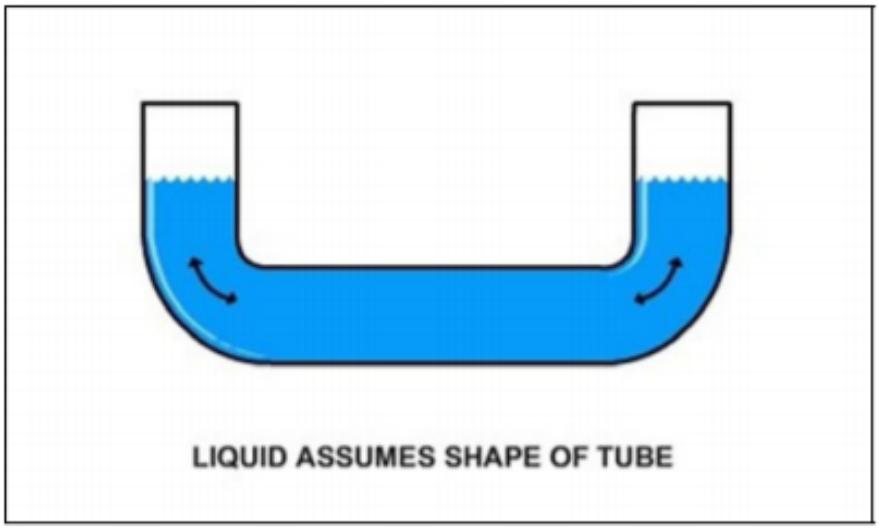
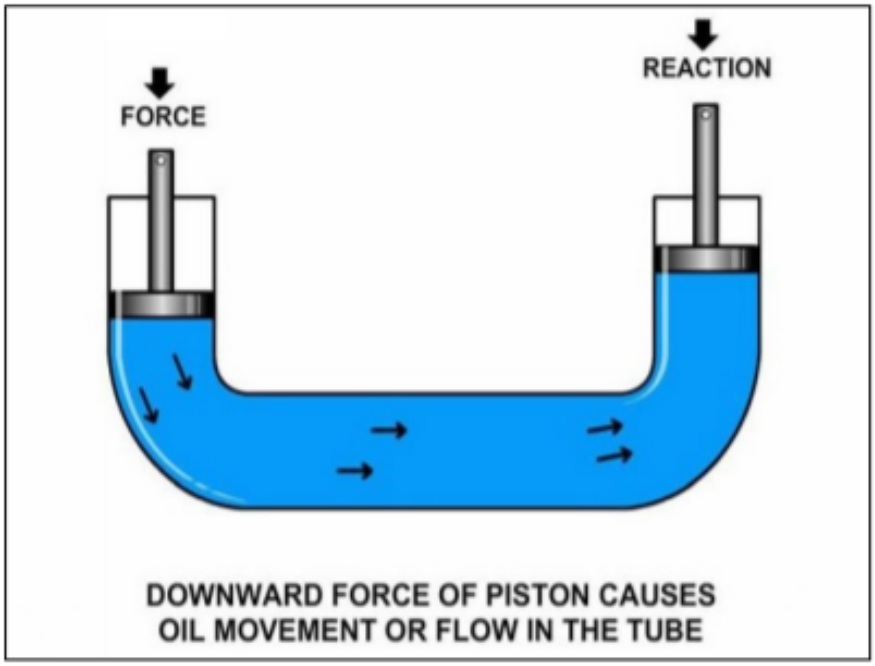
How Hydraulic Devices Work

Hydraulic systems use a liquid (usually oil) to transmit force. Force is applied to one point and is transmitted to a second point using an in-compressible fluid, or a fluid that cannot be compressed to a smaller volume.

Here's how they work:



Liquid is added to a container and takes the shape of whatever container it is in.



If force is applied to one side of the container, the water cannot be compressed, so the force is transmitted through the liquid. By applying a force to move the piston on one end, the piston on the other end will move the same distance with same amount of force.

This is also known as Pascal's Law. Pascal's Law says that pressure applied to the fluid will be transmitted throughout the entire container.

