Pathfinders Hydraulic STEM Engineering Maker Set

Welcome!

Thank you for choosing Pathfinders STEM Engineering Maker Set.
This Maker Set is designed to be an intuitive place for kids (and parents!) to design and build a wide variety of simple and complex machines.

You can use the Set in many ways, from a culmination activity to a unit on **Levers and Simple Machines** or **Hydraulics**, to a kickoff activity to a unit on **inventors** and **inventions**, and everything in between!

We have specifically not been too prescriptive, since this set is designed to give the students a hands-on activity with materials so they can have a tactile and rich experience designing and making machines that can be related to things they see in the world around them.
For a one hour (or so) program the challenges and machines they make can be simple, but once students get to the two to three hour time range, there is more opportunity to design, tinker and test, so students can be encouraged to make more complex machines (depending on the age level of course!)

We hope the following pages help you organize the materials for first time use, and outline items you will need - like basins for storage, and ideas about setting up samples to illustrate the ways the different linkages work. There is also a set of cards that can be used for challenges, should you wish.

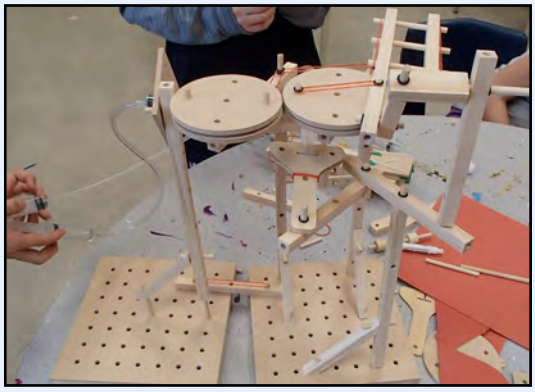
All material is free to copy and use in educational situations, and you can contact us to get a digital (pdf) format of the manuals (if you do not already have it!).

Our educational web site has pictures of machines made in classes and other pictures to help you make samples if you wish (some are also on the following pages...)

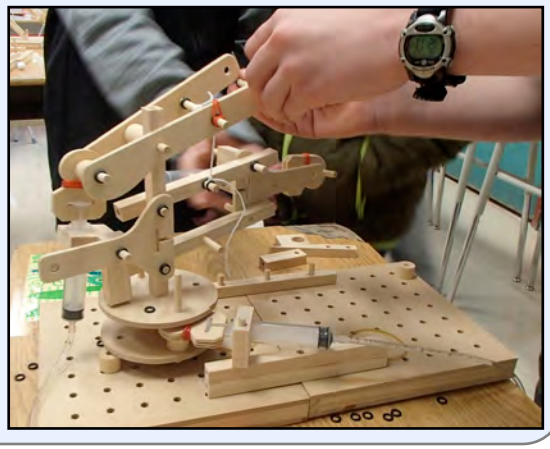
www.pathfindersdesign.net - see the **STEM Maker Set** section.

We do not include background information about what Work is, and levers and simple machines (inclined planes, screws and the like). We do have a glossary that does consider words that students should learn as you and they discuss the things they are making. Having students become familiar with vocabulary like friction, fulcrums, levers, effort (among a few) should be an outcome of the experience.

You do not have to be a rocket surgeon to use this kit! - let the students explore and, through experimentation and tinkering - everyone learns!



These students enjoyed the tinkering, and just made their machines more curious and interesting (or weird, depending on how you look at it) as the class progressed.
Some students are wired to tinker like this, so embrace the process and don't always worry about the outcome!



Outreach programs often have a short time for making machines, so best to pick a topic with up to two or three important things you want them to learn, and then let the kids build!

Outreach

If you want to have students make machines that throw something - a **Hurling with Hydraulics** class, you might consider that they learn 3 things:

1. **Levers can accelerate force**,
2. **Force applied closer to the fulcrum creates faster movement further away from the fulcrum,**
3. **Connecting levers can accelerate force even more!**

Having one to three core principles you want to reinforce is a great way to mix hands-on and knowledge outcomes.

In outreach programs the materials can be placed out on a table and the students can browse and use as needed.

Easy to pack up too!

