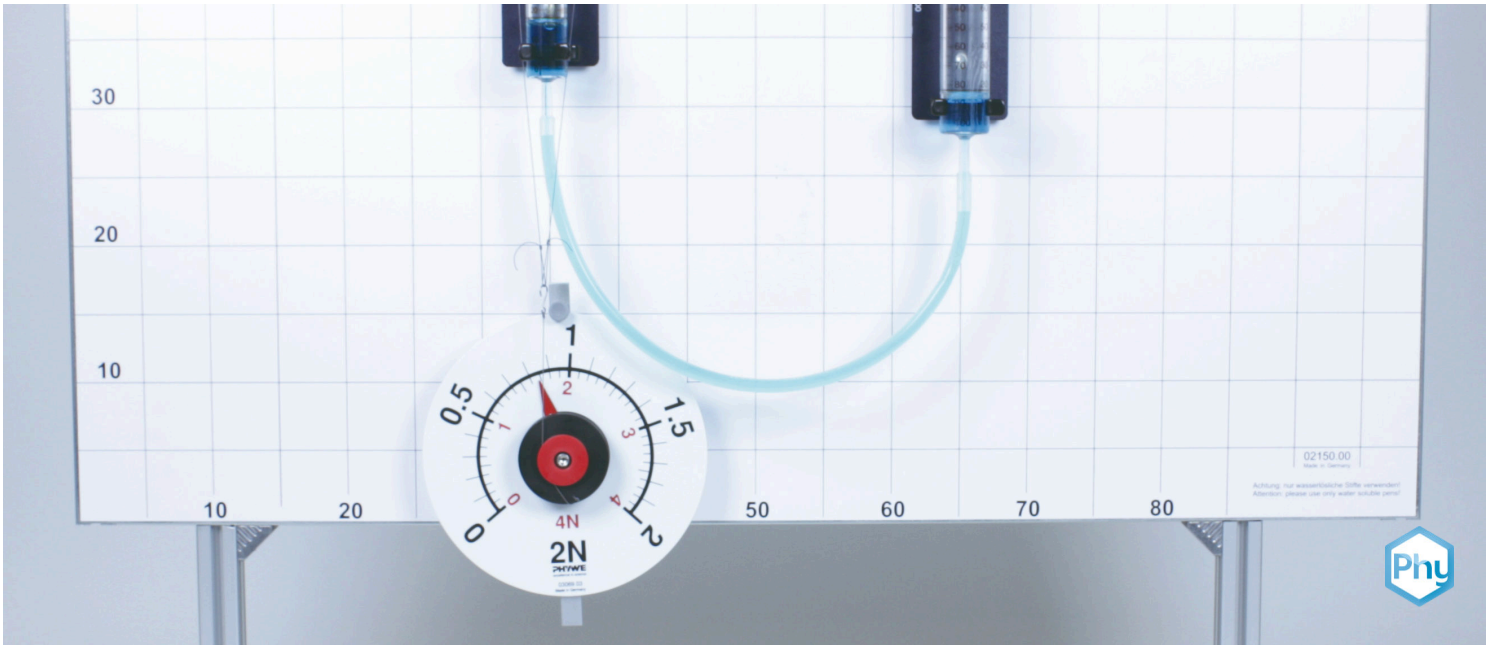
Hydraulic press



P1297000

Physics | Mechanics | Mechanics of liquids & gases

Difficulty level	Group size	Preparation time	Execution time
medium	-	10 minutes	20 minutes

This content can also be found online at:

http://localhost:1337/c/66c2eb7fca933a0002b6c5db

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General information

Application

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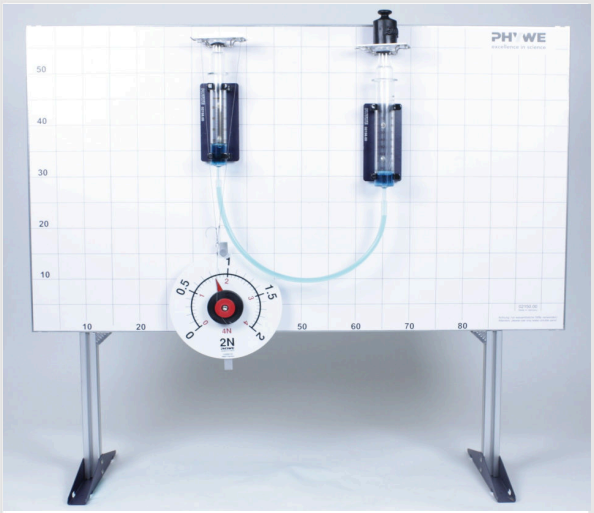

Fig. 1: Experimental setup

A hydraulic press is a force-bound pressing machine that works according to the hydrostatic principle. Hydraulic systems are force-forming devices in which the uniform and all-round spread of pressure in liquids is utilised. Forces are transmitted by piston pressure and their amount or direction is changed.

