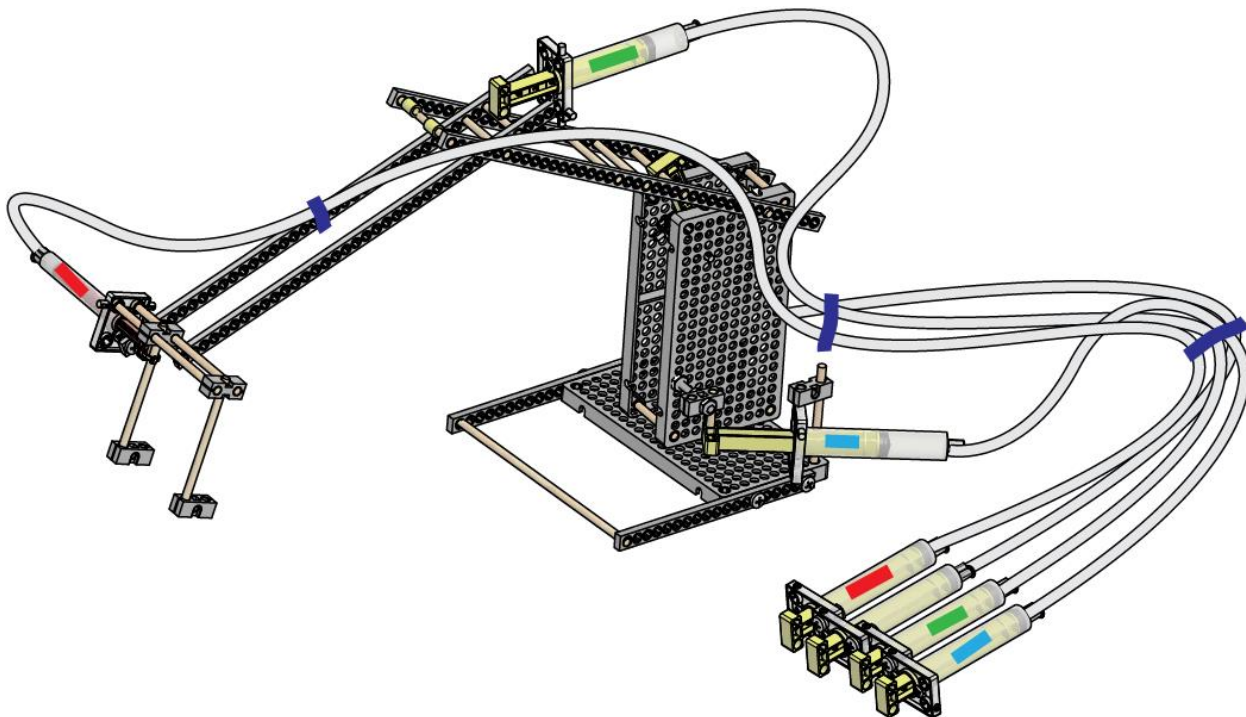


# ADVANCED HYDRAULIC ARM X2

## Build Guide

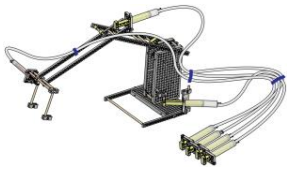
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This guide will take you through the following steps:

- **Cylinder Assembly:** Create the cylinders and cut the tubing for your hydraulic arm.
- **Fluid Power Lab:** An optional lab available at [teachergeek.com](http://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](http://TeacherGeek.com).

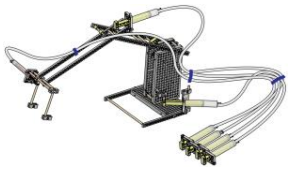


# ADVANCED HYDRAULIC ARM X2

## Build Guide

### Materials included in the TeacherGeek Advanced Hydraulic Arm Packs:

Component	Picture	# in 10 Pack	# For a Single Advanced Arm	# Required to Build Example Arm	# Extra -To Innovate Your Own Design
Strips		80	8	5	3
Dowel		80	8	5	3
Tubing		30M (100ft)	Cut 285cm (~10ft)	Cut 285cm (~10ft)	15cm (~6in)
Blocks		100	10	7	3
Hole Plate		30	3	3	0
Slide Stop 3in Section		10	1	1	0
#10 1.5in Screw		10	1	1	0
#10 1in Screw		140	14	12	2
#6 x .5in Screw		240	24	24	0
#10 Nut		160	16	14	2
#10 Locking Nut		10	1	1	0
Rubber Band		100	10	4	6
Cable Tie		20	2	1	1
13ml Cylinder Barrel		70	7	7	0
13ml Cylinder Plunger		70	7	7	0
13ml Cylinder Piston		70	7	7	0
4ml Cylinder Barrel		10	1	1	0
4ml Cylinder Plunger		10	1	1	0
4ml Cylinder Piston		10	1	1	0
1cc Silicone Grease Packet		10	1	1	0



# ADVANCED HYDRAULIC ARM X2

## Build Guide

### Other Materials:

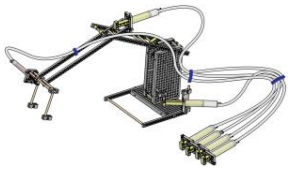
The TeacherGeek system is designed to be used with other materials you can find (materials not supplied in the TeacherGeek pack). Other materials could be craft supplies, from a recycling bin wood, metal, cardboard, or anything else you may have. These materials can be used to help you create your own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

Age Level Recommendation: 12 and above

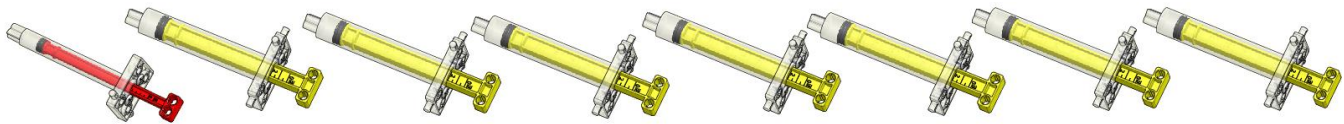


# ADVANCED HYDRAULIC ARM X2

## Build Guide

## Cylinder Construction

Repeat steps 1-5 below to create seven 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

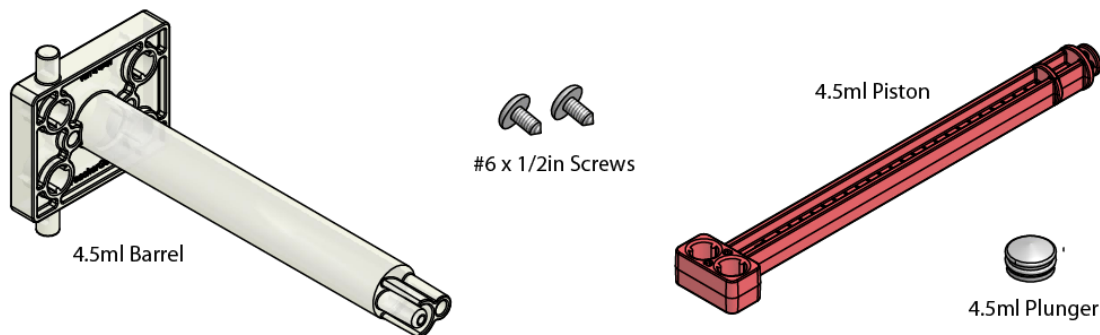
Gather your components. You will also need one silicone grease packet.

**Caution:** Do not assemble your cylinders without silicone grease.

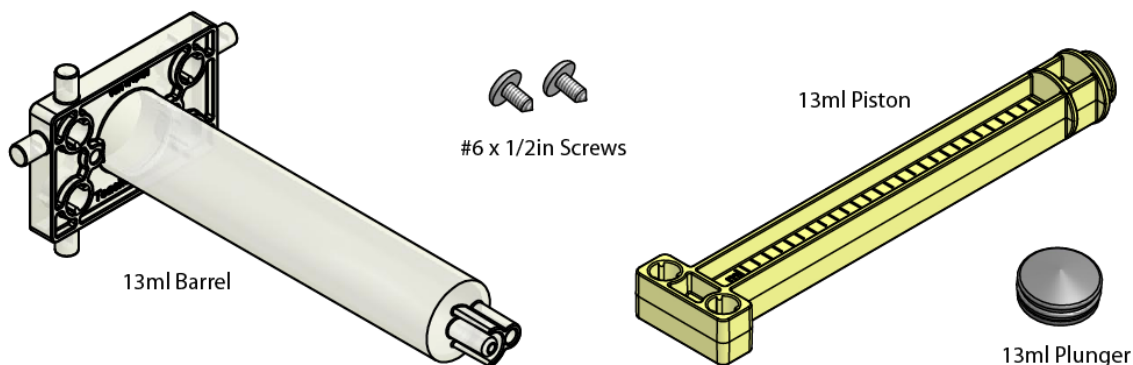
**Note:** The plunger will stick and fail without silicone grease lubricant.

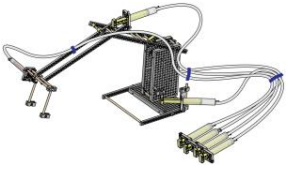


Components to create one 4.5ml cylinder:



Components to create one 13ml cylinder:



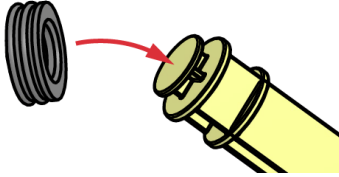


# ADVANCED HYDRAULIC ARM X2

## Build Guide

### Step #2

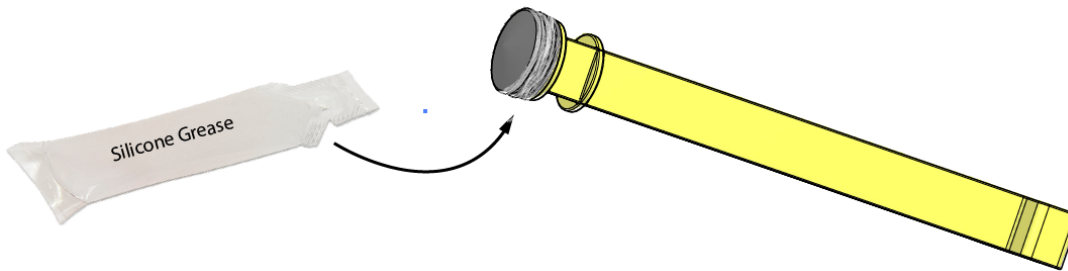
Place the plunger onto the piston.



### Step #3

Apply a small amount of silicone grease (best) or vegetable oil around plunger.

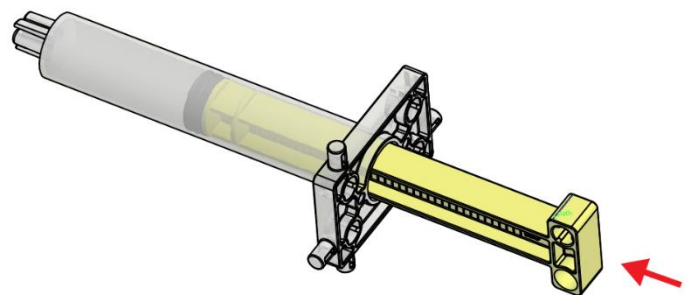
Note: Do not use Petroleum lubricants. They will cause the plunger to stick and fail.



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.

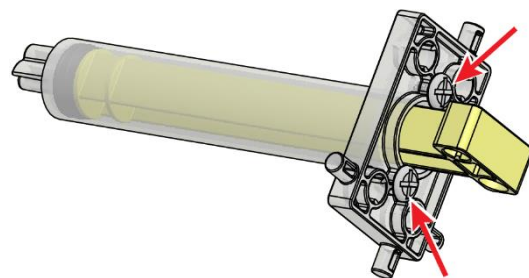
### Step #4

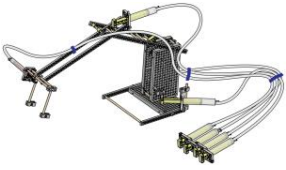
- Make sure the plunger is lubricated! If not, it will get stuck in the barrel.
- Insert the piston assembly into the barrel. Move the piston in and out to lubricate the barrel.