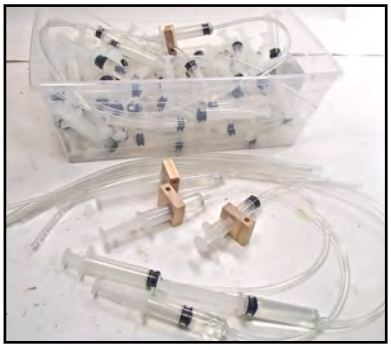
Most of the materials - placed in smaller plastic basins fit in about 3 - 4 large bins. Samples for display can be reused!

Museum and Science Center Spaces

For classroom use the materials can be left out for tinkering, and for Museum drop in areas, or Maker Spaces, you can leave out materials that are easiest to work with. If there is a short time, use samples on display that are less complex, and if a longer time is available consider more complex challenges!

For Maker Spaces it can make it a bit easier to leave some of the syringes attached to each other, with a linkage in the middle. This way they can grab one and attach it right away.

They are there to learn however, so you can decide if the filling and getting the bubbles out of a syringe should be a part of the experience!



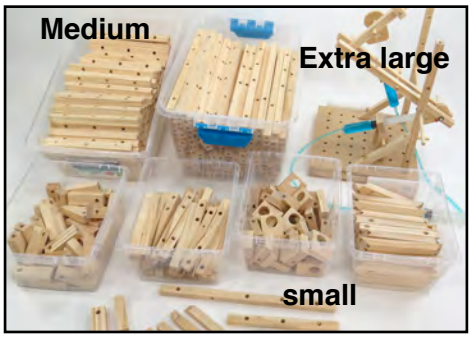
Leave some attached?

These students did the Mars Rover challenge - to make a rotating platform that could hold a cell phone and record a video as it turned.

Using the Set

Preparing the set for use.

There are a lot of pieces that need to be put into basins for ease of access by students. It is recommended to have a different basin or tub of some kind for each different piece, and since they vary in size we suggest that you get plastic basins as shown. If you have a classroom they don't need tops, but if you are doing an outreach program consider containers that close!
We like clear ones, so you can see inside when they are closed.



Basins
16 small 2 medium 1 large 1 extra large for the long pieces.
Optional - an extra large basin for the Syringes

A few other items can be handy, certainly some **rags, paper towel, or sponges**. When the kids pull the plungers out of the syringes and the water comes out (not if, when...).

String is great, kids can use it to lift with a winder, or to connect levers. Some in the set, you might need more! Pipe cleaners included, but you might need more!

Scotch tape or masking tape, for holding things together, no downside there.

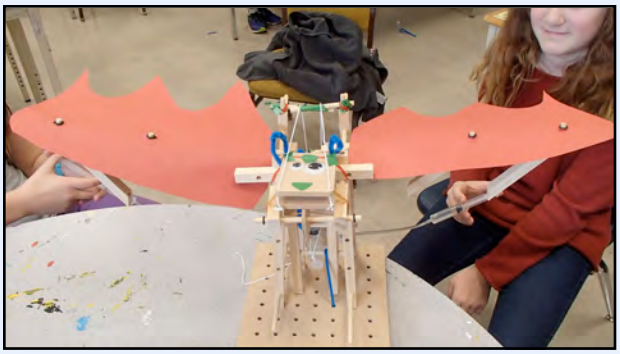
Art Materials - yes! - paper, cardboard, magic markers, feathers, googly eyes, - to make the work into an art piece!

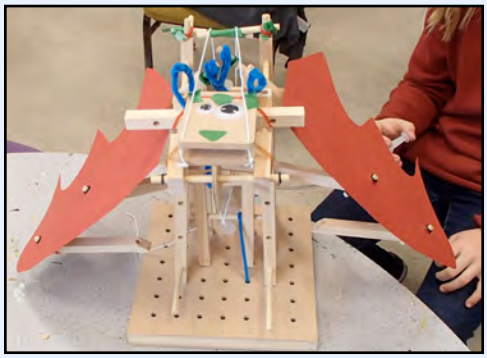
The great thing about the Maker Set is that it is made of wood, and the bad thing is that it is made of wood!