A hydraulic press is also used as a body part for cars, e.g. the pump piston. The pump piston creates pressure in the fluid, which also acts on the working piston (press piston). As the surface area of the press piston is significantly larger than the surface area of the pump piston, the force on the press piston is also significantly greater than that on the pump piston according to the law for hydraulic systems.

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Other information (1/2)

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Prior knowledge

Students need previous knowledge of hydraulic presses. It is also important to know "Pascal's principle".

Principle

A model of a hydraulic press is used to work out the principle mode of operation of hydraulic systems.

Other information (2/2)

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Learning objective

In this experiment, the students are supposed to understand the basics of the hydraulic press through an example.

Tasks

The task of this experiment is to understand the basic mode of operation of hydraulic systems. The students are supposed to discover the relationships between A, F and p.

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Safety instructions

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The general safety instructions for experimentation in science lessons apply.

Theory

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A hydraulic press is based on Pascal's principle: pressure exerted on an enclosed fluid is redistributed to every part of the fluid unchanged.

According to Pascal's principle, the pressure in a liquid is constant. A force F_1, which is applied to the area A_1 of the small piston, generates a change in the hydrostatic pressure which is then acting on the area A_2 of the large piston. This results in a force F_2 on the large piston. As the pressure is distributed evenly throughout the fluid according to Pascal's law, the following applies:

$p_{small} = p_{large}$ or $F_1/A_1 = F_2/A_2$

Using the equation, the area A_2 of the large piston is much larger than the area A_1 of the small piston, and the force F_2 acting on the large piston is also much larger than F_1. This allows a small force to be amplified into a large force.

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Equipment

Position	Equipment	Item no.	Quantity
1	PHYWE Demo Physics board with stand	02150-00	1
2	Torsion dynamometer	03069-03	1
3	Slotted weight, silver-bronze, 50 g	02206-03	2
4	Slotted weight, silver-bronze, 50 g	02206-03	2
5	Fish line, l. 100m	02090-00	1
6	Syringe holder on fixing magnet	02156-00	2
7	Gas syringe, 100 ml	02614-00	2
8	Plunger plate for gas syringes	02618-00	2
9	Silicone tubing, various diameters (7 mm)	39296-00	1
10	Commercial weight, 500 g	44096-50	1
11	Commercial weight, 200 g	44096-20	1
12	Marker, black	46402-01	1
13	Screw clamp	02014-01	2

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Setup and procedure

Setup (1/2)

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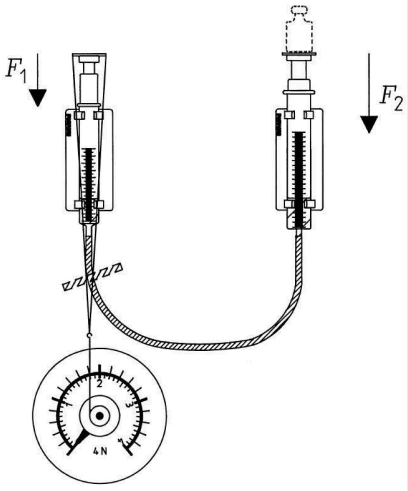

Fig. 2

- Determine the weight forces F_{K1} and F_{K2} before the lesson with the torsion dynamometer for the pistons with the plunger plate.
- Assemble the model of a hydraulic press on the demo board and position it so that the plunger plates are level with the upper edge of the board (Fig. 2).
- Place the torsion dynamometer on the lower edge of the board below the 50 ml gas syringe.

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Setup (2/2)

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- Place a fishing line 50 - 60 cm long over the plunger plate of the 50 ml gas syringe and guide it so that the loop formed by the line does not touch any other parts of the assembly once the dynamometer has been hooked in.
- If necessary, attach the tube to the board with an adhesive strip (Fig. 2).
- Set the torsion dynamometer to zero.
- Depict F_1 and F_2 symbolically on the demo board with a marker.