### Step #5

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





# ADVANCED HYDRAULIC ARM X2

## Build Guide

### Repeat

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



### Step #6:

Cut the following lengths of tubing:

Two 46cm (~18in) Sections

One 70cm (~28in) Section

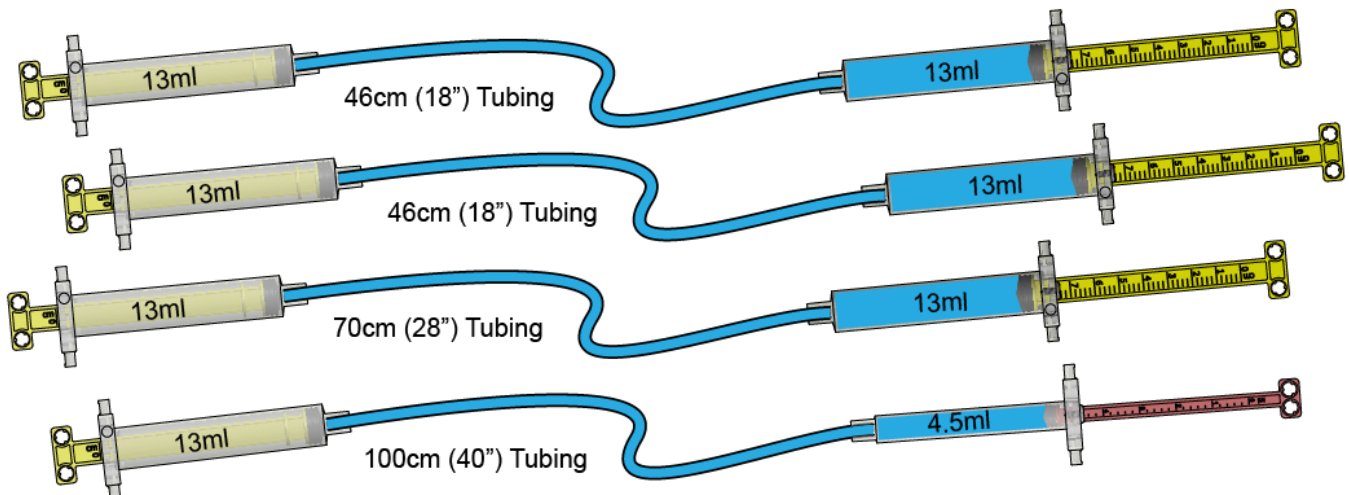
One 100cm (~40in) Section

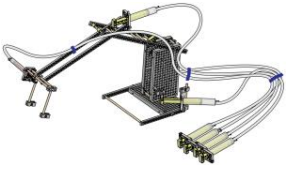
### Optional Fluid Power Lab

An optional lab is available at [teachergeek.com](http://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.





# ADVANCED HYDRAULIC ARM X2

## Build Guide

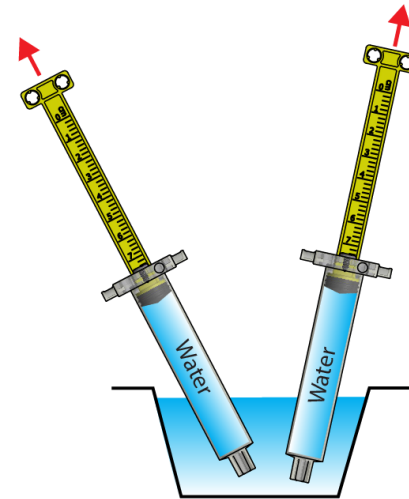
### Step #7

Fill each cylinder with water:

- Push the cylinder piston in.
- Place the cylinder tip under water.
- Pull the piston back to completely fill the cylinder with water.

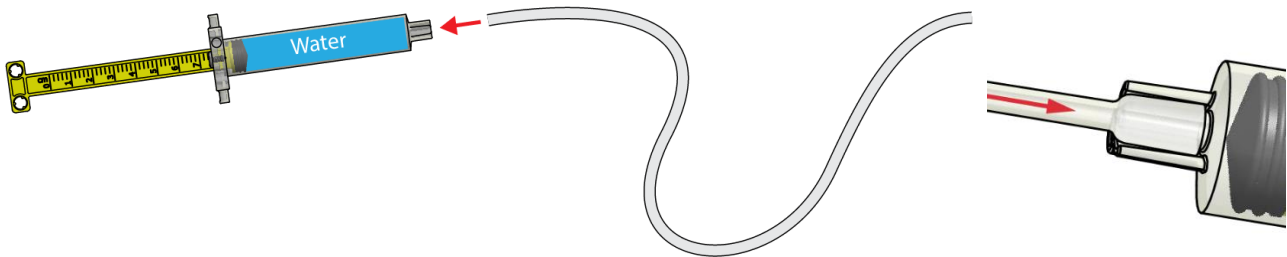
Note: There should be no air bubbles in the water filled cylinders.

Tip: Color the water.



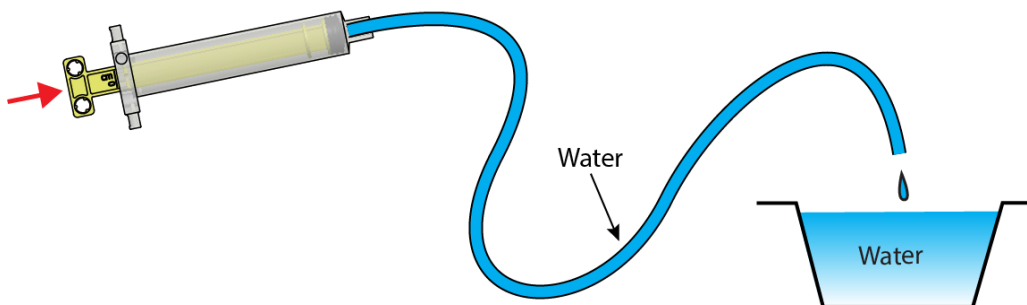
### Step #8

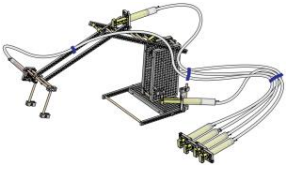
Attach the cut tubing to the first water filled cylinder. If you will be connecting a 13ml and a 4.5ml cylinder with tubing, attach the 13ml cylinder to the tubing first.



### Step #9

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



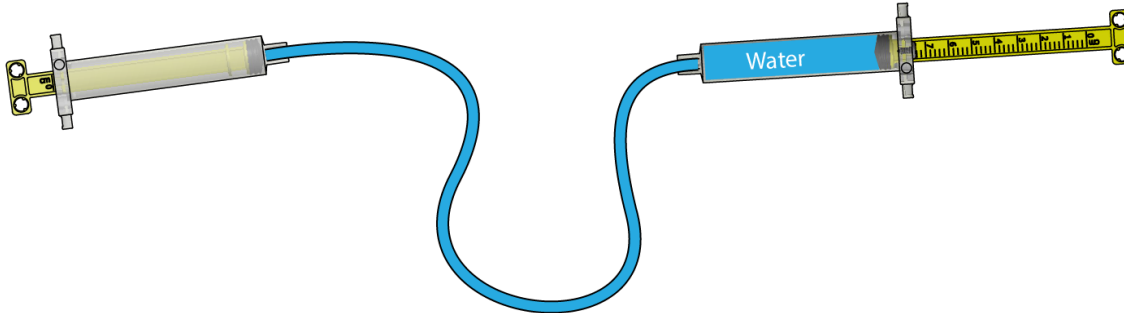


# ADVANCED HYDRAULIC ARM X2

## Build Guide

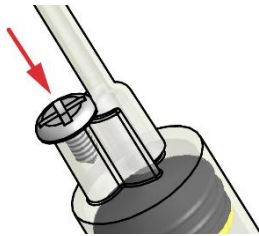
### Step #10

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

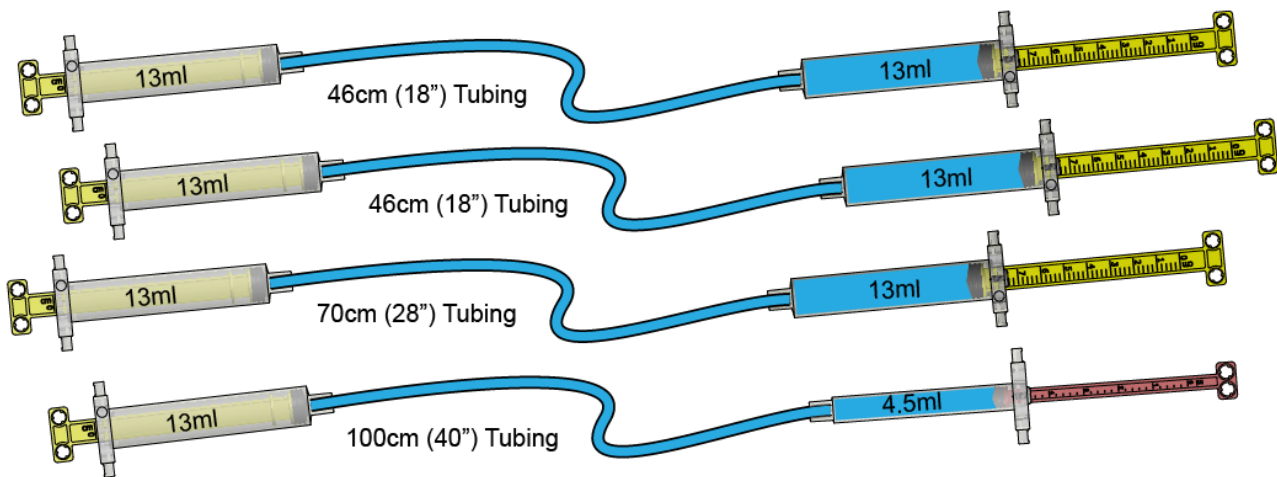


### Step #11

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



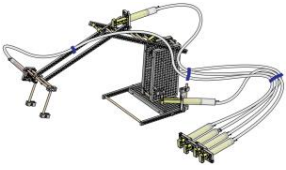
Have you repeated steps 8-12 to create the hydraulic systems listed below?  
If so, continue to the next page.



No Bubbles

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.





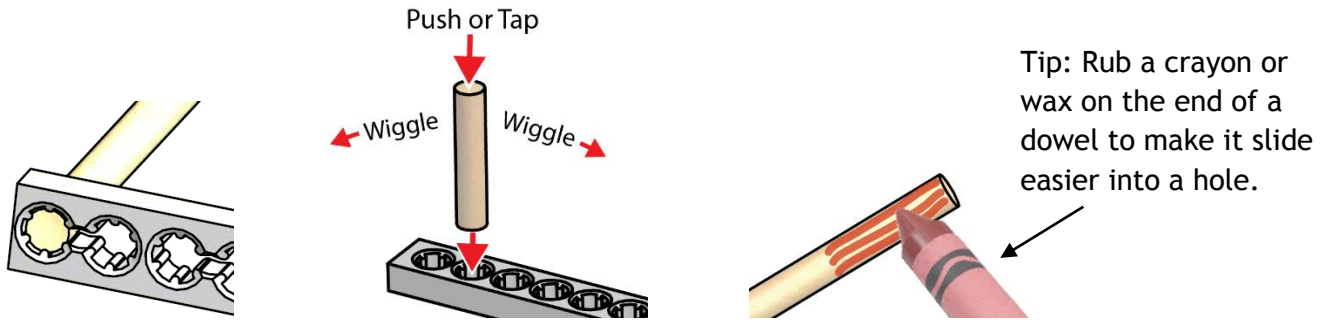
# ADVANCED HYDRAULIC ARM X2

## Build Guide

## How does the TeacherGeek system work?

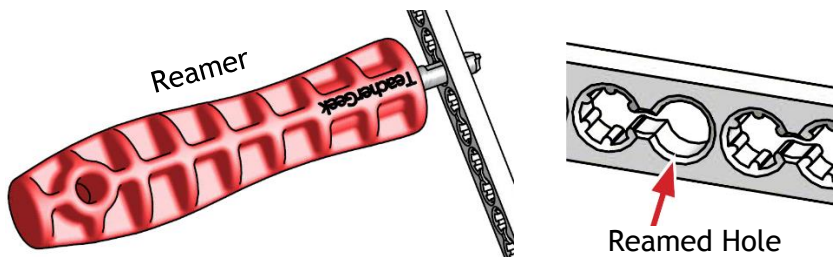
### Dowels & Holes

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.



