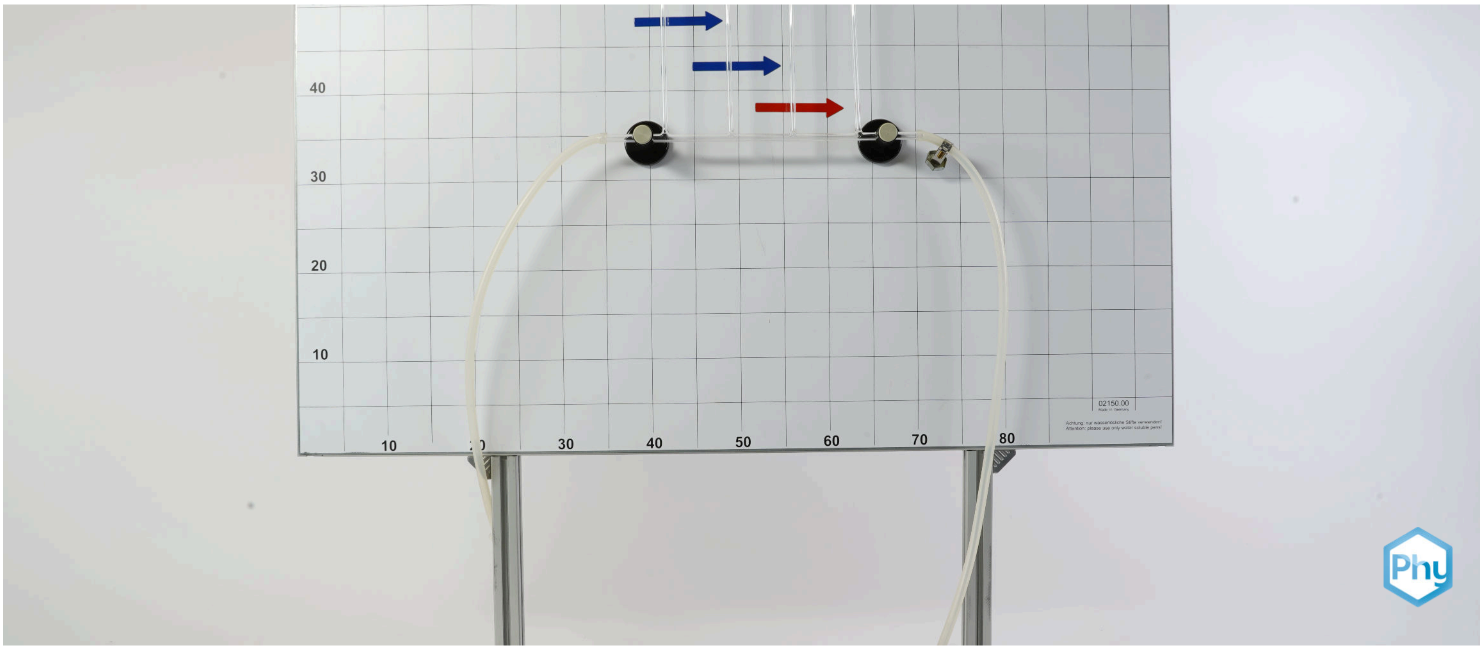
Pressure distribution in flowing liquids



P1297500

Physics | Mechanics | Mechanics of liquids & gases

Difficulty level	Group size	Preparation time	Execution time
medium	-	-	-

This content can also be found online at:

http://localhost:1337/c/66e3f607b9fd8b000221b2b5

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General information

Application (1/2)

