier. (See Figure 6 for an example.) When you have finished, try bending all of the joints at the same time. The straw should gently form a nice curve if you lined up all of the cuts along the straight line you drew.

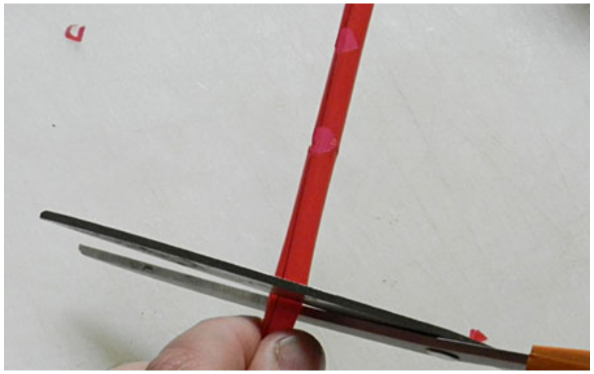


Figure 6. Cut each joint in the finger before cutting the finger to the length you need for your design. Make sure to leave the straw long enough to attach to the 'palm' or main structure of your robot hand

5. Cut the straw to length with your scissors. The length will depend on your design. Make sure to leave the straw long enough to attach to the 'palm' or main structure of your robot hand.
6. Cut a piece of thread at least four times the length of the finger. Close to one end, tie a nice fat knot. A figure eight knot (http://en.wikipedia.org/w/index.php?title=Figure-eight_knot_%28ropes%29&oldid=489913003) is a good knot for the job. Thread the other end through the needle.
7. Stick the needle (carefully!) through the straw just above one of the joints (as shown in Figure 7a). Using the needle-nose pliers, pass the needle down the length of the straw until it comes out of the opposite end of the straw. Repeat steps 6 and 7 with threads on the other joints (as shown in Figure 7b).

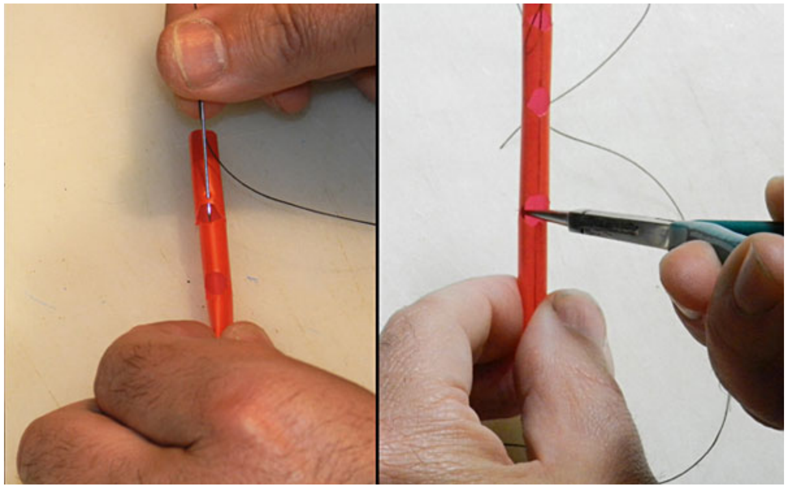


Figure 7 (7a, left; 7b, right). Push the needle carefully into the straw just above the joint (7a). Work it through with the needle-nose pliers and pass it down the length of the straw (7b).

8. Cut the threads from the joints so they are all the same length, at least a few inches from the end of the straw. Tie one of your rings to each thread (see the example in Figure 8).

Figure 8. A finger with three joints and one tendon for each joint. Pulling a ring makes the joint it is attached to bend.

9. With one hand, hold the straw upright, and place fingers from the other hand through the rings. Gently pull the rings one at a time and see what happens. Can you bend each of the joints independently? Look at your index finger again and see if you can bend each of the joints independently. Is your straw finger different than your real one? Is it the same?
10. Can you bend the joint closest to the fingertip without bending the others? Can you guess why? Can you bend your real finger that way? Because of the way the tendons in a real finger work, it is almost impossible to bend just the one joint.

Assembling the Robot Hand

1. Now that you have made one finger that is a lot like a human finger, it is time to make your complete robot hand. Using your design sketches and the techniques you just practiced, make several fingers. Cut as many straws as you need into as many fingers as your plan calls for. You can use thread tendons on each joint if you like. Or to make the hand simpler to control, you may decide to simply use one tendon per finger. If you do that, connect it to the joint closest to the fingertip.
2. Think about how your own hand has the fingers attached around the palm of your hand. Your robot hand needs some structure to join the fingers as well. Attach all of the fingers together in some way so that they look like the robot hand you designed. You can glue them to cardboard or wood, or mold some polymer clay around the straws. If you decide to use the clay, form the clay around the straws and then remove the straws, as shown in Figure 9. Have an adult help you bake the clay in the oven according to the manufacturer's directions. When the clay has cooled, reinsert the straws.

