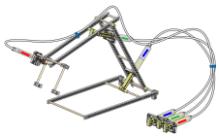
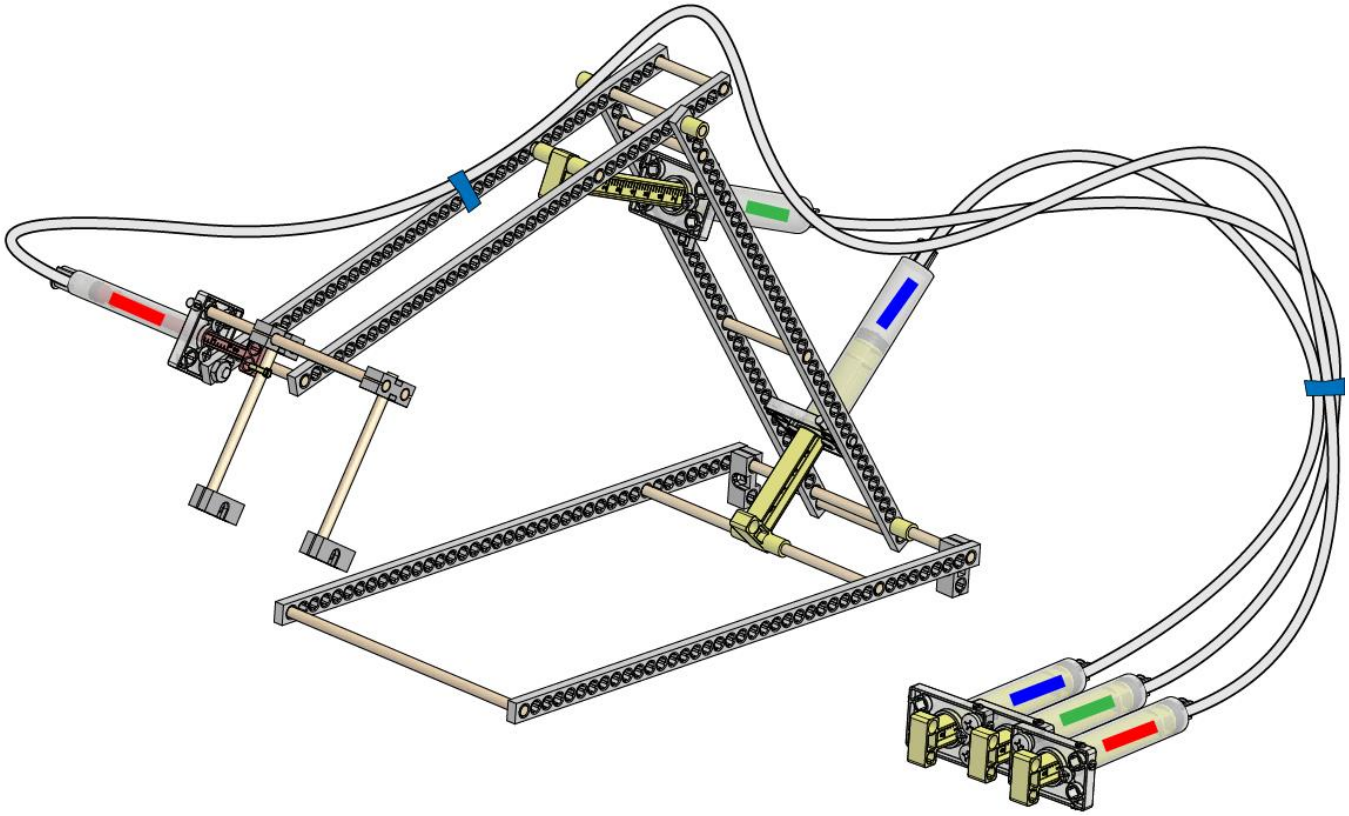


X2 HYDRAULIC ARM

Build Guide

Name: _____ Set: _____ Date: _____

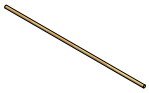
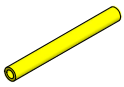
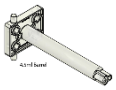


This guide will take you through the following steps:

- **Cylinder Assembly:** Create the cylinders and cut the tubing for your hydraulic arm.
- **Fluid Power Lab:** An optional lab available at teachergeek.com under *documents*. The lab allows you to explore fluid power science and engineering using the cylinders and tubing sections you created.
- **Hydraulic System Assembly:** Connect and fill cylinders to create hydraulic systems.
- **Frame Construction:** Build the arm frame and install the cylinders.
- **End Effector Development:** The end effector is a device or tool that is connected to the end of a robot arm. The end effector is a gripper on the example arm shown above. End Effector Options:
    - Create the example gripper (end effector).
    - Create your own end effector.
    - Create the example gripper and then change it into your own end effector.

Hydraulic arm videos and engineering challenges are available at TeacherGeek.com.

Materials included in the TeacherGeek X2 Hydraulic Arm Packs:

Component	Picture	# in 10 Pack	# For a Single Arm	# Required to Build Example Arm	# Extra -To Innovate Your Own Design
Strips		100	**10**	6	4
Dowel		80	**8**	4	4
Tubing		30M (100ft)	**Cut 2.85m (10ft)**	Cut 2.85m (10ft)	0
Blocks		100	**10**	6	4
Slide Stop 3in Section		10	**1**	1	0
#10 1in Screw		80	**8**	5	3
#6 x .5in Screw		180	**18**	18	0
#10 Nut		80	**8**	5	3
Cable Tie		20	**2**	1	1
13ml Cylinder Barrel		50	**5**	5	0
13ml Cylinder Plunger		50	**5**	5	0
13ml Cylinder Piston		50	**5**	5	0
4.5ml Cylinder Barrel		10	**1**	1	0
4.5ml Cylinder Plunger		10	**1**	1	0
4.5ml Cylinder Piston		10	**1**	1	0
1cc Silicone Grease Packet		10	**1**	1	0

Other Materials:

The TeacherGeek system is designed to be used with other materials you can find (materials not supplied in the TeacherGeek pack). Other materials could be craft supplies, from a recycling bin, wood, metal, cardboard, or anything else you may have. These materials can be used to help you create your own unique designs.

Tools Required:

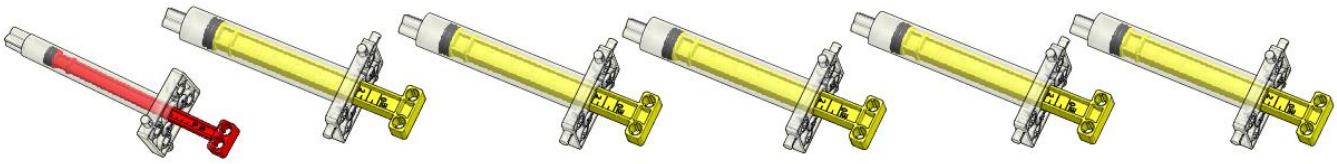
Tool	Picture	Use	# Required	# Suggested for Classes	Alternate
Reamer		Enlarge holes so dowels slide & rotate	1	1 for every 3-4 students	5.5mm or 7/32” drill bit and drill
Multi-Cutter		Cut wood, plastic, cardboard	1	1 for every 3-4 students	Side Cutters, Saw, Pruning Shears
Pliers		Tighten nuts, pull out dowels	1 -Optional	1 for every 3-4 students	Wrench
Phillips Screwdriver		Turn screws	1	1 for every 3-4 students	
Crayon or Wax		Rub on dowel to make it slide easier into a hole	1 -Optional	1 for every 3-4 students	Wax
Safety Glasses		Protect eyes	1	1 per student	Goggles

Age Level Recommendations: 12 and above with adult supervision.

Adult Supervision Required.

Cylinder Construction

Repeat steps 1-5 below to create five 13ml cylinders and one 4.5ml cylinder. The steps show construction of a 13ml cylinder, but same steps can be used to create the 3.5ml cylinder.



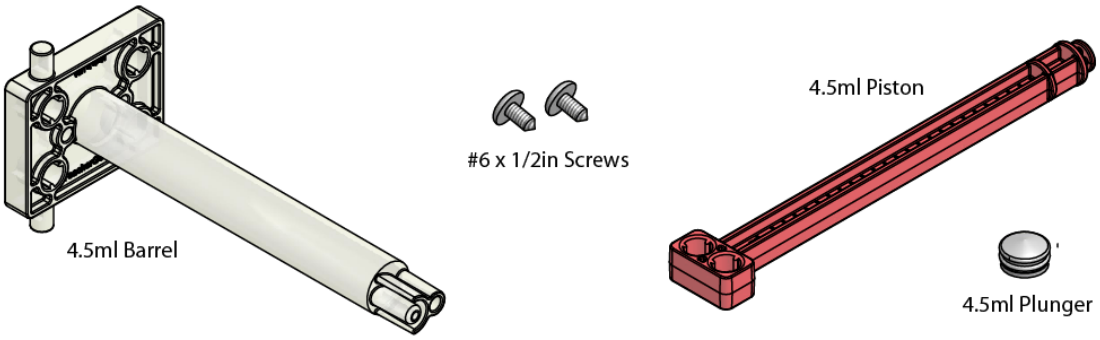
Step #1

Gather your components. You will also need one silicone grease packet.