### 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.

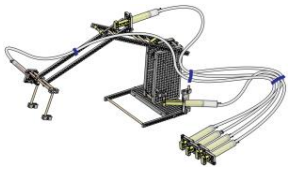
### Multi-Cutter

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.

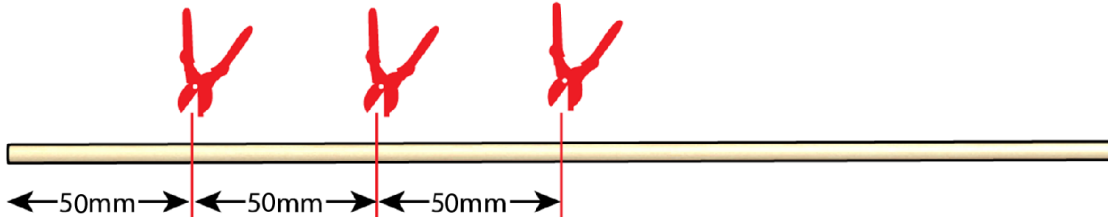


# ADVANCED HYDRAULIC ARM X2

## Build Guide

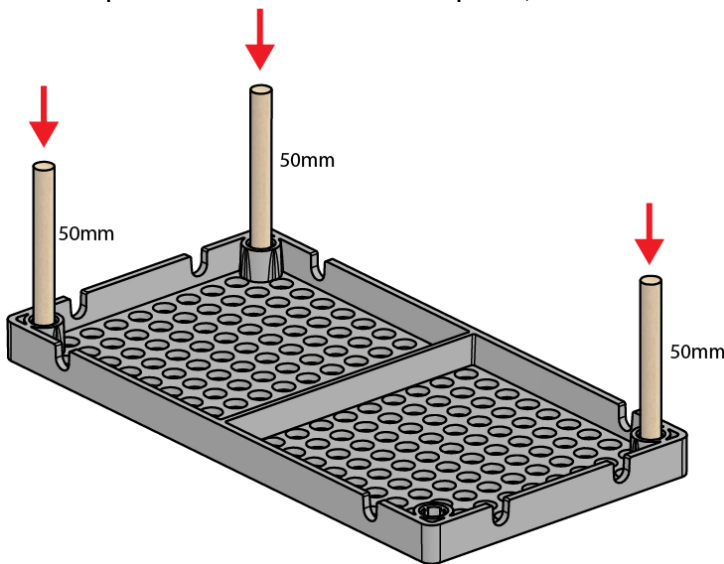
### Step #12

Cut three 50mm (2") dowels. Save the extra dowel pieces. You will use them later.



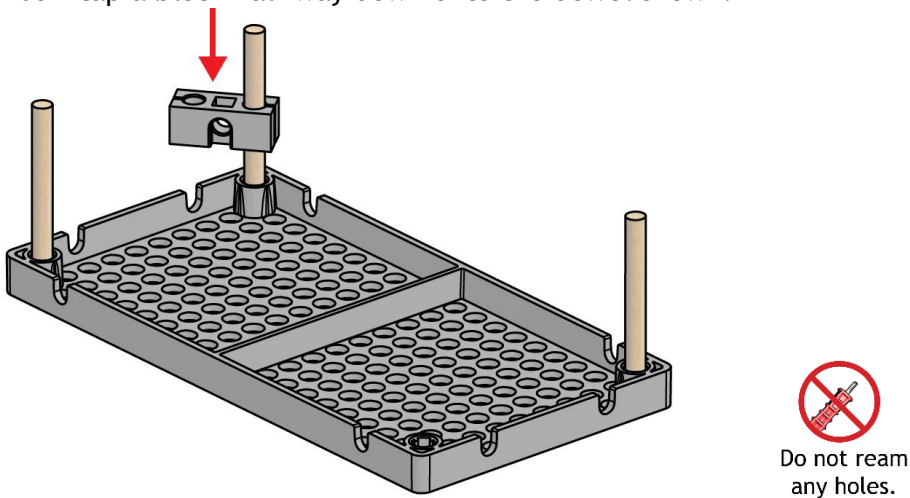
### Step #13

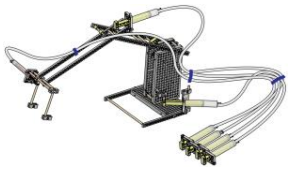
Push/tap the 50mm dowels into a plate, as shown.



### Step #14

Push/tap a block half way down onto the dowel shown.



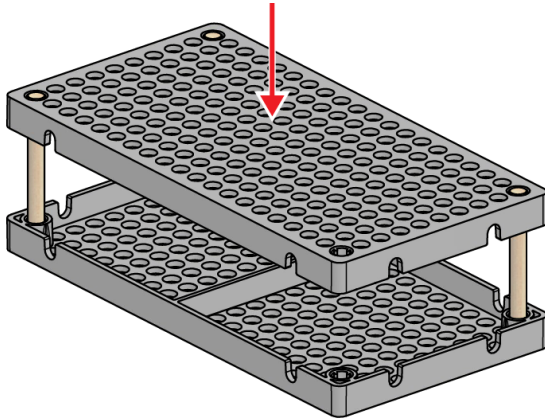


# ADVANCED HYDRAULIC ARM X2

## Build Guide

### Step #15

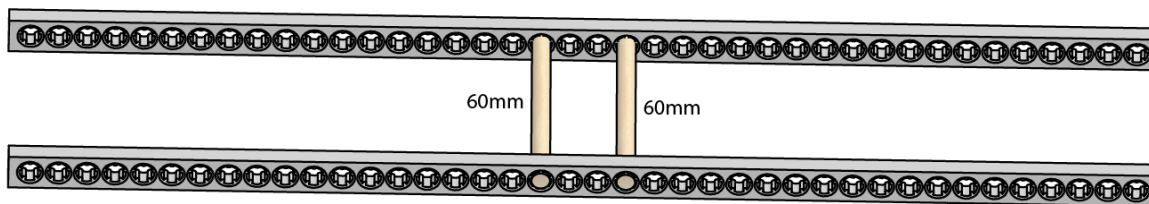
Push/tap a second plate onto the dowels from Step #3. This will become the waist for your arm.



Do not ream any holes.

### Step #16

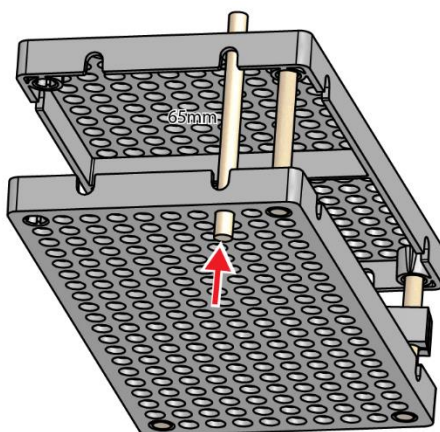
- a) Cut two 60mm (2 3/8") dowels.
- b) Push/tap the 60mm dowels into two strips as shown. This creates the main boom.



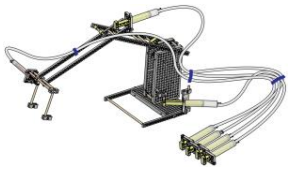
Do not ream any holes.

### Step #17

- a) Cut a 65mm (2 3/8") dowel.
- b) Slide the 65mm dowel into the plate holes.



Do not ream any holes.

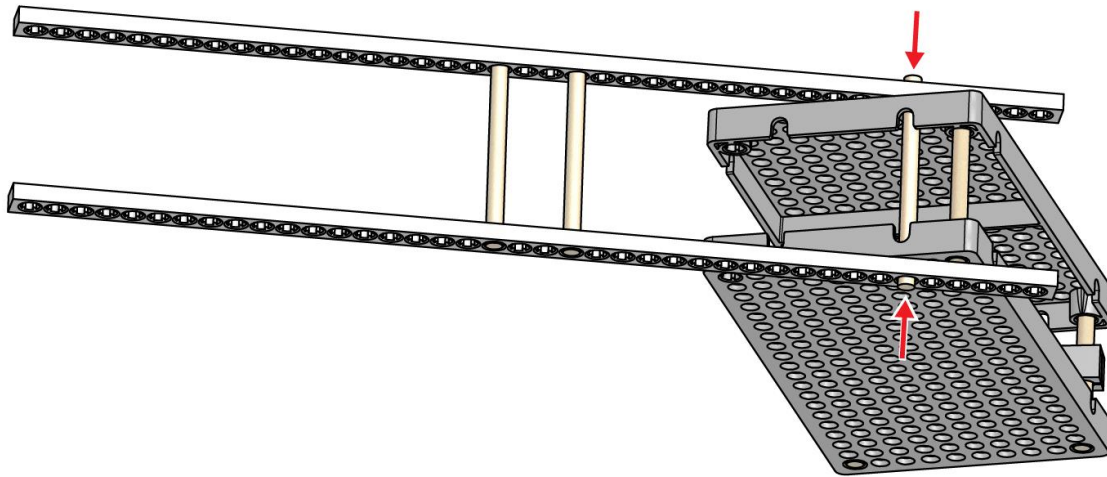


# ADVANCED HYDRAULIC ARM X2

## Build Guide

### Step #18

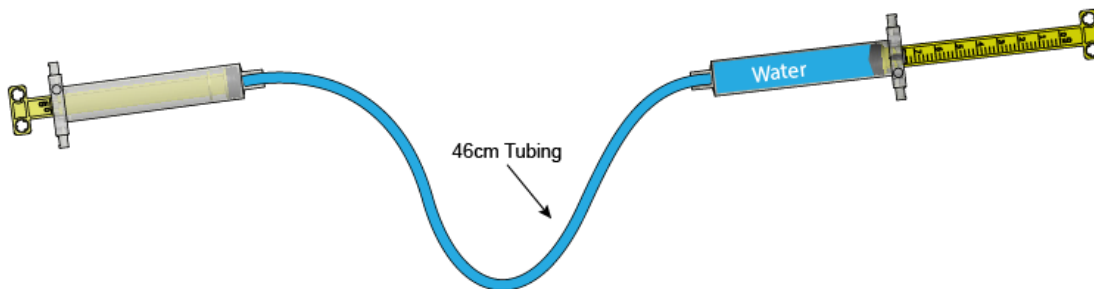
- a) Spread the main boom strips apart slightly and position them on either side of the 65mm dowel. Push/tap the strips together to attach them to the dowel. This creates the boom fulcrum (pivot point).



Do not ream any holes.

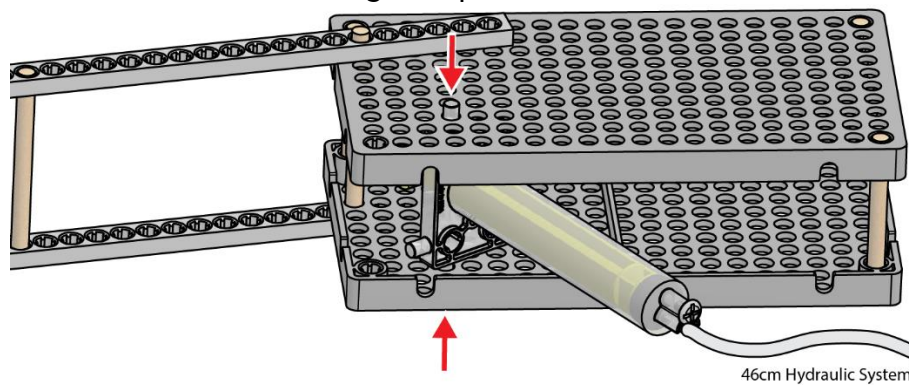
### Step #19

Get the hydraulic system, from Steps 1-11, with 46cm (18") of tubing.

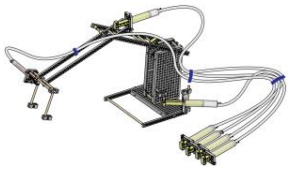


### Step #20

- a) Spread the plates apart to place a cylinder from Step #19 inside the plates. The cylinder should extend through the plate holes.



Do not ream any holes.

