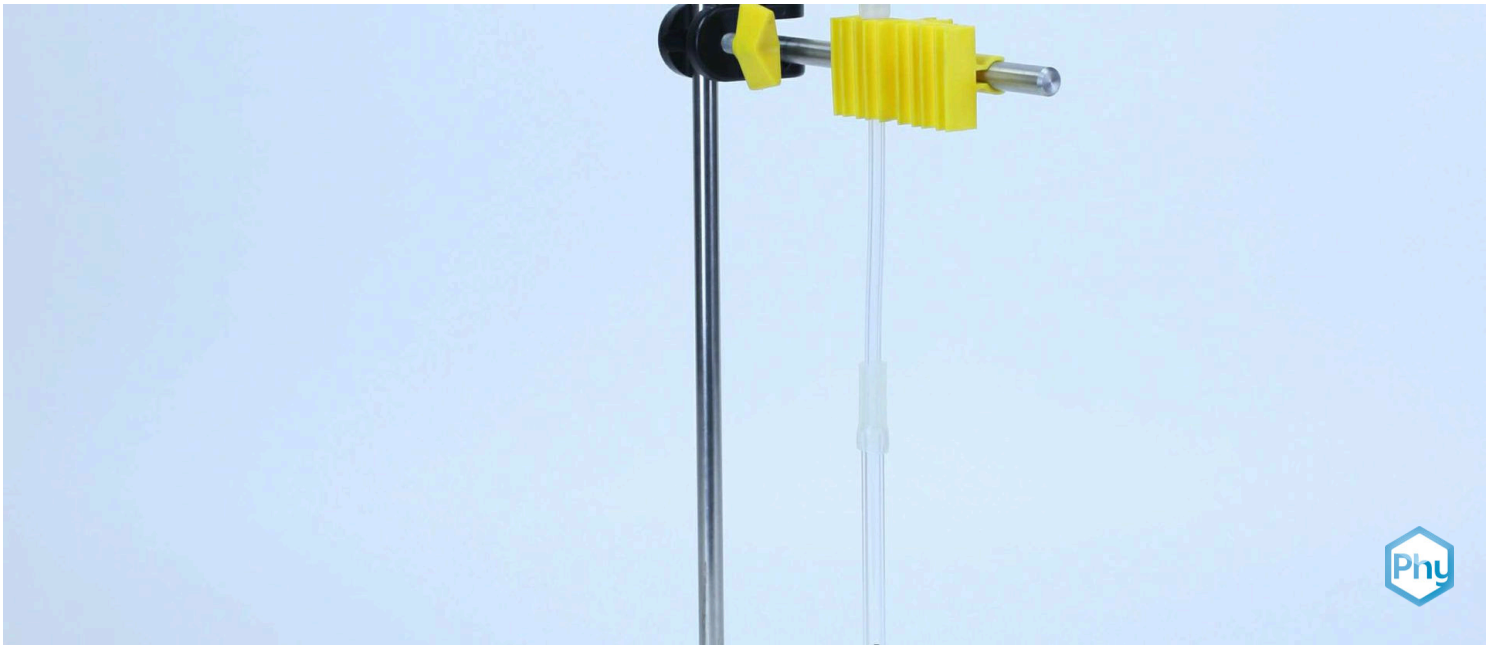
Hydrostatic pressure with Cobra SMARTsense



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/604f4bdb1d5969000384ae08

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Teacher information

Application

Experimental setup

In this experiment, students will learn about the correlations between the height of a water column and its hydrostatic pressure.

The hydrostatic pressure p is linearly dependent on the density ρ of the fluid, the acceleration due to gravity g and the height h of the water column. The pressure is conventionally measured in bar (bar) or pascal (Pa).

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

- $\rho = 1000\ kg/m^3 = 1 g/cm^3$ (for water)
- $g = 9,81\ m/s^2$
- $1\ bar = 10^5\ Pa = 10^5\ N/m^2$

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Other teacher information (1/2)

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Prior knowledge

The correlations between hydrostatic pressure p and the difference of the water levels in the manometer Δl should be explained theoretically to the students in advance of this experiment.

Scientific principle

The higher the water column, the greater the hydrostatic pressure that results from it.

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Other teacher information (2/2)

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Learning objective

Students should measure the directional independence of hydrostatic pressure (referred to as upward pressure, side pressure and ground pressure) using three probes. In addition, they are to understand the linear relationship between hydrostatic pressure and immersion depth.

Tasks

The students build a measuring set-up consisting of a pressure sensor, a connecting tube and various measuring probes.

