Hydraulic JudoBots

by lakiyama on January 15, 2012

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Intro: Hydraulic JudoBots

This is the Holy Grail among the students in my extracurricular engineering class. The project involves constructing a robot that uses a simple hydraulic system to power a lifting arm and a pivot. Two robots face off and try to throw one another off of a table! It'll make more sense after you watch the video...

I call them JudoBots because of the way they seem to throw and grapple with each other during combat.

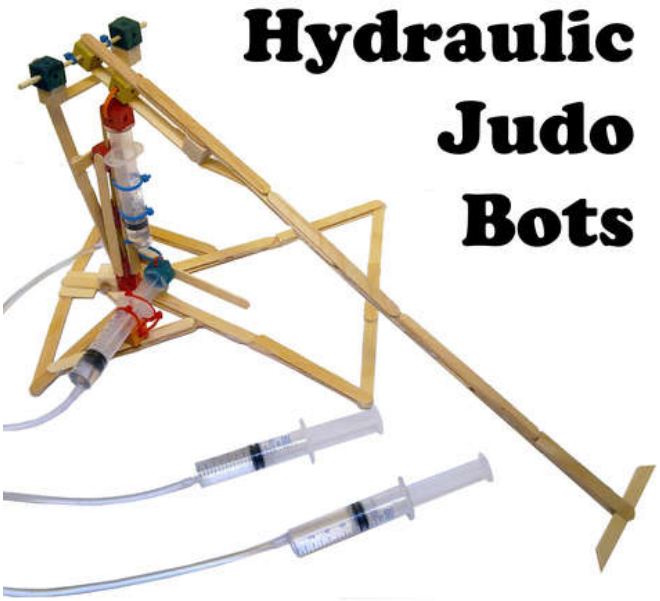
Although designed for children in grades 4-6, I think just about anyone can have fun with this. Even parent's can't resist trying it out :)

The bots are assembled from four components built separate from one another: the base, the stand, the arm, and the hydraulic system. The hydraulic system uses plastic syringes as pistons and water as the hydraulic fluid.

The cost per bot is about $4.00 and it will take up to 2 hours to complete, but you'll definitely need to schedule more time for some epic battles!

This project has been submitted for both the Teacher Contest and the Toy Challenge 2. I believe that JudoBots are a great project for both education and play in equal measure.

Learning Objective
By operating a JudoBot, students will experientially comprehend the basic principles of hydraulics. Building and testing Judobots offers students the opportunity to evaluate materials based upon density, rigidity, and mass. Using the JudoBots in battle gives students hands-on knowledge of how to utilize hydraulics to effectively apply leverage to manipulate a mass. When the project is finished, students will walk away with a new appreciation of applied engineering (and an awesome new toy!)



Step 1: Materials, tools, and design criteria

- Craft sticks
- Craft cubes
- Cubes with holes*
- Robust wooden skewers 1/8" diameter
- Decorative woodcraft (optional)
- 10ml plastic syringes**
- Vinyl tubing
- Adhesive bumpers
- 4" cable ties
- Hot glue guns
- Glue sticks
- Multicutter (recommended)
- Food dye (optional)

JudoBot Criteria

1. The base of each JudoBot must fit within a 10-inch square. This is to prevent students from building sprawling robots that cannot be flipped.
2. Material limitation: craft sticks (50), craft cubes (4), cubes with holes (12), syringes (4), adhesive bumpers (8), decorative woodcraft (5), everything else within reason.

Material limitations are in place to promote resourcefulness and to reduce cost. Also, clever students can no longer pile hundreds of sticks onto their bot in order to make it too heavy to move.

*The cubes pictured are actually from Bazic , but they have recently discontinued this product. Although the cubes depicted have holes drilled on all sides, this is not necessary. I chose to use Bazic's cube because they are colorful which helps illustrate the design.
**My usual supplier, TeacherGeek.com, seems to no longer offer bulk purchases of 10ml syringes. You'll need to shop around for 10ml HSW Soft-Ject luer syringes

Image Notes
1. 10ml HSW Soft-Ject luer slip syringes
2. 1/8" vinyl tubing

Step 2: The Base

It's all in the pictures!
(sometimes Chrome doesn't display the textboxes in Instructables. Reload if you don't see any)