Hydraulics and Robotics

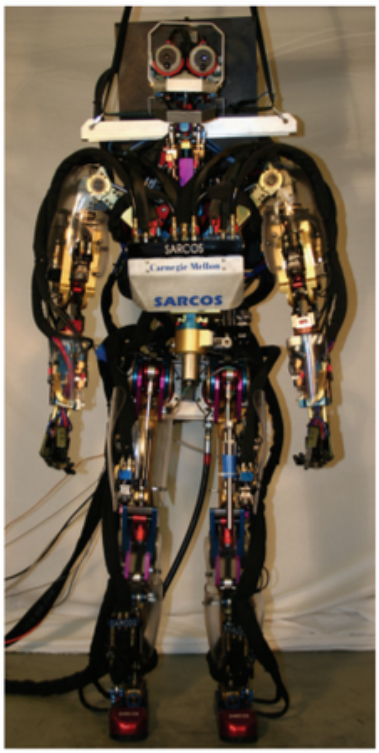
Take a look at these examples of robots that use hydraulics:

https://www.post-gazette.com/business/tech-news/2018/02/08/cmu-disney-lab-closes-collaborative-innovation-center-pittsburgh/stories/201802080159

This is a robot designed by Disney Research. It uses hydraulic joints to mimic human movement. It can be controlled by operators wearing a VR (virtual reality) headset!

https://yellrobot.com/beach-cleaning-robots-thailand/

Some robots use hydraulic power to move the tracks of the robot! Using tracks instead of wheels can make it easier for the robot to move across loose or rugged terrain, like sand. These robots can be useful in military situations, such as missions in Afghanistan or Iraq, where the terrain is mostly sand. These kinds of robots can also be used to clean up beaches!



https://www.researchgate.net/figure/Sarcos-Primus-System-and-simulator-11_fig1_224401296

This is a humanoid robot called the “Sarcos Primus System Humanoid Robot.” This robot has 51 separate joints! It was created to perform tasks for humans. For example, this robot can perform automated health care tasks, like filling prescriptions or handing out medication.

Optimizing Warehouse Flow

Large companies, such as Amazon, Target, and Walmart, receive millions of online orders. These orders must all be shipped within a certain time frame. To accommodate all of these orders, some large companies have devised a "flow" of products from one warehouse to another and from a warehouse to the customer.

Here's how it works:

- Many large companies have large "hub" warehouses. These warehouses are distribution centers where packages are loaded onto trucks and shipped to a new location (usually a fulfillment center).
- From the distribution center, the items arrive at a fulfillment center. This is the location where items are placed in packages to be sent to customers.
- At the fulfillment center, packages are assembled with the product(s) that were ordered online.
  - Warehouse workers must travel to each individual location where each item is stored and place that item in a box. For an online order with 5 or more products, this can take a long time!
- After the package is assembled, another warehouse worker must print a shipping label, seal the box, and place it in an "outgoing" mail bin.
- The packages in the "outgoing" mail bin are picked up by a delivery carrier, such as FedEx, USPS, or DHL.
- The delivery carrier delivers the package to the customer.

Although the flow of most warehouses is efficient to an extent, warehouse supervisors want to optimize this process. To optimize a process, one must first identify points of weakness in the current process. These points of weakness can be processes where errors occur often, processes that are slow or sluggish, and processes that are very expensive. Here are some examples of potential points of weakness in the warehouse item flow:

- Cost of paying workers: One warehouse could comfortably house a few hundred warehouse people, which is incredibly expensive. If the Atlanta, Georgia Amazon distribution center employs 250 warehouse workers for one shift, for 8 hours, at $12 an hour, that's $24,000 for one shift! Add on 2 more shifts (for 3 around-the-clock shifts), and that's $72,000 in one 24-hour period! If one considers all of the distribution centers, all the fulfillment centers, the delivery drivers... This is a ton of money!
- Cost of training workers: Companies have to train workers to do the job correctly and efficiently within a certain time period.
- Cost of employee turnover: There is a high level of turnover in warehouses. This means that people are not staying employed at the job for very long before they leave. This results in an increased number of hires and fires.
- Human error:
  - Printing the wrong shipping label for a package
  - Placing the wrong item in a customer's package
  - Not including all of a customer's order in their package (so the customer only receives 3 of their 5 items that they ordered)
- The process of employees hand-picking items for packages is not efficient.

After the potential points of weakness have been identified, a solution can be created to optimize the flow of product in a warehouse.

