The density of solid bodies by measuring the buoyancy with Cobra SMARTsense

In this experiment, the students learn to determine the buoyancy force of bodies and to calculate the corresponding physical values under certain conditions.

Physics > Mechanics > Mechanics of liquids & gases

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

This content can also be found online at:

http://localhost:1337/c/61239806e3e7380003d486ed

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Teacher information

Application

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Buoyancy force with SMARTsense

If one determines the weight forces of a body in air $F_{G,L}$ and in water $F_{G,W}$the difference between them can be used to calculate the buoyancy force F_A determine.

With the help of the density of water ρ_W and the mass m_W of the displaced water quantity, one can then calculate the volume V_K of the immersed body.

From the weight force $F_{G,L}$ and the acceleration due to gravity g the mass of the body m_K and finally from the quotient of mass and volume determine the density ρ_K of the body.

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Teacher information (1/2)

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Prior knowledge

Students should already have developed a basic understanding of how forces work and how to determine them using a force gauge.

Scientific Principle

Pressure differences at the top and bottom of bodies result in net forces on the body that reduce the weight force within a medium. A buoyant force therefore acts on a body immersed in water F_A which is the difference between its weight in air and in water. From this, the mass of the displaced water can be calculated and then, if the density of the water is known, the volume of the body. If one then determines the quotient of the mass and volume of the immersed body, one obtains its density.

Teacher information (2/2)

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Learning objective

Students should understand how static buoyancy affects bodies. The apparent reduction in weight under water can be used to determine the volume and density of an unknown body. The underlying relationships should be understood both physically and mathematically.

Task

Students:

1. Determine the buoyancy force of bodies from the difference of their weight forces in air and water.
2. Calculate the density of bodies from their weight in air and the volume of water displaced.

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Safety instructions

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

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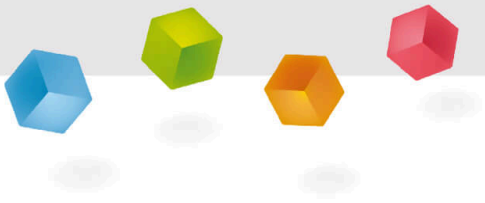

Student Information

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Motivation

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Ship floating in the sea

Buoyancy force with SMARTsense

Based on Archimedes' principle, it is possible for hot air balloons to fly or ships to float on water. For this purpose, the vehicles are constructed in such a way that the average density is lower than the medium in question. If the density of the body exceeds that of the medium, the body sinks to the ground, but its weight force is reduced by the opposing buoyancy force.

In this experiment you will learn to what extent the weight force is reduced by the buoyancy force and how to determine the average density of a solid body from the buoyancy force.

Task

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1. Determine the buoyancy force of bodies from the difference of their weight forces in air and water.

2. Calculate the density of the bodies from their weight in air and the volume of water displaced.

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Equipment

Position	Material	Item No.	Quantity
1	Cobra SMARTsense - Force and Acceleration, ± 50N / ± 16g (Bluetooth + USB)	12943-00	1
2	Support base, variable	02001-00	1
3	Support rod, l = 600 mm, d = 10 mm, split in 2 rods with screw threads	02035-00	1
4	Support rod with hole, stainless steel, 10 cm	02036-01	1
5	Boss head	02043-00	2
6	Aluminium column	03903-00	1
7	Steel Column nickel-plated	03913-00	1
8	Beaker, 100 ml, plastic (PP)	36011-01	1
9	Beaker, 250 ml, plastic (PP)	36013-01	1
10	Fishing line, l. 20m	02089-00	1
11	measureAPP - the free measurement software for all devices and operating systems	14581-61	1

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Additional equipment

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Position	Equipment	Quantity
1	Scissors	1

Structure (1/2)

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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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Structure (2/2)

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- Assemble the tripod base and the tripod rod into a tripod.
- Attach the force sensor with the short stand rod in the double socket.
- Pull a piece of fishing line through each of the holes on the iron and aluminum columns and make loops for hanging.
- Remove both screws from the 2nd double socket and also provide it with a loop of fishing line.

Procedure (1/5)

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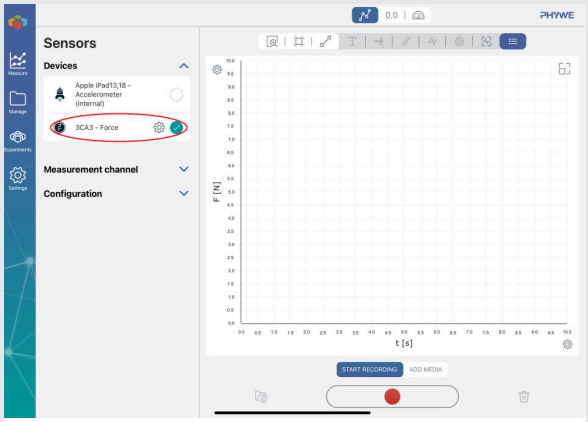
Switch on



Select sensor in measureAPP

- Turn on the force sensor by pressing the power button for several seconds.
- After successful switching on you will see a flashing LED (left picture).
- Start the measureAPP. Tap on the tab "Devices" and select the force sensor (right figure).