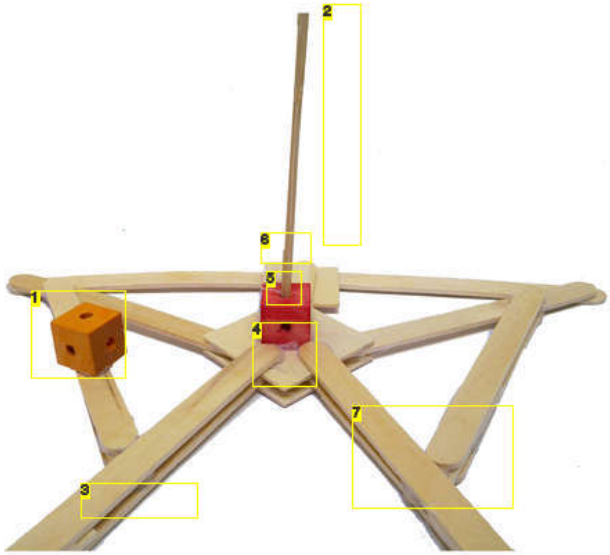


Image Notes
1. The piston that actuates the pivot is attached to this cube. This should be positioned slightly forward and 2" away from the pivot cube. Turning it at a slight angle helps, too.
2. Use good quality skewers because flimsy ones can break at the base, which means replacing the whole pivot cube.
3. Low clearance means difficult to get under
4. The position of the pivot influences the stability and performance of the whole bot. For example, a bot with the pivot positioned at the very back of the base is more prone to being flipped backward. However if the pivot is too close to the front, the bot may have insufficient leverage
5. Skewer is glued in

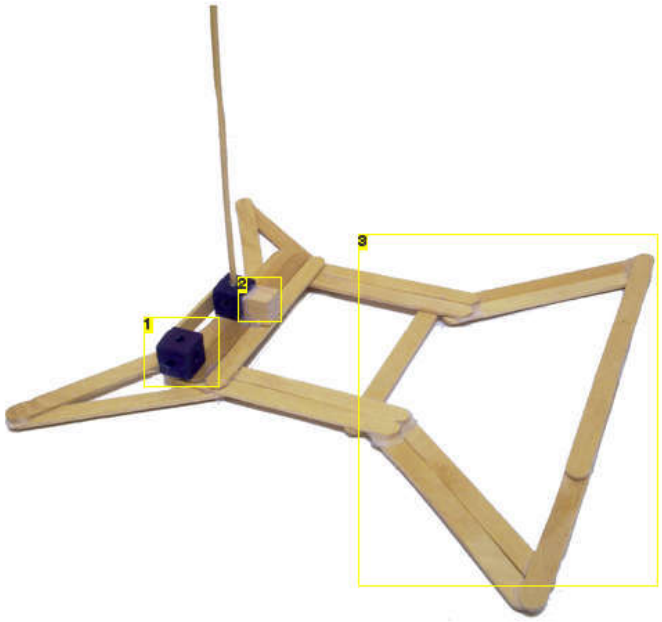


Image Notes
1. This is incorrect: the cube should be slightly forward of the pivot cube and turned at an angle
2. This position of this tan cube is incorrect: it should be behind the pivot cube to prevent it from interfering with the tubing
3. The base can be just about any shape that fits within a 10" x 10" square

6. Tan craft cube is glued behind the red cube for support
7. A rigid base made of layered craft sticks is more effective than a flimsy one.

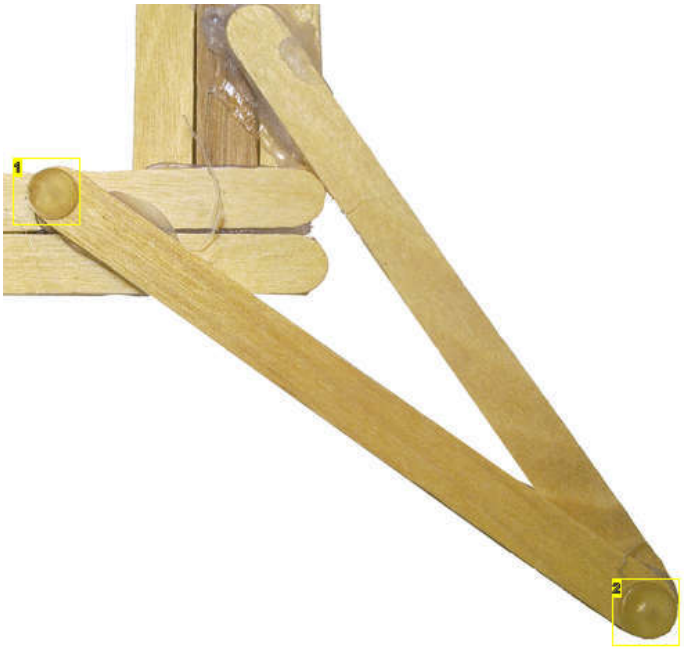


Image Notes
1. Bumpers are placed under the base to prevent the bot from sliding around. Position your bumpers carefully to achieve maximum stability (for example, under the pivot is where the most weight is sitting)
2. Although the bumpers have an adhesive backing, they should be glued on.