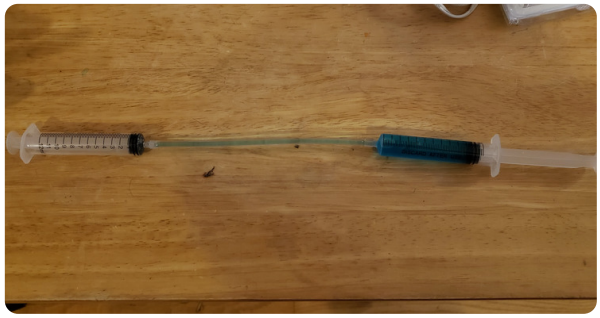
Creating a Warehouse Robot

Step One: Create the Basic Hydraulic Component

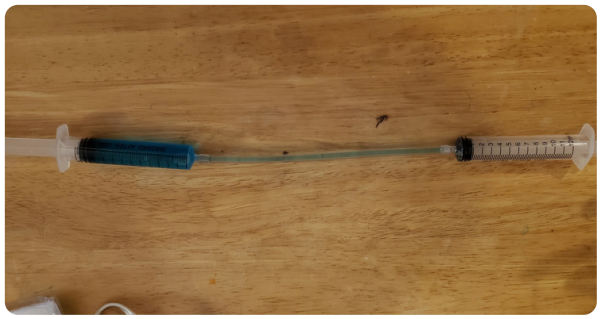
- Push one end of the piece of tubing over the end of the first syringe.

- Pull water into the syringe and tube. To do this, put the free end of the tubing into the container of water and pull the plunger on the syringe. To get rid of any bubbles, empty and refill the syringe several times.

- With the first syringe and the tubing full of water, push the free end of the tubing on to the second syringe.



- Test to see that your Hydraulic Syringe System works by depressing one syringe. This will push the water through the tubing into the other syringe, causing the plunger to move.



- Create 3 separate Hydraulic Syringe Systems, one for each component of your robot.

Building a Warehouse Robot

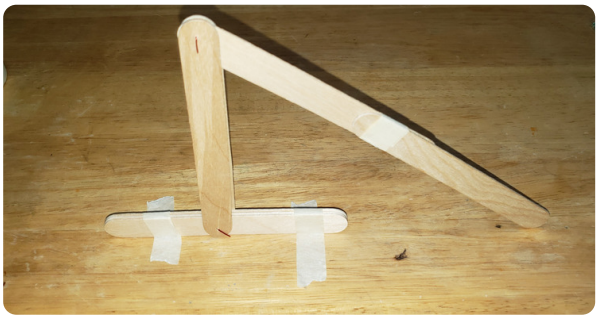
Step Two: Create Hydraulic Arms

- Drill holes in tongue depressors as follows:
  - Drill holes in the center of 3 tongue depressors
  - Drill a hole in both ends of 2 tongue depressors
  - Drill a hole in one end of 1 tongue depressor
  - Leave the last tongue depressor with no holes

- Take your 3 tongue depressors with a hole in the center and lay them on top of each other so the holes match up.
- Take 1 tongue depressor with holes at both ends and lay it perpendicular to the 3 already in place. Slide the new tongue depressor under the 3 that were already in place so the holes match up.
- Take second tongue depressor with holes at both ends and repeat the process, only this time, put it on top of the three original tongue depressors.
- Slide a 3/4“ piece of wire through all of these holes and bend the ends to hold in place.
- Add a piece of masking tape to each side to keep the structure from rotating.

- Use a 3/4“ piece of wire to attach the remaining tongue depressor with a hole at one end between the free ends of the two tongue depressors. You should be able to easily rotate this last tongue depressor. This is the lifting arm.

- Take your creation and use masking tape to stand it up, as shown in the picture.
- Extend the lifting arm by taping an additional tongue depressor to the lifting arm.

