Pumps and siphons

Physics > Mechanics > Mechanics of liquids & gases

Difficulty level	Group size	Preparation time	Execution time
medium	2	10 minutes	10 minutes

This content can also be found online at:

http://localhost:1337/c/5fda41feb5c96200036a6489

PHYWE

Teacher information

Application

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Experimental set-up for investigating the mode of action of pumps

Pumps are mostly used to convert the power of a rotating drive machine into lifting work. For this purpose, a pressure is generated with the aid of the pump.

One only speaks of a pump when it is used to convey incompressible fluids. Accordingly, the designation "air pump" is incorrect in that compressible air is pumped into a limited volume and compressed (compressor).

According to hydrostatics, the resultant pressure of a column of liquid results in:

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

In order for a pump to deliver a liquid to a certain height, this pressure must be reached or exceeded.

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Other teacher information (1/2)

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Prior knowledge

Students should have already learned basic pressure and volume.

Scientific principle

The principle of pump action is based on the assumption that only incompressible fluids can be pumped with the aid of a pump.

Annotation:

The unit of pressure is Pa or N/m^2.

According to the SI system: $1\ Pa = 1\ N/m^2$.

Other teacher information (2/2)

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Learning objective

Students will study and understand the operation of a simple feed pump.

Tasks

Have students build a simple pump and use it to investigate how it works.

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Safety instructions

The general instructions for safe experimentation in science lessons apply to this experiment.

Student Information

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Motivation

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Garden pump for pumping water from a well

Pumps are generally used to move liquids from one place to another.

Pumps work on the principle of creating a pressure that moves a fluid through a pipe or tube.

A classic example of a pump, which you may have used before, is the garden pump shown in the illustration. Here, a vacuum is created in a cylinder by the axial displacement of the piston, which sucks in the liquid (in this case water) and transports it from the ground to the surface.

Tasks

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In this experiment, you will familiarize yourself with how a simple pump works.

For this purpose, you will build a pump and study how it works. Then build a so-called siphon and find out how it works.

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Equipment

Position	Material	Item No.	Quantity
1	Support base, variable	02001-00	1
2	Support rod, l = 600 mm, d = 10 mm, split in 2 rods with screw threads	02035-00	2
3	Support rod, stainless steel, l = 250 mm, d = 10 mm	02031-00	1
4	Boss head	02043-00	1
5	Plate with scale	03962-00	1
6	Beaker, 100 ml, plastic (PP)	36011-01	1
7	Beaker, 250 ml, plastic (PP)	36013-01	1
8	Glass tube holder with tape measure clamp	05961-00	1
9	Syringe 20ml, Luer, 100 pcs	02591-10	1
10	Tubing connect.,T-shape,ID 8-9 mm	47519-03	1
11	Rubber stopper 26/32, 1 hole 7 mm	39258-01	2
12	Rubber stopper, d=9/5mm, w/o hole	39250-00	1
13	Glass bell with tube	03917-00	2
14	Glass tube,hooked, 160x30, 10p	36701-54	1
15	Glass tube, straight, l=80 mm, 10/pkg.	36701-65	1
16	Rubber ball,diam.15 mm	03921-00	2
17	Rubber tubing, i.d. 3 mm	39279-00	1
18	PVC tubing, inner dia. = 7 mm, l = 1 m	03985-00	1

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Set-up (1/6)

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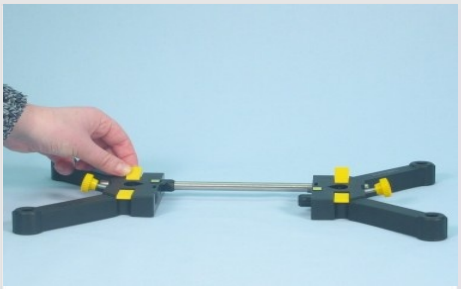
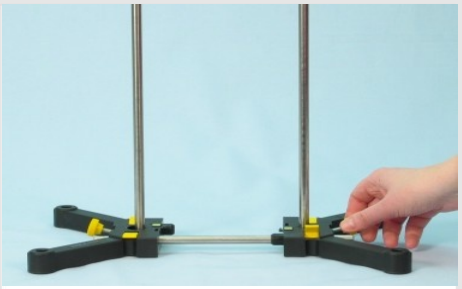
Connect the two halves of the support base with the 250 mm long support rod and secure them with the locking levers. Screw the split 600 mm support rods together. Place the two 600 mm long support rods in the support base halves and fasten them with the locking screws.



