

Robotics Badges: *Programming Robots 1*

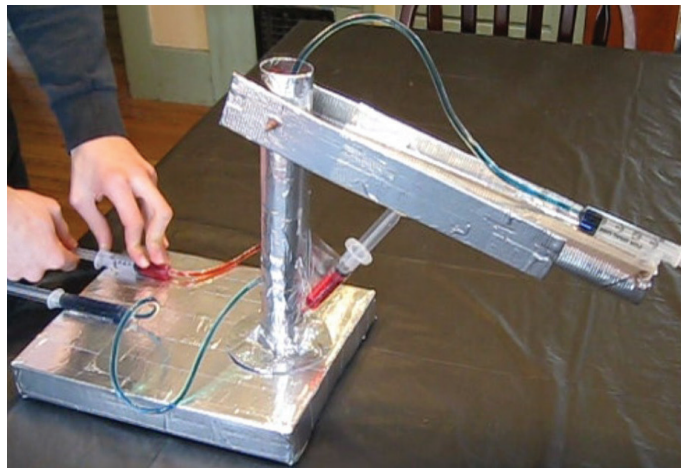
Instructions to Build a Hydraulic Arm

THINGS TO KNOW:

Some robots consist of only an arm! Robot arms are used in automobile plants and other industrial settings to move heavy objects like car bodies. Surgeons use robotic arms like the DaVinci to do delicate operations. And on the International Space Station, astronauts can stay inside and use the Canadarm (built by the Canadian Space Agency) to do work outside the spacecraft.

Hydraulic robot arms can lift a lot of weight. In a hydraulic system, liquid under high pressure is pushed back and forth. When you push in a controller on one side, a piston on the other side is pushed out. When you pull the controller out, the piston moves back in. (*figure a.*)

On a robot, the number of directions a part can move are called its “degrees of freedom.” This model robot arm can move up and down, and it has a “finger” that can move in and out, so it has two degrees of freedom. As you work, think about how you could add more degrees of freedom. (See the suggested extensions at the end of the instructions.)



Materials

- Medium-sized corrugated or other sturdy cardboard box
- Extra cardboard (you can cut the top off the box to use as scrap)
- 2 paper towel tubes (or fold scrap cardboard into square tubes)
- Sharpened pencil stub (approximately 3 ½ inches)
- 4 10-milliliter (mL) oral syringes with rubber rings (sometimes available free at pharmacy counters, or buy in bulk online)
- two 2-foot-long pieces of ¼ inch wide clear vinyl tubing (available in hardware stores)
- Rulers
- Scissors
- Duct tape
- Clear packing tape
- Foam tape squares
- Water
- Liquid food coloring, at least 2 different colors
- **Optional:** hot glue

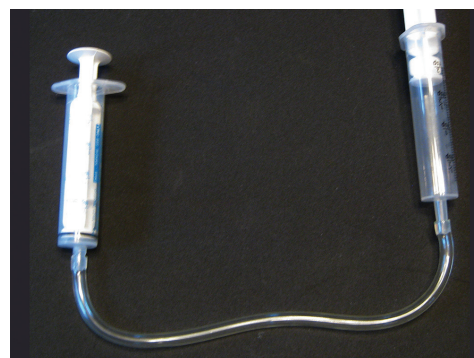


figure a.

(continued)

Steps

1. Start with the cardboard tube that will serve as a tower to hold the arm. You will poke some holes into it so you can thread the rubber tubing through it. Here's how:
 - About 2 inches from the bottom, use the pencil to poke a hole straight through both sides of the cardboard tube from front to back. Remove the pencil.
 - About 1 inch higher than the bottom holes, poke another hole, but don't go through the other side.
 - The last set of holes you're going to make will be perpendicular to the others. This will be for the hinge. Turn the tube so the original holes you made are on the sides (at 3 o'clock and 9 o'clock if you look straight down at it). About 2 inches below the top of the tube, poke a hole straight through both sides from front to back. (*figure b.*)
2. Take a piece of tubing and thread it straight through the bottom set of holes so some tubing is sticking out both ends. Cut a second piece 2 to 3 feet long. Thread it into the single hole near the bottom and out through the top. (*figure c.*)
3. Use duct tape or hot glue or tape to attach the tower to the base, near the edge. This will be the front of the base. The two ends of the vinyl tubing coming out of the holes at the bottom of the cardboard tube should be facing the back of the base. (See photo of finished robot arm for placement on base.)
4. Take the extra cardboard and cut two long rectangular strips, about as wide and long as a paper towel tube. These will be the supports for the arm. (*figure d.*)
5. Next, you will use the pencil to attach the arm to the tower. Hold the end of the first flat strip against one of the holes at the top of the tower so it sticks out straight (horizontally). At a spot at least an inch from the end of the flat strip, poke a pencil through the strip and into the hole. Keep pushing the pencil through the tower and out the other side. Hold the second strip against the other hole and push the pencil through it, too. Leave the pencil in place. Test that the arm can swing up and down. (*figure e.*)



figure b.



figure c.



figure d.



figure e.