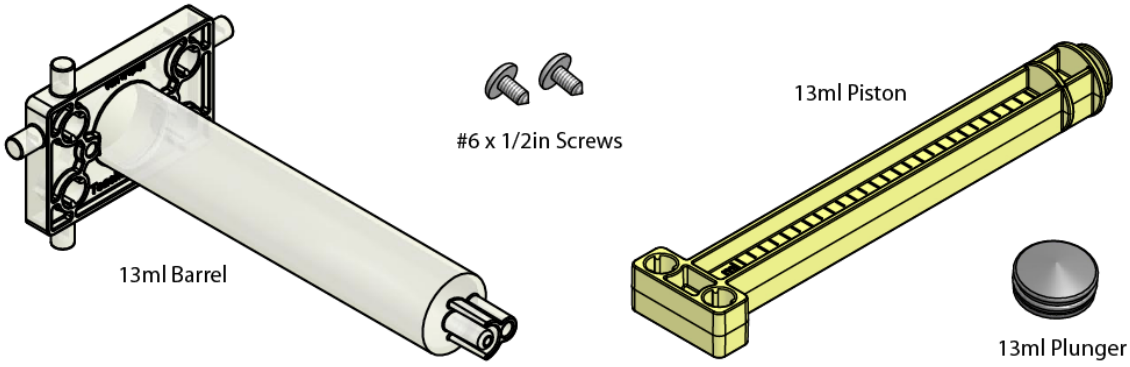
Caution: Do not assemble your cylinders without silicone grease.

Note: The plunger will stick and fail without silicone grease lubricant.

Components to create one 4.5ml cylinder:

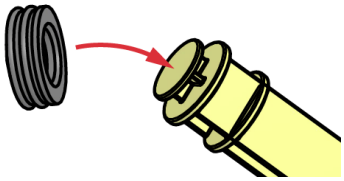


Components to create one 13ml cylinder:



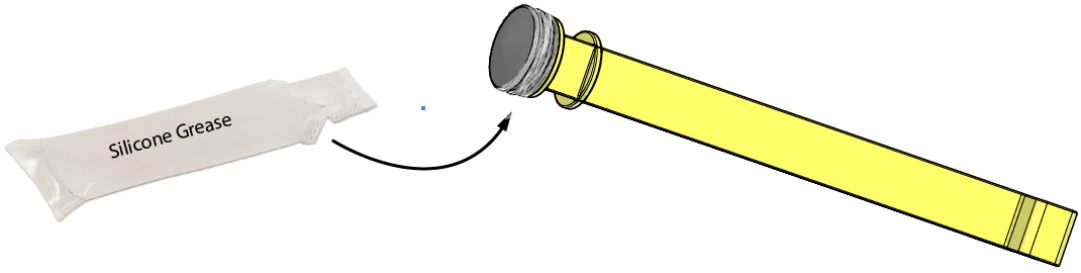
Step #2

Place the plunger onto the piston.



Step #3

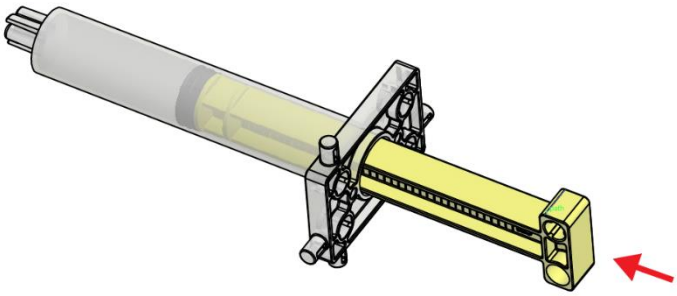
Apply a small amount of silicone grease (best) or vegetable oil around plunger.
Note: Do not use Petroleum lubricants. They will cause the plunger to stick and fail.



A small amount of silicone grease will lubricate many plungers (a 1cc packet can lubricate over 30 pistons). Save the extra lubricant to use later.

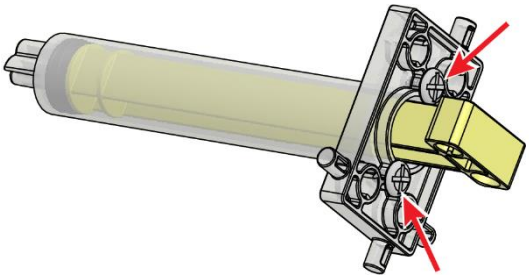
Step #4

a) Make sure the plunger is lubricated! If not, it will get stuck in the barrel.
b) Insert the piston assembly into the barrel. Move the piston in and out to lubricate the barrel.



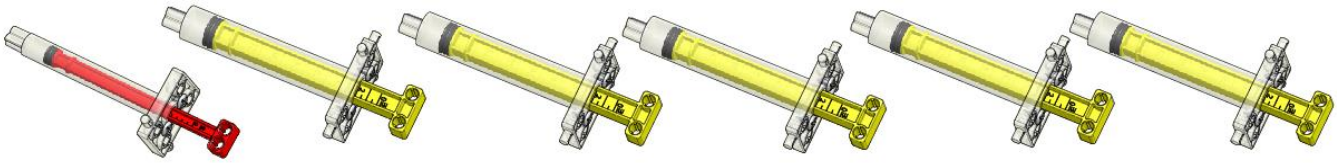
Step #5

Turn two #6 screws into the barrel to keep the piston from coming out.



Repeat

Did you repeat Steps 1-5 below to create five 13ml cylinders and one 4.5ml cylinder? If not, repeat the steps to create the cylinders.



Step #6:

Cut the following lengths of tubing:

60cm (~23”) ═══════════

85cm (~33”) ═══════════════

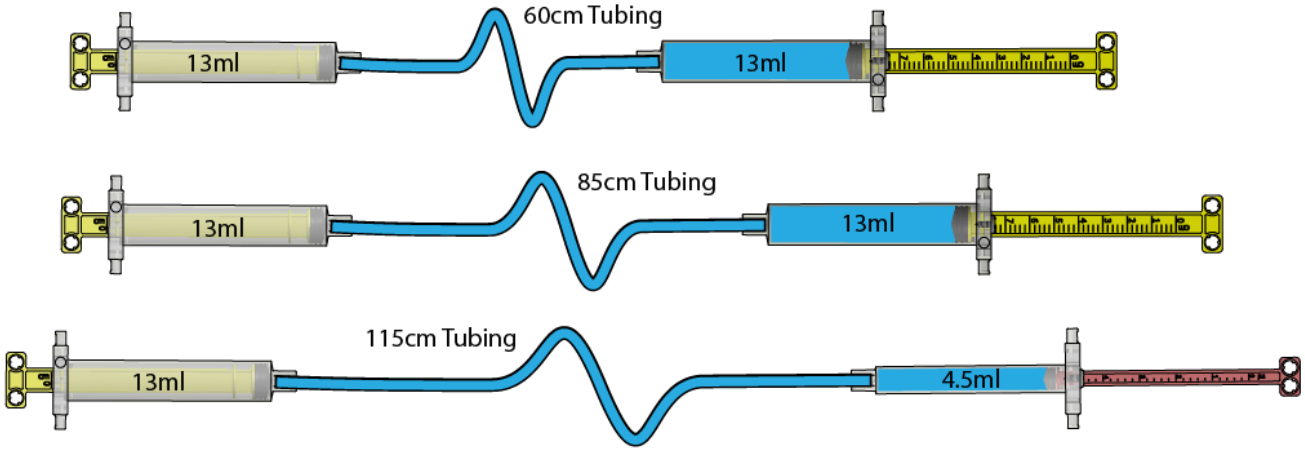
115cm (~45”) ═══════════════════

Optional Fluid Power Lab

An optional lab is available at teachergeek.com under *documents*. The lab allows you to explore fluid power science and engineering using the cylinders and tubing sections you created.

Hydraulic System Assembly

Follow steps 8-12 to connect and fill cylinders to create hydraulic systems. Use the cylinders and tubing from prior steps.



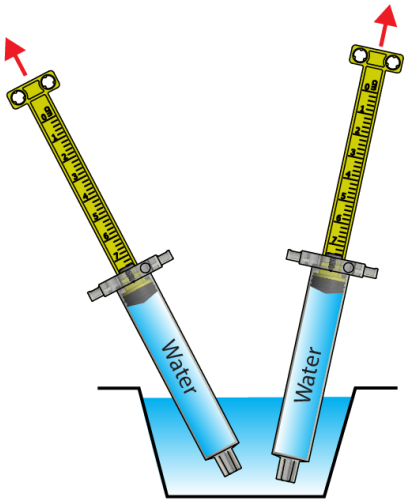
Step #7

Fill each cylinder with water:

a) Push the cylinder piston in.
b) Place the cylinder tip under water.
c) Pull the piston back to completely fill the cylinder with water.

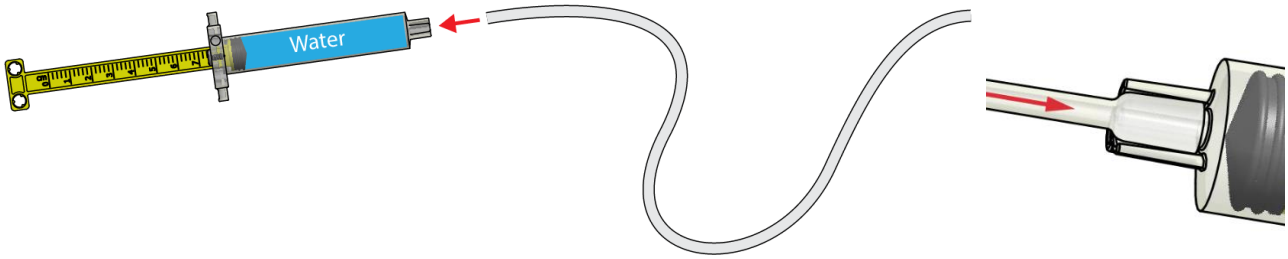
Note: There should be no air bubbles in the water filled cylinders.

Tip: Color the water.