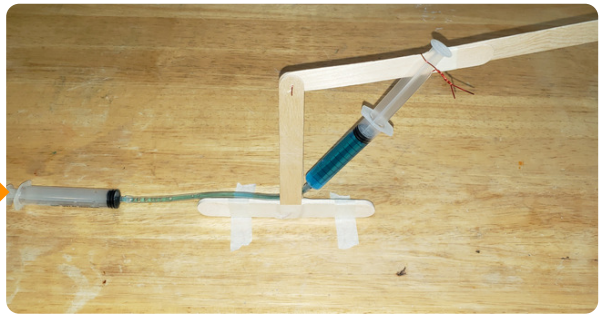


Building a Warehouse Robot

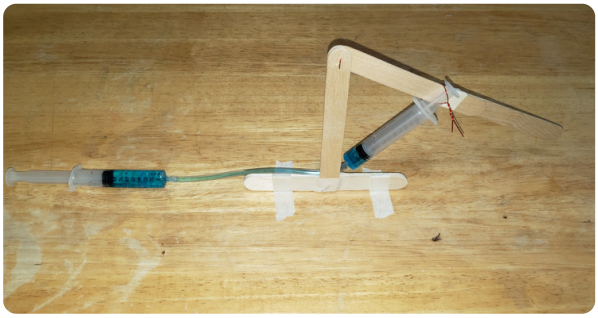
- Remove one syringe from the Hydraulic Lifting System, run the tube through the opening between the two tongue depressors and reattach the syringe.

- Attach the plunger of the syringe side of the structure to the lifting arm using the 4“ piece of wire. Twist the wire tight.
- The syringe that is not attached to the lifting arm is the control syringe.

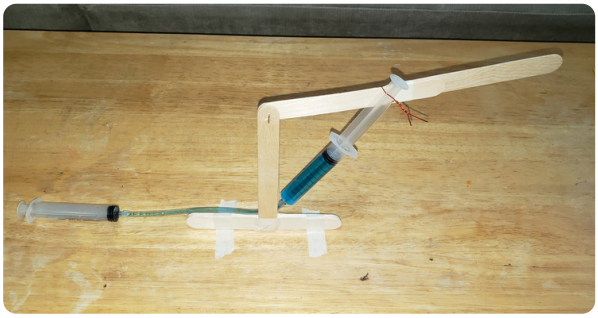
Control Syringe



- To lower your arm, pull the plunger of the control syringe so that the syringe attached to the arm empties and pulls the arm downward.



- To raise your arm, push in the plunger of the control syringe so that the syringe attached to the arm fills up and pushes the arm upward.



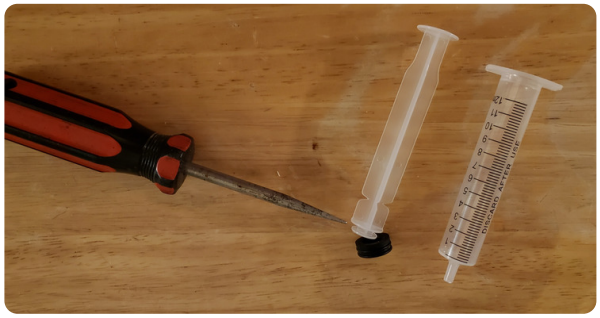
- Think of ways to change this component such as:
  - To shorten your arm, remove the tongue depressor at the end of the arm.
  - To lengthen your arm, add an additional tongue depressor at the end of the arm.
  - To strengthen your arm, use tongue depressors sandwiched together to replace individual tongue depressors.
  - To make your base more stable, attach the base permanently to a piece of wood or cardboard using glue.
- Repeat the steps above to create a second arm for your robot.

Building a Warehouse Robot

STEM CAREER ADVENTURES

Step Three: Create a Rotating Base for Your Robot

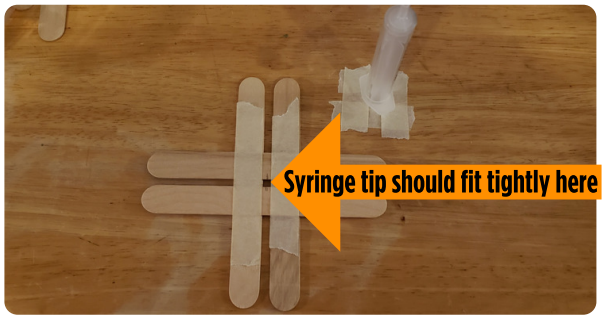
- Pull plunger out of extra syringe and pry off the piece of rubber on the end.



