

Hydraulics Notes

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Hydraulics are one of the those uses of physics that we're around everyday and never realise it! Ever wondered how someone can stop a car just by pushing a pedal with their foot? Or how a pilot can fly a huge plane using their muscles?

Hydraulics 😊 is the answer to both of these and many more questions 😊

A hydraulic system: essentially it's a closed system of pipes or cylinders filled with a liquid (usually oil), with a movable plunger (called a piston) at different ends. It works on the basis of pressure in liquids.

Let's remind ourselves about how pressure in liquids works...

Pressure in a liquid: is transmitted equally throughout a liquid in a closed system. This means that the pressure exerted at one point in the liquid is transmitted to all other points in the liquid. But it has to be a closed system for this to be the case.

How does this happen? The particles in a liquid cannot be compressed so the pressure is the same through the liquid.

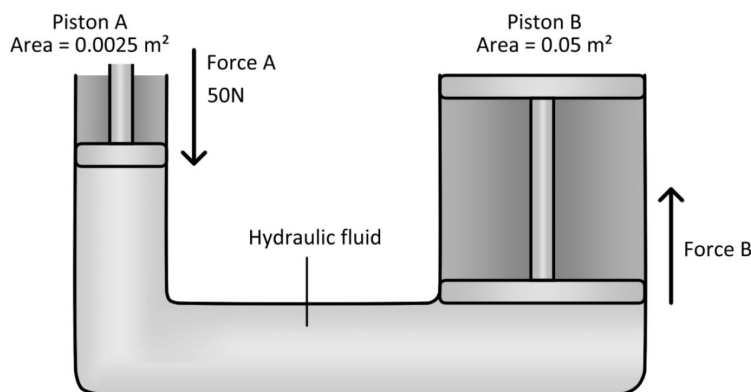
Why doesn't this happen in gases? The particles in gases are much further apart so they can be compressed. This is why gases aren't used in hydraulic systems but compressed gases are useful for spray cans for example.

Let's have a look at an exam style question 😊 The figure below shows a labelled diagram of a simple hydraulic system. Questions often use diagrams quite like this.

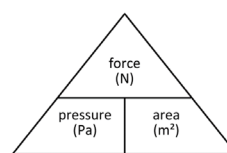
Example 1: The diagram below shows part of the braking system of a car.

A force of 50 N was applied to piston A via the brake pedal. Piston A has a cross sectional area of 0.0025 m^2 .

Calculate the force that would be experienced by piston B.



Step 1: Calculate the pressure of Piston A.



Pressure = force ÷ area

$$\text{Pressure} = 50 \text{ N} \div 0.0025 \text{ m}^2$$

$$\text{Pressure} = 20\,000 \text{ Pa}$$

Step 2: Using this pressure value calculate the force experienced by Piston B.

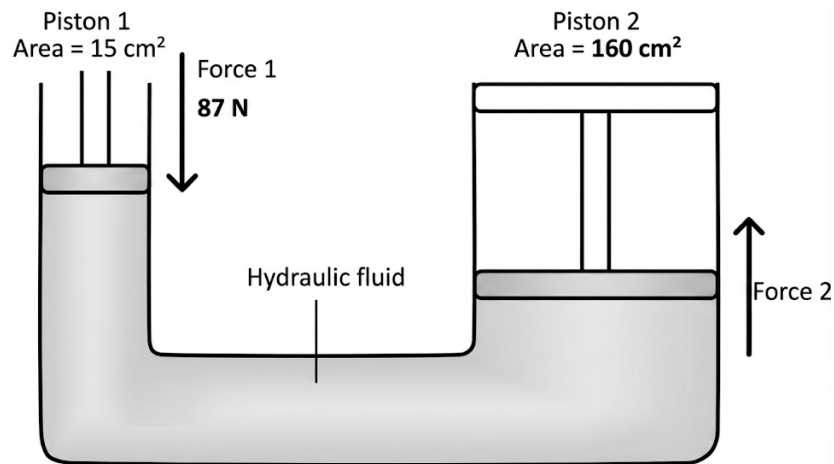
Force = pressure × area

$$\text{Force} = 20\,000 \text{ Pa} \times 0.05 \text{ m}^2$$

$$\text{Force} = 1000 \text{ N}$$

Let's have a look at another example while we're here 😊 Check out the next page.

Example 2: The figure below shows a diagram of a simple hydraulic system. A manufacturer is adapting this basic design to operate the lifting arm of a mechanical digger.



Using information from the figure above, calculate the upward force exerted by Piston 2.

Step 1: unit conversions. Ok, first thing we need to do is convert those cm² measurements into m².

Remember that 10 000 cm² = 1 m².

Convert 15 cm² into m² by dividing it by 10 000.

$$15 \text{ cm}^2 \div 10\,000 = 0.0015 \text{ m}^2$$

Convert 160 cm² into m² by dividing it by 10 000.

$$160 \text{ cm}^2 \div 10\,000 = 0.016 \text{ m}^2$$

Step 2: Calculate pressure at Piston 1. We'll use the pressure question for this now that we have the area in m².

$$\text{Pressure} = \text{force} \div \text{area}$$

$$\text{Pressure} = 87 \text{ N} \div 0.0015 \text{ m}^2$$

$$\text{Pressure} = 58\,000 \text{ Pa}$$

Step 3: Calculate the force for piston 2. Using this pressure value calculate the force experienced by Piston B.

$$\text{Force} = \text{pressure} \times \text{area}$$

$$\text{Force} = 58\,000 \text{ Pa} \times 0.016 \text{ m}^2$$

$$\text{Force} = 928 \text{ N}$$

That's it 😊