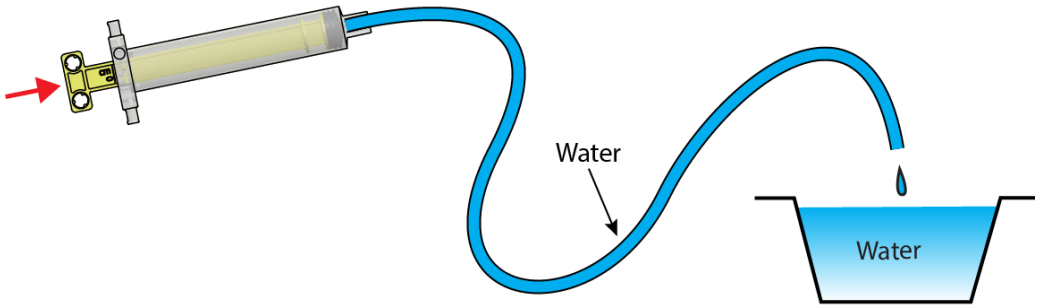
Step #8

Attach the cut tubing to the first water filled cylinder. If you will be connecting a 13ml and a 4.5ml cylinder with tubing, attach the 13ml cylinder to the tubing first.



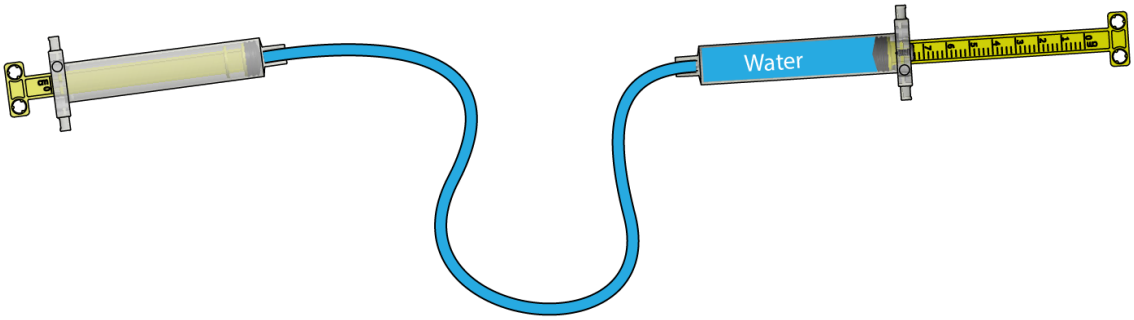
Step #9

Push in the cylinder piston completely to fill the tubing with water. The cylinder and tubing should have no air in them.



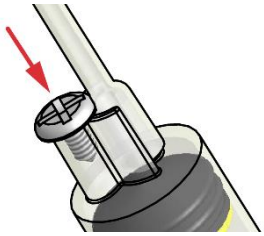
Step #10

Attach the water filled tubing to the second water filled cylinder. **Your hydraulic system is finished.**

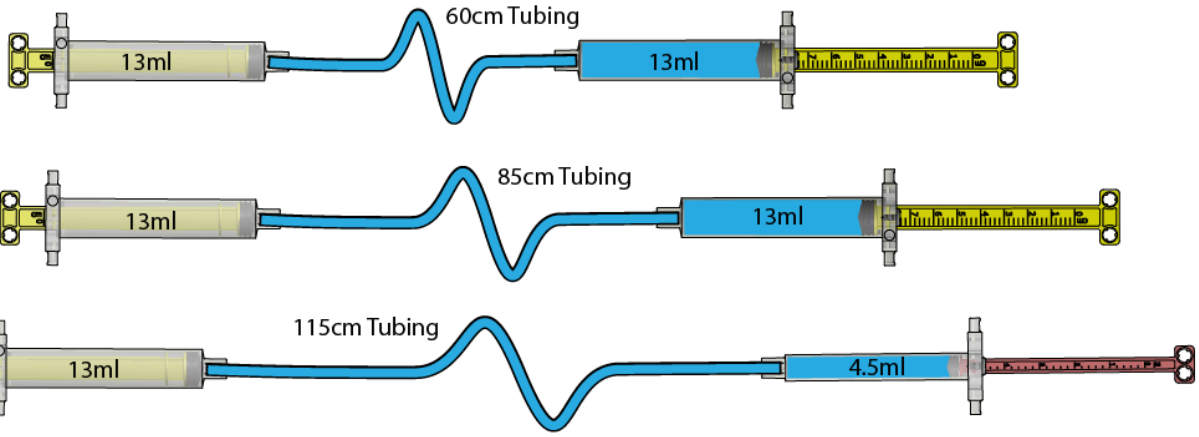


Step #11

Insert a screw into the hole aside the cylinder tips to keep the tubing from pulling off.



Have you repeated steps 8-12 to create the hydraulic systems listed below?
If so, continue to the next page.

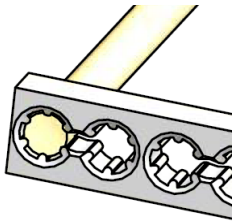


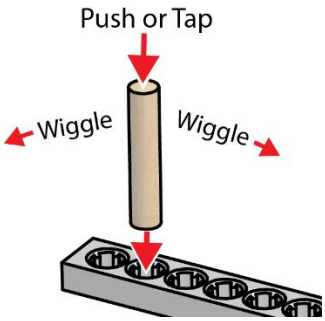
Your hydraulic system will not work well if air is in the cylinders or tubes. You will periodically have to remove tubing from a cylinder to bleed the lines (remove air from the lines), and refill the lines.

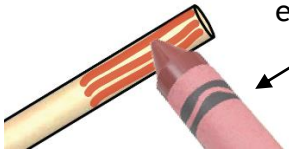
How does the TeacherGeek system work?

Dowels & Holes

TeacherGeek components have holes that wooden dowels press securely into. If you are having trouble pushing a dowel into a hole, tap it with a hammer, the side of your closed cutter, or pliers.



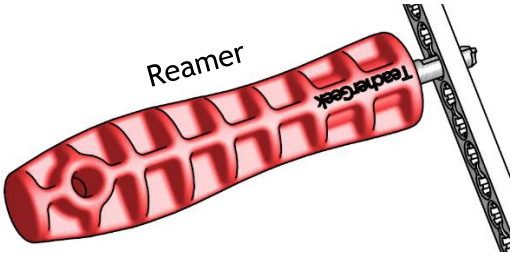


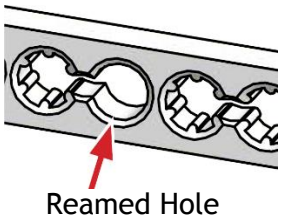


Tip: Rub a crayon or wax on the end of a dowel to make it slide easier into a hole.

Reaming

Ream holes to create a loose fit for dowels to rotate or slide. **Caution:** Do not ream holes that you want the dowel to stay pressed into. Dowels will fall out of reamed holes.





Directions will use these images to tell you when and when not to use the reamer.

This picture reminds you not to ream holes. →

← This picture tells you when to ream holes.

Multi-Cutter

Need to cut a wooden dowel or plastic strip? Use a multi-cutter. Do not use multi-cutters on metal, or other hard materials. Wear safety glasses when using multi-cutters.

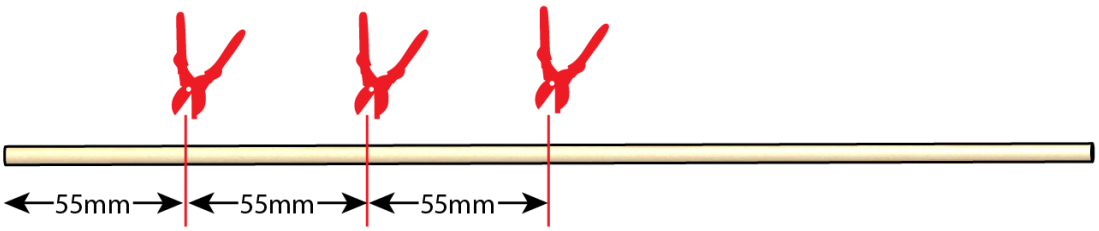
Innovation

TeacherGeek allows you to learn and grow with your projects. Start with an example, experiment and redesign it, or create something new from scratch.

Frame Construction

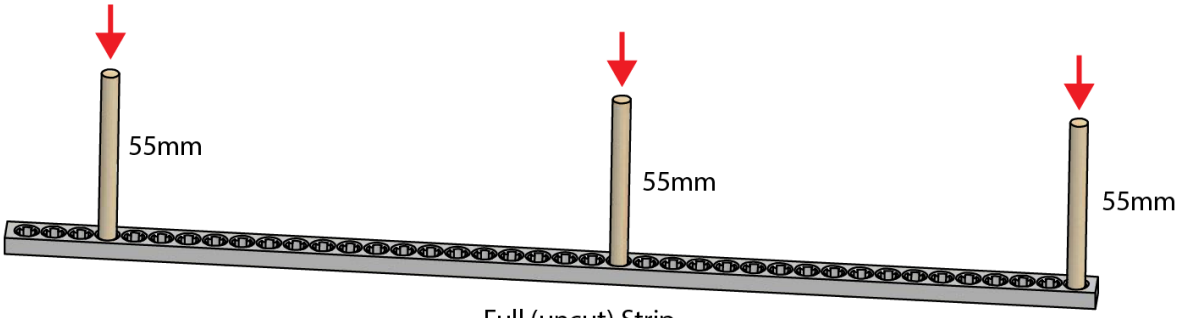
Step #12

Cut three 55mm (~2 1/8”) dowels. Save your cutoff dowels and strips throughout this activity. You will use them later.