The base has been varnished, but all the wood pieces will absorb water, so if they get wet they will expand and the dowels will jam in the holes. If water spills from the syringes (which happens!) have a rag or paper towel handy to dry them as soon as possible. It the pieces get wet and expand just set them aside overnight and they will dry and be fine. Best to have instructors give students new dowels or pieces if they are very wet as the pieces will be too tight to easily work with.

Most of the set is made of wood, so many of the pieces, while cut as accurately as we can get them, were once a tree, - so there will be pieces that are too snug, or need a little gentle persuasion to fit perfectly. If a piece is too tight in the holes, better to remove it from the set than to have a child banging at it or getting frustrated as it can't be moved.

See the information about the pieces - to get an idea about what each piece can do and where it often is used.





These students took the Leonardo winged machine challenge and added a mouth that opened and shut, for a flying dragon!

If you are doing a specific unit, such as **Machines to Help Us Lift Things**, or a Maker Space in the run up to halloween - **Lift that pumpkin!**, or (my favourite) **Hurling with Hydraulics,** it might be good to go online and find pictures of the kinds of machines that do those things. The **www.pathfindersdesign.net** has pictures of machines (and videos) that are free to use. Having the students research samples of machines that do those things is good too (not many hydraulic catapults out there though, darn!).

Make a bulletin board!

(leave the gerbil picture from the last unit, it's so cute!)

Decide on your level of written work.

If you are using this set with a classroom, you might consider asking the students to submit a drawing of their designs before they make it, along with an outline of what they hope (plan) it will do. Afterwards, students can also do a write-up of what happened, what worked, and what did not work, along with some ideas about how it might look in the real world.

If you are doing an outreach program it would be best to introduce your topic, for example: "**Making Lifting Machines**" describe how they use levers, discuss a bit about hydraulics, explore the samples on the tables (see below) and then away they go! - don't worry about the written work!

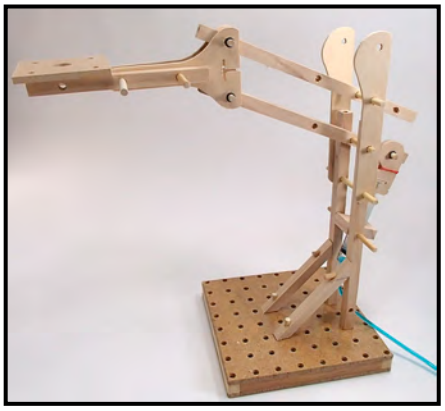
If you have a specific challenge for the session, - perhaps you want the students to lift something vertically (so the platform stays flat), have a few samples of the way in which the pieces can make a **horizontal** lifter. See our **Challenges** cards for project ideas!

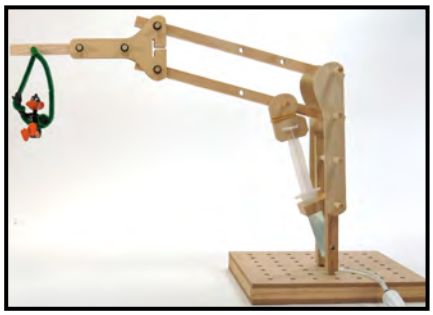
Sometimes kids struggle with an initial design, as they may not have done an activity that is this open-ended.

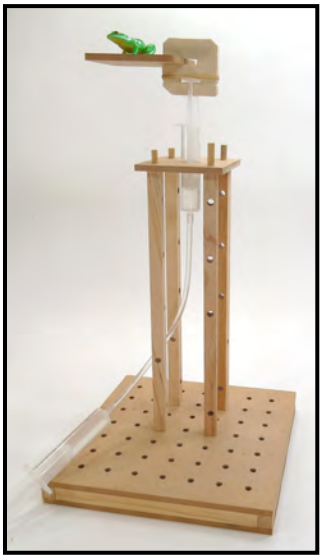
In the introduction, we often suggest to them that they copy a sample on the table, - to get them going, then add their own ideas to it. We like to have a simple sample, and show how, if you turn it sideways - or upside down - it makes a whole new machine!

Make a few simple samples if you think students need ideas! Let them play with the samples to learn how they work!

