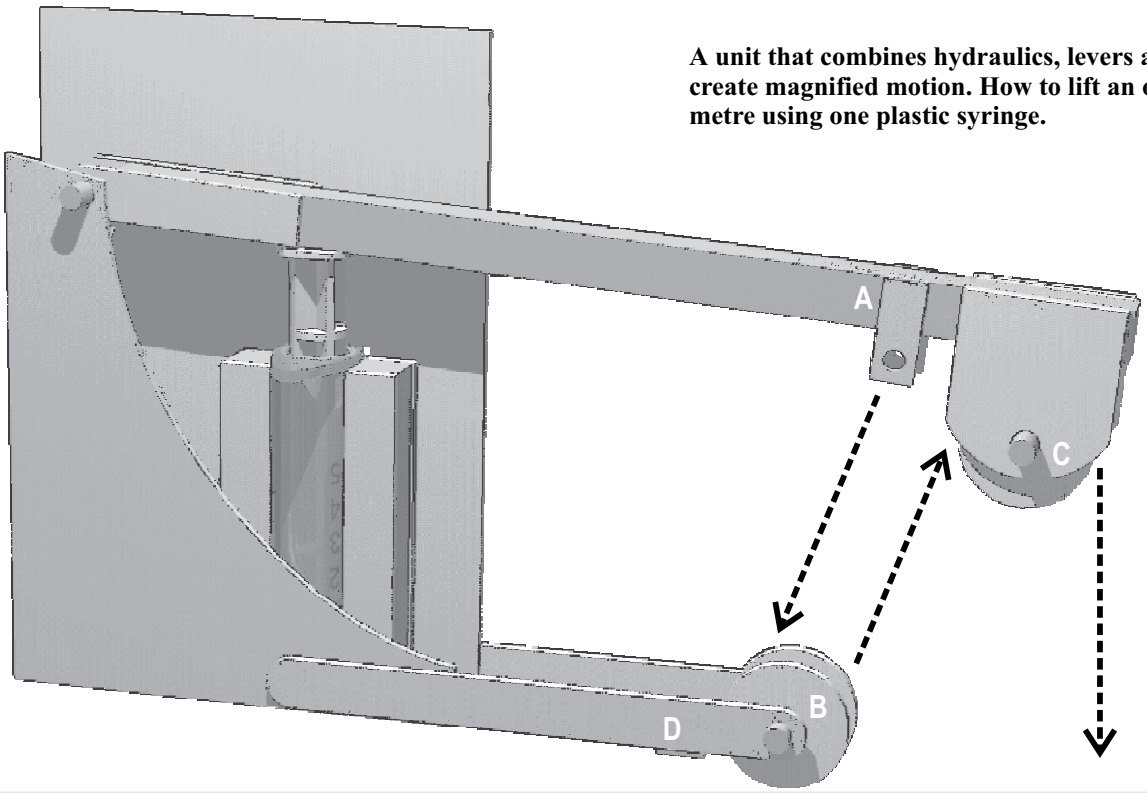

A unit that combines hydraulics, levers and pulleys to create magnified motion. How to lift an object half a metre using one plastic syringe.

Transferring a force from one place to another via an hydraulic unit of two syringes and a length of PVC tubing presents few problems. If the tube is filled from the tap, by running water through it, you can push out any air. Fit the two syringes, one in and one out, to the tubing under water. *(You don't need to be under water - use the sink!)* When one syringe is pressed the other one opens - and that's it!
If children make individual hydraulic devices then inevitably the two syringes are going to be close together (to save expensive tubing). Sadly this obscures the 'magical' effect of instant response. There are lots of ways to connect two moving parts that are only 30cm apart, so when one part moves the other one does - big deal. No, to see the magic at work the two components, the action and response, need to be as far apart as possible. What that response might be, is unimportant; just that it happens. It's possible to fill a whole 30m roll of tubing with water and push a syringe onto each end. With this someone will be able to move an object placed in another room at the other end of the corridor! INSTANTLY! Push a beaker of cutlery off the filing cabinet with a tiny movement of one finger 30 metres away - it's amazing, and it's probably all you need to do to demonstrate why water works and air doesn't. It's much more satisfying than making a mechanical grab that doesn't work because the syringes have been fastened with sticky tape and that's got wet.

The unit shown above was the result of many requests we had from schools which were involved in a national technology challenge. They had to build a model which included a wide variety of mechanical systems including hydraulics. The problem they all had was how to move something more than a few centimetres, perhaps even have a hydraulic lift in a model building.

The unit is shown with one card side cut away to expose the syringe. This is set between two short pieces of 10mm wood which has been 'expanded' to be the same thickness as the syringe by the addition of two sections of lolly stick. The two lugs on the syringe fit into two slots in the card. When the syringe is operated it pushes against a lever **A**. This is a lever of the third class. It doesn't increase force - it increases motion. The end of the lever moves further than the part that's being pushed.

The lever operates a pulley system. A string can be fastened to the lever **A**, taken round the pulley **B** and up and round pulley **C**.
At the end of the string is whatever you want to move. Now you have to think hard about this next bit!
When the lever rises it lifts the load by same amount, but at the same time it has to increase the length of string between **A** and **B**, and **B** and **C**. The only place this extra string can come from is the length between **C** and the load. So the load gets lifted this much extra. In the case illustrated the lever multiplies the movement of the syringe by a factor of about 4 and the pulleys add another 4 + 4 (well, a little less). We have increased the movement that was applied to the syringe about 12 times. *Of course, we have increased the apparent weight of the load about 12 times too!*

If you look closely you will see another anchor point for string on the bottom bar at **D**. Starting the string there would give us another increase in lift, and if we went round the pulleys twice . . . .