First, the students investigate whether the pressure in the water depends on the direction. In the second part of the experiment, they are then asked to determine the hydrostatic pressure p in the water depending on the immersion depth h.

Safety instructions

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

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Student Information

Motivation

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Scuba divers

Liquids and gases exert a certain pressure depending on depth/height.

For example, think of diving to the bottom of the pool in a swimming pool. With increasing depth, the pressure on your body increases. This phenomenon is usually noticeable in the eardrum. In scuba diving, you even have to take breaks when surfacing from certain depths, so that your body can adapt to the changes in the prevailing ambient pressure.

In this experiment you will learn how the height of the water column is related to the resulting hydrostatic pressure.

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Equipment

Position	Material	Item No.	Quantity
1	Cobra SMARTsense - Absolute Pressure, 20 ... 400 kPa (Bluetooth + USB)	12905-01	1
2	Support base, variable	02001-00	1
3	Support rod, stainless steel, l = 600 mm, d = 10 mm	02037-00	1
4	Boss head	02043-00	1
5	Probes for hydrostatic pressure	02634-00	1
6	Beaker, Borosilicate, low form, 600 ml	46056-00	1
7	Silicone tubing, ID 8 mm	47531-00	1
8	Support rod, stainless steel, l = 250 mm, d = 10 mm	02031-00	1
9	Glass tube holder with tape measure clamp	05961-00	1
10	measureAPP - the free measurement software for all devices and operating systems	14581-61	1

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Set-up (1/4)

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For measurement with the **Cobra SMARTsense sensors** the **PHYWE measureAPP** is required. The app can be downloaded free of charge from the relevant app store (see below for QR codes). Before starting the app, please check that on your device (smartphone, tablet, desktop PC) **Bluetooth** is **activated**.

iOS

Android

Windows

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Set-up (2/4)

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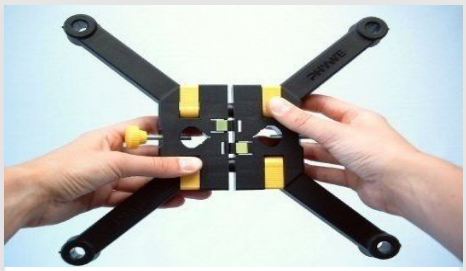
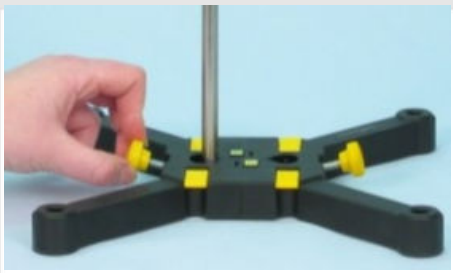
First screw the split tripod rod together and then connect the two tripod base halves. Then build a tripod with the tripod base and the long tripod rod (600 mm).

Connecting the stand rods



Connecting the tripod base halves



Assembly of the tripod

Set-up (3/4)

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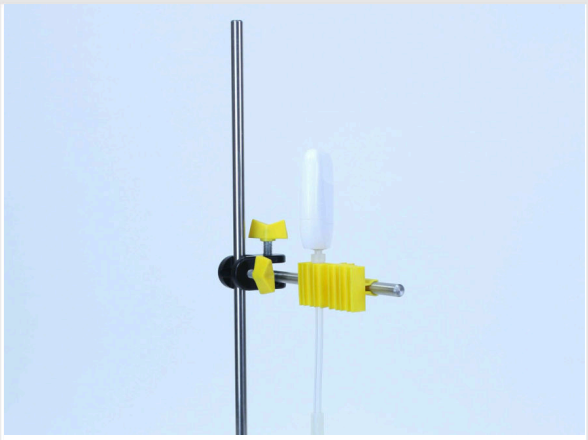

Pressure sensor in a glass tube holder

- Then clamp the double socket with the short stand rod and the glass tube holder to the long stand rod as shown.
- Turn on your Cobra SMARTsense-Pressure. Connect the connection tube to the bottom of the sensor and insert the tube into the glass tube holder so that the sensor cannot fall out.
- Put a short piece of silicone tube (about 3-5 cm) onto the connection tube of the sensor.
- Fill the beaker with water.