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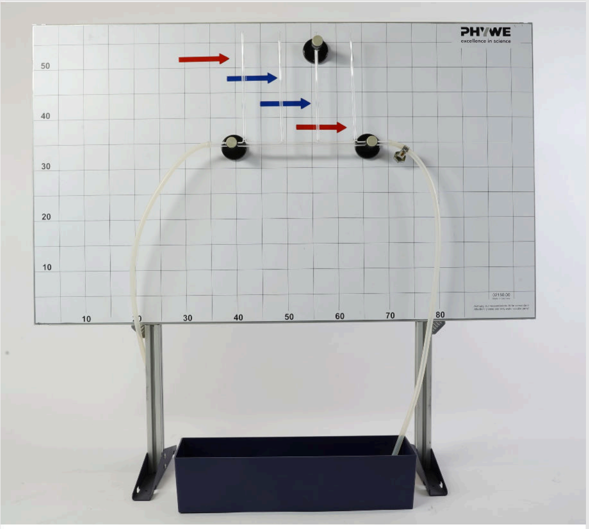

Fig. 1: Experimental setup

Static pressure is the pressure in a flowing liquid or in a flowing gas that is measured perpendicular to the direction of flow. This static pressure depends on the flow velocity. The relationship is described by Bernoulli's law: The greater the flow velocity of a liquid or gas, the lower the static pressure.

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Application (2/2)

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This principle has already been used in everyday life, e.g. the atomiser. In such an atomiser, air flows through a nozzle. The flow velocity is relatively high in the area of the nozzle and the static pressure is therefore low according to Bernoulli's law. Due to this low pressure, the liquid in a vessel is literally sucked in. It emerges from an opening and is atomised by the fast-flowing air.

Other information (1/2)

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Prior knowledge

Students should have prior knowledge of static pressure and "Bernoulli's law".

Principle

The aim is to investigate the behaviour of pressure in a flowing liquid.

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Other information (2/2)

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Learning objective

The students are to be shown and taught about the pressure distribution in flowing liquids in this experiment. The students are supposed to understand "Bernoulli's law".

Tasks

Students are to observe how pressure behaves in a flowing liquid. The students should be familiar with static pressure and understand Bernoulli's law.

Safety instructions

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The general safety instructions for experimentation in science lessons apply.

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Theory

Pressure distribution in flowing liquids refers to the static pressure that can be measured perpendicular to the direction of flow in a flowing liquid or in a flowing gas. This static pressure depends on the flow velocity. This in turn increases as the pipe cross-section is reduced. The relationship between flow velocity and pressure is described by Bernoulli's law. It states that the greater the flow velocity of a liquid or gas, the lower the static pressure.

With a constantly flowing liquid, the reduced diameter can lead to an increased flow velocity and also to a decreased static pressure.

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Equipment

Position	Equipment	Item no.	Quantity
1	PHYWE Demo Physics board with stand	02150-00	1
2	Hook on fixing magnet	02151-03	1
3	Clamping holder, 0-13 mm, fixing magnet	02151-07	2
4	Scale for demonstration board	02153-00	1
5	Pointers f. Demonst.Board, 4 pcs	02154-01	1
6	Flow pipe w.uniform cross-section	02765-00	1
7	Flow pipe w.varying cross-section	02766-00	1
8	Storage tray, 413 x 120 x 100 mm	47325-01	1
9	Rubber hose, various diameters (8 mm)	39283-00	1
10	Beaker, 100 ml, plastic (PP)	36011-01	1
11	Microspoon, steel	33393-00	1
12	Pinchcock, width 20 mm	43631-20	1
13	Pipette with rubber bulb, long	64821-00	1
14	Patent blue-V, 25 ml	48376-05	1
15	Screw clamp	02014-01	2

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Setup and procedure

Setup and procedure(1/3)