Show some examples.



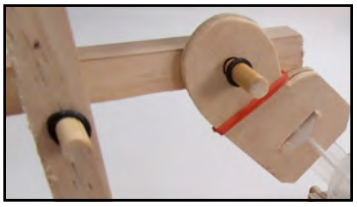




Describe the Parts

It is a good idea to pick up and show the pieces - and describe what they do - and if you wish show where they are used in a sample that is on display. Show how the linkages work - with an elastic band to hold them together, - how the O rings hold the dowels in place - how the small dowels fit nicely inside the ends of the pieces- and hold them nicely in the base, this is very helpful!

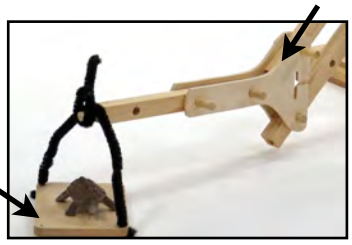
Spend a few minutes describing the attributes of the parts.

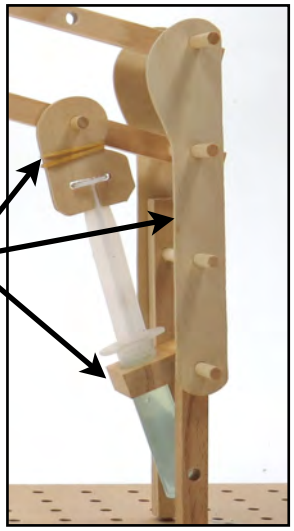


O rings hold pieces together.

Linkages connect pieces

Platforms hold things

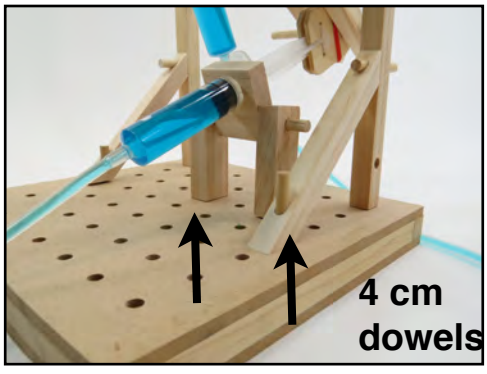




Dowels

The dowels are pretty straightforward, however it is a good idea for the instructors to model for the students how to put the dowels in and out of the holes - **using a twisting action** and encouraging the students to not bang them or try to yank them hard if they are jammed. Pulling the dowels straight up while twisting a bit when removing or inserting them, and working them gently as they insert them into the holes is best. Tight dowels can be removed from the set if they are hard to get in!

Model careful insertion and removal of the dowels

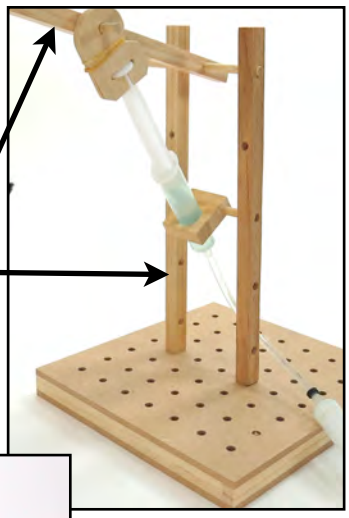


4 cm dowels

Longer dowels are good, then you don't need the O-rings to keep things together!

Long wood pieces

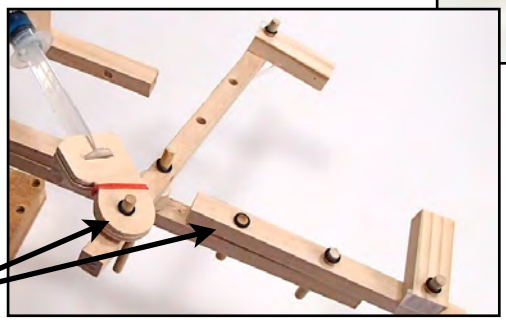
Note the holes on the long pieces, there are 4 holes in one direction and 1 hole in the other direction. Remind them to watch this as they make their machine, so they don't have to take pieces apart as they build (encourages them to plan ahead a bit!).



