Pressure in gases (Item No.: P1297600)

Curricular Relevance

Area of Expertise: Physik
Education Level: Klasse 7-10
Topic: Mechanik
Subtopic: Mechanik der Gase
Experiment: Druck in Gasen

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

Additional Requirements:

Experiment Variations:

Keywords:

Principle and Equipment

Principle

An enclosed amount of gas is to be compressed by the pressure of a plunger, and an investigation is to be made as to which relationship thereby exists between the pressure of the gas and the pressure force acting on a defined area.

Equipment

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

Set-up and procedure

Set-up

- Use the holders to position the gas syringes, with plungers removed, at the top edge of the demo-board.
- Connect the syringes with an approximately 50 cm length of silicone tubing.
- Use the dynamometer to determine the weight forces F_{K1} and F_{K2} for the plungers, each inclusive plunger plate, and note the values.
- Push the plunger of gas syringe 1 (50 ml) completely in, right down to the bottom.
- Push the plunger of gas syringe 2 (100 ml) so far in the cylinder, until the bottom surfaces of the two plungers are at about the same height.
- Make a loop from the fishing line which is sufficiently large to fit over the plunger plate of syringe 1.
- Position the torsion dynamometer so underneath syringe 1 , that after hooking it to the loop, the loop touches neither the tubing nor the syringe or its holder, and the dynamometer is set to zero. If necessary, fix the silicone tubing to the board with a strip of adhesive tape.
- Use the pen to symbolically denote F_1 and F_2 on the demo-board (Fig. 1).

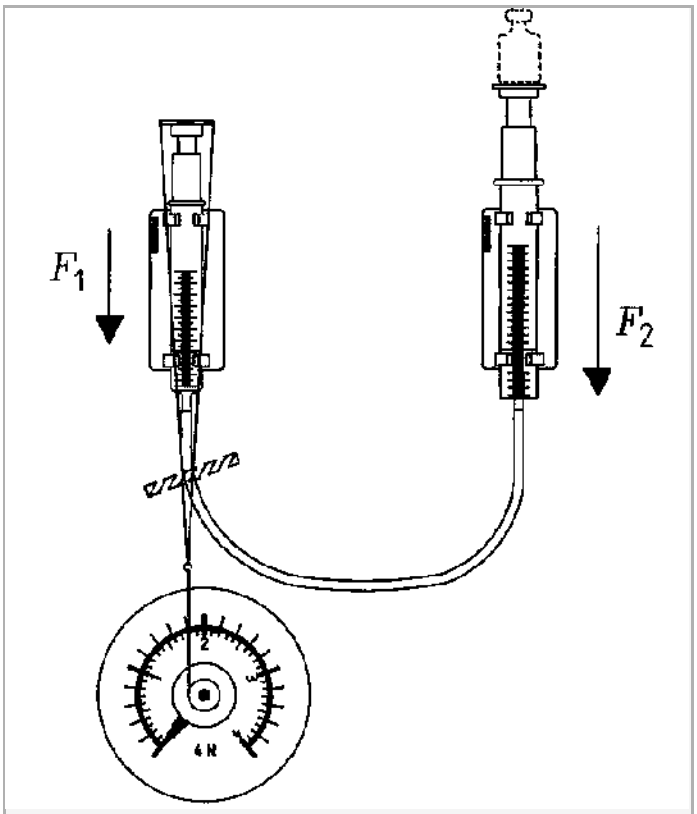

Fig. 1

Procedure

- Make clear, that the system is in equilibrium; enter the forces $F_2 = F_{K2}$ and $Fsub1 = F_{K1}$ in Table 1. Load plunger 2 with $m_B = 200g$.
- Balance out the two plungers to some extent by hand, to lessen the unavoidable frictional forces between the plungers and the cylinders.
- Read oft from the dynamometer the tractive force F_z which is required, together with F_{K1}, for the equilibrium of the system; enter F_z in Table 1.

  Note: The determination of F_z should be carried out quickly, particularly with heavy loads, because the plungers can keep sliding down somewhat. Because of the relatively large tolerances for the values of F_z it is judicous to round them oft to two significant figures. When this is done, the numerical values for F_B, F_{K1} and F_{K2} must be similarly rounded oft.
- Vary the load on plunger 2, determining the corresponding values for force F_z and noting them.