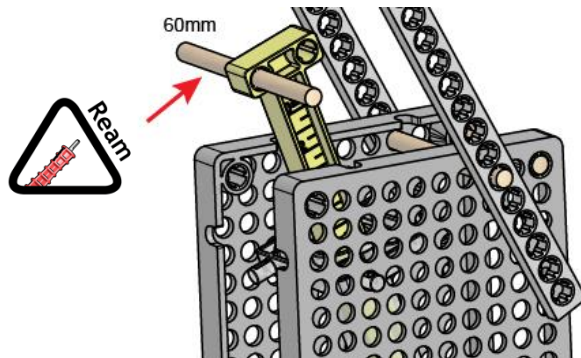


# ADVANCED HYDRAULIC ARM X2

## Build Guide

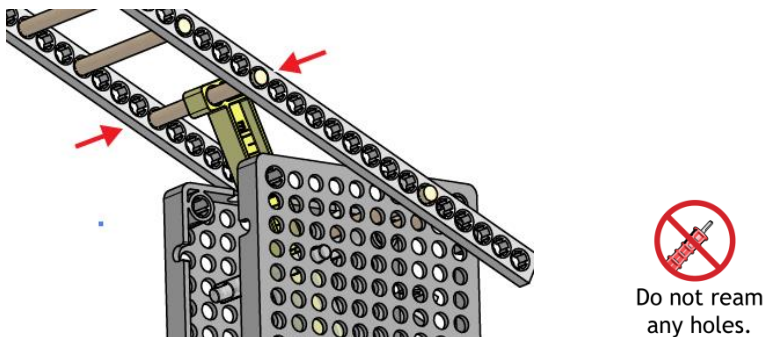
### Step #21

- Ream the hole shown on the cylinder piston.
- Cut a 60mm (2 3/8") dowel and slide it into the reamed hole.



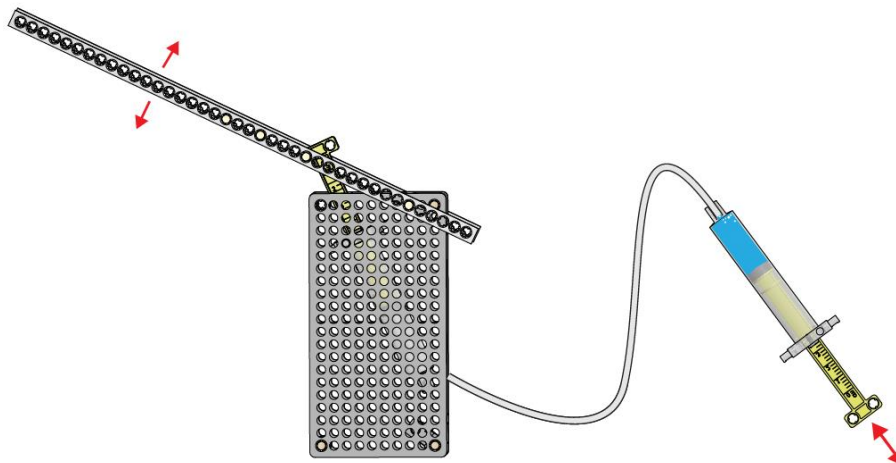
### Step #22

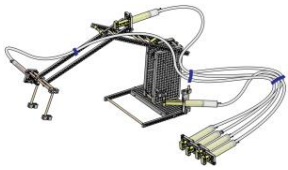
- Spread the main boom strips apart.
- Insert the 60mm dowel from Step #11 into the strip holes.
- Push/tap the strips back together to attach the 60mm dowel.



### Step #23

You have created the shoulder for your arm.  
The boom should move as the cylinders are pushed and pulled.



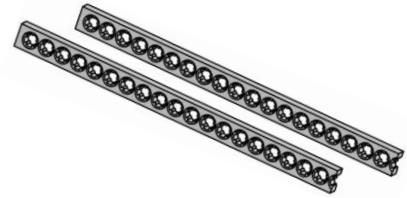
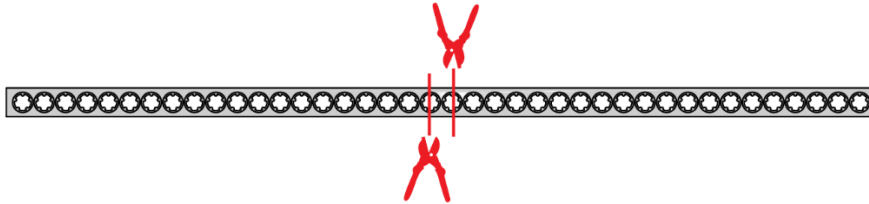


# ADVANCED HYDRAULIC ARM X2

## Build Guide

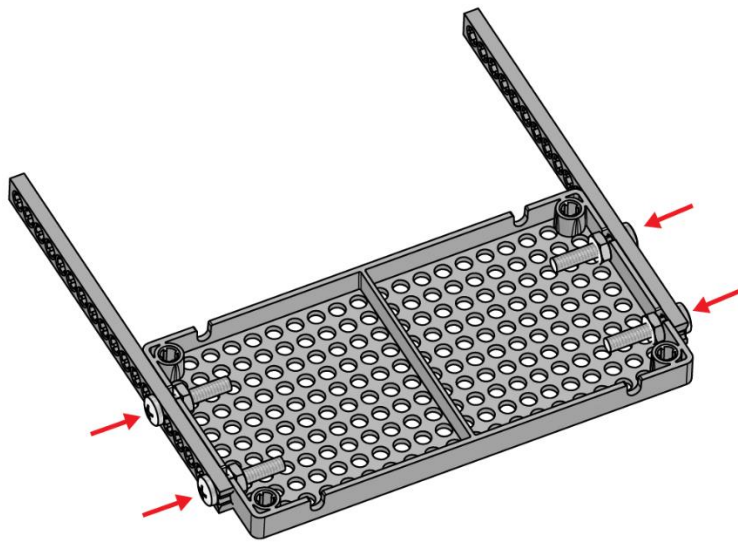
### Step #24

Cut a strip in half. Strips do not have a center hole so they must be cut as shown to get two equal length pieces.



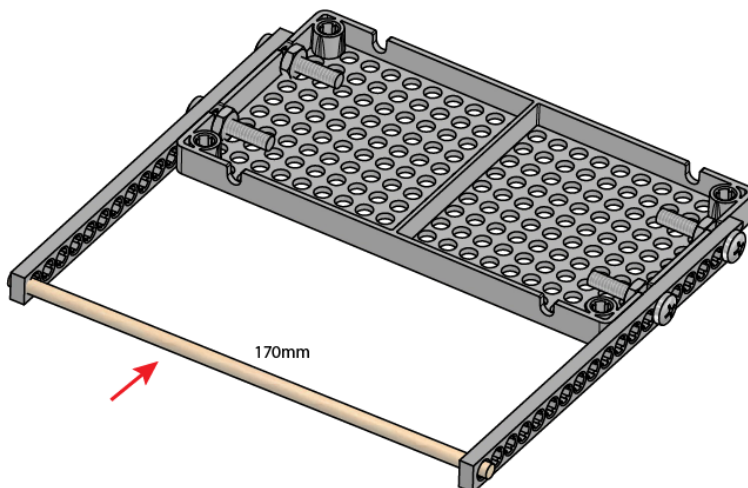
### Step #25

Use four #10 screws and nuts to attach the cut strips to a plate.

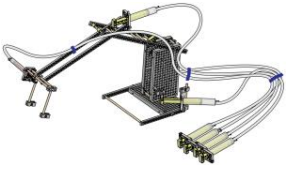


### Step #26

Cut a 170mm (6 5/8") dowel and push/tap it into the last holes on the strips. This forms the base of your arm.



Do not ream any holes.

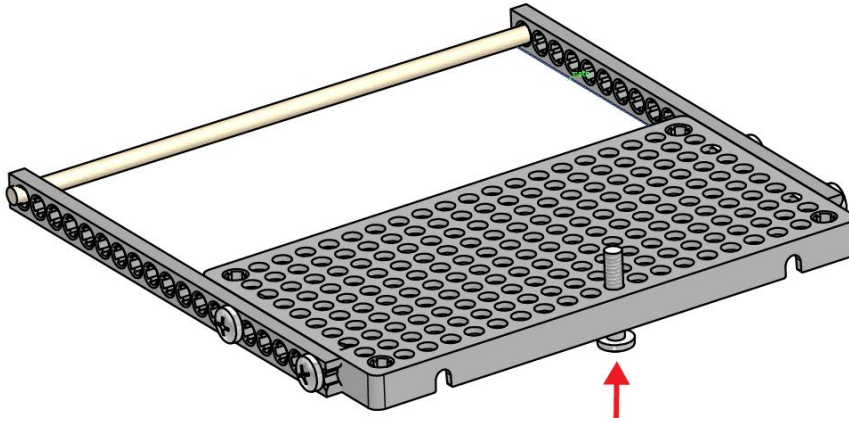


# ADVANCED HYDRAULIC ARM X2

## Build Guide

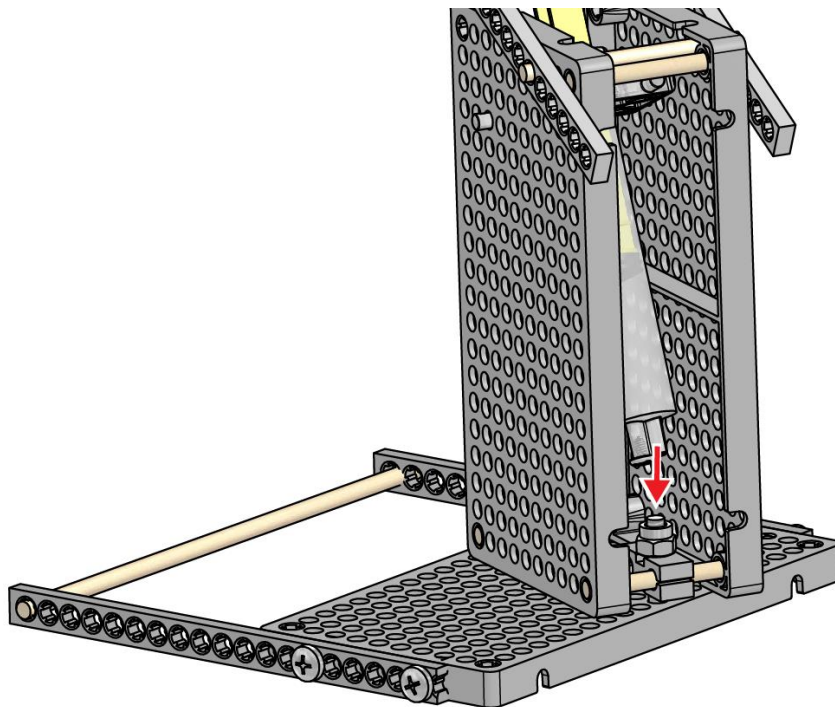
### Step #27

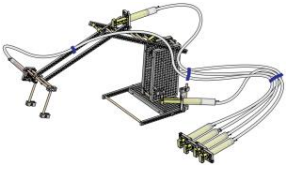
Place a #10 x 25mm (1in) screw up through the back center of the plate.



### Step #28

- Turn the screw from Step #17 into the block on the waist.
- Turn a locking nut onto the screw to hold the waist to the base.  
The screw and nut should be loose to allow the waist to easily turn on the base.