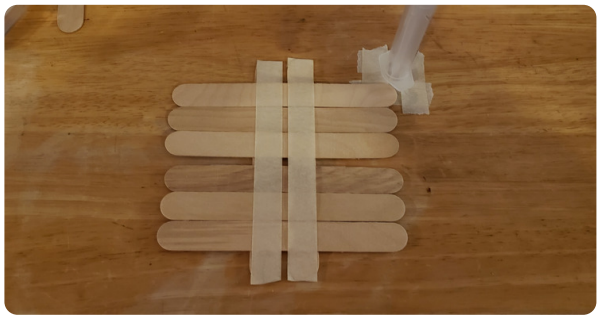
- Tape the end of the plunger that normally sticks out of the syringe to the table.

- Push the body of the syringe back on to the plunger. The body should now rotate freely about the plunger.

- Make a platform using 8 of the tongue depressors and masking tape, leaving a hole in the middle that fits tightly over the tip of the syringe.

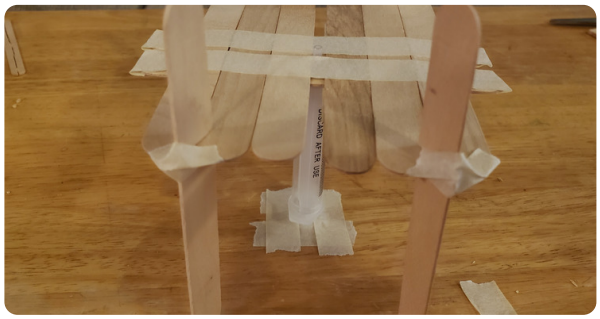


- Use 4 more tongue depressors to create a larger platform.
- Add 2 depressors to each side of the 2 already in place.
- Use masking tape to connect all of the tongue depressors.

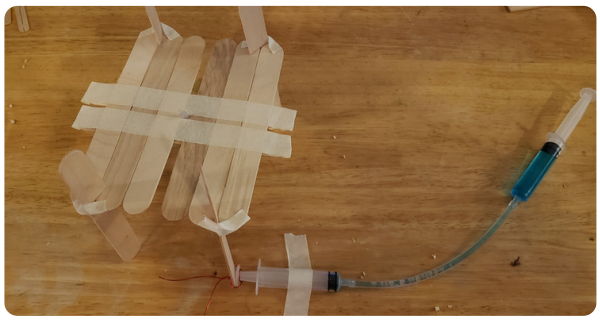


Building a Warehouse Robot

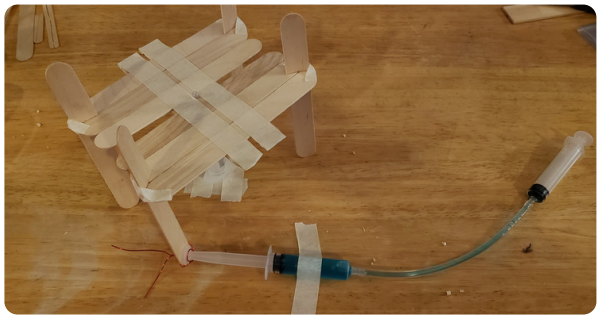
- Use the remaining 4 tongue depressors to make legs to keep the platform from wobbling. To do this, use a scissors to cut notches in the 4 tongue depressors.



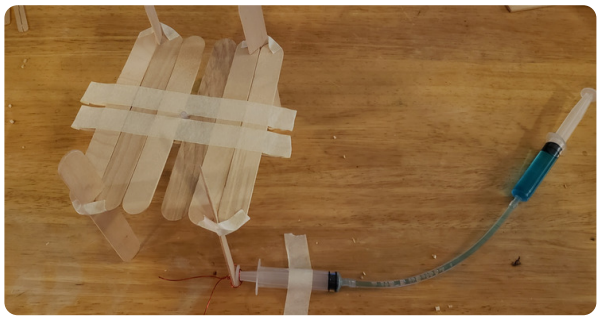
- Place the platform over the tip of the syringe. The platform should fit tightly over the tip of the syringe so that the body of the syringe and the platform move together. If necessary, use a piece of tape to keep the platform and the body of the syringe moving together.



- Place the Hyrdaulic Syringe System so that the plunger in the empty syringe touches one of the legs.
- Use a 4“ piece of 22 gauge wire to attach the end of the plunger to the leg that it is touching.
- Tape the empty syringe to the table.



- The syringe that is not touching the leg is the control syringe.
- To rotate the base in one direction, push in the plunger of the control syringe so that the syringe attached to the leg fills up and rotates the platform in one direction.