Step #13

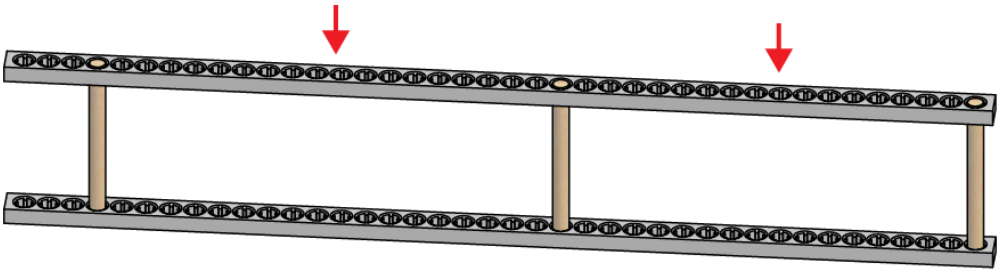
Push/tap the 55mm dowels from step #13 into a strip as shown.



Do not ream any holes.

Step #14

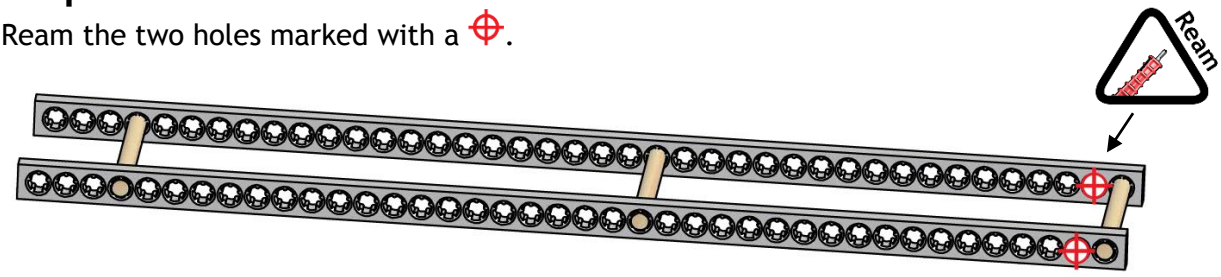
Push/tap a second strip onto the 55mm dowels.



Do not ream any holes.

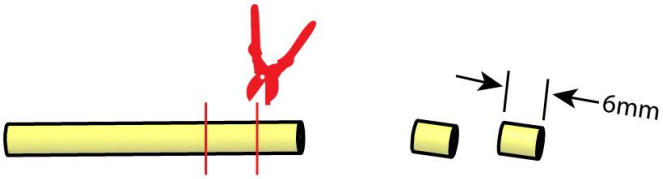
Step #15

Ream the two holes marked with a ⌖.



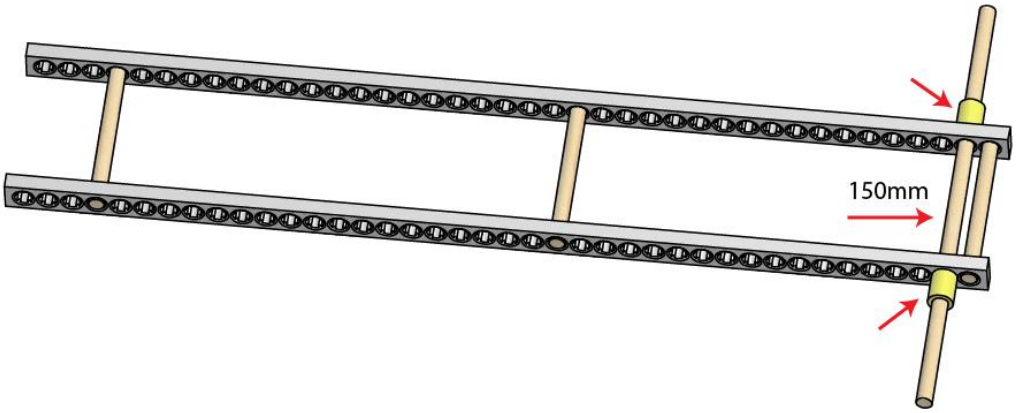
Step #16

Cut two 6mm (1/4”) sections of slide stop.



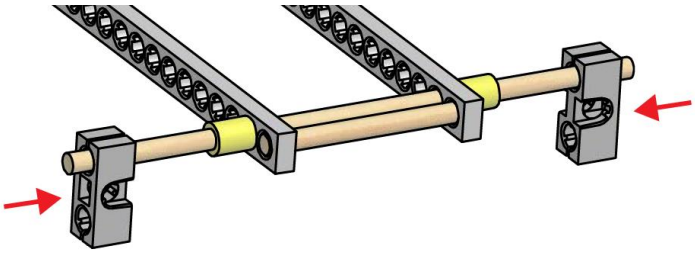
Step #17

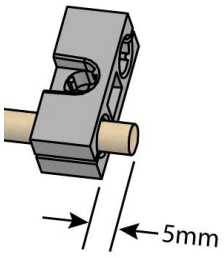
a) Cut a full dowel in half to get two 150mm (6”) dowels.
b) Place one of the 150mm dowels into the reamed holes from Step #16. Save the other 150mm dowel.
c) Use the two sections of slide stop from Step #17 to center and hold the dowel in the holes.



Step #18

Push/tap blocks, pointing in the same direction, onto the 150mm dowel. Position blocks 5mm (~1/4”) past the end of the dowel.

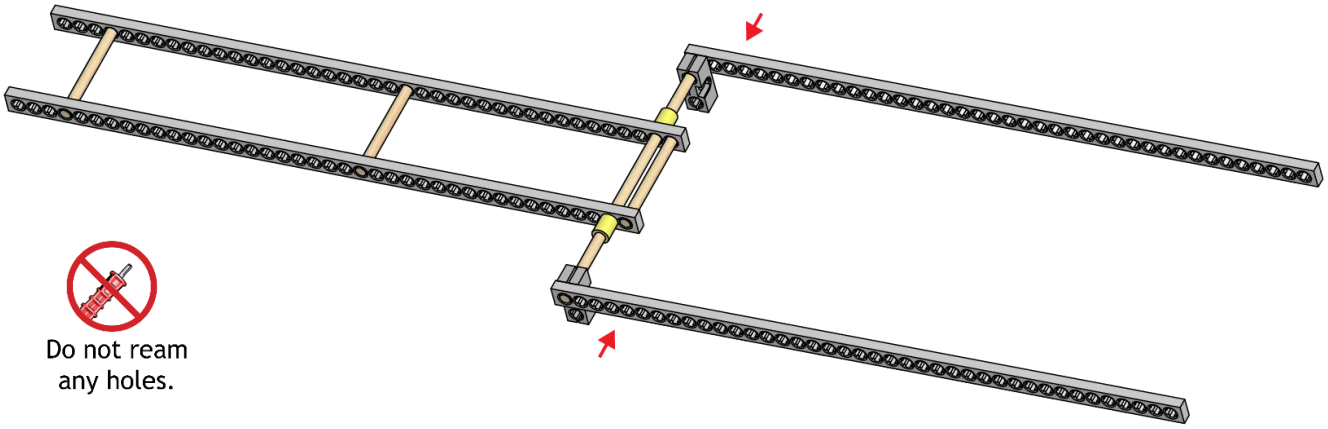




Do not ream any holes.

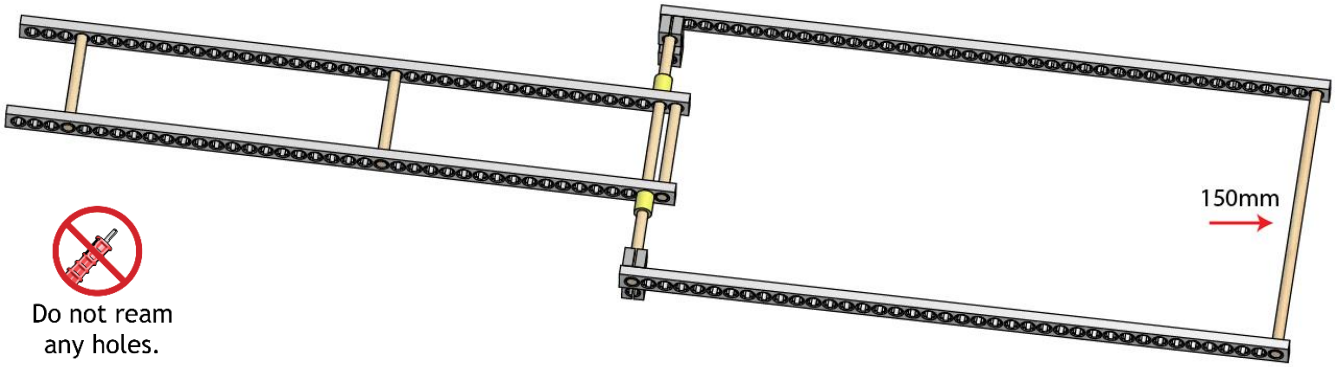
Step #19

a) Place the assembly on a table with the blocks pointing down.
b) Push/tap strips onto the ends of the 150mm dowel.



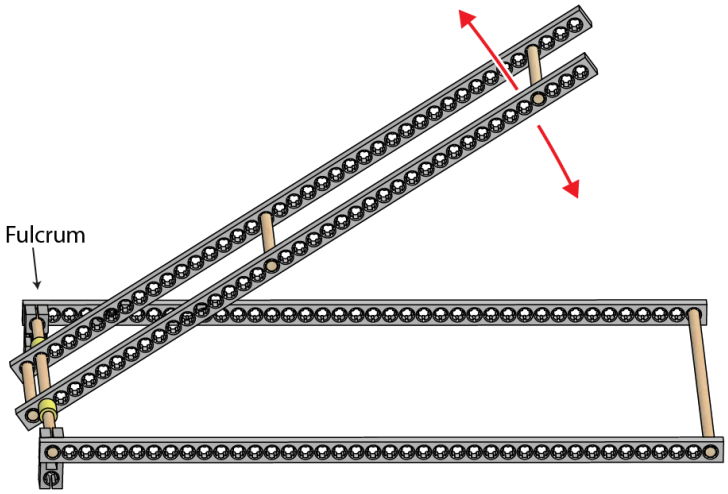
Step #20

Push/tap the extra 150mm dowel, from Step #18, between the ends of the strips.