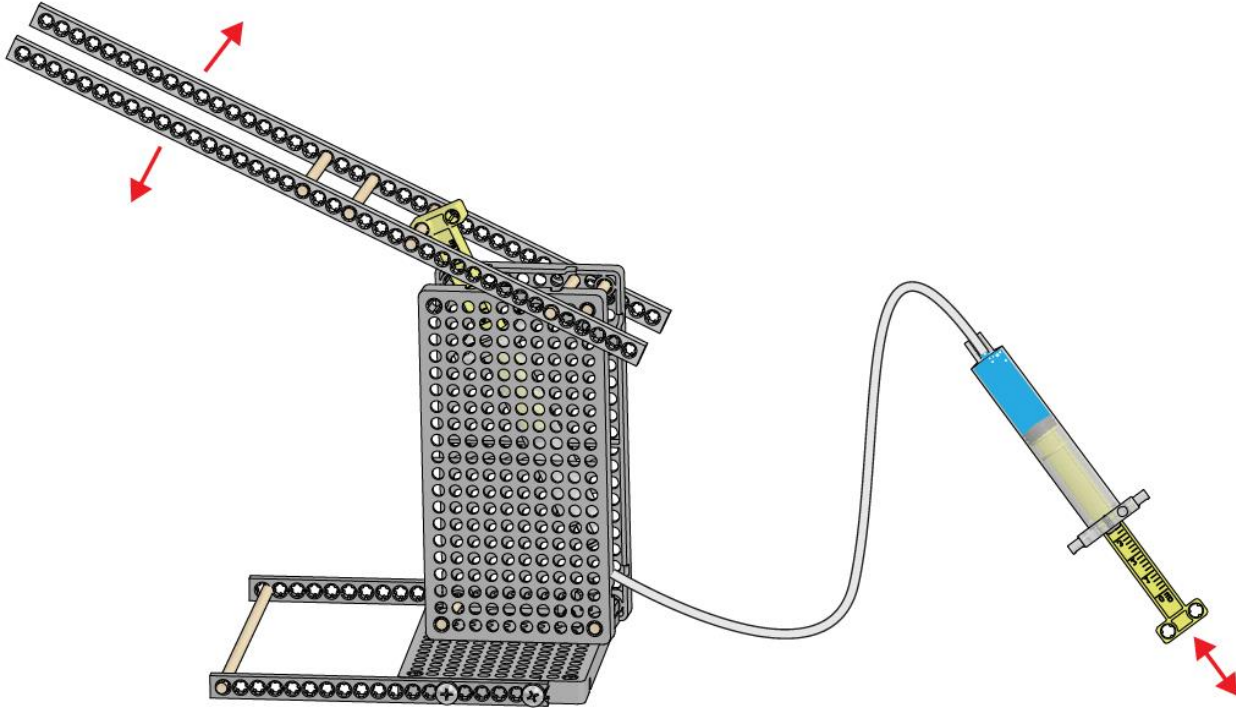


# ADVANCED HYDRAULIC ARM X2

## Build Guide

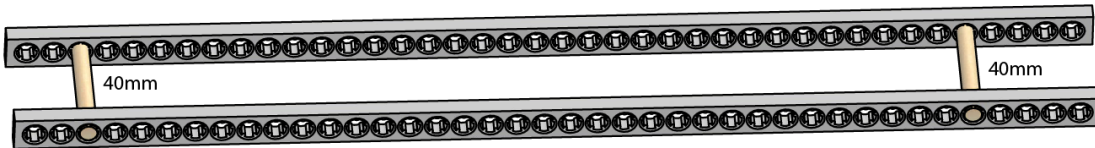
### Play!!!!

Experiment with your hydraulic system and lever arm.




### Step #29

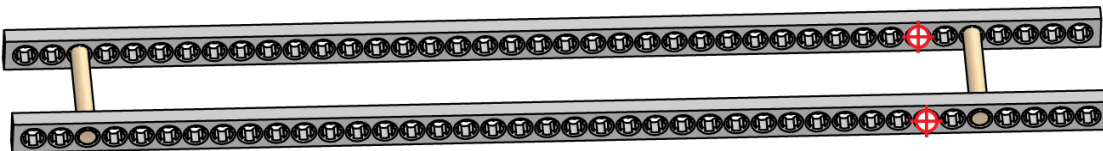
Create the forearm by cutting 40mm (1 5/8") dowels and placing them into strips.



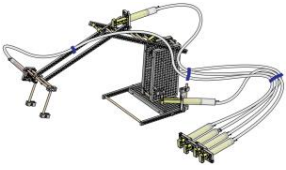
Do not ream any holes.

### Step #30

Ream the two holes marked with a .





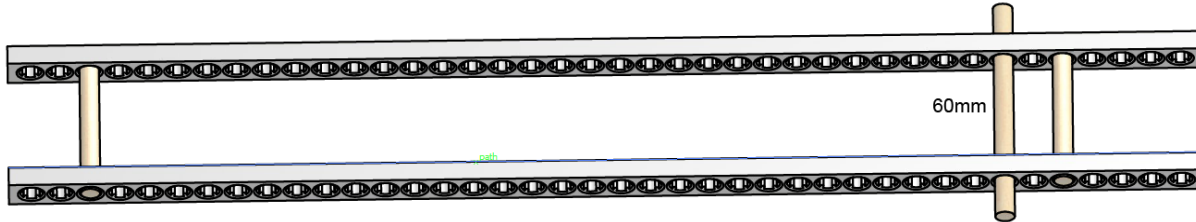


# ADVANCED HYDRAULIC ARM X2

## Build Guide

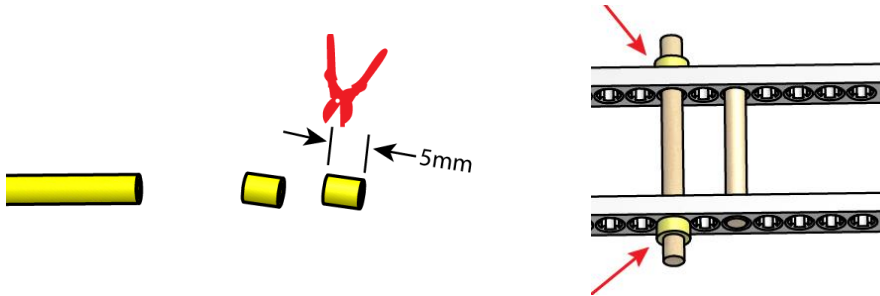
### Step #31

Cut a 60mm (2 3/8") dowel and slide it into the reamed holes.



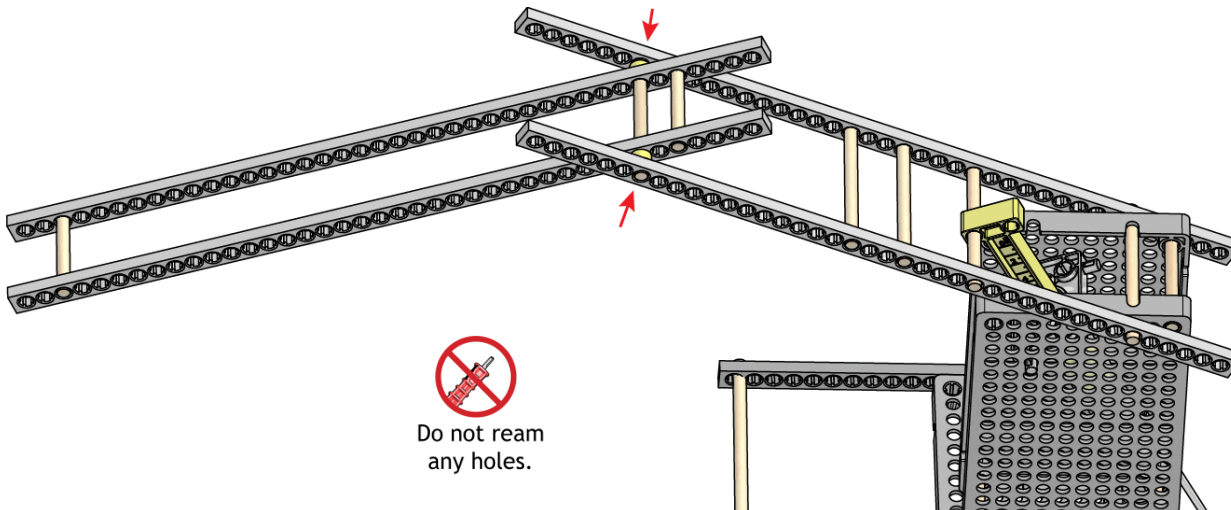
### Step #32

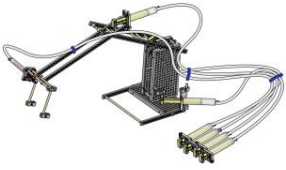
Cut slide stop into two 5mm (~3/16in) sections. Slide the 5mm sections onto the 60mm dowel. This becomes the forearm.



### Step #33

Spread the strips on the main arm apart to insert the forearm 60mm dowel. Push/tap the strips together to attach the forearm. This becomes the elbow.



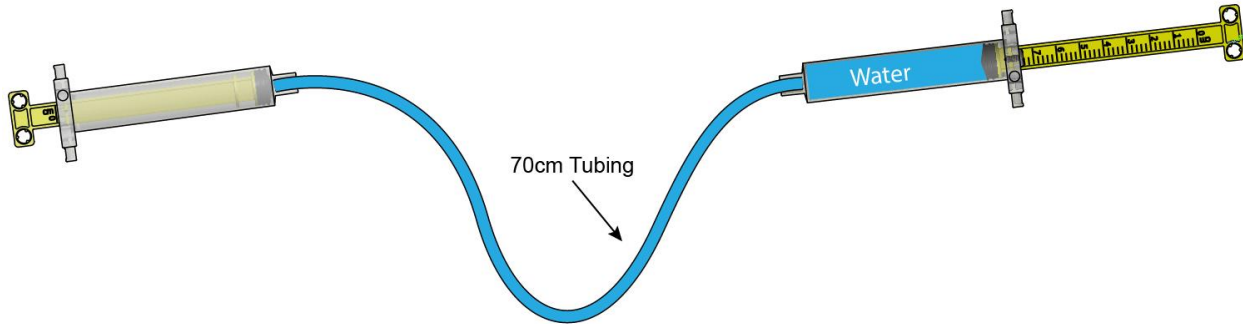


# ADVANCED HYDRAULIC ARM X2

## Build Guide

### Step #34

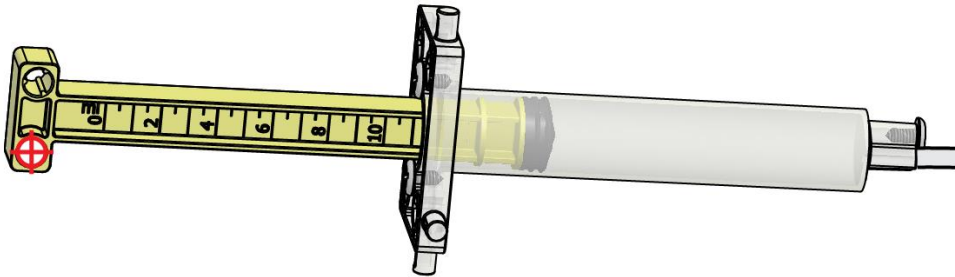
Use 70cm (~28in) of tubing and two 13ml cylinders to create your second hydraulic system. See the *Cylinder Assembly and Fill Guide* at [teachergeek.com](http://teachergeek.com) for instructions.



### Step #35

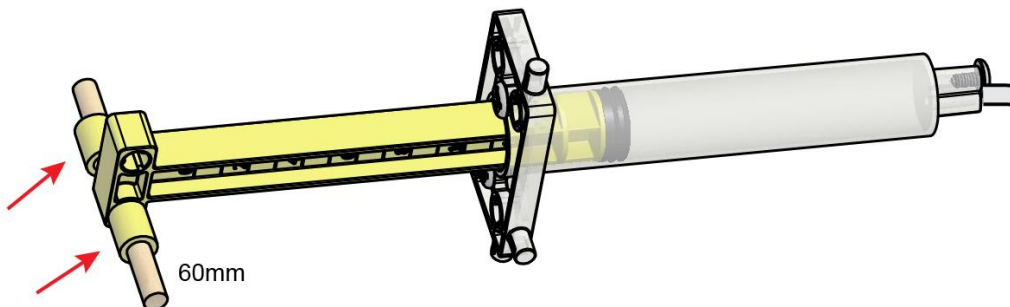
For one of the cylinders from step #24:

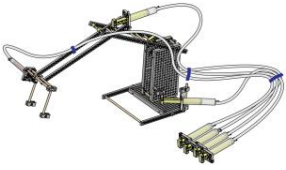
- Take out one of the #6 screws and turn the piston as shown.
- Place the #6 Screw back into the piston.
- Ream the hole marked with a  $\oplus$ .



### Step #36

- Cut a 60mm (2 3/8") dowel.
- Slide the 60mm dowel into the reamed hole from Step #25.
- Cut slide stop sections and use them to secure the 60mm dowel to the piston.



