The hydraulic press (Item No.: P1297000)

Curricular Relevance

Area of Expertise:	Education Level:	Topic:	Subtopic:	Experiment:
Physik	Klasse 7-10	Mechanik	Mechanik der Flüssigkeiten	Hydraulische Presse

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	10 Minutes	20 Minutes	1 Student

Additional Requirements:

Experiment Variations:

Keywords:

Principle and equipment

Principle

The principle of how a hydraulic system functions is to be worked out on the basis of a model of a hydraulic press.

Equipment

Position No.	Material	Order No.	Quantity
1	Demo Physics board with stand	02150-00	1
2	Torsion dynamometer	03069-03	1
3	Slotted weight, black, 50 g	02206-01	2
4	Slotted weight, silver bronze, 50 g	02206-02	2
5	Fish line, l. 100m	02090-00	1
6	Syringe holder on fixing magnet	02156-00	2
7	Gas syringe, 50 ml	02610-00	1
8	Gas syringe, 100 ml	02614-00	1
9	Plunger plate for gas syringes	02618-00	2
10	Silicone tubing i.d. 7mm, 1 m	39296-00	1
11	Commercial weight, 500 g	44096-50	1
12	Commercial weight, 200 g	44096-20	1
13	Marker, black	46402-01	1

Set-up and procedure

Set-up

- Prior to the lesson, determine the weight forces F_{K1} and F_{K2} for the plungers with plunger plates, and completely assemble the model of a hydraulic press on the demo-board (see Notes). Position the model so that the plunger plates are at the height of the top of the board (Fig. 1).
- Position the torsion dynamometer at the lower edge of the board, underneath the 50 ml gas syringe.
- Lay a 50 ... 60 cm length of fishing line over the plunger plate on the 50 ml gas syringe, and lead it further so that the loop formed by the line after fitting it to the dynamometer does not touch any other part of the apparatus. If necessary, fix the Silicone tubing to the board with a strip of adhesive tape (Fig. 1).
- Set the dynamometer to zero.
- Use the pen to symbolically denote F_1 and F_2 on the demo-board.

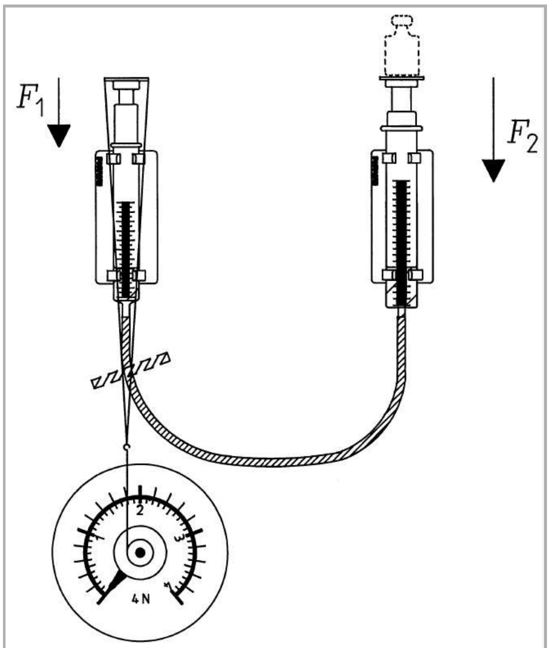

Fig. 1

Procedure

- Note the forces F_{K1} and F_{K2}; bring the students to realize that the system is in equilibrium, and that at first $F_1 = F_{K1}$ and $F_2 = F_{K2}$; enter the values for F_1 and F_2, the forces generating pressure, in Table 1.
- Load the working plunger (the plunger of the 100 ml syringe) with $m_B = 100g$ (= F_B) and read oft from the dynamometer the tractive force F_z , which is required, together with F_{K1}, for the equilibrium of the system; enter m_B and the value measured for F_z in Table 1.

  Notes: Should the friction between the plungers and the walls of the cylinder be relatively large, we recommend the following procedure: First press one of the plungers by hand and measure F_z, the force which results when the plunger is let go of. Carry out the same procedure with the other plunger, then calculate the average value for F_z and note it. Because of the relatively large tolerances for the values of F_z they should be rounded off to two significant figures. This means that the numerical values for F_B, F_{K1} and F_{K2} should be similarly rounded oft. (see Results).
- As a result of the loading of the working plunger with weights of different mass m_B, the force F_B and so F_2, vary. Measure and enter the force F_z which is required each time.