Longer pieces give more room to place the syringe holder - makes it easier to adjust too!

O-rings

The black O-rings help keep dowels in place, but for the most part they are not needed, until the machines get complex and pieces need to be held in place while more is being added. We use yoghurt (or the like) container lids for students to hold them on their working table! Trays for pieces are a good idea if you have a maker space!



Use O rings as needed!

Filling the syringes

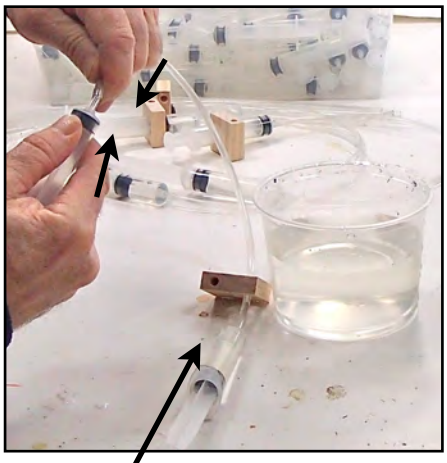
You can add a drop of food coloring to give the water a slight colour!

It is a good idea to demonstrate how to charge the syringes (add water to them). You can leave them attached to each other with a holder in the middle and the students can use them ready to go, or show how to fill up a syringe and insert it into the syringe that is on the machine they are making. For small children it can be hard to attach the tube if it is new, but once it has been inserted a few times it is looser and easier to insert into the syringe. If the tube gets too loose at the end, simply snip off 3 mm and then it will be snug.

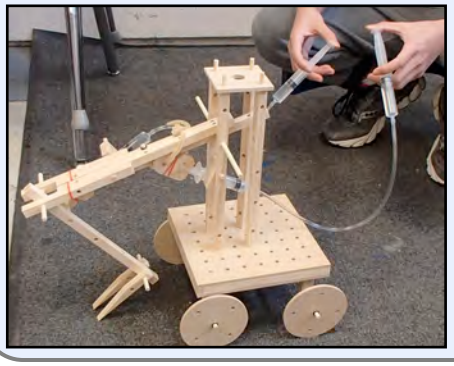
Always fill the syringe with a tube attached!

Generally speaking the best plan is to fill the syringe at a filling station away from the machines they are making, so if something happens and water is spilled, the students do not get water on the base.

Ideally the kids learn that if they tilt the syringe up, the bubbles float up to the top of the tube, then with the syringe in the upright position they can push the bubbles out the tube, (then insert into the water and refill).



Slide on a linkage piece and add the second syringe (plunger in!)



This student took the challenge to create a machine that could push itself across a surface - it could pull itself the other way too!

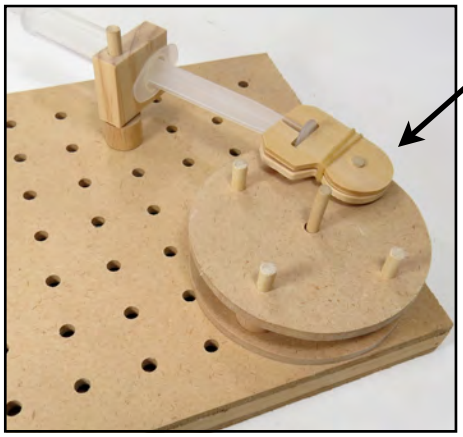
If a syringe is already attached to the machine, show how the plunger on the machine syringe has to be pushed all the way in so there are no bubbles in the water when the master syringe and tube is attached to it. Having bubbles however is a great learning experience as when they pull the plunger the air expands and they learn about the idea that air molecules are loosely attached, and water molecules are tightly packed. When this happens they learn to pay attention to how air in a piston is not good!
The students can be reminded not to pull the plunger out - but it will happen!

