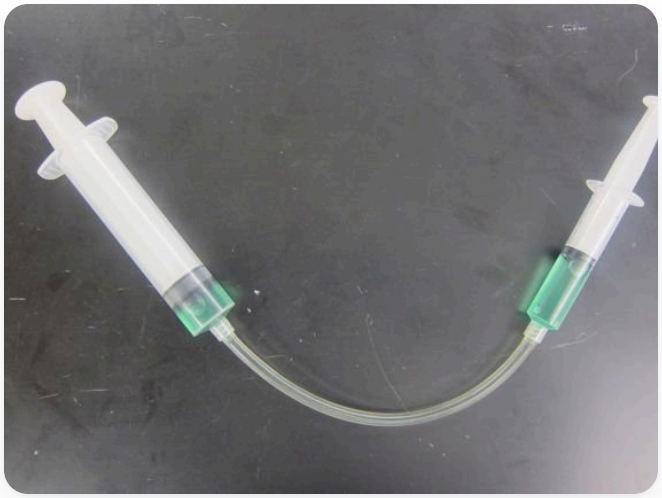
EQUIPMENT BUILD PLAN

AIR & WATER PRESSURE

Hydraulic Syringe Pairs

Two syringes joined by a length of plastic tubing make the simplest working hydraulic system. With equal syringes the force and travel match; with a large and a small syringe you can feel the force multiply; filled with air instead of water, the system goes spongy. A 30-foot version shows how fluids carry pressure across a room almost instantly.

> Written from Bruce's original workshop handout. Bruce's final review of this plan is in progress.



DIFFICULTY	BUILD TIME
Beginner	15-30 minutes
COST	**SAFETY**
About $10 for several sets	Everyday care
GOOD FOR	
Teachers, Families, Makers	

What it shows

Push one plunger and feel the other one push back, multiplied.

Key ideas: Pascal's principle, hydraulics, force and area, incompressibility of liquids, mechanical advantage

Safety (Everyday care). Use needle-free syringes only. Do not aim squirting syringes at anyone's face. Keep paper towels handy for drips.

CONSTRUCTION

Build it

Materials

- [ ] **Plastic syringes, needle-free, in at least two sizes** · 2-4 per set
  Two of the same size plus one larger and one smaller
- [ ] **Plastic tubing, 1/4 in outside diameter** · 6 in to 30 ft lengths
  Must fit snugly over the syringe tips
- [ ] **Water** · 1 cup
- [ ] **Food coloring** · a few drops
  Optional, makes the water easy to see

Tools

Scissors

Cup or bowl of water

Paper towels

1

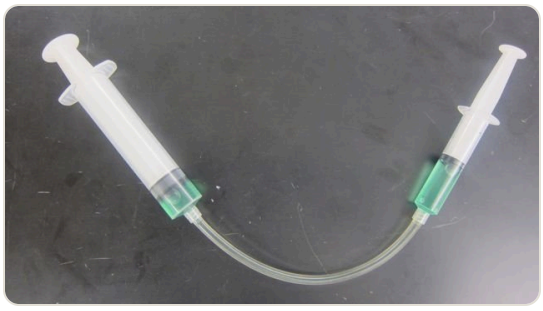
Cut the tubing

Cut tubing into a few lengths: a short piece of about 6 inches to a foot for handheld sets, and a long piece (up to 30 feet) for the long-distance set.

2

Fill the large syringe and tubing

Attach the tubing to the larger syringe. Put the free end of the tube in colored water and pull the plunger out to draw water through the tubing and into the syringe.



3

Push the large plunger all the way in

Press the large plunger fully in, leaving the tube full of water. Point the free end into the cup so any air bubbles escape.

4

Fill and connect the small syringe

Fill the smaller syringe with water, tap out any air, and push its tip into the free end of the water-filled tube. Try to trap as little air as possible.

5 **Try a same-size pair**

Build a set with two syringes of the same size. Push one plunger and the other moves out the same distance, with the same force.

6 **Try a large-and-small pair**

Push the small plunger and the large one moves out with more force but a shorter distance. Push the large one and the small one shoots out farther with less force.

7 **Make an air-filled pair**

Connect two same-size syringes with air instead of water. Pushing one plunger compresses the air first, so the other one lags behind and never moves the full distance.

8 **Build the long-distance set**

Join two same-size syringes with about 30 feet of water-filled tubing. Stretch it across the room and push: the far plunger moves almost instantly.

THE PHYSICS

How it works

Pascal's principle says that pressure applied to a fluid in a closed container is transmitted equally to every part of the fluid. When you push one plunger, the pressure rises everywhere in the water, including against the face of the other plunger.

Using it

- Have two students each hold one plunger of a large-and-small pair and push against each other. Who wins, and why?

Pressure is force divided by area. The same pressure acting on a larger plunger produces a larger force, in proportion to its area. Because plunger area depends on diameter squared, a syringe twice as wide has four times the area and pushes with about four times the force.

There is no free lunch: the water pushed out of the small syringe spreads across the wide one, so the large plunger moves a shorter distance. Force times distance (the work) stays roughly the same on both sides, minus friction.

Water is nearly incompressible, so it transfers motion directly. Air compresses, so an air-filled pair feels spongy and loses travel. This is why car brakes must be free of air bubbles.

- Measure plunger diameters, calculate the area ratio, and compare it with how far each plunger moves.
- Compare the water-filled and air-filled pairs and connect the difference to brake lines and hydraulic lifts.
- Use the 30-foot set to show how quickly pressure travels through a fluid.
- Challenge students to build a simple hydraulic arm or lift from cardboard using syringe pairs.

GO FURTHER

Variations

- Mix and match three or more syringe sizes and record force and distance for each pairing.
- Use different tubing lengths, from 6 inches to 30 feet, and see whether the length changes the force.

IF IT DOESN'T WORK

Troubleshooting

IF THIS HAPPENS	TRY THIS
The plungers feel spongy.	There is air in the system. Disconnect, push the bubbles out under water, and reconnect.
Water leaks at the syringe tip.	The tubing is too loose. Use tubing with a slightly smaller inside diameter or trim the end and refit it.
The plunger is hard to push.	Check the tubing for kinks and make sure the receiving plunger is not already at the end of its travel.

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