Observations and evaluation

Observations

Pressure plunger: $A_1 = 4.91\,cm^2 \approx 4.9\,cm^2$

$F_{K1} = 1.03N \approx 1.0N$

Working plunger: $A_2 = 7.54cm^2 \approx 7.5\,cm^2$

$F_{K2} = 1.46N \approx 1.5N$

Table 1

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

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Evaluation

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

The graph of F_1 as a function of F_2 gives a straight line which passes through the origin (Fig. 2). This means that:

$F_1 \sim F_2$ or $F_1 / F_2 = constant$

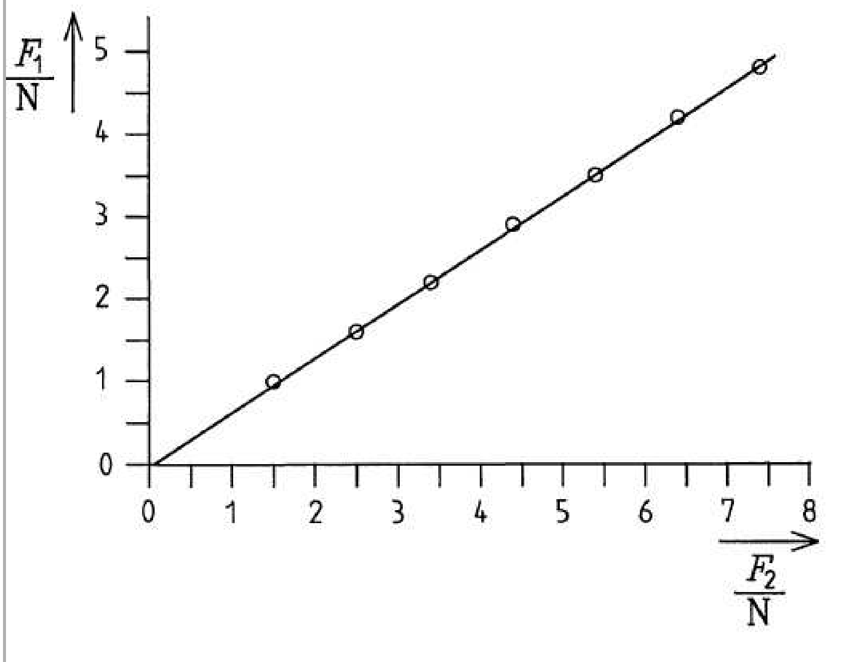

Fig. 2

This is confirmed, within the accuracy of the experiment, when the quotient F_1/F_2 is calculated (see Table 1, column 6). The average value is about 0.65. This is the same value as that for A_1/A_2, as $A_1 / A_2 = 4,9 cm^2 / 7,5 cm^2 = 0,65$.

With the hydraulic press, therefore, the forces have the same relationship to each other as the cross-sectional areas on which they work:

$$F_1 / F_2 = A_1 / A_2$$

From which:

$F_1 / A_1 = F_2 / A_2$ oder $p_1 = p_2$

The pressure caused by F_1 acts at the same strength everywhere in the incompressible liquid, and so also on the surface area A_2.

Remarks

The model of the hydraulic press should be put tagether before the lesson to save time. To avoid air bubbles in the cylinders or in the connecting tubing to as great an extent as possible, we recommend the following procedure: Press the plunger of the 50 ml gas syringe down to the bottom of the cylinder- hold the nozzle of the syringe under water and fill the cylinder to a height of 2 to 3 cm by drawing back the plunger-turn the syringe upside down, press the plunger as far as it will go into the cylinder, put the holder on the demo-board and clamp the syringe to it; fit an approximately 50 cm length of silicone tubing on the nozzle of the 100 ml sysringe - use the plunger to suck up water until the tubing and two thirds of the cylinder are full of water- turn the syringe upside down, hold the tubing up and depress the plunger so far, that the air bubbles have escaped and the tubing is so full of water, that water begins to run out of it -fit the free end of the tubing on the nozzle of the 50 ml syringe and position the 100 ml syringe on the board with the second holder.

One must accept relatively large measurement errors in this experiment, as forces of friction can be quite large. Errors also occur from the tolerance of the values read off from the dynamometer. The hydraulic press, just like other hydraulic systems (hydraulic lifts, car brakes etc.), is based on the working principle that one can use a small force F_1 on a pressure piston which has a smaller cross-sectional area A_1 to generate a pressure which exerts a very large pressure force F_2 on a working piston, provided a sufficiently large cross sectional area A_2 has been selected for this.