Step 3: The Stand

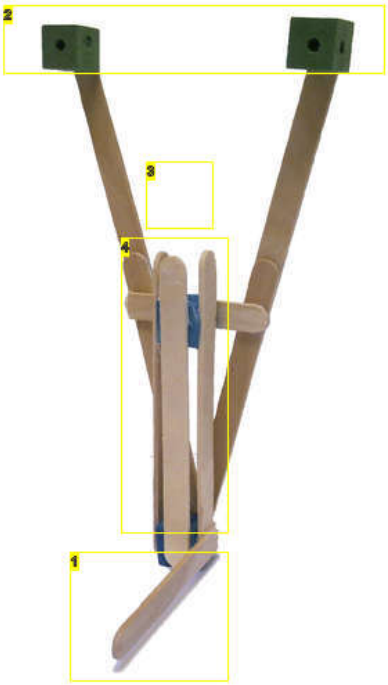


Image Notes
1. The piston that actuates the pivot pushes and pulls on this stick.
2. The holes of these cubes need to be horizontally aligned. It may not look like it in this picture, but it is
3. This is just an example of the stand in its simplest form.
4. The pivot column must be built in front of the V shape. If it isn't, the piston may not attach or function correctly.

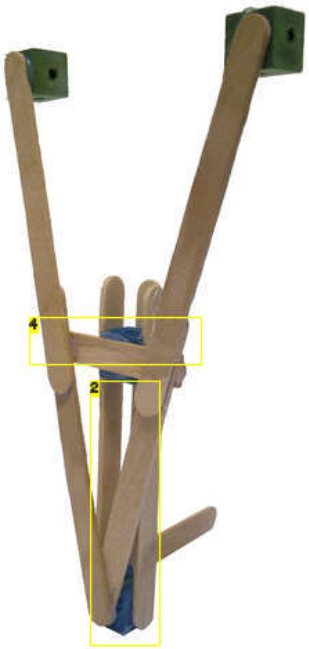


Image Notes
1. The pivot column is built around two holed cubes. The holes of these cubes need to be vertically aligned. This part will fit onto the skewer that's attached to the base
2. The pivot column is built around two holed cubes. The holes of these cubes need to be vertically aligned. This part will fit onto the skewer that's attached to the base
3. Firmly attach 1/2 of a craft stick here

4. Firmly attach 1/2 of a craft stick here

Step 4: The Arm and the Wedge

Image Notes
1. This cube is attached to the stand
2. This cube is attached to the piston
3. The wedge

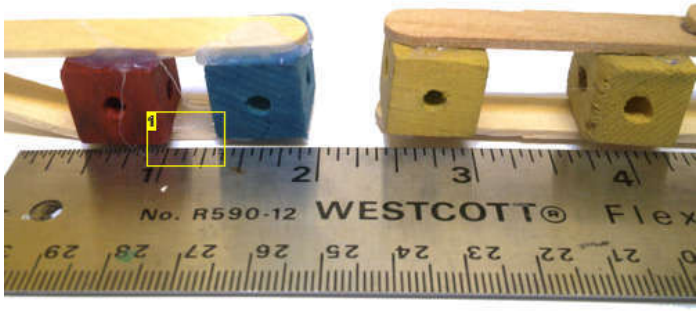


Image Notes
1. The two holed cubes in the arm should be spaced apart by 1/4" to 3/4"