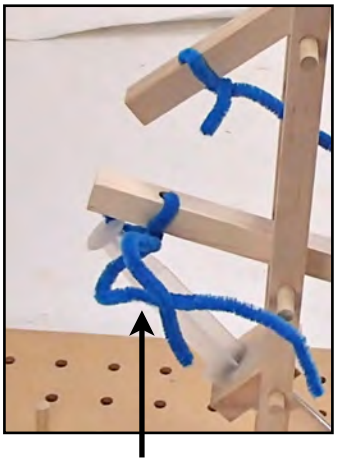
Attaching syringes

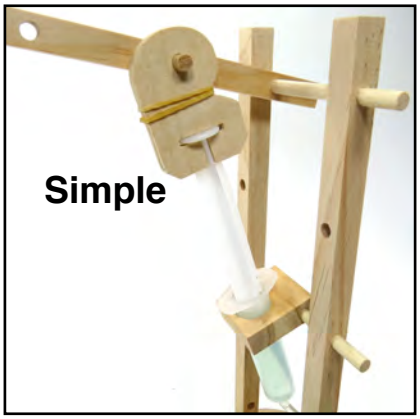
How to attach syringes

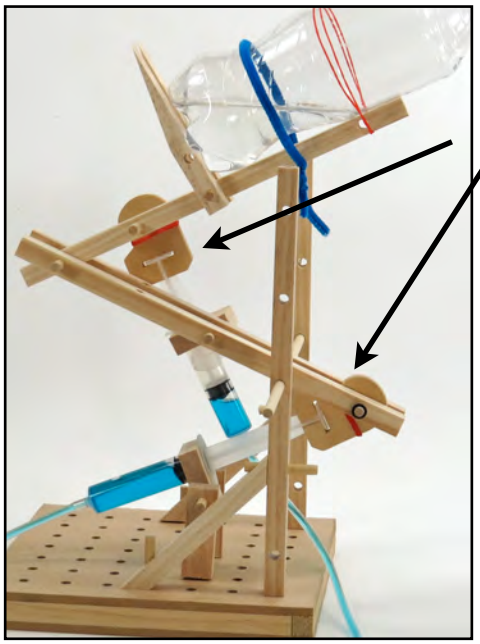
It is a good idea to note to the students how the syringes are attached, and how to use the syringe holders (the wood one, and the square mdf one), as well as model how to attach a syringe holder with an elastic
Syringe plungers can be attached to a lever with the linkage, or a piece of pipe cleaner - through the hole on the plunger. Demonstrate or point out the two methods.

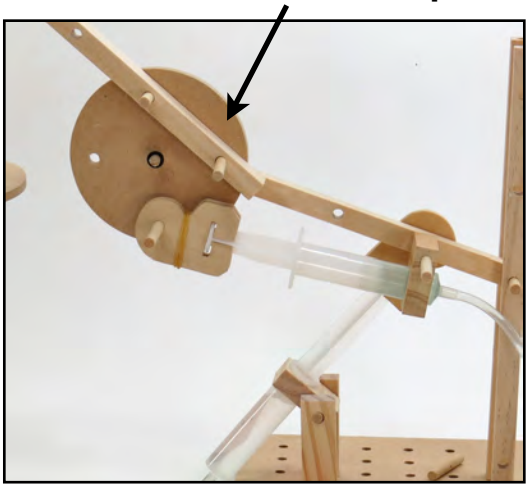
There are so many ways to attach syringes! Here are a few...

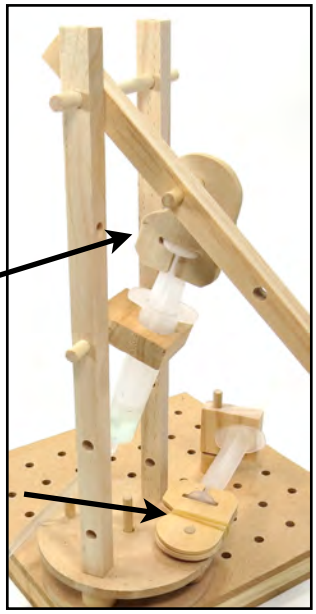












Remember!