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Observations and evaluation

Observations

$F_{K1} = 1.03N \approx 1.0N$
$F_{K2} = 1.46N \approx 1.5N$
$A_1 = 4.91cm^2 \approx 4.9cm^2$
$A_2 = 7.54cm^2 \approx 7.5cm^2$
$A_1 / A_2 = 0.65$

Table 1

Load on plunger m_B/g	F_B/N	F_Z/N	F_2/N	F_1/N	F_1/F_2
0	0.0	0.0	1.5	1.0	0.67
200	2.0	1.2	3.5	2.2	0.63
300	2.9	1.8	4.4	2.8	0.64
400	3.9	2.5	5.4	3.5	0.65
500	4.9	3.1	6.4	4.1	0.64
600	5.9	3.7	7.4	4.7	0.64

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Evaluation

Determine the cross-sectional areas of the plungers, A_1 and A_2 by measurement and calculation (if they are not provided) and note them. Enter the quotient A_1 / A_2 below them.

Calculate the values for F_B according to $F_B = m_B * g$, round them oft and enter them in Table 1, column 2.

Use the formulas $F_2 = F_{K2} + F_B$ and $F_1 = F_{K1} + F_Z$ to calculate the forces which act on the plungers. Note them in Table 1, columns 4 and 5.

The graphical representation of $F_1 = f(F_2)$ gives a straight line which passes through the origin, within the accuracy of the measurement (Fig. 2). It follows from this, that $F_1 \sim F_2$ or $F_1 / F_2 = konstant$, in agreement with the figures for the quotient F_1 / F_2 in the last column of Table 1.

The average value for the quotient F_1 / F_2 is almost 0.65.

The quotient A_1 / A_2 has the value 0.65, so that:

$F_1 / F_2 = A_1 / A_2$ or

$F_1 / A_1 = F_2 / A_2$ or

p_1 / p_2

When pressure is exerted on an enclosed amount of gas, the gas pressure is the same everywhere:

$p = F_1 / A_1 = F_2 / A_2 = \ldots = F_n / A_n$.

Remarks

The experiment is not successful when there is noticeable friction between the plungers and the cylinders of the gas syringes, or when the plungers do not close weil. To remedy this, thoroughly clean the sliding surfaces with a liquid which dissolves tat, e.g. alcohol, and lightly lubricate the plungers, e.g. with glycerol.

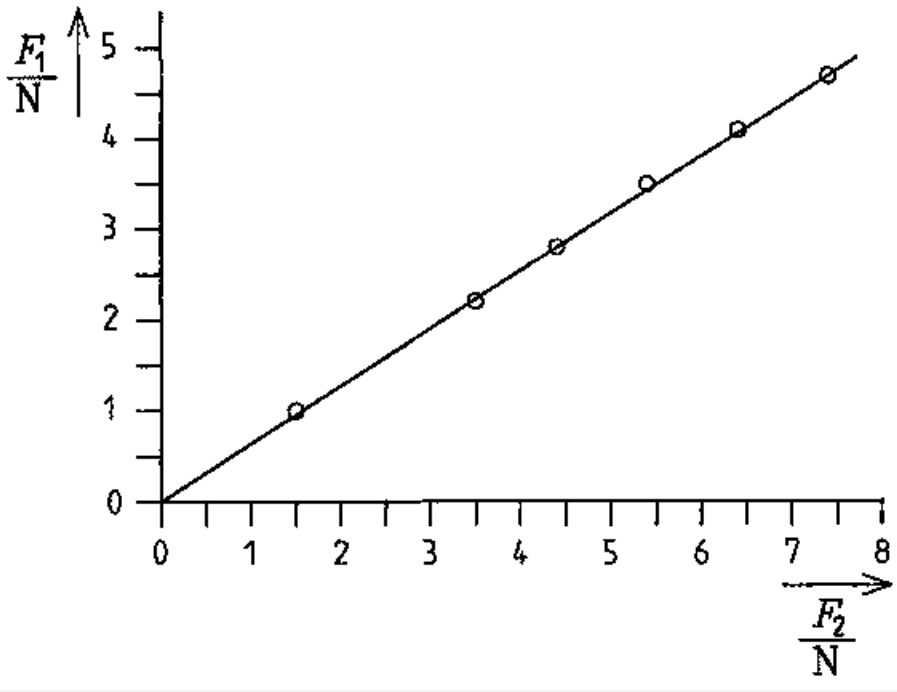

Fig. 2