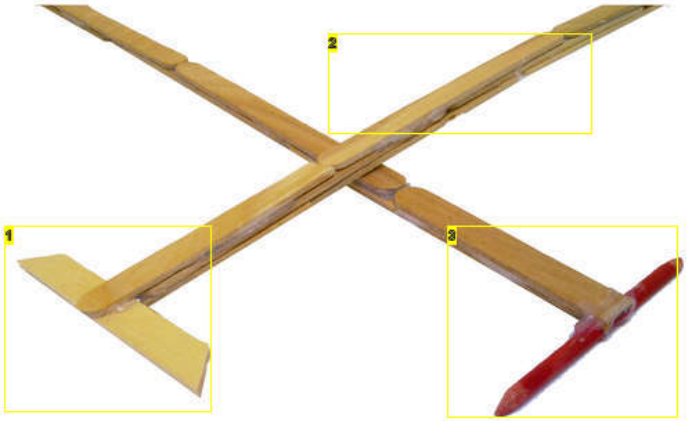


Image Notes
1. The wedge design is crucial because it plays a significant role in determining how effective your bot is at getting under the opponent's base.
2. Layer the craft sticks like brickwork for increased rigidity. Flexible arms don't lift as well.
3. These wedges are just examples - I'm sure there are some clever designs out there...

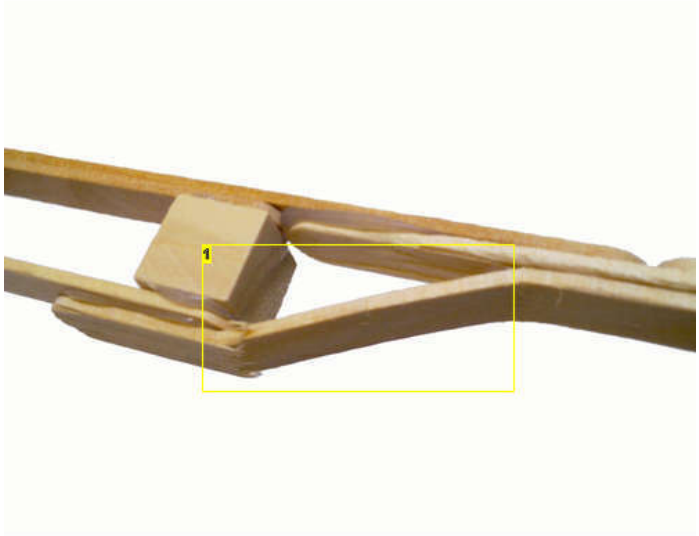


Image Notes
1. S-bend is created by cracking a stick without breaking it. Looks cool and helps keep the arm rigid.

Step 5: Assembling the pieces

Image Notes
1. The stand should slide onto the base without much trouble
2. Use a cable tie or tape to prevent the stand from being pulled off of the base

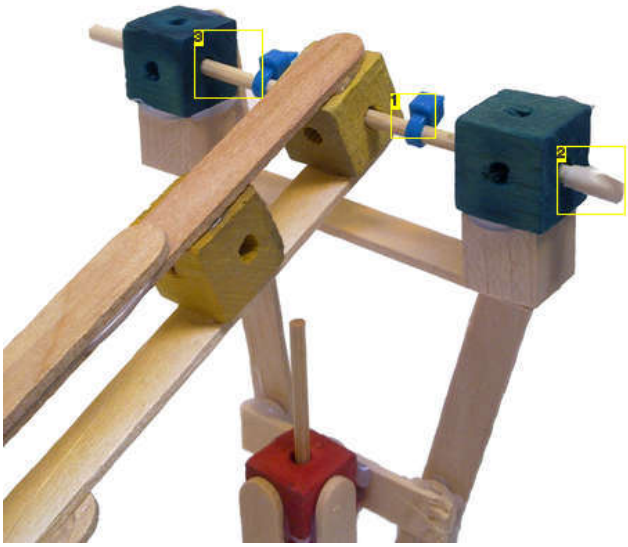


Image Notes
1. Use cable ties to prevent the arm from sliding around
2. Wrap tape around the end of the skewer to prevent it from sliding out
3. The arm is attached to the stand with a skewer.