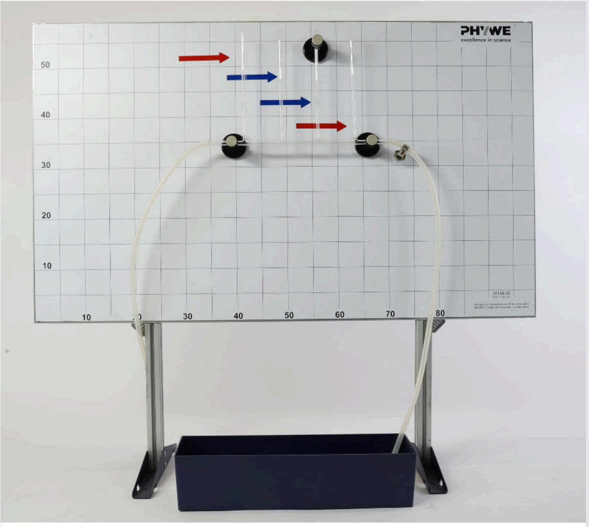

Fig. 2

1st experiment

- Attach the flow pipe with a constant diameter horizontally to the demo board using the clamps and secure it against tilting using the hook (Fig. 2)
- Place the bowl under the flow pipe (to catch overflowing water while the flow is being regulated to a desired height of the water column and the air bubbles are being removed).
- Push a tube of suitable length onto both ends of the flow pipe.

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Setup and procedure (2/3)

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- Connect one hose to the tap, fit the other with the hose clamp and lead it to the drainage basin.
- With the hose clamp loosened, carefully turn on the tap.
- Now use the hose clamp to regulate the flow so that the first riser does not overflow and the last one has a water column of several centimetres.
- Colour some water in the beaker and add a few drops of the solution to each riser using the pipette.
- Mark the height of the water columns in the risers with arrows.
- Formulate a statement about the height of the water columns.

Setup and procedure (3/3)

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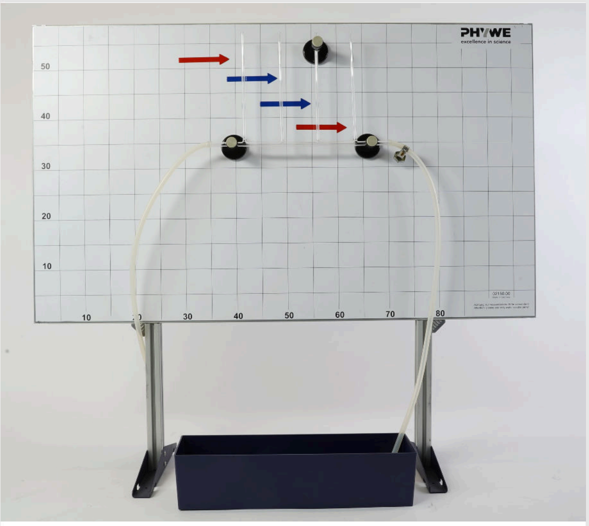

Fig. 2

2nd experiment

- Now replace the pipe with the constant diameter from the first setup with a pipe with a varying diameter.
- Proceed as in experiment 1.

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Result

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1st result

The height of the water columns decreases from the beginning of the flow pipe.

2nd result

The height of the water columns - seen from the beginning of the flow tube - is much lower in the last two risers than in the first two. It is very low in the centre riser, which is attached to the narrowing of the flow tube.

Evaluation (1/2)

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1st evaluation

After removing the flow pipe from the demo board, the scale is placed at the tips of the pointers. This shows that the height of the water columns in the riser tubes decreases linearly. The height of the water columns is a measure of the pressure ($p = \rho * g * h$), which prevails perpendicular to the direction of flow and is called static pressure.

So the following applies: In a flowing liquid, the static pressure decreases linearly in the direction of flow if the flow cross-section is the same everywhere.

The cause of the linear decrease in static pressure are frictional forces that occur between the liquid and the pipe wall as well as within the liquid.

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Evaluation (2/2)

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2nd evaluation

Within the narrowing of the flow pipe, the static pressure is much lower than before and after it. In order for the same amount of liquid to flow through all pipe cross-sections per unit of time, the liquid particles must be accelerated. This happens at the expense of the static pressure.

Notes

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If the friction could be eliminated, then all water columns would have the same height in experiment 1 and all but the column above the narrowing would have the same height in experiment 2.

The Bernoulli equation applies to the steady flow of incompressible, frictionless liquids:

Total pressure = static pressure + dynamic pressure or

$p_{ges} = p + 1/2p - v^2$ with

$V =$ Flow velocity and

$\rho =$ Density of the flowing liquid .

The dynamic pressure acts in the direction of the flow. It is called dynamic pressure in analogy to static pressure..

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