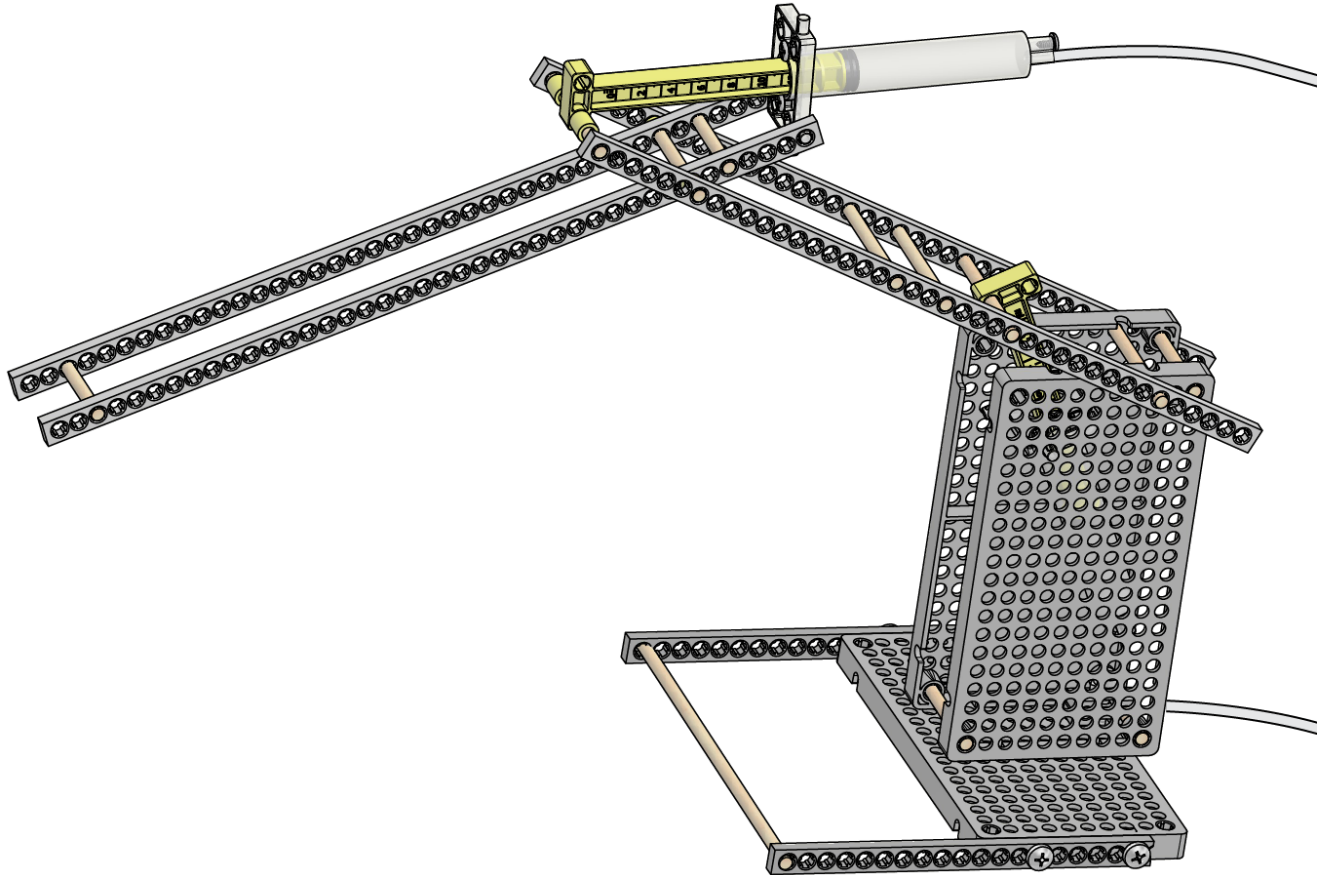


# ADVANCED HYDRAULIC ARM X2

## Build Guide

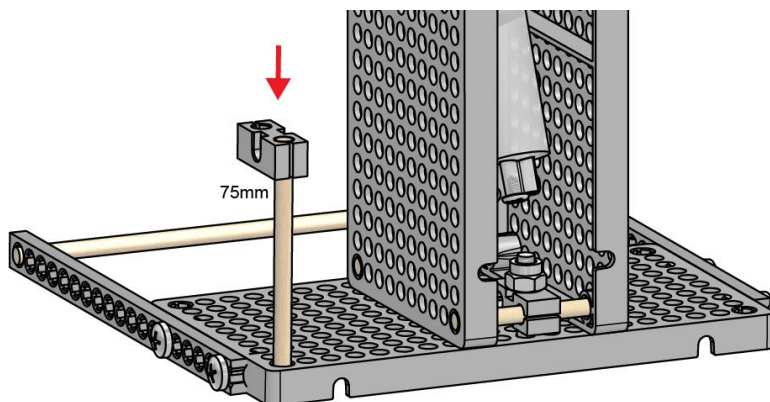
### Check it out!

Your Hydraulic arm should look like this. It is not done yet. You still need to make it turn and give it an end effector (gripper).

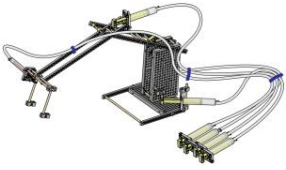


### Step #37

- Cut a 75mm (~3in) dowel.
- Push/tap the dowel into the corner base hole.
- Push/tap a block on top of the dowel.



Do not ream any holes.

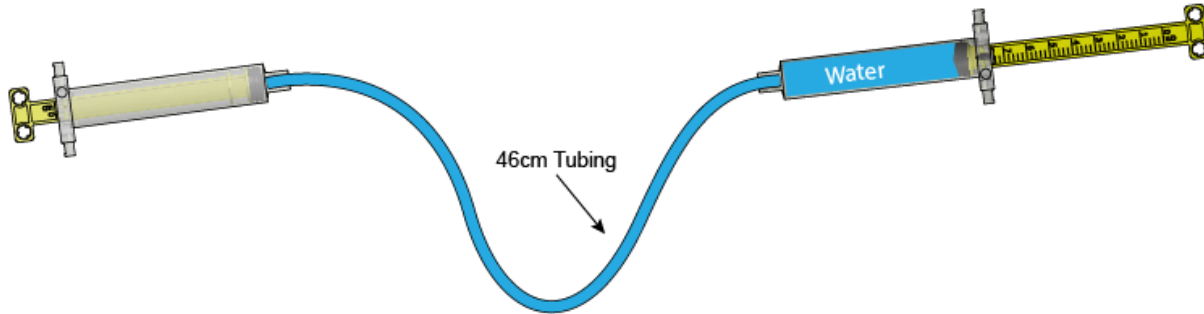


# ADVANCED HYDRAULIC ARM X2

## Build Guide

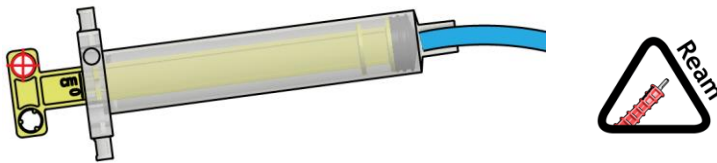
### Step #38

Use 46cm (~18in) of tubing and two 13ml cylinders to create your third hydraulic system. See the *Cylinder Assembly and Fill Guide* at [teachergeek.com](http://teachergeek.com) for instructions.



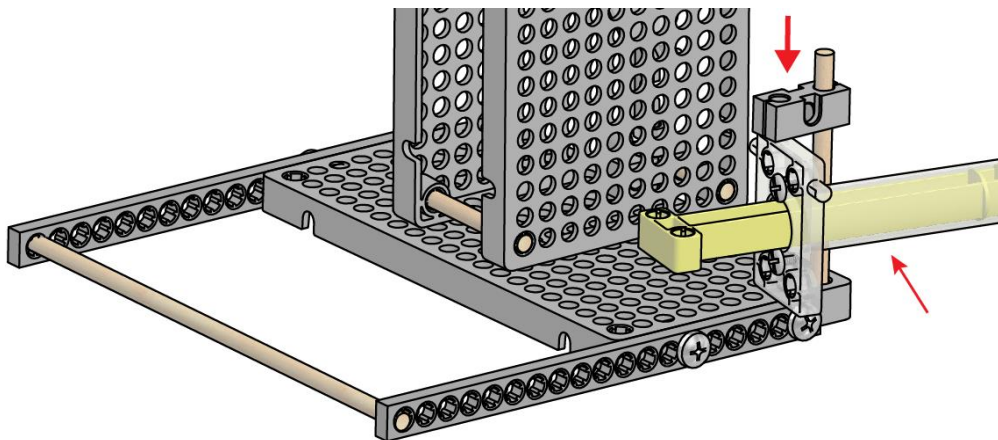
### Step #39

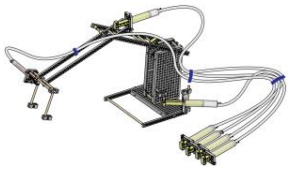
Ream the hole marked with a  on a cylinder from Step #28.



### Step #40

Attach the reamed cylinder from Step #29 by sliding the block down.



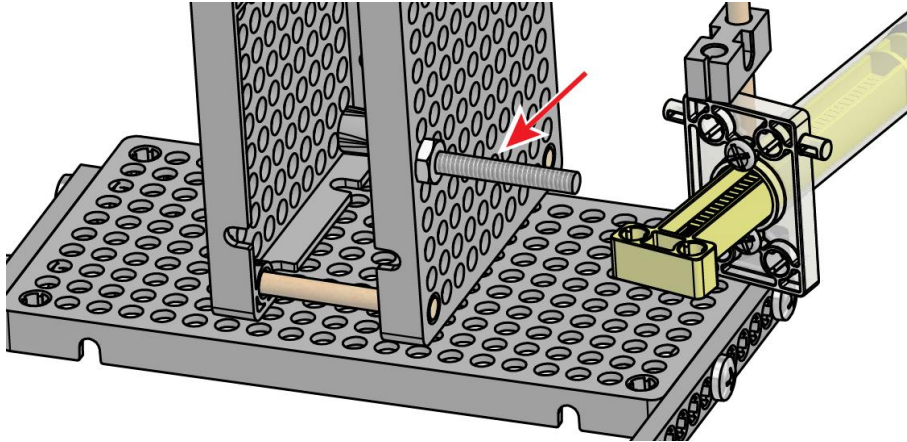


# ADVANCED HYDRAULIC ARM X2

## Build Guide

### Step #41

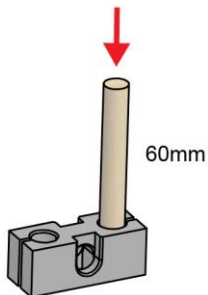
Place a 38mm (~1.5in) screw through the plate on the waist and secure it with a nut.



Do not ream any holes.

### Step #42

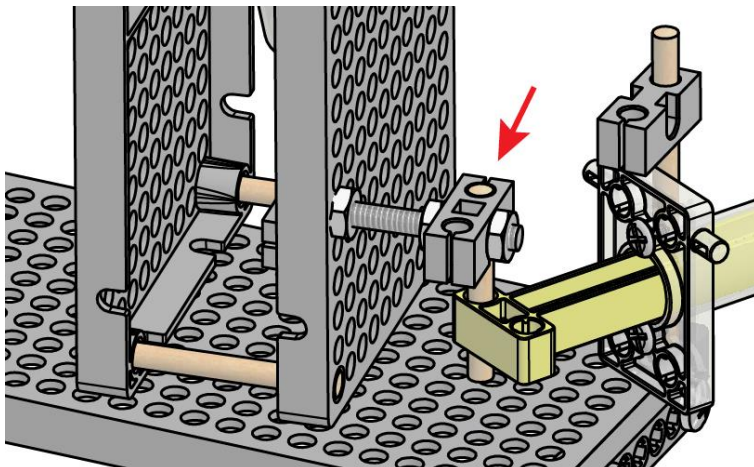
- Cut a 40mm (~1 1/2") dowel.
- Tap the 60mm dowel into a block.



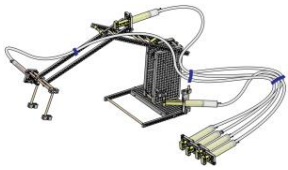
Do not ream any holes.

### Step #43

- Insert the 60mm dowel into the reamed hole on the cylinder piston.
- Use two nuts to secure the block to the 38mm screw. Tighten the nuts.



Do not ream any holes.