- Let them be creative, and encourage them to tell you how it works
- Take pictures Ask questions Have fun! Enjoy guided discovery

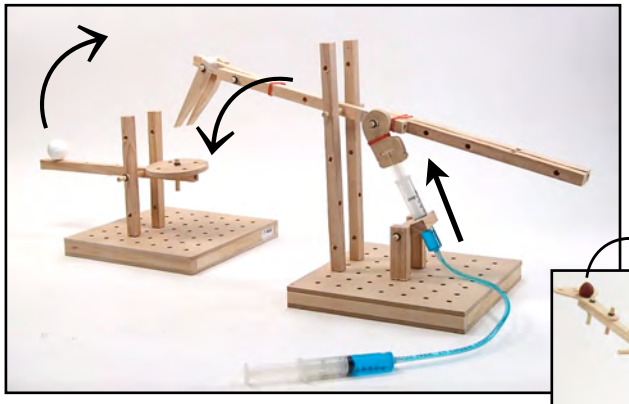
Activity Ideas - Design Challenges!

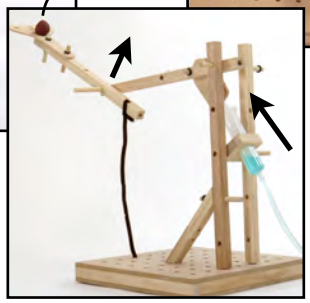
The **Design Challenges** give students a place to start in making a machine that has a purpose of some kind, from helping disabled people get around, to throwing things, to a Rube Goldberg machine that does random things designed to be creative and unusual.

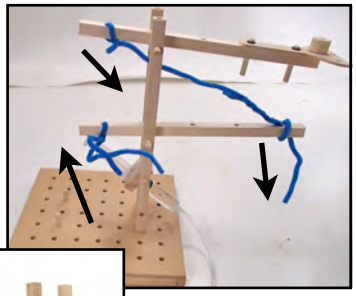
You program may lie anywhere between giving a specific (simple) task - such as **lift a small pumpkin 6 cm** (at halloween) - to "**make a machine with two different levers**" - which is totally open-ended and has no specific task in mind (except they have to know the 3 different levers!).

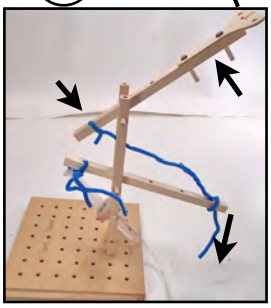
When used over time - kids get the hands-on experimentation that is important to learning. As they progress and have more confidence, challenge them to make their machine work better, and do more things, or do them more efficiently. You can also create themes and have the students create machines around that theme (as on page 4 and below). Have art materials so they can decorate them, or create one giant machine with bases in all directions! - the world is your oyster!

Make a Hurling Machine!







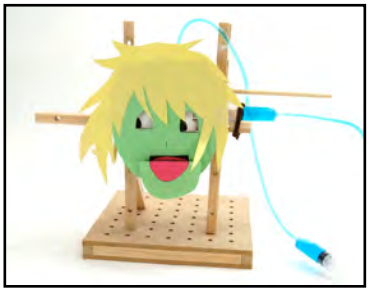


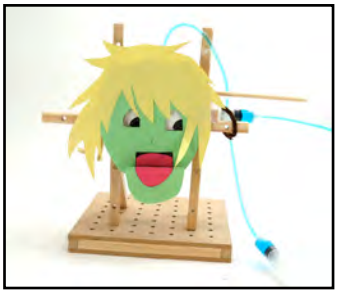
Use pipe cleaners to connect pieces!

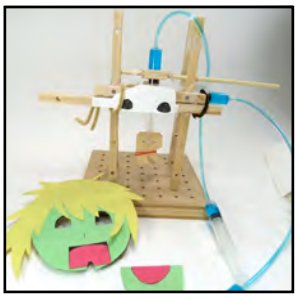
Simple!

Complex!

Animate a Face!







Finally! - Share your work!

Have a look at the **Lawrence Hall of Science** Flickr Site - Ingenuity Lab@ the Hall - Hydraulics
https://www.flickr.com/photos/lhsingenuitylab/albums/72157659273676949 - great stuff!

Email us with your activities and we will put a link from our Educational Web site!

If you have any questions or concerns, please email our lead designer Derek at:
derekwulff@pathfindersdesignandtechnology.com (long address, yes, but worth the email!)