(continued)

6. Place the second paper towel tube between the flat strips. Slide it down about 3 inches from the tower. This will give the arm clearance when it moves up and down. Secure the flat strips to the cardboard tube arm with duct tape or hot glue. (*figure f.*)
7. You're ready to finish off the hydraulic systems. (Check out the photo of the separate hydraulic system to see how they work.) Take the ends of the vinyl tubing coming out of the tower facing towards the box. Connect syringes to them. These are the control pumps. Stretch the tubing out until the top of the syringes sit over the back edge of the box, opposite the arm. Use clear tape or hot glue to attach the syringes to the box so you can see the plunger move in and out of the syringe. Make sure you can easily move the end of the plunger back and forth.
8. Take the end of the vinyl tubing that's coming out of the top of the cardboard tube tower. Attach a syringe. Position this syringe on top of the arm so that the plunger is hanging off the end. The plunger on this syringe will be used to pick up objects. Secure the syringe with clear packing tape or hot glue. (*figure g.*)
9. Attach a syringe to the end of the vinyl tubing that's coming out of the bottom of the tower facing the arm. This syringe will push and pull the arm from underneath. To position it correctly:
 - Gently pull the vinyl tubing back through the tower towards the control box until the tip of the syringe is resting against the tower.
 - Hold the syringe at an angle so it is tilted away from the tower and place the end of the plunger under the arm tube. Take a foam tape square and press it onto the arm at the spot where the plunger is touching it. This will help keep the plunger in the right spot while allowing it to slide when the arm moves. (*figure h.*)
 - If needed, you can keep the syringe in place by wrapping a strip of clear packing tape around the syringe and the tower.
10. Finally, it's time to fill the hydraulic systems with water. Be careful not to get the cardboard wet! Here's what to do:
 - Push the plungers on the syringes on the end of the arm and underneath the arm all the way in.

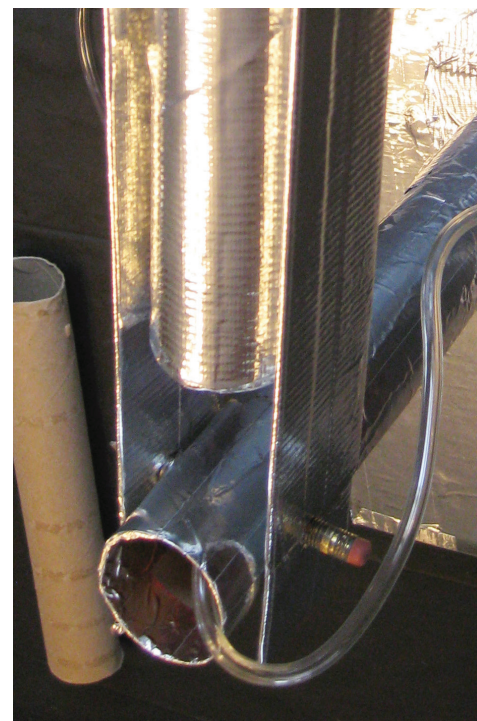


figure f.



figure g.



figure h.

(continued)

- Turn the entire contraption sideways so the plungers on the control pumps are facing up. Pull those plungers all the way out.
- Slowly and carefully, pour some water into the first open syringe. Add just a drop of food coloring. Put the plunger back in. Slowly and gently, push the plunger in. Be sure to stop before the plunger on the other end pops out! If there are air bubbles, remove the plunger from the top syringe and push the other syringe all the way. Add a little water and replace the plunger. Repeat if needed.
- Fill the other hydraulic system the same way, but make the water a different color. (*figure i.*)

11. To test out your robot arm, carefully push and pull the plungers on the control syringes. One should make the arm go up and down. The other should make the plunger on the end of the arm go in and out. To pick something up with the plunger, take some tape or a pipe cleaner and make a basket-style handle on a plastic cup.

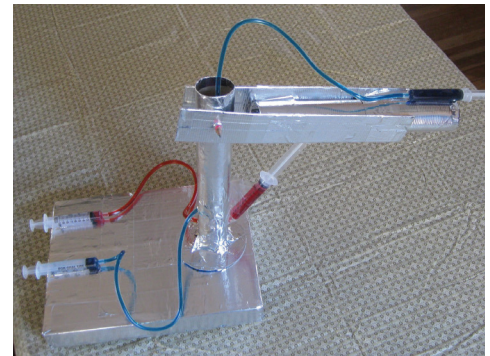


figure i.

Want More Challenge? Try this!

- Design a robot hand to go with the arm from a selection of parts such as drinking straws and string. Search online for instructions on how to build a robotic hand.
- Make an electric solenoid. A solenoid would be used on a real hydraulic robot to push the piston/plunger in and out. Search online for instructions on how to build the electric solenoid hand that uses materials like a drinking straw, wire, AAA battery, tape, and straight pin (like a hat pin, with a ball on the end).