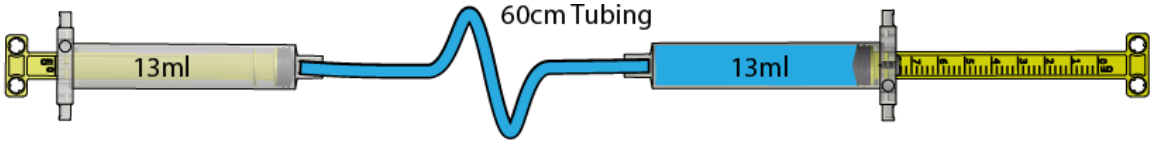
Good Job.

You have just completed the base and first boom of your hydraulic arm. You should be able to pivot the boom at the fulcrum.



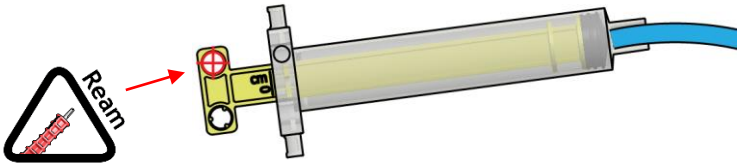
Step #21

Get the hydraulic system, from Steps 8-13, with 60cm (~24in) of tubing.



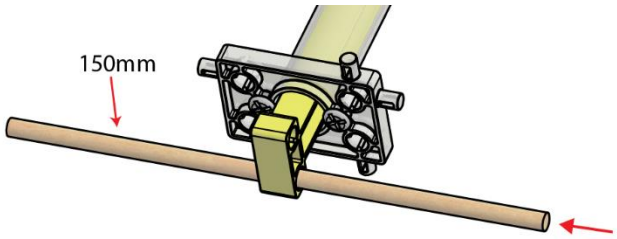
Step #22

Ream the hole marked with a ⊕ on one of the cylinders from 60cm hydraulic assembly.



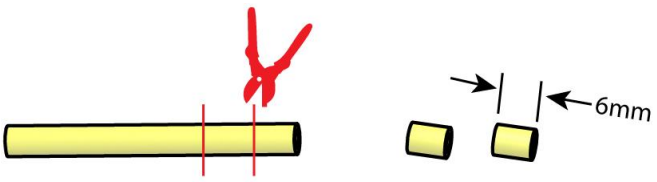
Step #23

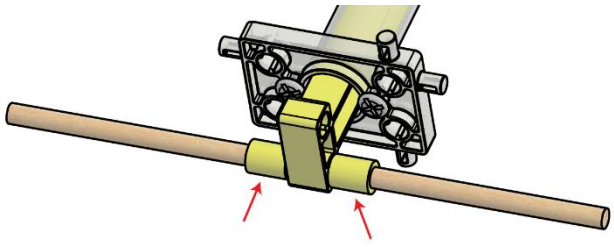
a) Cut a new 150mm (6”) dowel.
b) Insert the 150mm dowel into the reamed hole from Step #22.



Step #24

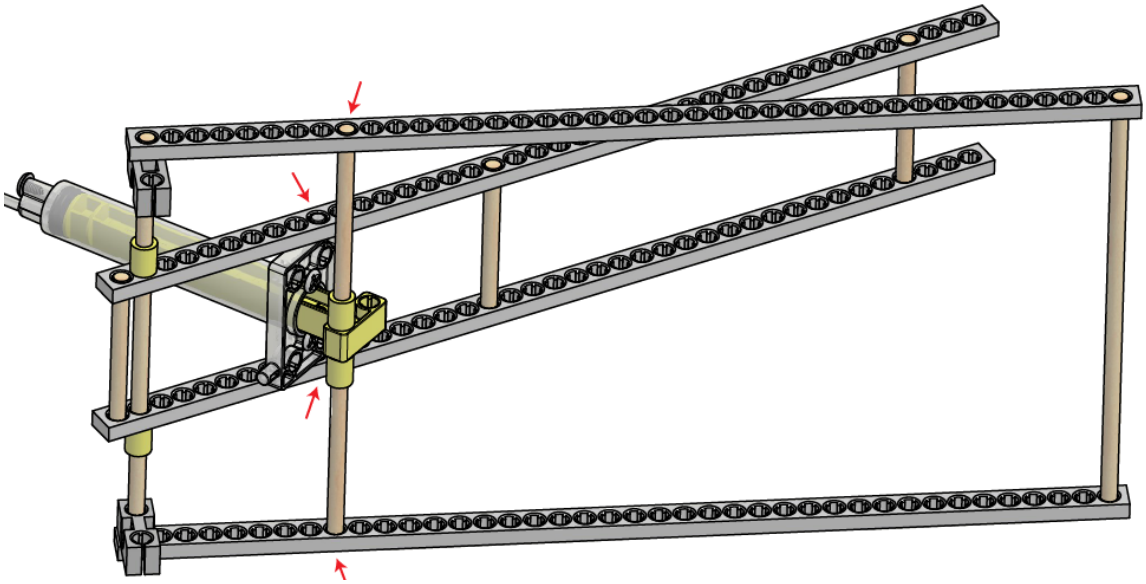
a) Cut two 6mm (1/4”) sections of slide stop.
b) Use the slide stop sections to center and hold the 150mm dowel in the piston.





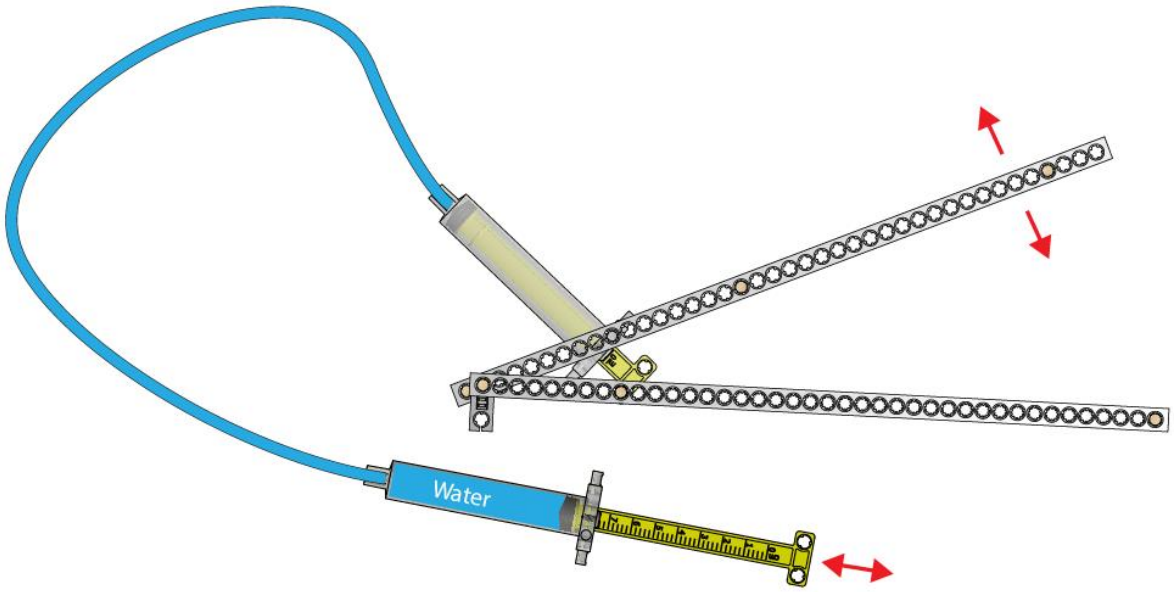
Step #25

Place the cylinder assembly, from Step #24, between the base and boom. The position of the cylinder assembly does not have to be the same as the picture. You can change it later.



Experiment!!!

Move the piston and lever. Do they move with the same distance and force?



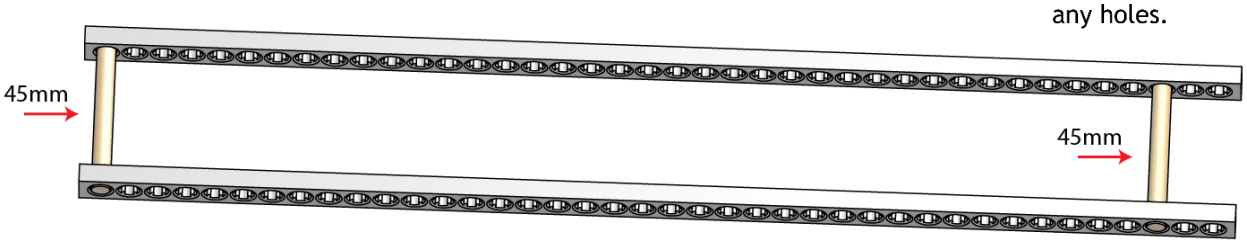
Step #26

Create the second boom

a) Cut two 45mm (1 ¾”) dowels.

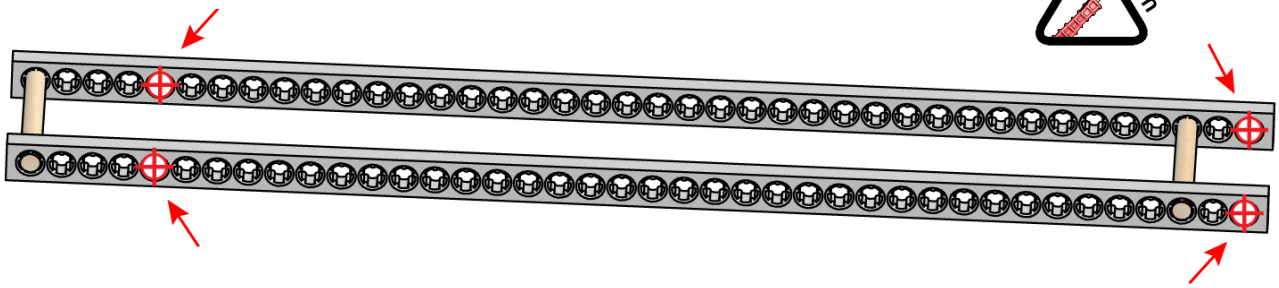
b) Insert the 45mm dowels in-between two full strips.

