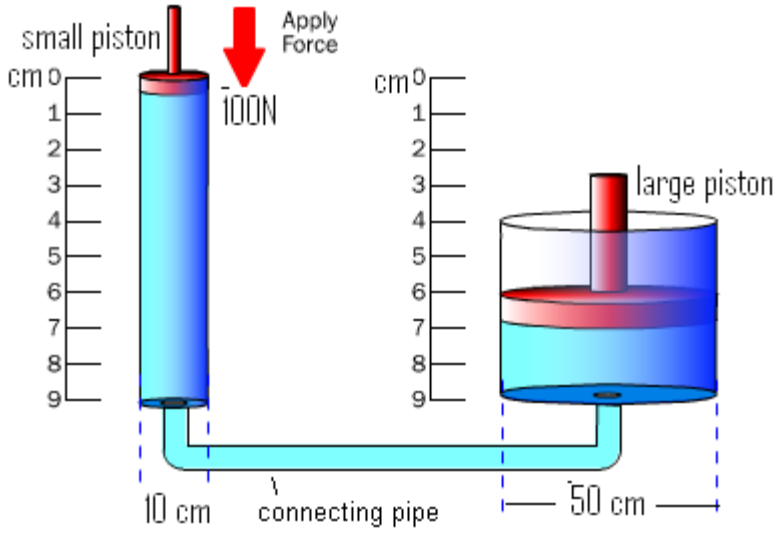
Constructing a model of a simple hydraulic system



The diagram above shows a simple hydraulic system consisting of a small piston and a large piston in the cylinders and a liquid-filled connecting pipe.

A. Here is a very simple way of making a model of such a hydraulic jack with two vertical syringes of different diameters.

1. You will need:

A small syringe (20 ml)

A large syringe (100 ml)

A small length of rubber tubing (about 10 cm)

(Note the syringes can be purchased at the pharmacy and the rubber tubing is available at any aquarium shop.)

2. Remove the needle from the syringe.

   Be careful not to prick your finger while doing so.

3. Insert the nozzle of the syringe into one end of the rubber tubing.

Nozzle of syringe fitted inside rubber tubing

(You might apply your knowledge of physics, particularly thermal expansion for this procedure if the diameter of the tubing is too small to fit over the syringe jet.)

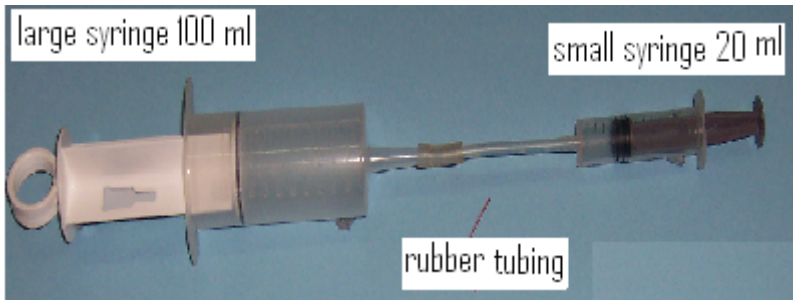
Immerse this end of rubber tubing into some warm water for a few minutes and try fitting it over the syringe nozzle. You may need to try a few times before the tubing fits the syringe jet.)

4. The syringes are half-filled with oil. (Water can be used but forms bubbles of air).

5. Join their jets with the tubing. Pushing down one piston lifts the other. Use a small weight on the smaller syringe to lift a greater one on the larger syringe.

6. A small force is being magnified. Compare the distances through which the two weights move.

7. Repeat the above procedure with the other end o f the tubing fitting over the large syringe so that your model looks like the one shown below.



(Note the barrel of the syringes represents the cylinders, the rubbe rtubing represents the connecting pipe between the two pistons.)

8. Push the piston of the large syringe and observe what happens inside the barrel of the small syringe.

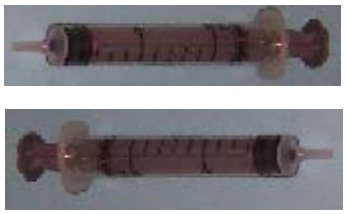
Note that the system works provided there is no leakage of the liquid between the pistons and the barrels.