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Set-up (4/4)

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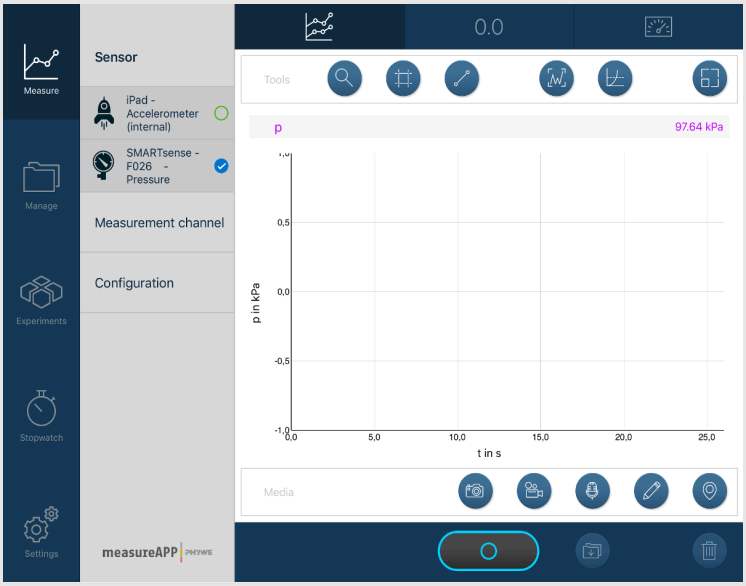

Start the measureAPP on the tablet and switch on the Cobra SMARTsense Absolute Pressure (hold down the I/O button for approx. 3 seconds).

Connect the sensor by selecting it in the measureAPP.

Finally, set the digital measurement display. The pressure that is now displayed there equals the ambient pressure.

Procedure (1/3)

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Probes for hydrostatic pressure

- Use the following probes in successively to measure the pressure in different directions:

1. Hook-shaped bent probe (ground pressure)

2. Right angled bent probe (side pressure)

3. Straight probe (upward pressure)

- To do this, insert the required measuring probe into the lower end of the short silicone tube and push the connecting tube of the sensor so far into the short silicone tube that it meets the probe.

- Then immerse the respective measuring probe 5 cm deep into the water (note the markings on the probes) and note the displayed values in Table 1 in the log. Take a total of three measurements for each probe.

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Procedure (2/3)

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Experimental setup

- Use only the straight probe for the second part of the experiment.
- In the measureAPP settings, set "Measurement on keystroke", select the diagram display and start the measurement.
- Lower the probe into the water 1 centimetre at a time until you reach 10cm and record a reading for each depth of immersion. Then finish the measurement and save it. You can recall your measurement under "My measurements". Transfer the readings to Table 2 in the protocol.

Procedure (3/3)

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- To disassemble the tripod base, press the buttons in the middle and pull both halves apart.

Disassembly of the tripod base

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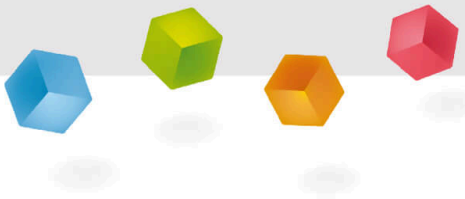

Report

Table 1

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Pressure gauge	$p\ [hPa]$			$mean\ value\ [hPa]$
Ground pressure				
Side pressure				
Upward pressure				

Note the results of the first part of the experiment in the table. Then, determine the mean value from the readings for p

Depth of immersion: $h = 5\ cm$

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Table 2

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$h\ [cm]$	$p\ [hPa]$	$h\ [cm]$	$p\ [hPa]$
1		6	
2		7	
3		8	
4		9	
5		10	

- Fill out **Table 2** with the measurement results for the hydrostatic pressure depending on the immersion depth.

Task 1

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Do the upward pressure, ground pressure and side pressure differ from each other at the same immersion depth?

- ○ No, the pressure acts equally in all directions.
- ○ Yes, the order is: upward pressure < side pressure < ground pressure
- ○ Yes, the order is: side pressure < ground pressure < upward pressure

Check

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Task 2

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Consider the diagram that has been created from the values in Table 2. What is the correlation between the immersion depth h and the hydrostatic pressure p?

- ○ The pressure does not change with increasing immersion depth.
- ○ The pressure decreases with increasing immersion depth.
- ○ The pressure increases with increasing immersion depth.

Check

Task 3

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What statements can you make about the hydrostatic pressure after the measurements?

- ☐ The hydrostatic pressure depends on the height of the water column.
- ☐ The hydrostatic pressure is not dependent on the height of the water column.
- ☐ The hydrostatic pressure is not dependent on the density of the liquid.
- ☐ The hydrostatic pressure depends on the density of the liquid.

Check

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