Do not ream any holes.



Step #27

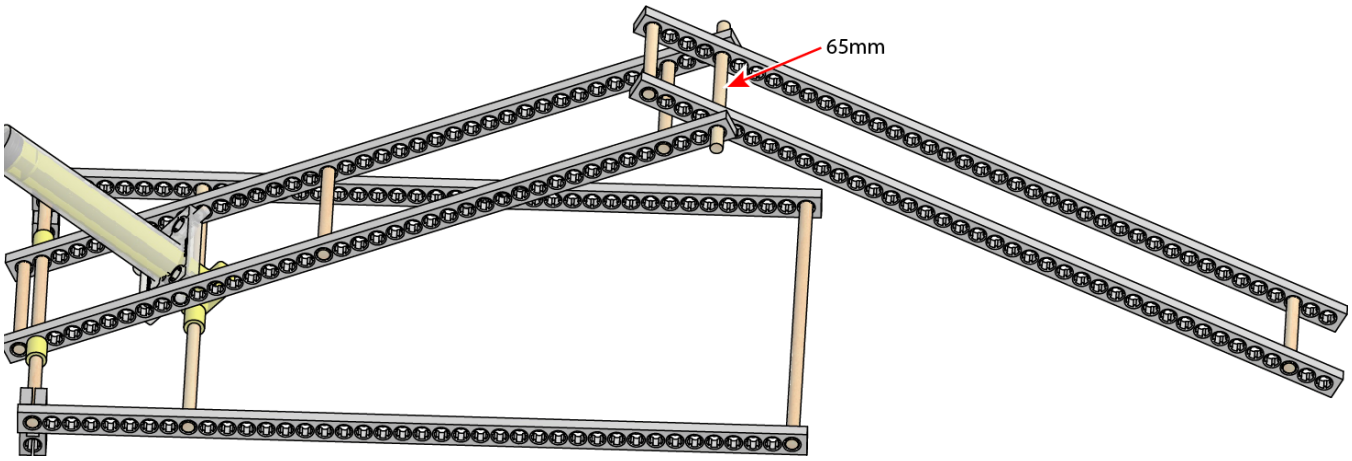
Ream the four holes marked with a ⌖.



Step #28

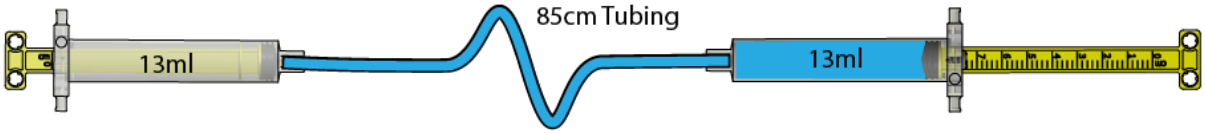
a) Cut a 65mm (2 1/2”) dowel.

b) Insert the 65mm dowel into the reamed holes to connect the first and second boom.



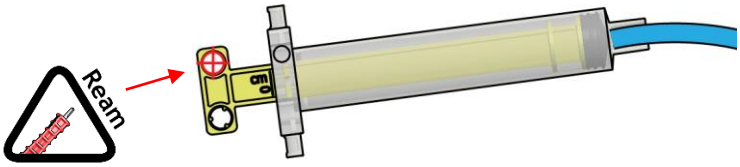
Step #29

Get the hydraulic system, created during Steps 8-13, with 85cm (~34in) of tubing.



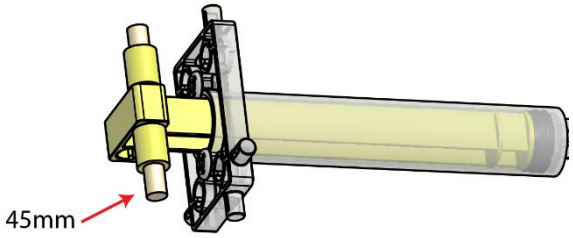
Step #30

Ream the hole marked with a ⌖ on one of the cylinders from 85cm hydraulic assembly.



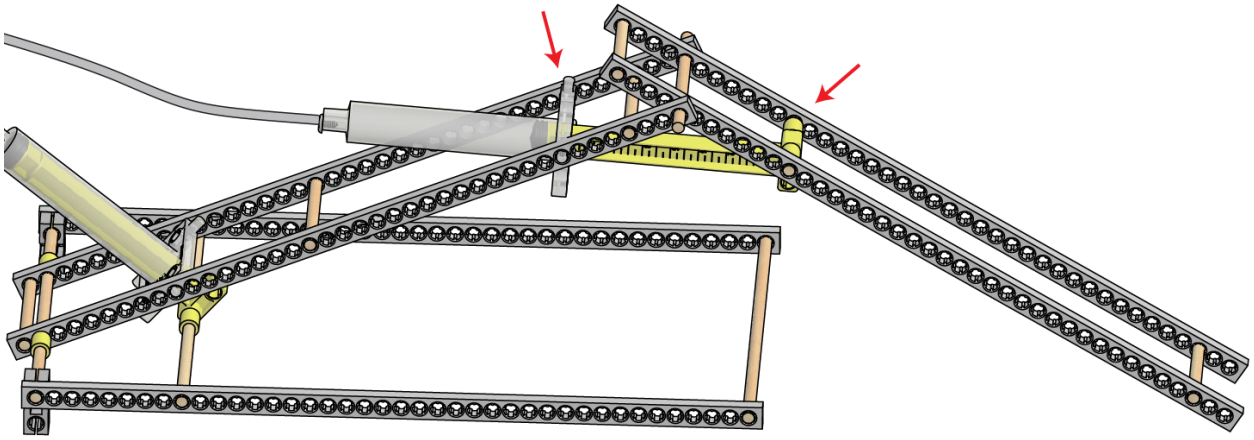
Step #31

a) Cut a 45mm (1 ¾") dowel.
b) Insert the 45mm dowel into the reamed hole from Step #30.
c) Cut two 6mm (1/4") slide stop sections.
d) Use the slide stop sections to center and hold the 45mm dowel on the piston.



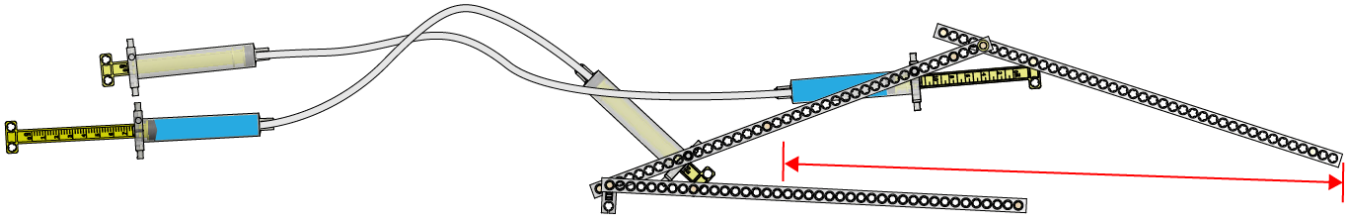
Step #32

Place the cylinder assembly from Step #31 in-between the first and second boom. Placement of the cylinder assemblies does not have to be as shown.



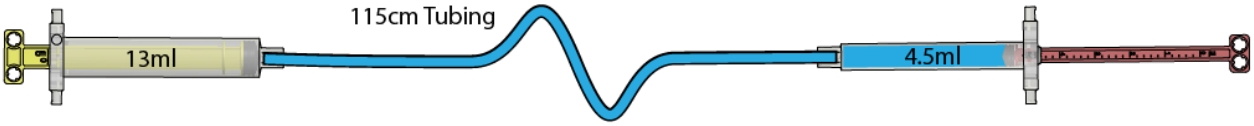
Step #33

Change where the cylinders attach to allow your arm to move from as far in to as far out as possible.



Step #34

Get the hydraulic system, created during Steps 8-13, with 115cm (~45”) of tubing. This system will be used to power your arm end effector.