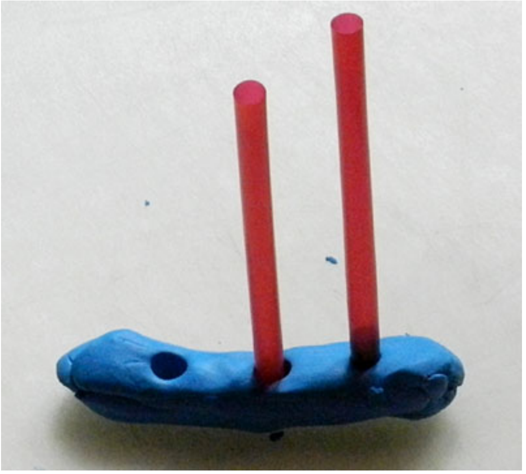


Figure 9. Mold the polymer clay around the straws first, then remove the straws and bake the clay according to directions. The small strip shown here could be part of a larger 'palm'.

Our test robot hand was made by gluing the straw fingers to a piece of wood. It is shown below in Figure 10, but yours will look different.

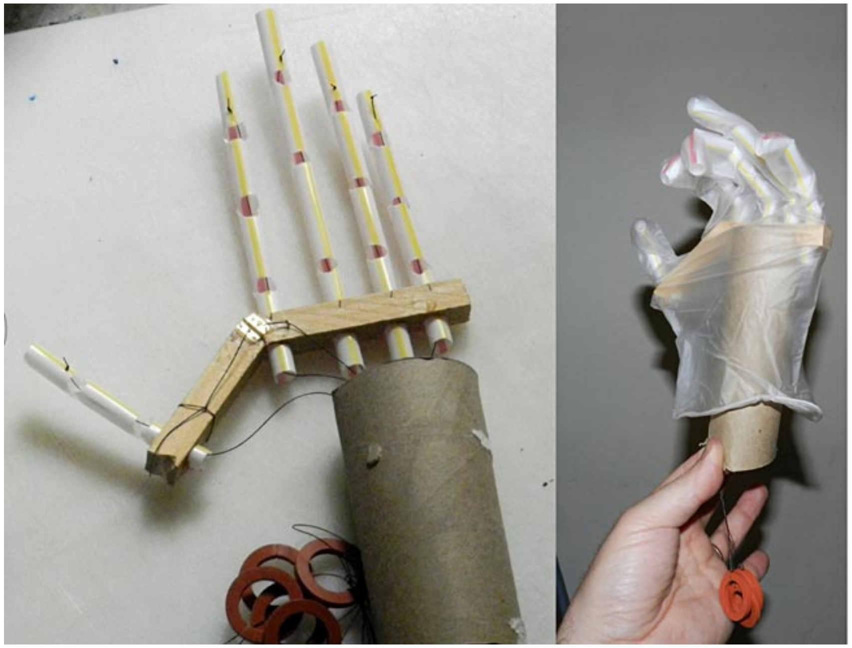


Figure 10. The hand we made at Science Buddies to test this project. The thumb is jointed separately and has a rubber band in the back to provide the return spring. Since our hand is shaped somewhat like a human hand, it fits inside a medical glove which makes the fingers a little less slippery. You could use something like this if you find the hand needs a little more grip. Besides gloves (or just the glove fingers) for extra grip, you can also use skinny balloons of the kind used to twist balloon animals.

Testing Your Design

Part of engineering is testing your creation to see if it works as well as you want it to.

1. Hold the robot hand steady on a support or have a friend help you. Place your fingers in the rings and pull the tendons. Do the fingers curl correctly? Does it look like it closes and grabs the way you planned it?
2. See if your robot hand will pick up the object or grab the item or do whatever you designed it to do. If it does, congratulations! Can it do a better job? What could you do to improve it (http://www.sciencebuddies.org/engineering-design-process/testing-redesign.shtml)? If it can't pick up or grab the object, why not? This is your chance to figure what went wrong and make changes, or just make it better. Are the fingers too long? Too short? Do they bend in the right place? Try some experiments to figure it out then go back and remake the parts.
3. Use your robot hand to pat yourself on the back - you did it!