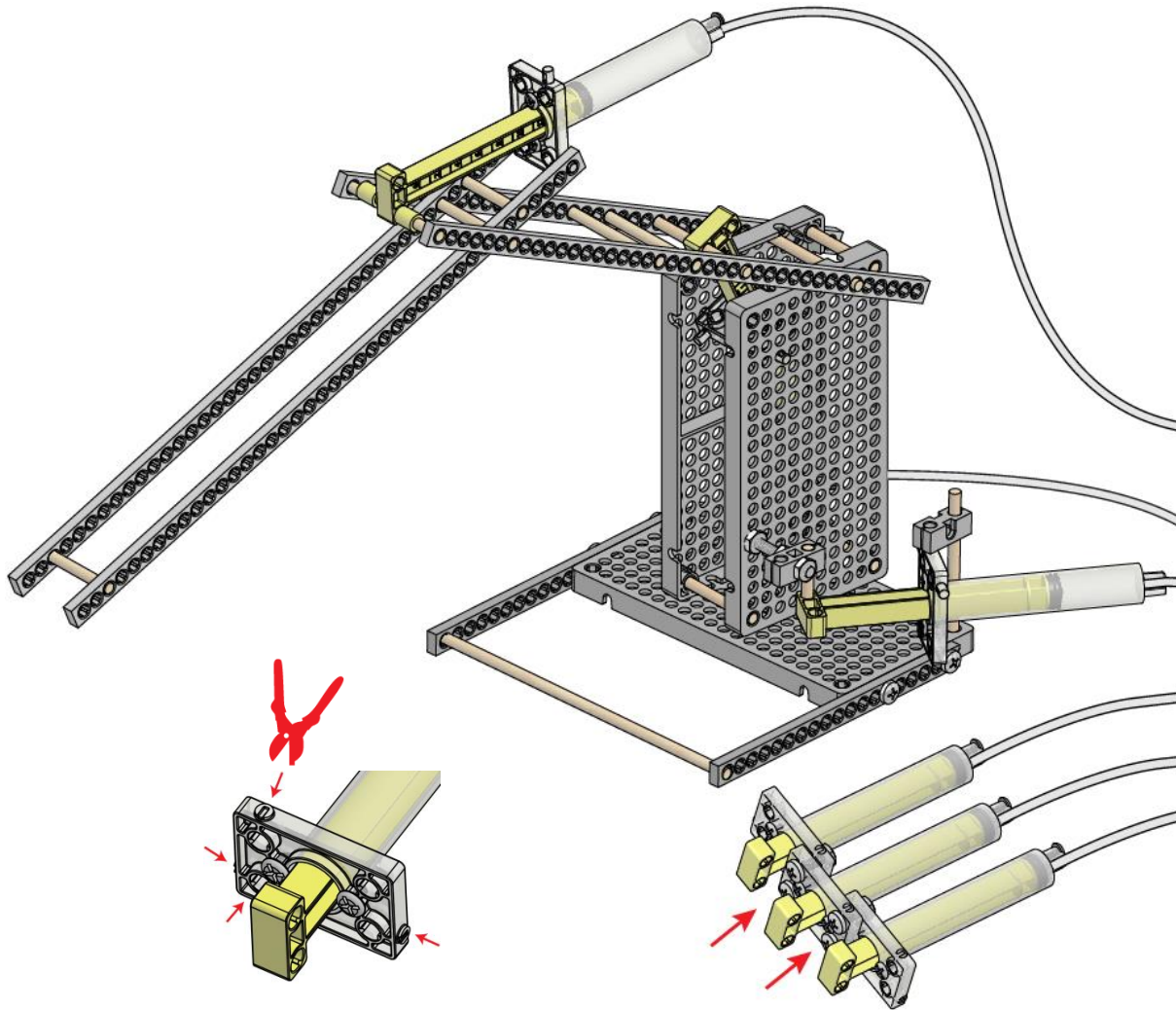


# ADVANCED HYDRAULIC ARM X2

## Build Guide

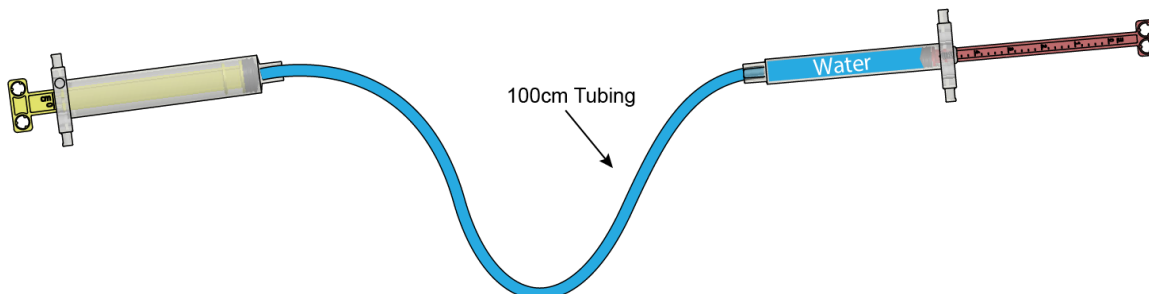
### Step #44

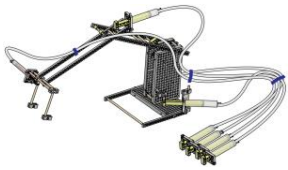
- Cut the pins off of the three cylinders that are attached to your arm with tubing.
- Use screws and nuts to attach the cylinders together to form a control panel.



### Step #45

Use 100cm (~18in) of tubing, one 13ml cylinder and one 4.5ml cylinder to create your fourth hydraulic system. See the *Cylinder Assembly and Fill Guide* at [teachergeek.com](http://teachergeek.com) for instructions.



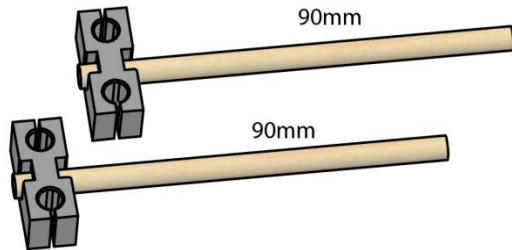


# ADVANCED HYDRAULIC ARM X2

## Build Guide

### Step #46

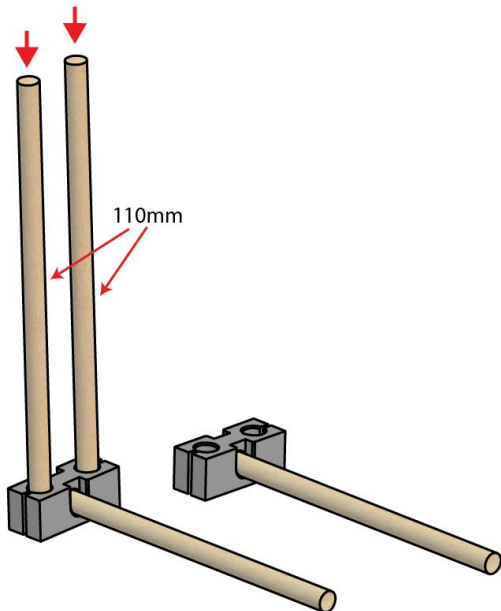
- Cut two 90mm (~3.5in) dowels.
- Push/tap blocks onto the dowel ends.



Do not ream any holes.

### Step #47

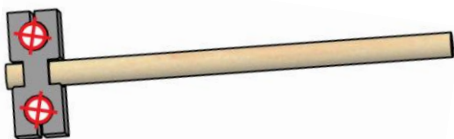
- Cut two 110mm (~4 3/8in) dowels.
- Push/tap the dowels into one of the blocks from Step #36.

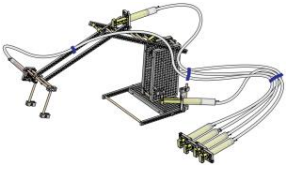


Do not ream any holes.

### Step #48

Ream the holes in the block with open holes.



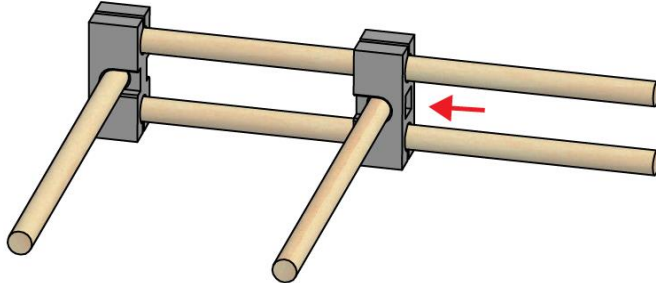


# ADVANCED HYDRAULIC ARM X2

## Build Guide

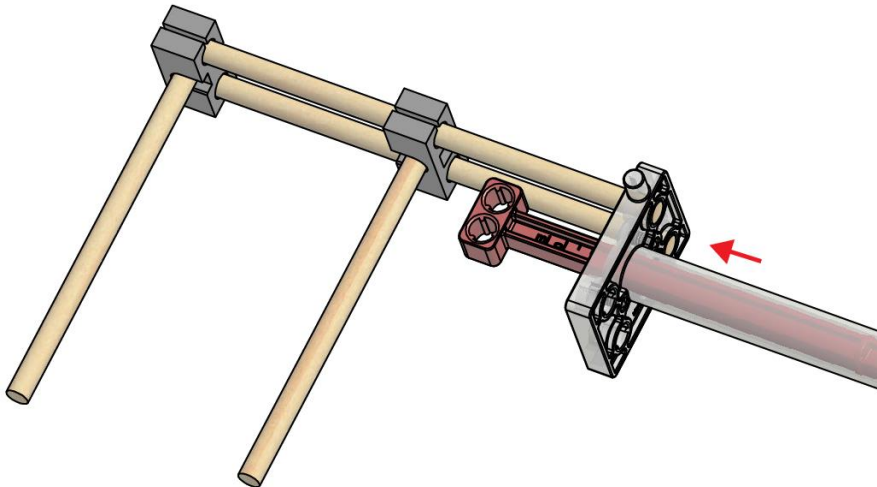
### Step #49

Slide the reamed block from Step #38 onto the 110mm dowels from Step #37.



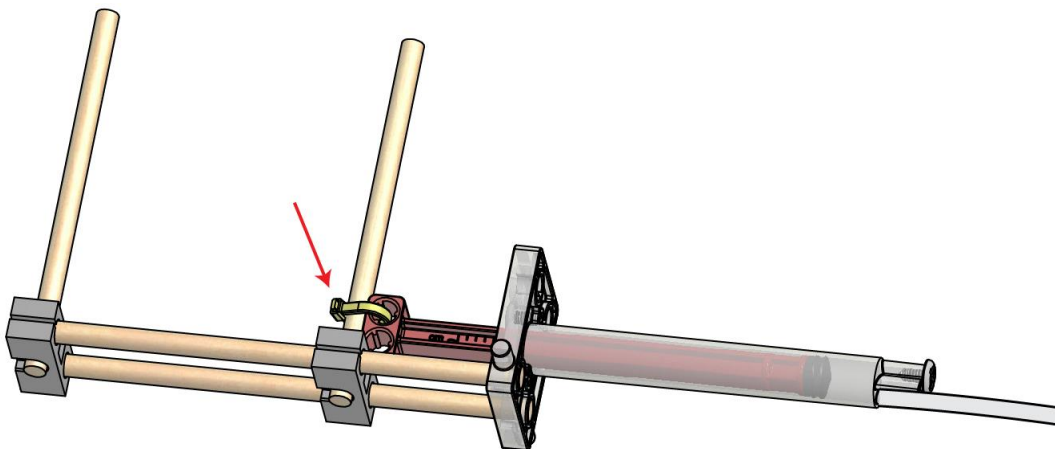
### Step #50

Push/tap the 3.5ml cylinder from your hydraulic system onto the 110mm dowels.