Procedure (1/2)

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1. Note the forces F_{K1} and F_{K2} and realise that the system is in balance and that initially $F_1 = F_{K1}$ and $F_2 = F_{K2}$.
2. Enter the values for the pressure-generating forces F_1 and F_2 in Table 1.
3. Pressurise the working plunger (piston of the 100 ml syringe) with $m_B = 100g (= F_B)$ and read the tensile force F_z on the dynamometer which, together with F_{K1}, is required for the equilibrium of the system.
4. Enter m_B and the measured value for F_z in Table 1. (Notes: If the friction between the piston and the cylinder walls is relatively high, the following procedure is recommended: First press one of the pistons by hand and measure the force F_z which is set after the piston is released. Proceed in the same way with the second piston, form the average value for F_z and notes this down. Due to the relatively large tolerance for the values of F_z it makes sense to round the numerical values to two digits. Then the numerical values for F_B, F_{K1} and F_{K2} have to be rounded accordingly (see result).

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Procedure (2/2)

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5. Vary the force F_B by loading the working piston with weighing pieces of different masses m_B and thus F_2.
6. Measure and note the force F_z required in each case.

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Evaluation

Observation

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m_B/g	F_Z/N	F_B/N	F_2/N	F_1/N	F_1/F_2
0	0,0	0,0	1,5	1,0	0,67
100	10,6	1,0	2,5	1,6	0,64
200	1,2	1,9	3,4	2,2	0,65
300	1,9	2,9	4,4	2,9	0,66
400	2,5	3,9	5,4	3,5	0,65
500	3,2	4,9	6,4	4,2	0,66
600	3,8	5,9	7,4	4,8	0,65

Tab. 1

Pressure piston:
$A_1 = 4,91cm^2 \approx 4,9cm^2$

$F_{K1} = 1,03N \approx 1,0N$

Working piston:
$A_2 = 7,54cm^2 \approx 7,5cm^2$

$F_{K2} = 1,46N \approx 1,5N$

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Evaluation (1/2)

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First, the values for the force $F_B = m_B g$ are calculated and entered in column 3 of Table 1. Then the forces $F_2 = F_{K2} + F_B$ and $F_1 = F_{K1} + F_Z$ are calculated and entered in columns 4 and 5.

The graphical representation of F_1 as a function of F_2 results in a straight line through the origin of the coordinates (Fig. 2). This means $F_1 \sim F_2$ or $F_1/F_2 = konstant$

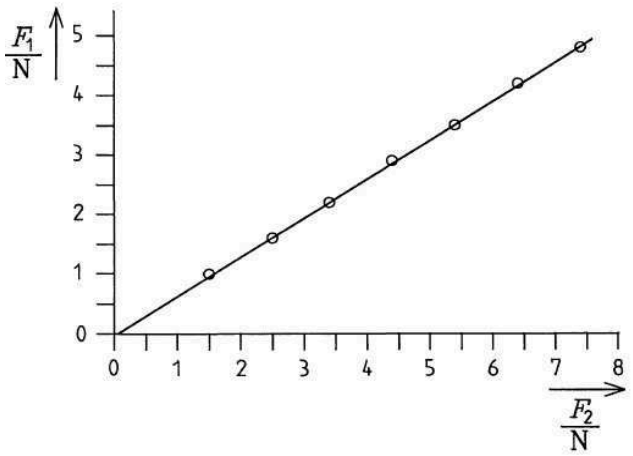

Fig. 3

Evaluation (2/2)

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This finding is confirmed in the context of measurement accuracy after calculating the quotients F1 /F2 (see Table 1, column 6), the mean value of which is approximately 0.65. This is the value of the quotient A_1/A_2 because $A_1/A_2 = 4,9cm^2/7,5cm^2 = 0,65$

In the hydraulic press, the forces therefore behave like the cross-sectional areas on which they act: $F_1/F_2 = A_1/A_2$

It follows from this: $F_1/A_1 = F_2/A_2$ or $p_1 = p_2$

In the incompressible liquid the pressure generated by F_1 has the same effect everywhere and therefore also on the surface A_2.

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Notes (1/2)

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To save time, the hydraulic press model should be assembled before the lesson. To avoid air bubbles in the cylinders or in the connecting hose as much as possible, the following is recommended: Push the plunger of the 50 ml gas syringe right to the bottom of the cylinder - hold the nozzle of the syringe in water and fill the cylinder 2 to 3 cm high by pulling out the plunger - turn the syringe upside down, push the plunger into the cylinder as far as it will go, place the holder on the demo board and clamp the syringe in place; Push a silicone tube about 50 cm long onto the nozzle of the 100 ml syringe - draw in water with the plunger until the tube and two thirds of the cylinder are filled - turn the syringe over, hold the tube upwards and push the plunger in until the air bubbles have escaped and the tube is so full that water begins to run out - push the free end of the tube onto the nozzle of the 50 ml syringe and place the 100 ml syringe on the board with the second holder.

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