Assembling the support base

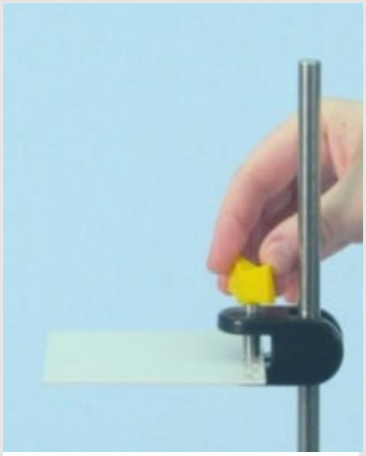
Screwing the support rods



Place long support rods in the base

Set-up (2/6)

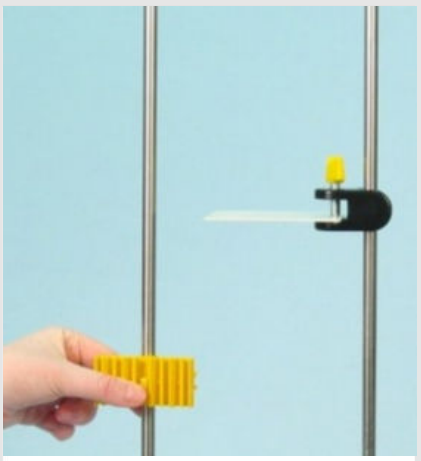
PHYWE



Attach scale plate to boss head

Attach the plate with scale to one of the two support rods using the boss head.

Attach the glass tube holder to the other support rod.



Fasten glass tube holder

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Set-up (3/6)

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Put the glass tube into the stopper

Insert the hooked glass tube into the rubber stopper.

Put a rubber ball in one of the glass bells and close it with the rubber stoppers.

Closing the glass bell jar

Set-up (4/6)

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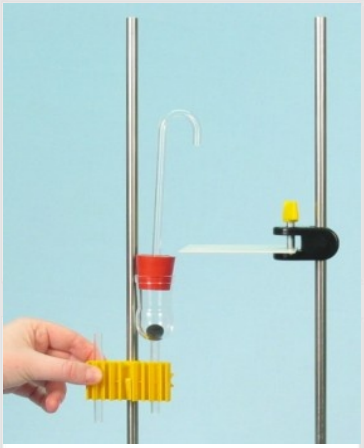

Attach glass bell to glass tube holder

Attach the glass bell with the hooked glass tube and another glass tube to the glass tube holder.

Then insert the T-shaped hose connector into the hole of the other rubber plug and attach a short piece of silicone hose to each of the other two ends of the connector.

Connect the silicone hose to the ends of the T-piece.

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Set-up (5/6)

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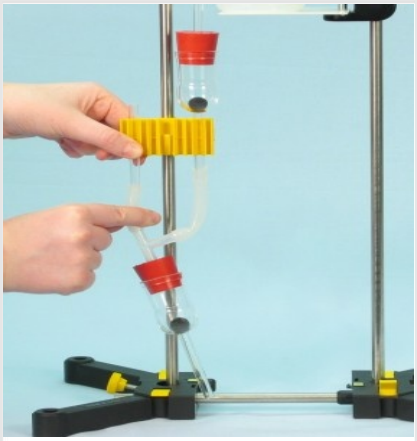
Close the glass bell jar together with the rubber ball with the help of the stopper.

Put a rubber ball in the other glass bell jar and close it with the rubber stopper with connector.

Connect the T-shaped connector to the additional glass tube and the other glass bell.