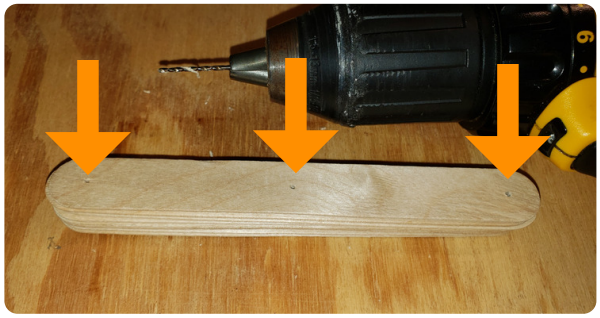
- To rotate the base in the opposite direction, pull the plunger of the control syringe so that the syringe attached to the leg empties and rotates the platform in the opposite direction.

- Think of ways to change this component such as:
  - To make it stronger and more stable, use glue to build the platform and attach the tongue depressors.
  - To make it taller, shorter, wider or thinner, build a different size platform or legs.

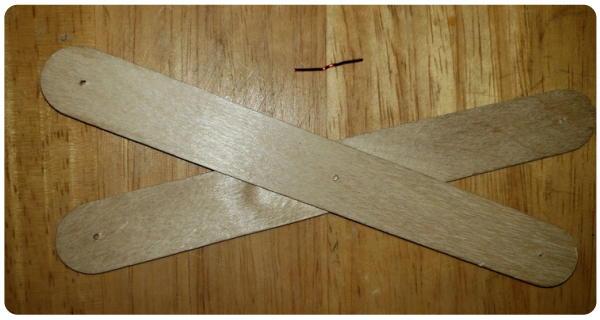
Building a Warehouse Robot

Step Four: Creating a Hydraulic Lift for Your Robot

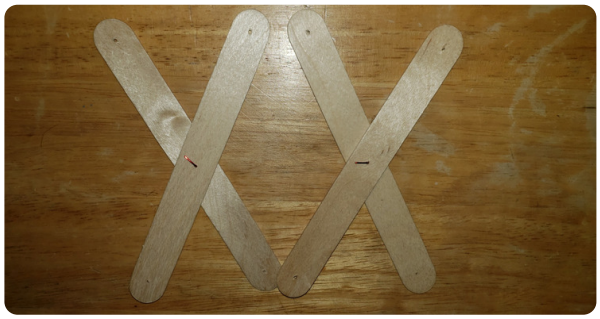
- Drill holes in 8 tongue depressors by stacking them and drilling holes toward each end and in the middle.



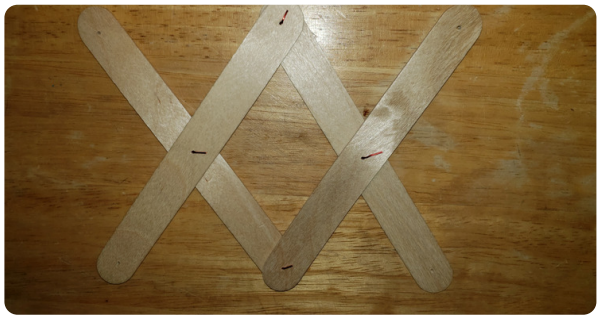
- Attach two of the tongue depressors by putting a 3/4“ piece of wire through the center holes and bending the ends. You should be able to spin the tongue depressors about the piece of wire.
- Repeat this with the remaining tongue depressors so that you have 4 sets of attached tongue depressors.



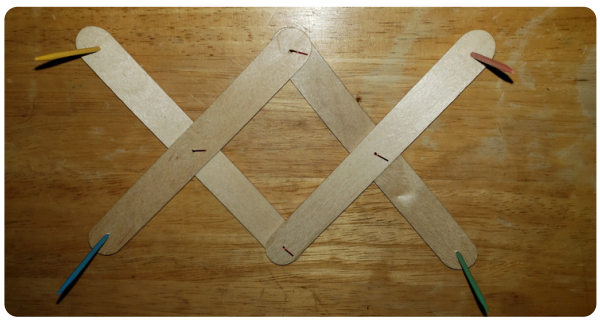
- Place two sets of tongue depressors next to each other. Make sure the top tongue depressors are both pointing in the same direction as shown.