B. The hydraulic brake system of a car consists of a master cylinder and four slave pistons, one at each wheel.

You can now construct a similar model with one master cylinder and two slave cylinders.

1. Materials needed:

Two syringes, A and B (10 ml each)



One syringe, C (20ml),

One T-shaped connector

Three small lengths of rubber tubing (about 10 cm long)

2. Connect each of the rubber tubing to one end of the T-shaped connector

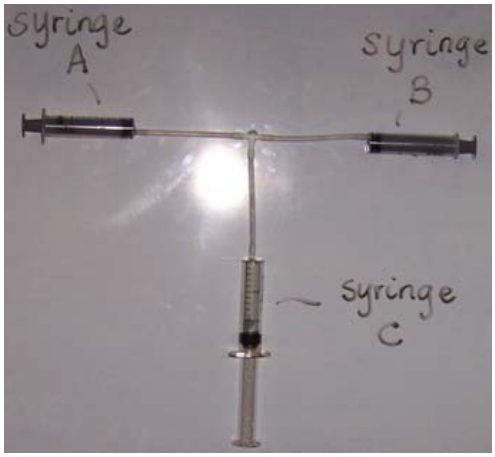
3. Then connect the other ends of two rubber tubing to the two smaller syringes.

(Remember to remove the needles from the syringes first!)

4. Now place the small opening of the large syringe into a coloured liquid and by pulling the piston, fill the barrel of this syringe through a small length. You will observe the liquid filling the barrel.

5. Keep the piston still and fit the third rubber tubing on the opening of this syringe

Your model should now look like this.



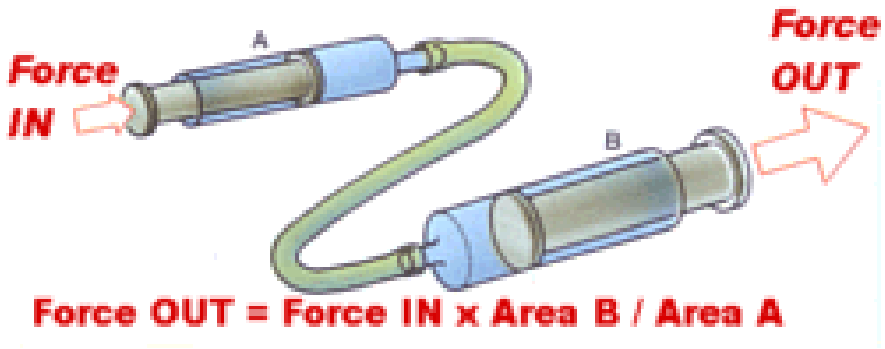
C. Pressure is transmitted through liquids

Liquids cannot be compressed. . They are said to be **'incompressible'.**

If you fill a syringe with water and press the plunger by putting your thumb over the nozzle, it will not move. This is because the water in the syringe cannot be compressed.

The fact that liquids cannot be compressed is extremely useful. It means that **pressure can be transmitted through liquids.**

In your model, when you connect the two syringes together with the rubber tubing and then fill them with water, you observe that pressing one plunger in makes the other one come out. In fact, you have **transmitted pressure** from one plunger to the other.