Connect the T-piece to the other glass bell jar

Set-up (6/6)

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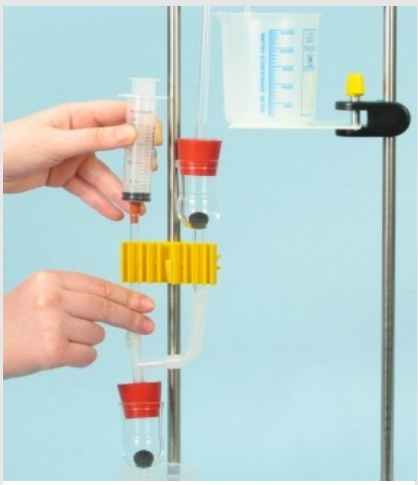
Pull the rubber hose over the syringe

Slide a piece of rubber tubing (about 8 mm long) onto the opening of the syringe.

Put this into the 80 mm long additional glass tube.

Place the plastic measuring cup on the plate as a collection vessel.



Insert the rubber hose into the glass tube

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Procedure (1/3)

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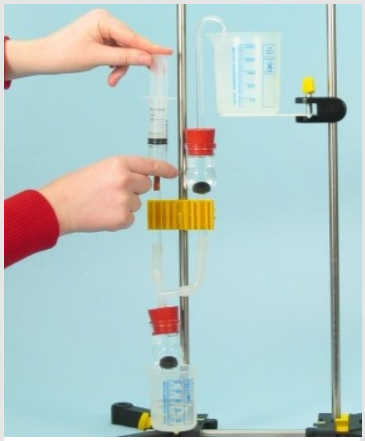

Moving the piston up and down

- Dip the lower part of the pump, i.e. the tip of the glass bell, into the filled beaker (100 ml).
- Move the plunger of the syringe up and down until water flows out of the opening of the curved glass tube.
- Observe the behavior of the two rubber balls as they pump.

Experiment set-up

Procedure (2/3)

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Filling the beaker

- Fill the 600 ml beaker with 400 ml of water. Wrap a 60 cm long silicone tube in a spiral form into the large beaker with water and make sure that the tube fills completely with water!
- Press the rubber plug onto the upper end of the hose.

Press the rubber plug into the hose

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Procedure (3/3)

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Pull the tube into the other beaker

- Now pull the end of the tube into the other beaker and lift the remaining tube out of the large beaker so that the tube runs in a large arc from one beaker to the other.
- Remove the plug and observe the process.

Unplugging

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Report

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Task 1

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Experiment 1: Pumps: Drag the words to the right place!

When the piston of the gas syringe is pulled, the _____ ball closes the respective valve.

When the piston of the gas syringe is pushed, the _____ ball closes the respective valve.

upper lower

Check

Task 2

PHYWE

Describe why one ball must close the valve when pressed and the other ball must open the valve.

- ○ No correlation can be derived for this.
- ○ This occurs due to the pressure generated within the T-shaped connector, which is located between the two glass bells.

Check

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Task 3

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Does the opening of one valve and the closing of the other valve have to happen at the same time? If so, why do you think?

- ○ Yes, it must be done at the same time, otherwise the required pressure could not be generated and the pump would be very inefficient.
- ○ No, it doesn't have to happen at the same time, because the required pressure is also generated this way, if the hoses are long enough.

Check

Task 4

PHYWE

Experimental part lifter:

What can you observe?

- ○ Nothing's happening.
- ○ The water flows constantly from one tank to the other.
- ○ The water flows into the other container.
- ○ The water's in the hose.

Check

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Task 5

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When does the process come to a halt?

- ○ Once the initially full vessel is almost empty.
- ○ Once the water has drained out of the hose.
- ○ Once half the water has been decanted.

Check

Task 6

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How high can you lift water with a suction and pressure pump? Calculate the water column h_w out of relationship $p_0 = \varrho_w \cdot h_w \cdot g$ with $\varrho_w = 1000\,kg/m^3$, $g = 9,81\,m/s^2$ and $p_0 = 1013\,hPa$:

- $h_w = 14,66\,m$
- $h_w = 8,11\,m$
- $h_w = 16,88\,m$
- $h_w = 10,33\,m$

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Slide	Score / Total
Slide 20: Experimental part Pumps: Observation	0/2
Slide 21: Pump test section: Pump action	0/1
Slide 22: Pump test section: Prerequisite	0/1
Slide 23: Experimental part lifter: Observation	0/1
Slide 24: Test section lifter: End of operation	0/1
Slide 25: Maximum pump height	0/1

Total 0 / 7

Solutions Repeat

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