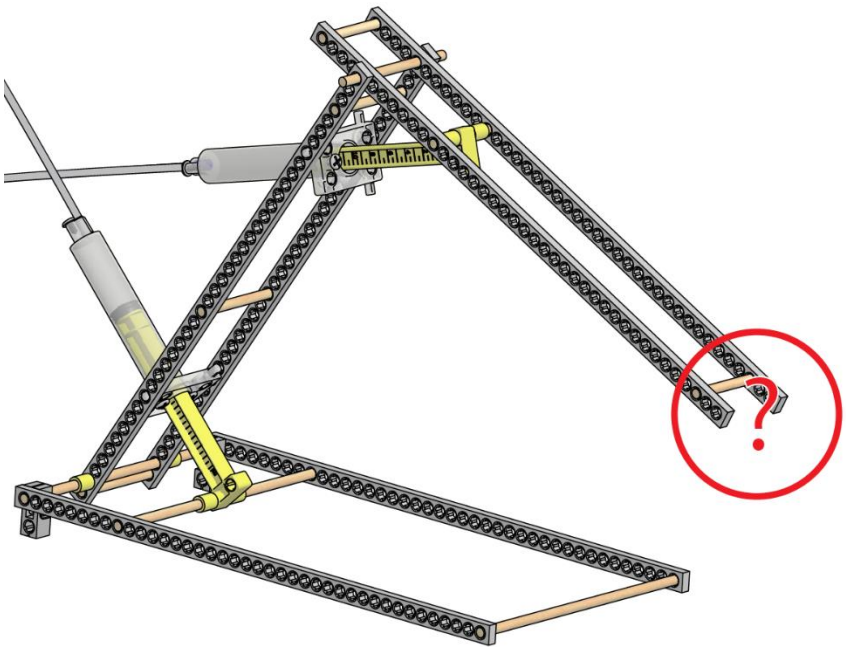


End Effector

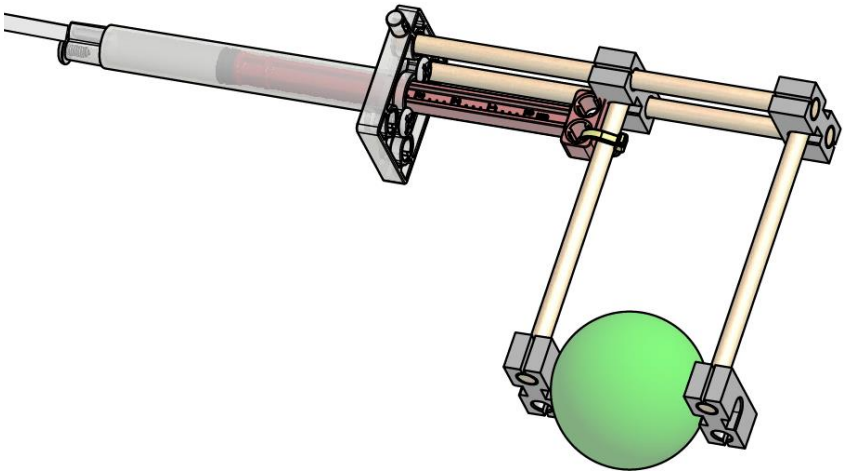
It is now time to create the end effector. The end effector is a device or tool that is connected to the end of a robot arm (where the hand would be). The end effector you create should be for the task your robot must complete. The end effector could perform tasks such as griping, suction, scooping, dispensing, or welding.

End Effector Options:

a) Create the example gripper (end effector).
b) Create your own end effector.
c) Create the example gripper and then change it into your own end effector.



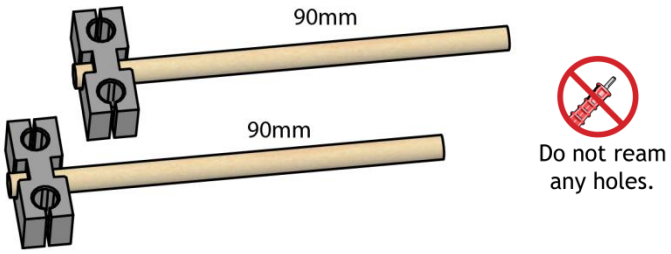
Example Gripper (End Effector)



Example griper holding a ball

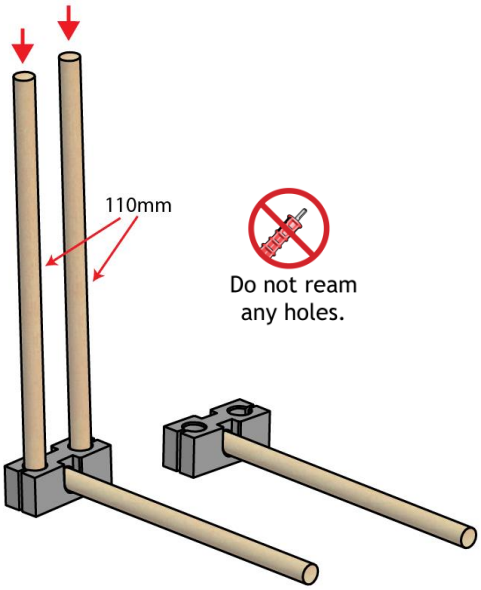
Step #35

a) Cut two 90mm (~3.5in) dowels.
b) Push/tap the dowels into two blocks.



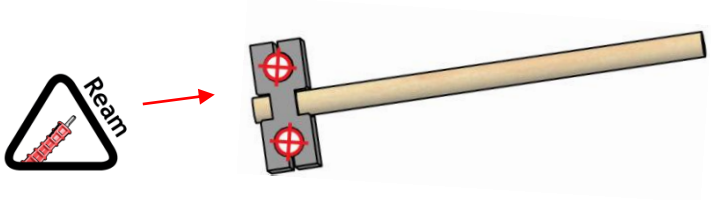
Step #36

a) Cut two 110mm (~4 3/8in) dowels.
b) Push/tap the dowels into one of the blocks from Step #35.



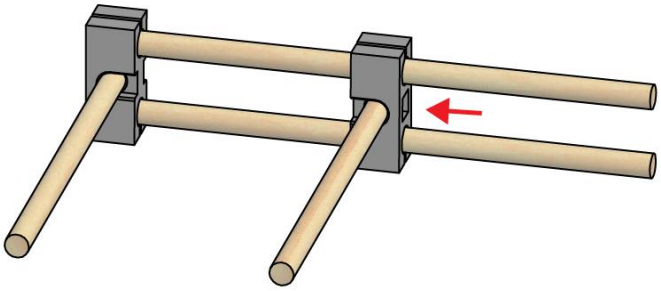
Step #37

Ream the holes marked ⊕ in the block assembly shown.



Step #38

Slide the reamed block assembly from Step #37 onto the 110mm dowels from Step #36. If the block does not slide easily, ream the holes again.

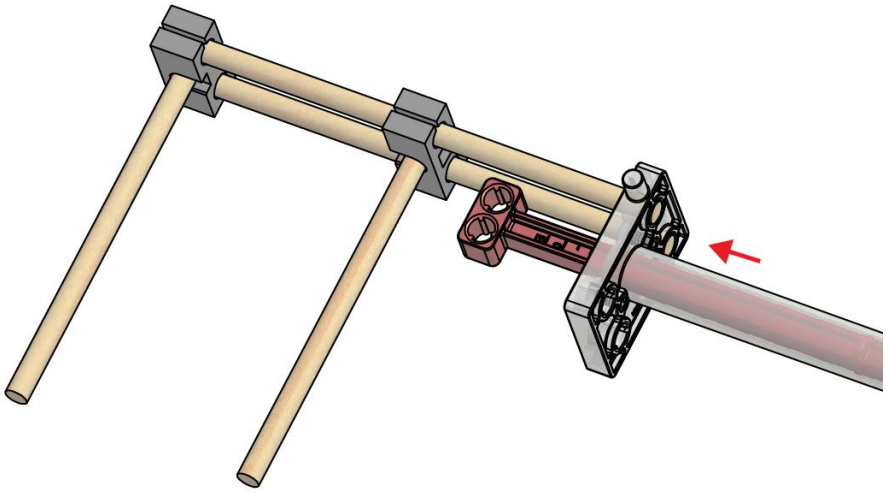


Step #39

Get the hydraulic system, created during Steps 8-13, with 115cm (~45”) of tubing. This system will be used to power your gripper.

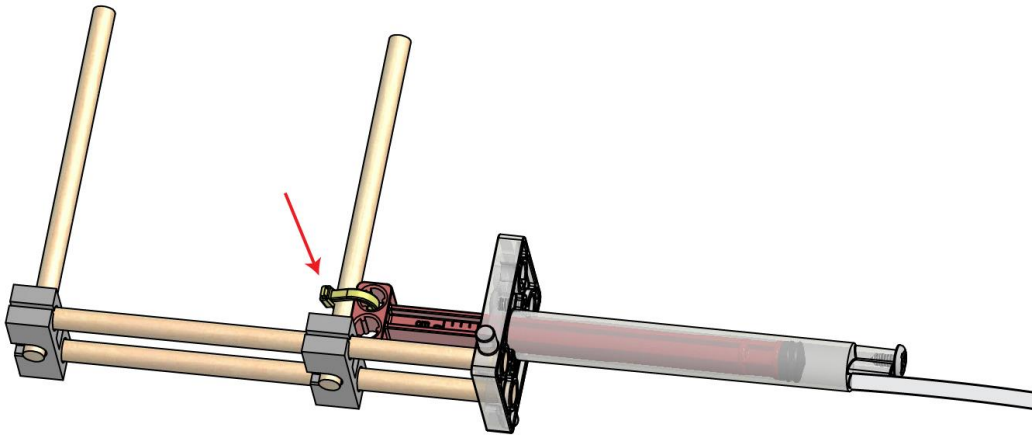
Step #40

Push/tap the 3.5ml cylinder from your hydraulic system onto the assembly from step #38.



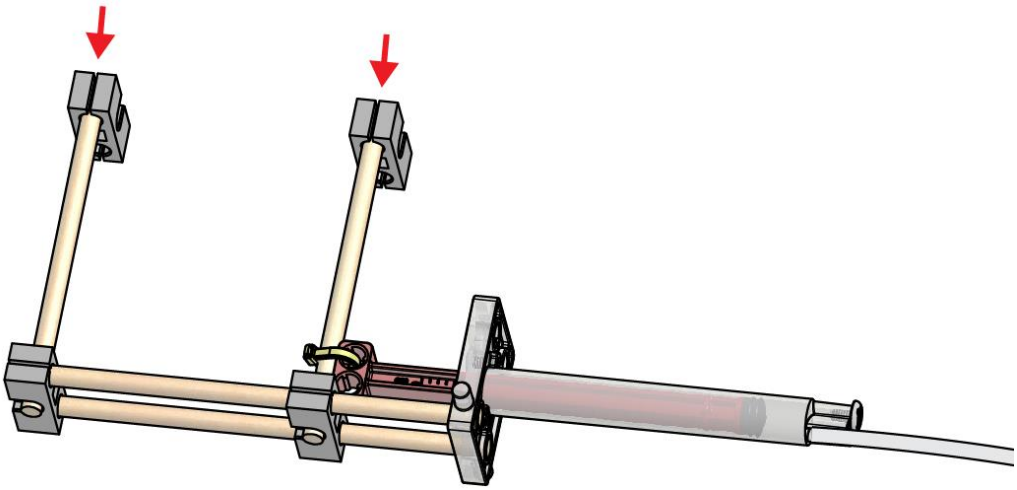
Step #41

Use a cable tie to attach the cylinder piston to the dowel on the sliding block.