Application in car hydraulic brake system

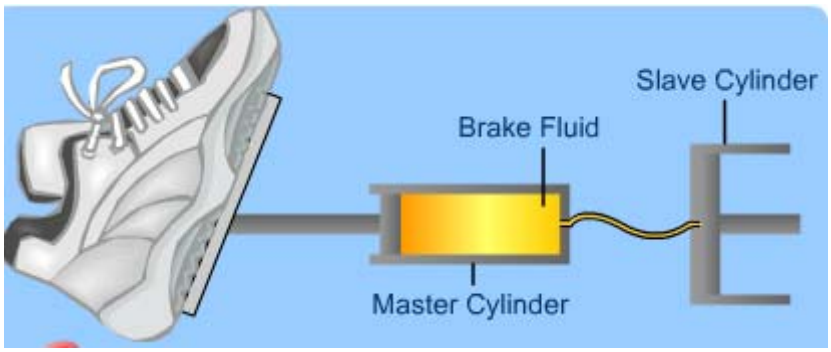
The brakes in cars are a good example of a basic piston-driven hydraulic system. When you depress the brake pedal in your car, it is pushing on the piston in the brake's actuate to press the brake pads against the brake rotor to stop the car. (Actually, in almost all cars on the road today two master cylinders are driving two slave cylinders each. That way if one of the master cylinders has a problem or springs a leak, you can still stop the car.)

If you wish to learn more about the hydraulic system, click on the following website.

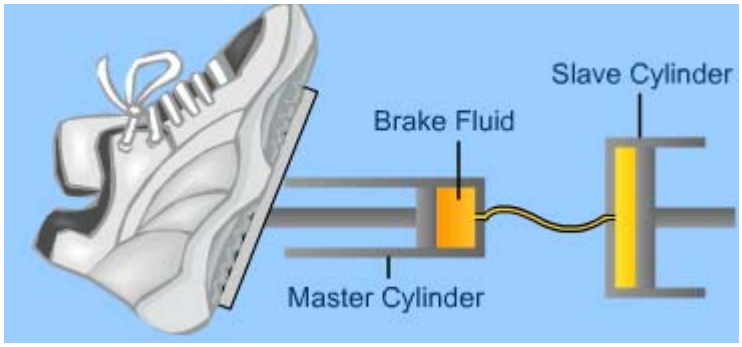
http://science.howstuffworks.com/hydraulic1.htm

So how does the car turn the small force that you apply to the brake pedal into the huge force needed to stop a speeding car?

http://www.s-cool.co.uk/topic_quicklearn.asp?loc=ql&topic_id=4&quicklearn_id=4&subject_id=16&ebt=316&ebn=&ebs=&ebl=&elc



If you look at the diagram on, you can see that the brake cylinder by the pedal (the master cylinder) that the driver presses is very narrow. But the cylinders by the brakes (the slave cylinders) are very wide. This means they apply a much larger force. WHY?



Driver's foot pushing the small piston of the master cylinder. Observe the fluid transmitted into the slave cylinder and pushing the piston of the slave cylinder.

Why?

If you push the master cylinder with a force of 12N and it has an area of $3cm^2$.

Using the equation: Pressure = force / area

Pressure on the master cylinder = 12 N / 3 cm^2

= 4 N / cm^2

Now, because pressure is the same throughout the system, , the pressure in the slave pistons must also be $4N/cm^2$.

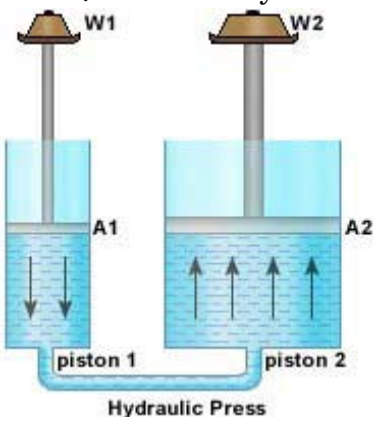
If the slave cylinders have an area of $12cm^2$, using the equation:

Force = Pressure x area

Force = 4 x 12

Force = 48N

Worksheet The Hydraulic Press



(c) (i) Is the pressure on the horizontal line same?

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(ii) Justify your answer.

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(d) (i) Equate the pressures at piston 1 and 2.

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(ii) Obtain W_2 as subject of formula.

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(e) Calculate W_2, taking W_1 = 50 N, A_1 = 2 cm^2, A_2 = 5 cm^2.

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(f) Write down a conclusion to this activity.

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1. (a) What pressure is exerted at piston 1?

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(b) What pressure is exerted at piston 2?

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