- Use 3/4“ pieces or wire to attach the ends of the tongue depressors that are next to each other. This is the first leg of your Scissors Lift.
- You should be able to expand and contract the leg by pulling the free ends of the tongue depressors towards and away from each other.
- Use the remaining two sets of tongue depressors to make the second leg. The second leg should look identical to the first leg.

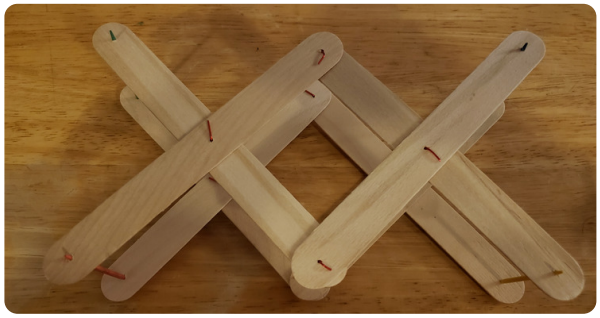


- Collect your toothpicks from your teacher.
- Push the points of the four toothpicks through the holes at the ends of the first leg.

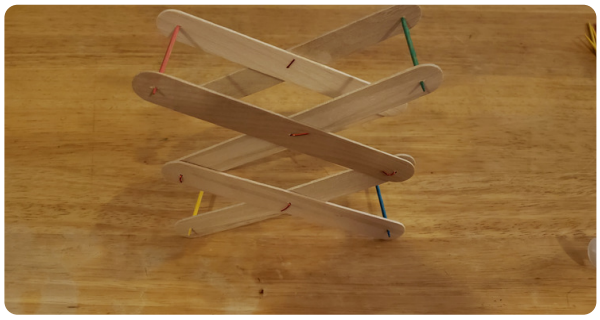


Building a Warehouse Robot

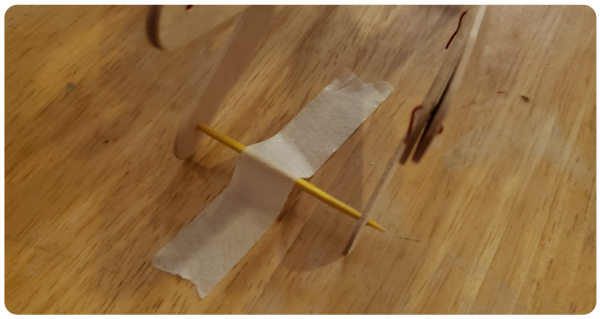
- Line the second leg up with the first leg and press the other end of each toothpick through the holes at the end of the second leg.
- This is your scissors lift. You should be able to expand and contract the lift by pulling the toothpicks towards and away from each other.



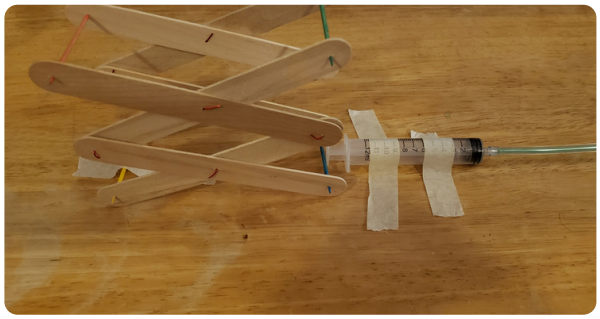
- Set the Scissors Lift upright on the table with the legs contracted (i.e. so it is short instead of tall).



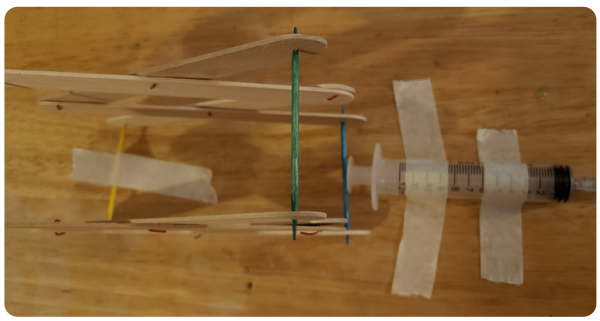
- Tape one of the toothpicks at the bottom of the Scissors lift to the table leaving the other toothpick free to move.