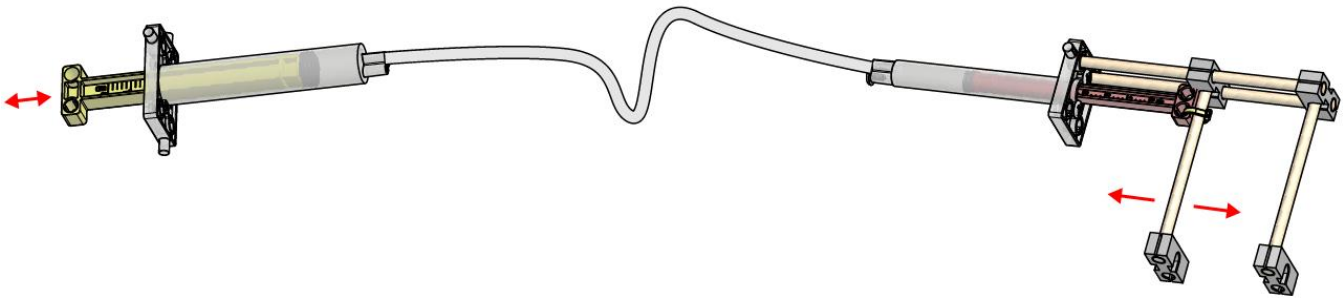
Step #42

Place blocks onto the ends of the 60mm dowels.



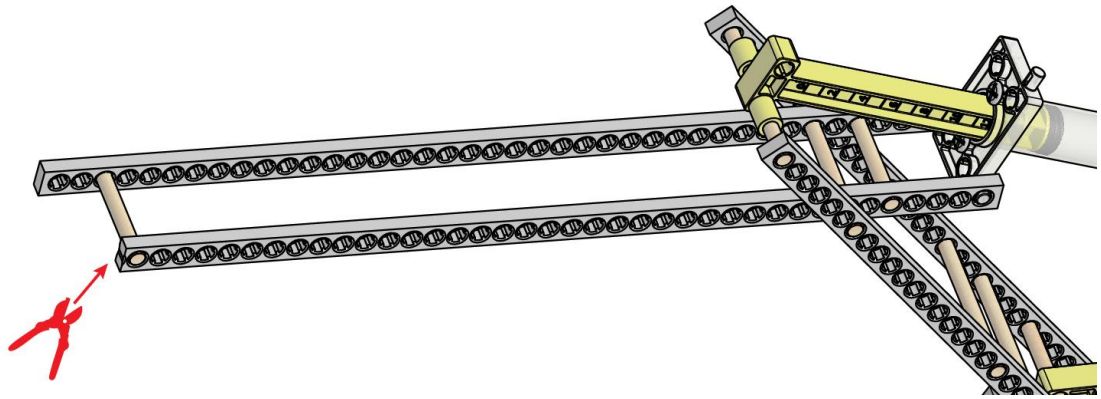
Step #43

Your Gripper is finished. Move the 13ml cylinder piston. It should move the gripper finger.



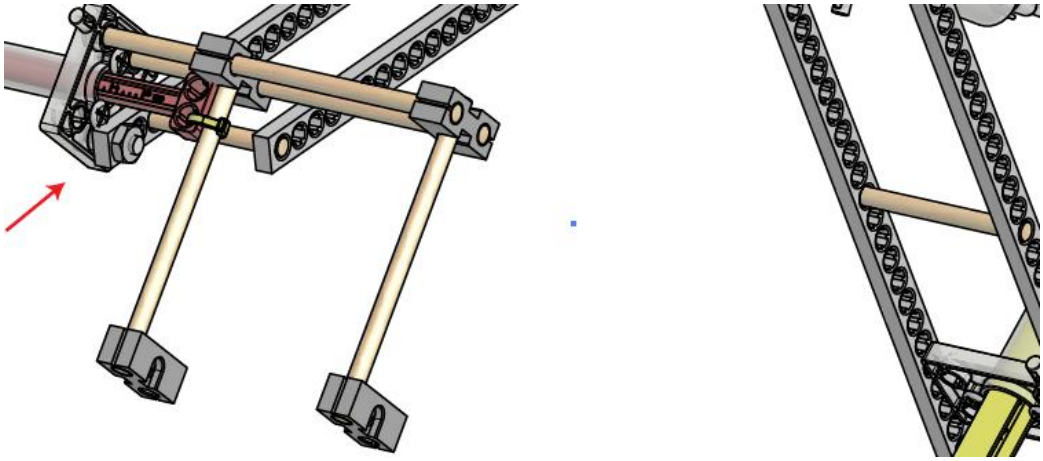
Step #44

Cut the connector strip as shown on the second arm boom.



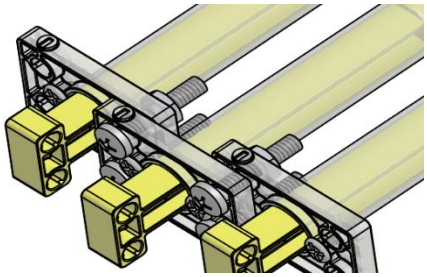
Step #45

Use a screw and nut to attach the gripper to the forearm.



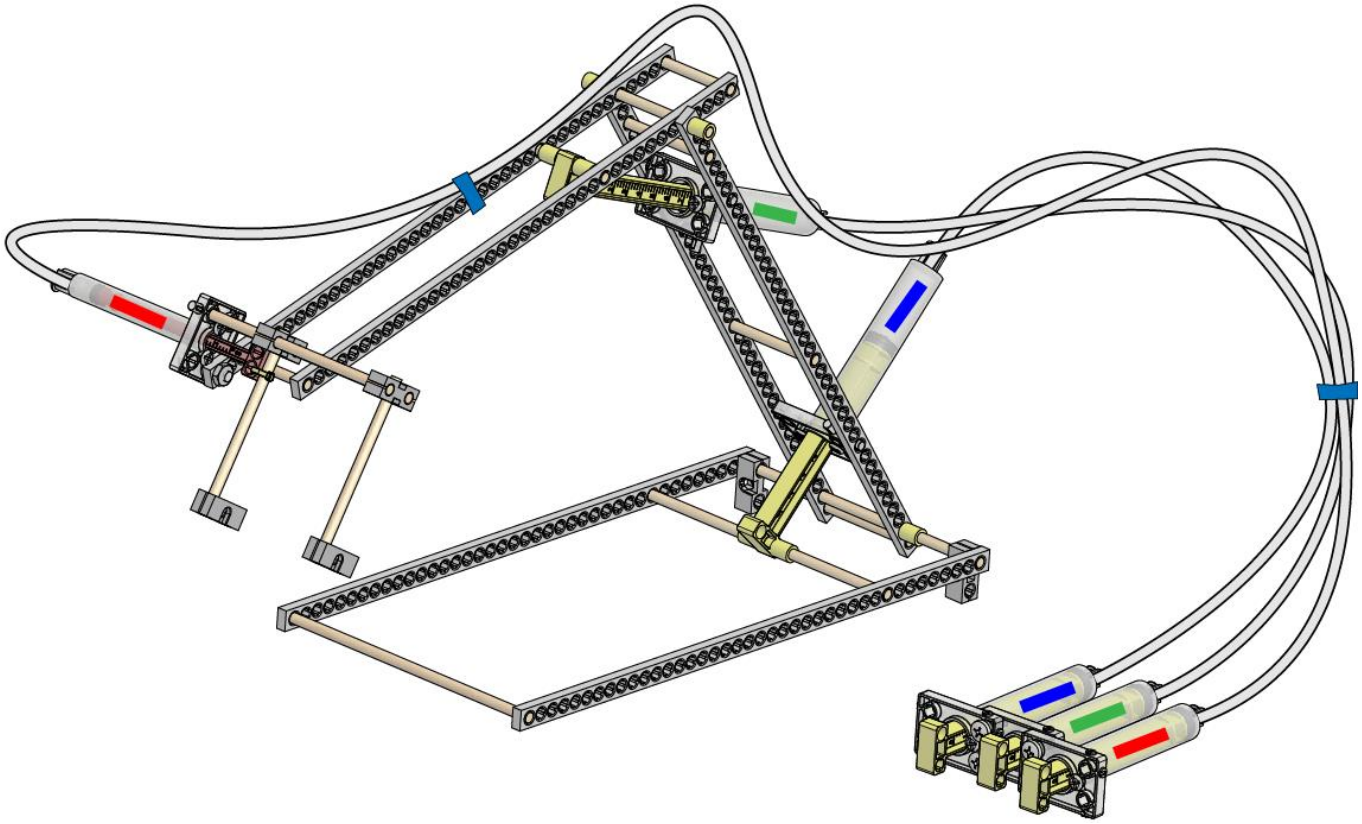
Step #46

Use a screw and nut to attach the gripper controlling cylinder to the control panel.



Step #47

a) Use tape to attach the tubing to the arm. Make sure you do not crimp (smash) the tubing.
b) Use different colored permanent markers or tape to identify the control panel cylinders that connect to arm cylinders.
c) Change your arm to allow it to travel the greatest distance and best pickup objects.



Your example arm is finished.
It is your turn to play with it, improve it, and change it into your own design.

Hydraulic arm engineering challenges are available at TeacherGeek.com under *documents*.