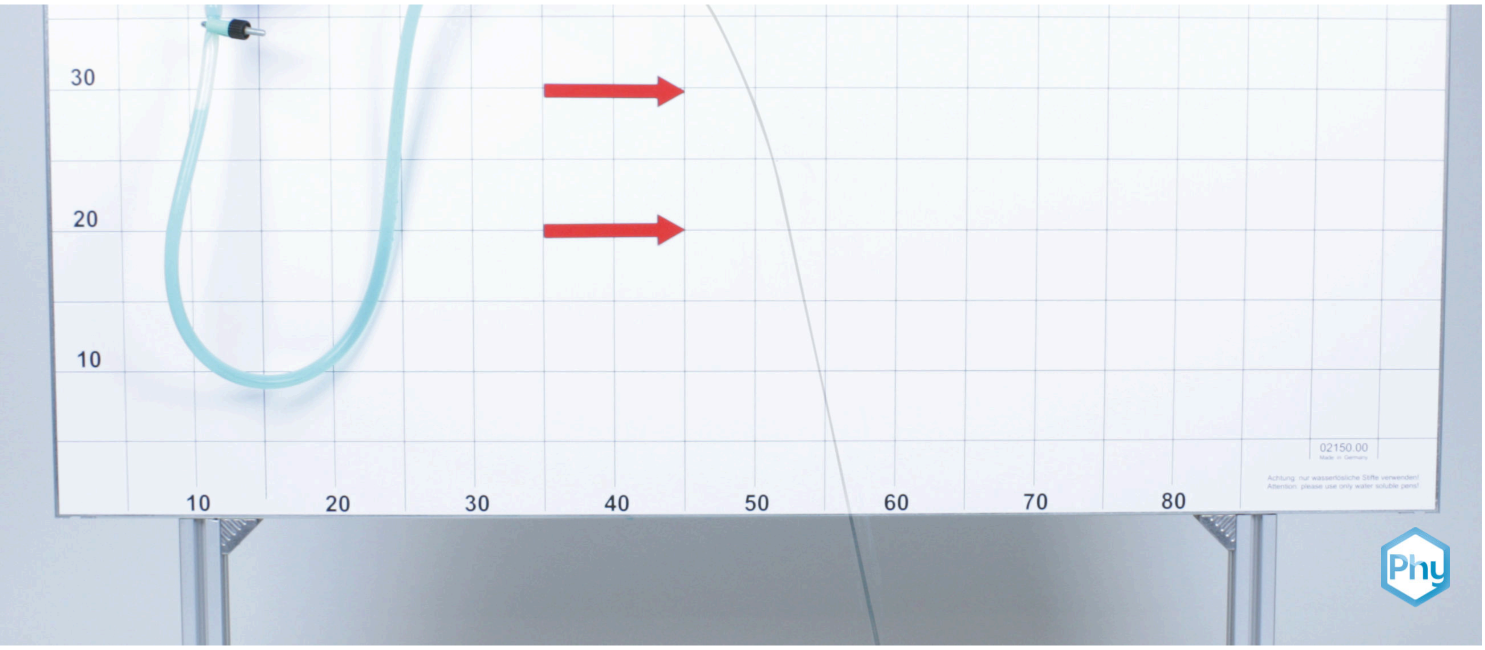
Efflux velocity from a vessel



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/66d96fcfdfd1b20002588569

General information

Application

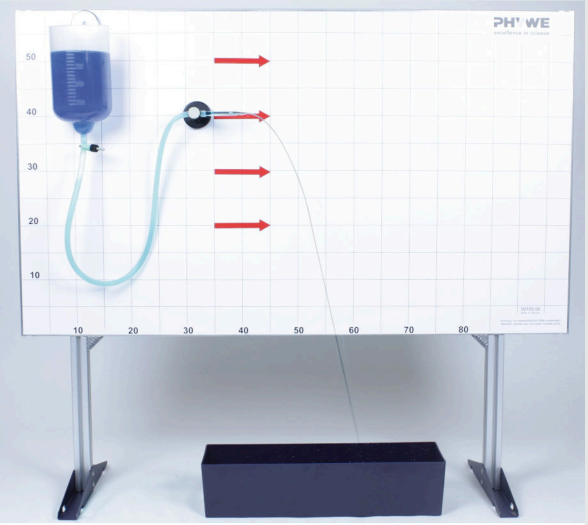


Fig. 1: Experimental setup

Efflux velocity is the speed at which a liquid or gaseous substance of very low viscosity (e.g. water) flows out of an opening in the vessel containing it.

The simplified description of the efflux velocity (v) is defined as

$$v = \sqrt{2gh}$$

It only depends on the pressure level, but not on the density of the liquid. When a water-filled bathtub is emptied, the efflux velocity is always higher at first and decreases as the water level falls.

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Other information (1/2)

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Prior knowledge

The students should have prior knowledge of efflux velocity and hydrostatic pressure.

Principle

The aim is to investigate the behaviour of the velocities at which water emerges from a vessel that has outlet openings at different heights in the wall.