Step 6: Make a hydraulic system

This part can be a bit tricky for students. Although the process is fairly simple, it isn't easy to commit to memory by watching it done once or twice. You may want to outline these steps on a whiteboard:

1. Connect tubing to one syringe
2. Fill completely with water
3. Point the tip of the syringe up and push on the plunger. This expels all of the air and fills the tubing with water
4. Refill halfway and set aside
5. Submerge the tip of the second syringe and repeatedly pump the plunger to expel air. Fill halfway
6. Connect the syringes and try it out. If the total amount of water in either syringe exceeds the 10ml mark then there is too much water in the system. There should be little to no air bubbles, too.
7. Glue on a holed cube to the end of one plunger in each set

For extra fun, use food dye to color the water

Image Notes
1. Tubing is cut into 2' lengths
2. Holed cube is glued onto the end of one piston in each system

Step 7: Attaching the pistons

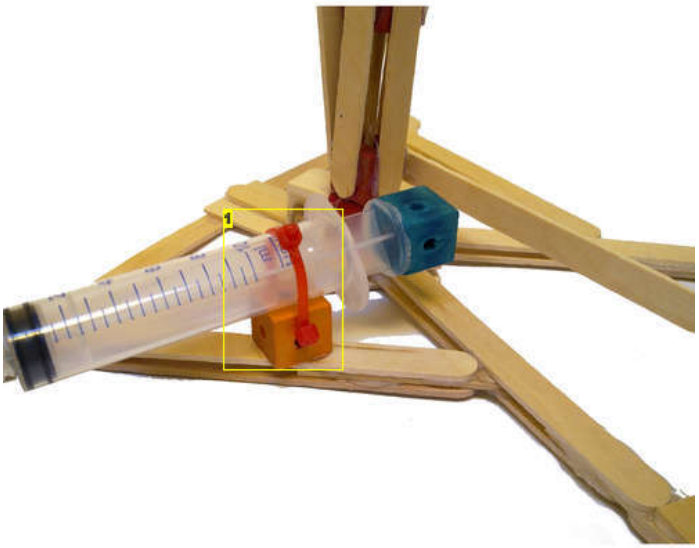


Image Notes
1. Tie the pivot piston to the cube on the base. You may need to combine two ties for this

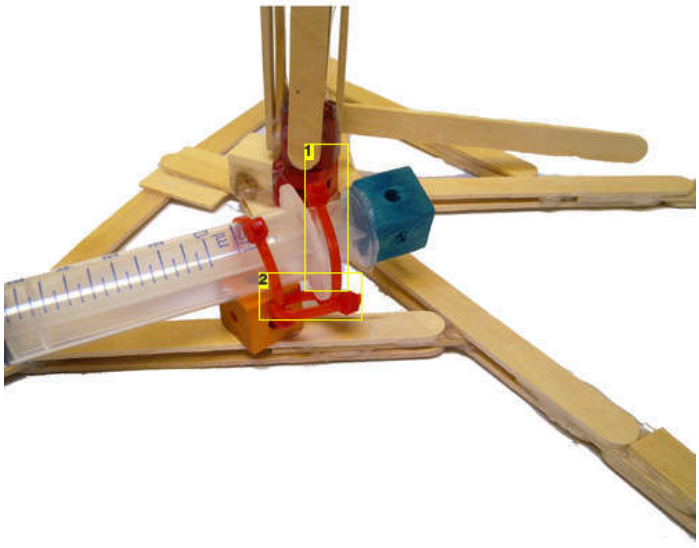


Image Notes
1. This tie wraps around the piston itself, not the casing
2. This cable tie holds the other two together

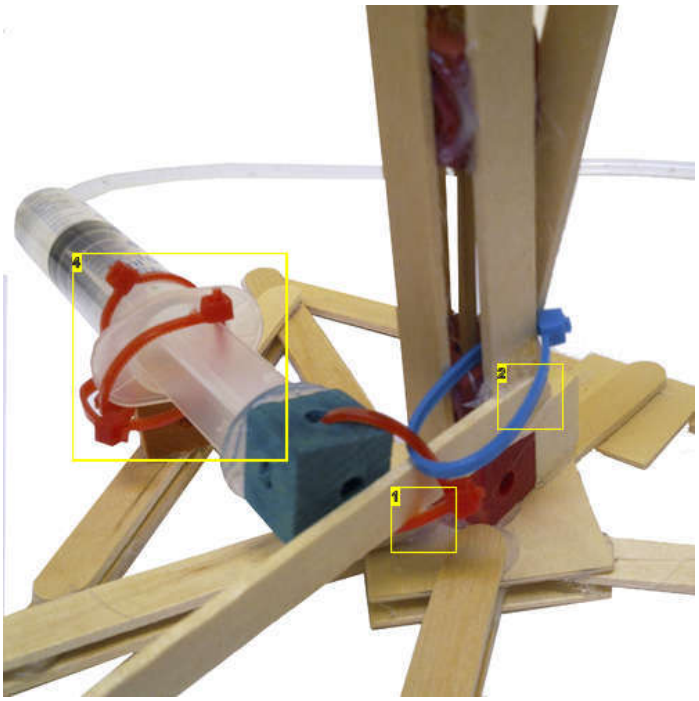


Image Notes
1. The red tie binds the cube on the end of the piston to the stick
2. Bind the red tie to the pivot column. This prevents the piston from sliding around too much.
3. From the previous picture: note how there is one cable tie around each side of the 'hilt' of the piston. This is what prevents it from sliding out of place
4. Note how there is one cable tie around each side of the 'hilt' of the piston. This is what prevents it from sliding out of place