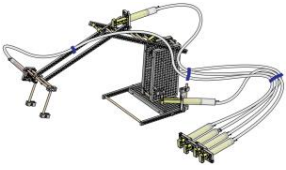


### Step #51

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





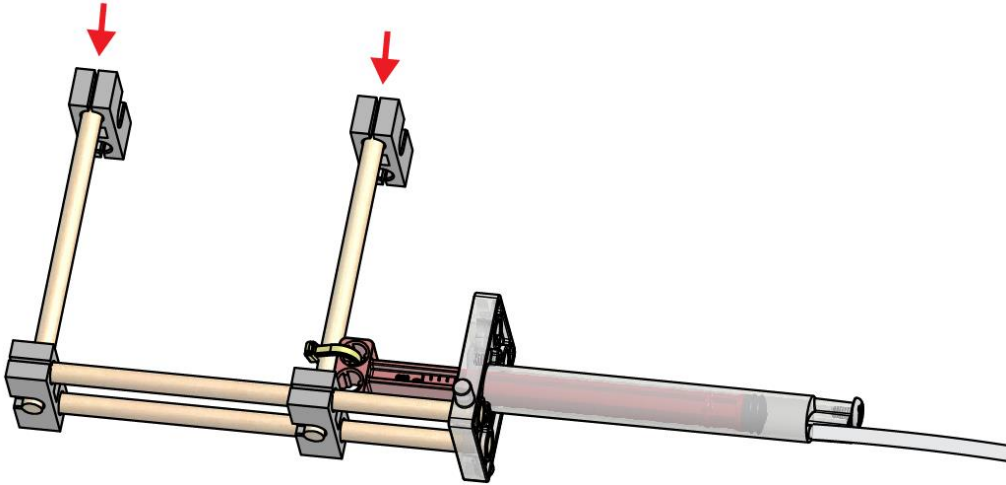


# ADVANCED HYDRAULIC ARM X2

## Build Guide

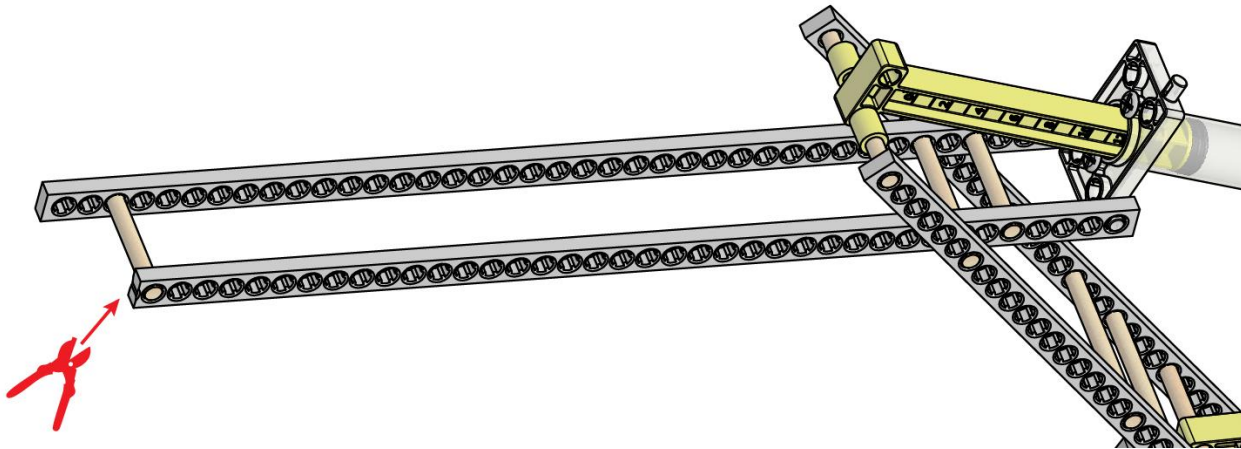
### Step #52

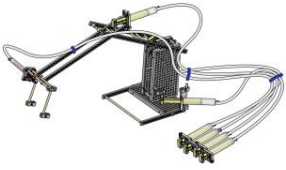
Place blocks onto the ends of the 60mm dowels. This creates your gripper. It is now time to attach it to your arm.



### Step #53

Cut the last two holes off one of the strips on the forearm.



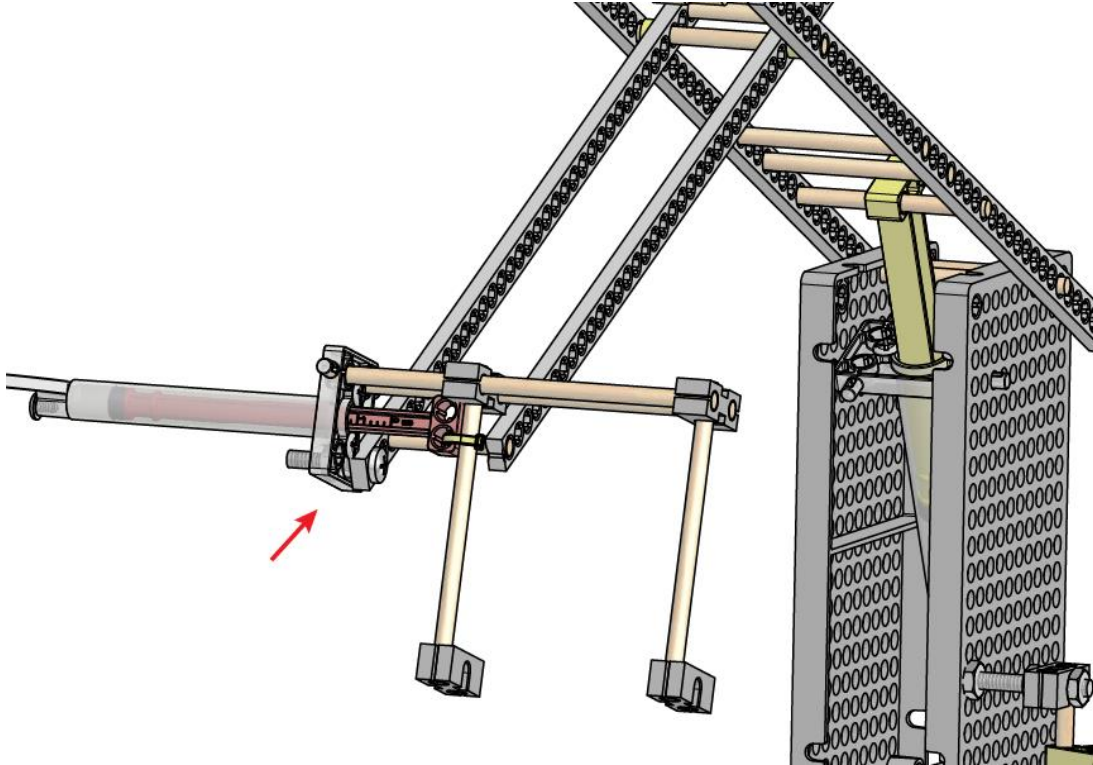


# ADVANCED HYDRAULIC ARM X2

## Build Guide

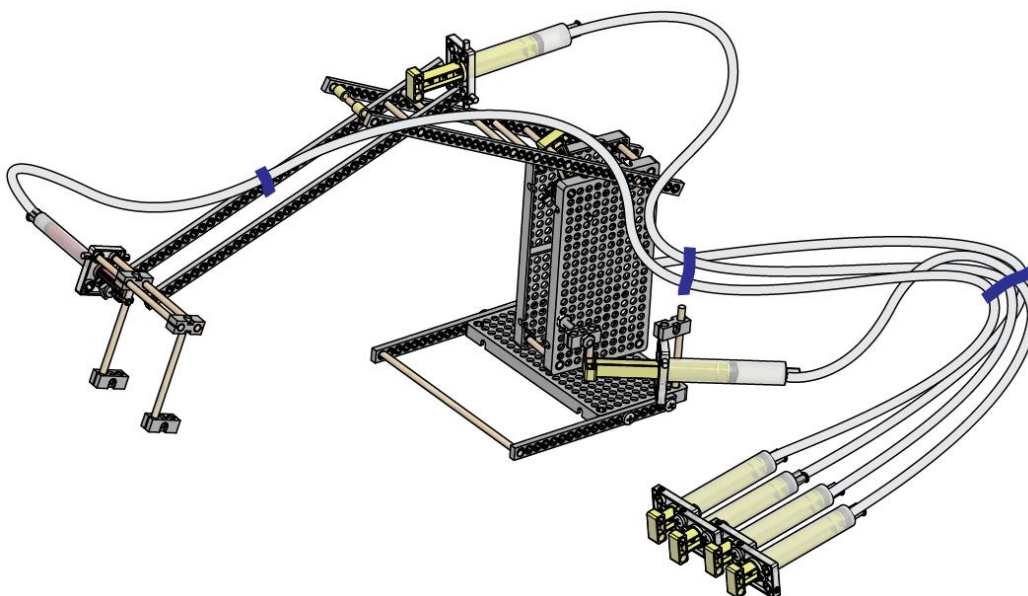
### Step #54

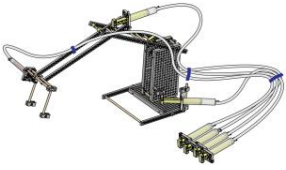
Use a screw and nut to attach the gripper to the forearm.



### Step #55

- Screw the loose gripper cylinder to the control panel.
- Use tape to attach the tubing to the arm. Make sure you do not crimp (smash) the tubing.



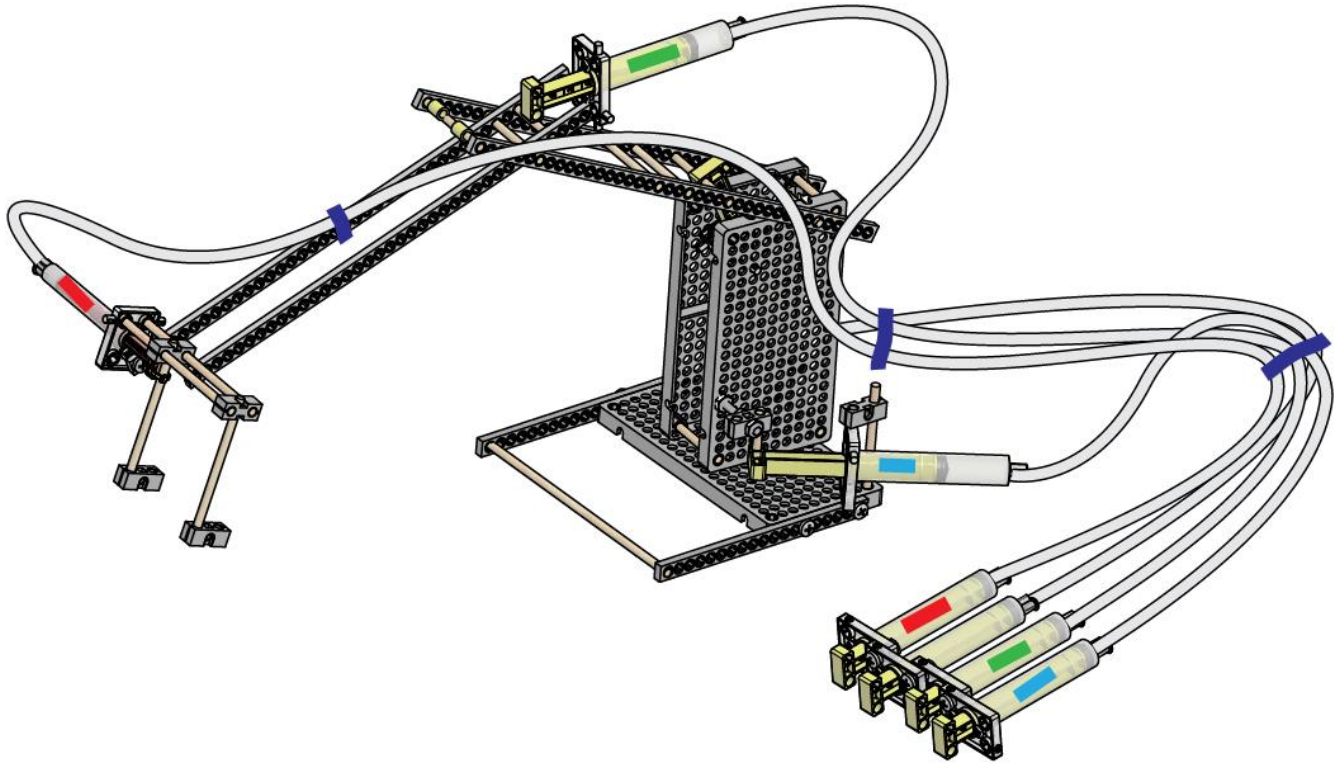


# ADVANCED HYDRAULIC ARM X2

## Build Guide

### Step #56

Use different colored permanent markers or tape to identify what control panel cylinders connect to what arm cylinders.



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