Other information (2/2)

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Learning objective

The principle of efflux velocity is to be explained to the students in this experiment. The students are supposed to learn what role heights play in this.

Tasks

The task of this experiment is to observe the behaviour of the velocities at which water emerges from a vessel that has outlet openings at different heights in the wall.

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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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With efflux velocity it is relatively easy to determine the speed at which a liquid flows out of a vessel through openings due to hydrostatic pressure.

At first, the water can only flow out so forceful that the jet does not reach higher than the original water surface.

The hydrostatic pressure is:

$$p = \rho \cdot g \cdot h$$

The hydrostatic pressure is therefore dependent on h (height). The greater h is, the greater the hydrostatic pressure.

This results in different velocities at which the water emerges from the vessel.

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Equipment

Position	Equipment	Item no.	Quantity
1	PHYWE Demo Physics board with stand	02150-00	1
2	Pointers f. Demonst.Board, 4 pcs	02154-01	1
3	Marker points for demonstration board, 24 pcs	02154-02	1
4	Clamping holder, 0-13 mm, fixing magnet	02151-07	1
5	Storage tray, 413 x 120 x 100 mm	47325-01	1
6	Overflow vessel on fixing magnet	02158-00	1
7	Graduated beaker, 1000 ml, plastic (PP)	36640-00	1
8	Screw clamp	02014-01	2

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Setup and procedure

Setup and procedure (1/2)

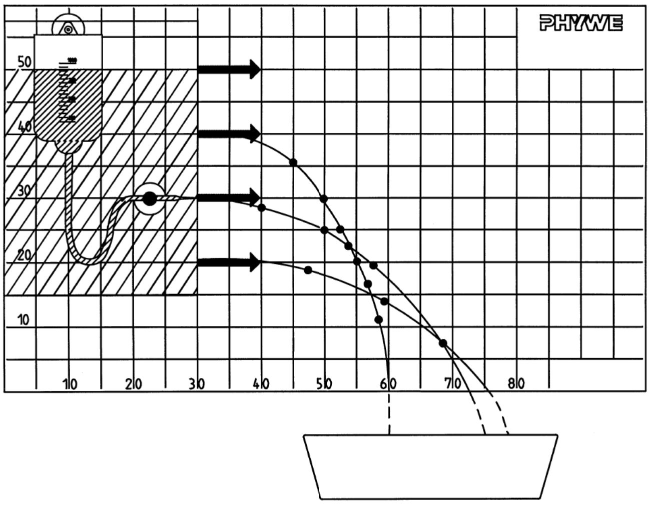

Fig. 2

- Place the overflow vessel on the white side with the line grid at the top left of the demo panel .
- Place and tighten the hose clamp directly in front of the glass nozzle.
- Pour 1000 ml of water into the vessel and remove the trapped air bubbles by squeezing the tube.
- Draw the outline of an imaginary larger vessel on the board, which is to be modelled by the outlet vessel. (Fig. 2)

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Setup and procedure (2/2)

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- Use the pointers to mark the water level and suitable points where the outlet openings should be located.
- Place the bowl on the table under the board to collect the water.
- Using the clamp holder, place the nozzle of the outlet vessel on the panel so that it ends in front of a marked outlet opening and lies horizontally.
- Loosen the hose clamp and outline the path of the water with dots of the same colour.
- Tighten the hose clamp and pour the leaked water back into the outlet vessel.
- Place the clamp holder with the nozzle in front of the second and then also in front of the third outlet opening and proceed in the same way as before.
- Each time use dots of the same colour.

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Evaluation

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Evaluation (1/2)

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The deeper the outlet opening, the further away from the vessel the water jet runs, i.e. the greater the efflux velocity of the water.

The paths that the water has taken, labelled with dots, are drawn on the board with the marker (indicated in Fig. 1). This results in parabolas that are all the more compressed the deeper the outlet opening is.

The fact that the efflux velocity is greater the deeper the outlet opening is explained by the gravitational pressure, which is proportional to the height h of the water column above the outlet opening:

$$p = \rho \cdot g \cdot h$$

because of

$$F = p \cdot A = \rho \cdot g \cdot h \cdot A$$

Evaluation (2/2)

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A pressure force F proportional to the depth h acts on the emerging water jet which accelerates the emerging water particles and thus determines their velocity.

Although this pressure force is also proportional to the area A, this has no effect on the speed at which the water escapes. This is because as the cross-sectional area A increases, so does the mass of water escaping per unit time, which is accelerated by the pressure force.

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Note

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Because the nozzle opening is small, little water escapes from the vessel per time unit; and if the observation times are kept relatively short in each case, the water level in the outlet vessel therefore only drops slightly overall during a partial process. It is therefore sufficient to pour back the water that has escaped.

It is not absolutely necessary to use the white side of the board for this experiment. However, it does offer some advantages, including the drawing of the large vessel and positioning the outlet openings and the nozzle.

It is advisable to also place a large absorbent cloth under the bowl to catch splash water.

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