Image Notes
1. Use at least three ties to bind the piston that actuates the arm to the frontmost stick of the pivot column.

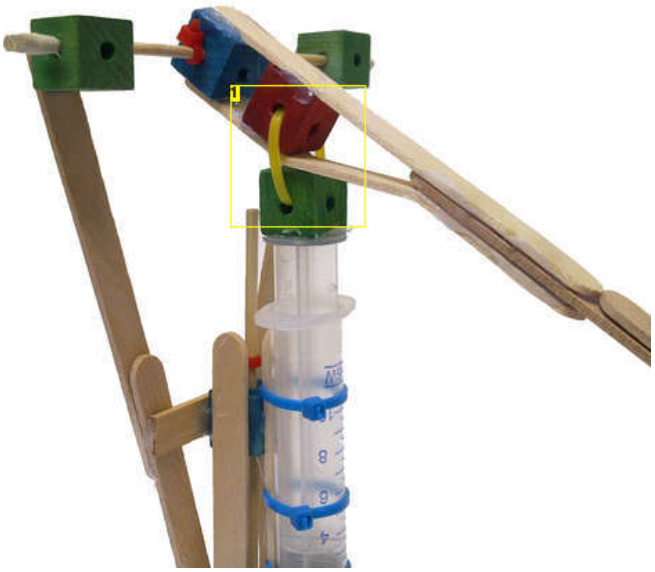


Image Notes
1. Ties these cubes together and you're done!

Step 8: Tweak and Adjust

After everything has been assembled, try it out and make necessary adjustments.

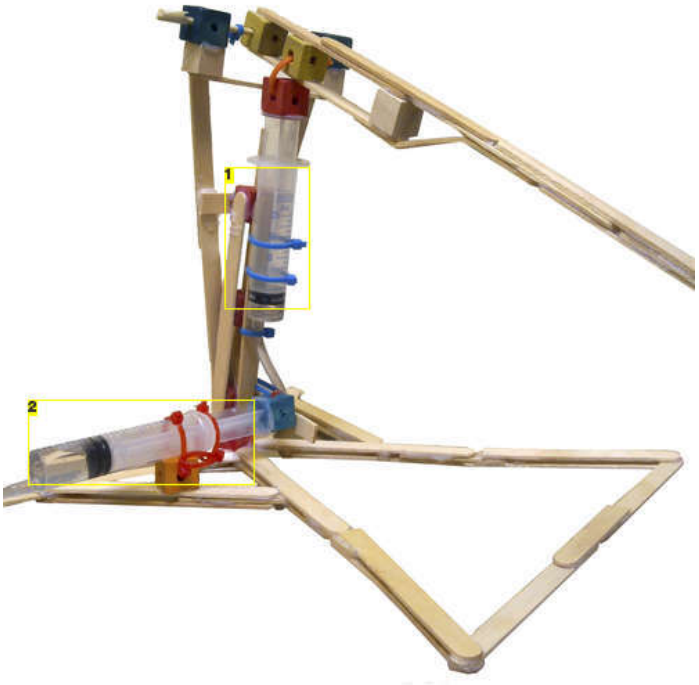


Image Notes
1. Sometimes this piston is positioned too high or low, resulting in the arm not being able to touch the table or not able to extend high enough to flip opponents.
2. Reposition this piston if the arm is swinging too far in one direction. You can do this by removing and regluing the cube. Or perhaps you prefer to have a 'strong side.'