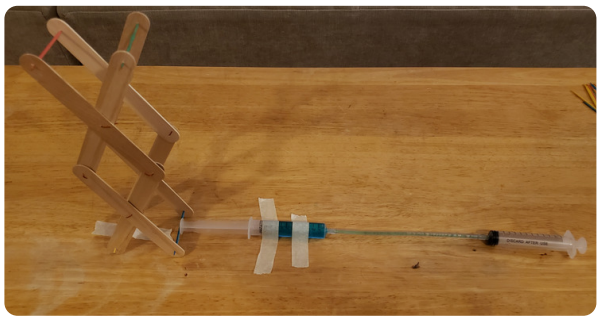
- Place the Hydraulic Syringe System next to the Scissors lift so that the empty syringe is touching the toothpick that is free to move.



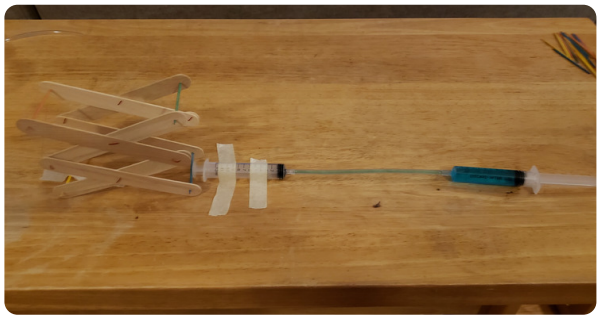
- Tape the body of the syringe to the table and tape the end of the plunger to the toothpick.



- To raise your lift, push in the plunger of the control syringe so that the syringe attached to the lift fills up and pushes the leg inward.

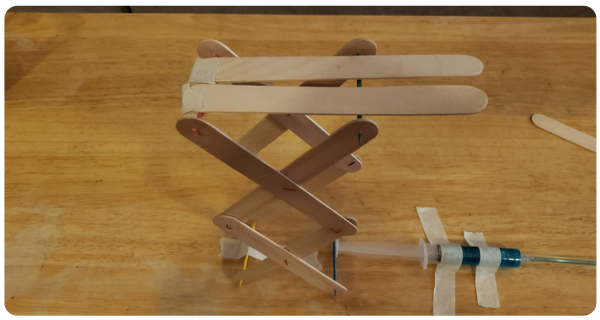


- To lower your lift, pull the plunger of the control syringe so that the syringe attached to the lift empties and pulls the leg outward.



- Add a platform to the top of your lift by taping two tongue depressors to one of the toothpick on one side of the top of the lift. Leave other end of the top of the lift free to move.

- Raise and lower your platform.



- Think of ways to change this component such as:
  - Make it shorter by using one less set of tongue depressors on each leg.
  - Make it longer by using one extra set of tongue depressors on each leg.
  - Make it stronger by using two tongue depressors sandwiched together to replace each tongue depressor.

Step Five: Attach the Components Together

- Use tape or glue to attach the components together to create your robot!
  - Make sure that you leave the free syringes accessible so that you can still make your robot move!
- You may combine the components in any way you want. Be sure to think about how to make your robot most user-friendly and best able to do its job.

Designing the Ideal Shelf System

Follow the steps below to design a shelf system that would be ideal for your robot.

Step 1: Choose a Product to Stock

Your robot will work in a warehouse gathering all of the items for an online order placed by a customer. Your robot must gather all of the items before the order can be boxed and shipped. Choose the type of product your robot will manage.

- Food Items: Provide shelving for an online grocery store.
- Clothing Items: Provide shelving for a large clothing retailer.
- Electronics: Provide shelving for a large electronics store.
- Something else: Choose another type of item for your robot to manage and get your teacher's approval

Step 2: Design Your Shelving System

Use the space below to design a shelving system that will work with your robot and the product you want to stock. Make sure your shelving system meets all of the requirements:

- Your shelving unit must be able to store items in 3 dimensions (meaning there needs to be multiple items in a row horizontally, vertically, and from front to back)
- Your shelving unit must have a system in place that will allow for each location on the shelving unit to be identified. (You can use a grid system to identify each location or create a different system).
- Each location needs to be accessible for your robot. (Note: If your robot will not be able to reach to the back of each shelf, you can design a system to bring items to the front of the shelf - similar to a vending machine)
- All items stored on the shelving unit should be labeled in the drawing.Information about how many of each item can be held on your shelving unit should be listed.