Variations

- Does your robot hand need more reach? Perhaps you can design an arm out of wood or cardboard tubes to reach farther. If your arm needs to bend, hinges from the hardware store for joints and some extra thread for tendons could be a great start.
- What other materials can you think of to make a robot hand from?
- Engineering is often inspired by nature. What else can you see around you that you can build from simple materials?

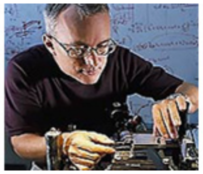
Related Links

- Science Fair Project Guide (http://www.sciencebuddies.org/science-fair-projects/project_guide_index.shtml)
- Other Ideas Like This (http://www.sciencebuddies.org/science-fair-projects/search.shtml?v=solt&pi=Robotics_p001)
- Robotics Project Ideas (http://www.sciencebuddies.org/science-fair-projects/recommender_interest_area.php?ia=Robotics)
- My Favorites (http://www.sciencebuddies.org/science-fair-projects/recommender_show_favorites.php)

If you like this project, you might enjoy exploring these related careers:

Robotics Engineer

Have you watched "The Transformers" cartoon series or seen the "Transformers" movies? Both shows are about how good and evil robots fight each other and the humans who get in the middle. Many TV shows and movies show robots and humans interacting with each other. While this is, at present, fantasy, in real life robots play a helpful role. Robots do jobs that can be dangerous for humans. For example, some robots defuse landmines in war-stricken countries; others work in harsh environments like the bottom of the ocean and on the planet Mars. At the heart of every robot is a robotics engineer who thinks about what a robot needs to do and works with several engineering disciplines to design and put together the perfect piece of equipment. Read more (http://www.sciencebuddies.org/science-fair-projects/science-engineering-careers/ApMech_roboticsengineer_c001.shtml)



Mechanical Engineer

Mechanical engineers are part of your everyday life, designing the spoon you used to eat your breakfast, your breakfast's packaging, the flip-top cap on your toothpaste tube, the zipper on your jacket, the car, bike, or bus you took to school, the chair you sat in, the door handle you grasped and the hinges it opened on, and the ballpoint pen you used to take your test. Virtually every object that you see around you has passed through the hands of a mechanical engineer. Consequently, their skills are in demand to design millions of different products in almost every type of industry. Read more (http://www.sciencebuddies.org/science-fair-projects/science-engineering-careers/ApMech_mechanicalengineer_c001.shtml)

Robotics Technician

Robots are no longer futuristic machines. Robots are here and now and are used in manufacturing, health care, service industries, and military applications. They perform tasks that are repetitive and hazardous—things that humans don't want to do or are unsafe to do. But robots are still machines, which means they require humans to build, maintain, program, and keep them functioning efficiently. Robotics technicians work with robotics engineers to build and test robots. They are responsible for installing and maintaining robots and keeping them in working order for their employers. If you are interested in working with robots, your future is here and now. Read more (http://www.sciencebuddies.org/science-fair-projects/science-engineering-careers/ApMech_roboticstechnician_c001.shtml)

Biomedical Engineer

Shakespeare described humans as a "piece of work," and others have called the body "the most beautiful machine," but like any machine, sometimes body parts need repairs or servicing when the body cannot take care of the problems itself. That's where biomedical engineers come in. They use engineering to solve problems in medicine, such as creating replacement body parts, drug-delivery systems, medical instruments, and test equipment. Their work helps restore health and function, and improves the quality of life for people who are sick or injured. Read more (http://www.sciencebuddies.org/science-fair-projects/science-engineering-careers/HumBio_biomedicalengineer_c001.shtml)

Credits

Howard Eglowstein, Science Buddies

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If you have purchased a kit for this project from Science Buddies, we are pleased to answer any question not addressed by the FAQs on our site. Please email us at help@sciencebuddies.org (mailto:help@sciencebuddies.org?subject=Grasping%20with%20Straws:%20Make%20a%20Robot%20Hand%20Using%20Drinking%20Straws) after you have checked the Frequently Asked Questions for this PI at http://www.sciencebuddies.org/science-fair-projects/project_ideas/Robotics_p001.shtml#help

In your email, please follow these instructions:

1. What is your Science Buddies kit order number?
2. Please describe how you need help as thoroughly as possible:

   Examples

   Good Question *I'm trying to do Experimental Procedure step #5, "Scrape the insulation from the wire. . ." How do I know when I've scraped enough?*
   Good Question *I'm at Experimental Procedure step #7, "Move the magnet back and forth . . ." and the LED is not lighting up.*
   Bad Question *I don't understand the instructions. Help!*