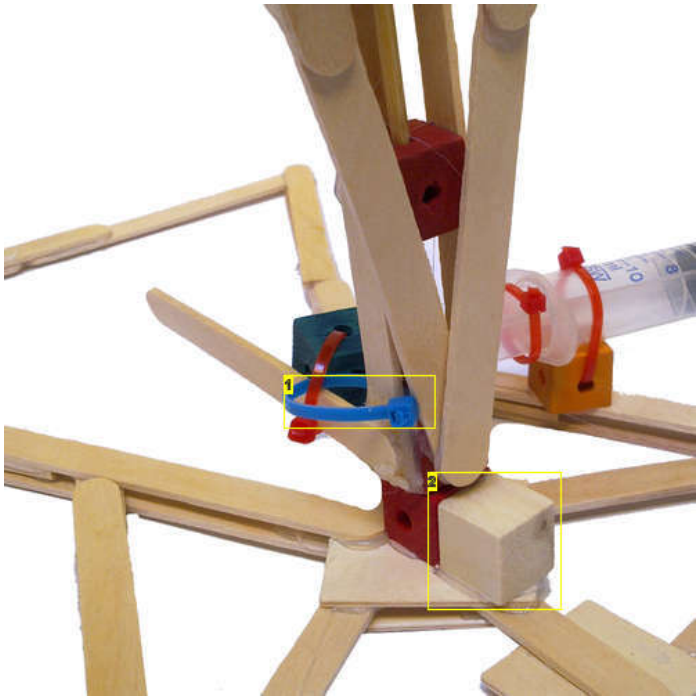


Image Notes
1. Try tightening this tie to adjust the range of the arm.
2. Be sure an extra cube or two is supporting the pivot!

Step 9: Battle Time!!

The arena consists of two 10" squares spaced apart by 2" - 4" drawn onto a tabletop (depicted in the video). Ideally there should be about 6" between the sides of the squares and the edge of the table.

Rules of engagement:

1. JudoBots begin by squarely facing each other with the front of the base touching the edge of the square and the arm completely extended.
2. On the count of three, fight!
3. There are three ways to win a fight: flip your opponent, push your opponent off of the table, or if your opponent experiences a hydraulic failure.
4. A stalemate occurs when the bots are both active but unable to reach one another.
5. A draw occurs if both bots are either flipped or have fallen off.
6. Students must strive to control their JudoBot with precision.

Hydraulic failure most often occurs when the plunger is yanked out of the syringe. Repairs are not as straightforward as filling the lines, so emphasize the importance of operating the JudoBots with precision. If you see a student recklessly pulling on the syringe in the heat of battle, call for a time out. It's better to spend a few seconds reminding your student to slow down than it is to spend a minute or two fixing the line.

The first time students battle it will look like two poorly programmed machines bumbling into each other. This is normal - it just takes some practice before getting the hang of the controls and basic tactics.

Step 10: Presenting this information to your class

I break this project up into two parts: 1. Construction and assembly, and 2. Attaching the hydraulics and battling

1. Prepare two working JudoBots and an extra hydraulic system before class.
2. Demonstrate how to operate one JudoBot in front of your class. Tell them right away about the importance of operating the JudoBot with precision, and show them what happens when a piston is yanked on too hard.
3. Let each student have a chance to operate a JudoBot, though not in combat. This allows the students to experientially grasp what hydraulics are, which is necessary because you will be referring to that concept a lot.
4. Afterwards, have the students focus on you as you disassemble a JudoBot into it's 4 components: base, stand, arm and hydraulic system. Show students the key features of each part, such as the materials used for the pivot column and how it operates. Do not explain how to create or attach the hydraulic system yet.
5. Once you feel confident that the students comprehend how to construct each part, allow them to access the materials and begin.
6. At the beginning of the second part of class, show the students how to create a hydraulic system and outline each step on the board. You may want to show them a second or third time. Demonstrate how to attach each hydraulic system to the JudoBot
7. Finally, remind your students to operate their bots with precision once again! Never yank unrestrainedly on the controls.

Step 11: Further thoughts

This project is relatively new in my curriculum lineup, so there are lots of unexplored ideas. How could this be motorized? What new element could make the battles more interesting and decisive? Could this idea be turned into a toy that uses easily interchangeable parts which allow children to customize their bots and battle with their friends? If you try this out, post some photos and share your insight. Or if you don't, let me know what you think of it anyway :) Thanks for reading through this Instructable - now go forth and create an unforgettable experience for the kids in your life with awesome engineering projects!

Same materials, different project

Related Instructables

How to join a F.I.R.S.T robotics team by skyrunner06

How To Make A Winning Knex Battle Bot by Killer~SafeCracker

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Knex Battle Bot (Starter Bot) by halo99

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