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Procedure (2/5)

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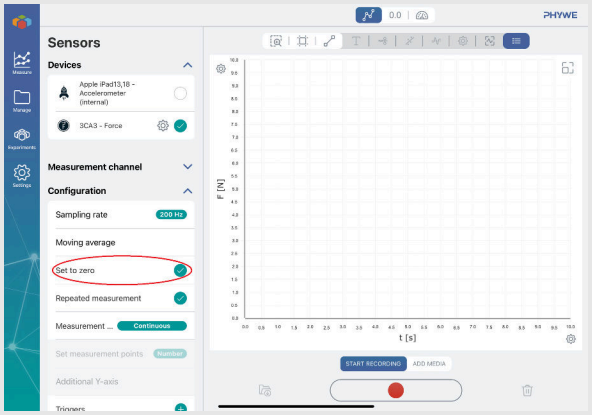
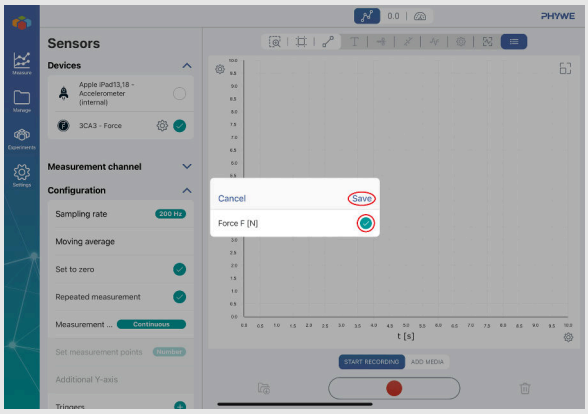
- Tap the "Configuration" tab and select "Set to zero" (figure on the left). In the window that appears, tap on the force sensor.
- Exit the window by clicking on save (right image).





Implementation (3/5)

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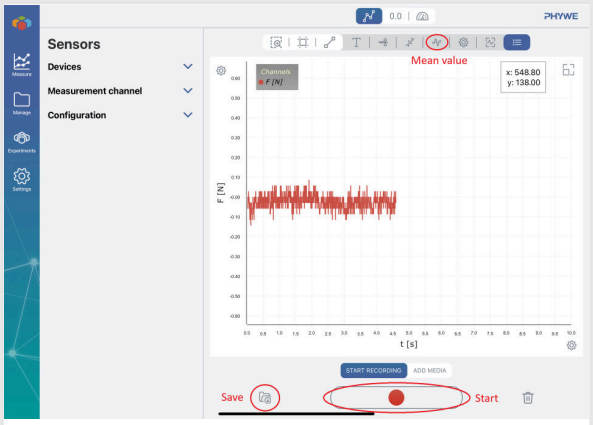

Execution - Measurement

- Hang the first body (aluminum, iron column, double socket) on the fishing line to the force sensor.
- Start the measurement (figure).
- Stop the measurement after a few seconds.
- Then determine the mean value of the force (using the evaluation tool) and record it in the table of the protocol.

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Procedure (4/5)

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Execution - Measurement

- Save the measurement.
- Repeat the measurement of the weight force in air for all remaining bodies.
- Now place the measuring cup filled with water under the force sensor.
- Repeat the above measurement for all three bodies while they are completely immersed in the water and record the readings for complete immersion in the table.

Procedure (5/5)

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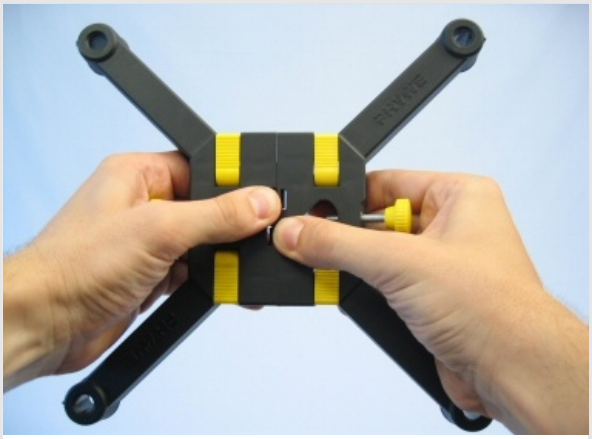

Feedthrough - Tripod base

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

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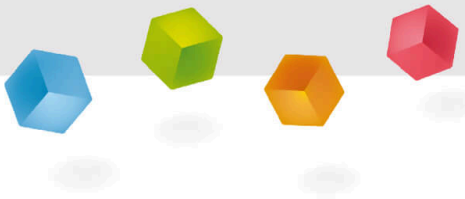

Report

Table 1

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Enter your readings in the table.

Body	$F_{G,L}\,[N]$	$F_{G,W}\,[N]$	$F_A\,[N]$	$m_W\,[g]$	$V_K\,[cm^3]$	$m_K\,[g]$	$\rho_K\,[\frac{g}{cm^3}]$
Aluminium columr							
Iron column							
Double socket							

Note on F_A | Note on m_W | Note on V_K | Note on m_K | Note on ρ_K

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Task 1

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Look at the course of the calculation again and describe it in words and formulas.

1. [ ]: Difference of weight forces of body in air and water gives buoyant force. 2. $m_W =$ [ ] and $V =$ [ ] with [ ]: The buoyancy force divided by the acceleration due to gravity gives the mass of water displaced and this gives the volume, since the density of water is equal to [ ] is. 3. [ ]: The weight of the body in air divided by the acceleration due to gravity gives the mass of the body. m_K. 4. [ ]: From the mass of the body divided by its volume, you get the density you are looking for.

m_W / ρ_W

$\rho_W = 1\,g/cm^3$

$\rho_K = m_K / V_K$

$F_A = F_{G,L} - F_{G,W}$

$m_K = F_{G,L} / g$

F_A / g

$.1\,g/cm^3$

Check

Task 2

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Which of the following statements is true?

- [ ] The buoyancy force of the double sleeve is the greatest.
- [ ] The sum of the buoyancy forces of both columns is greater than that of the double socket
- [ ] The buoyancy force of the aluminium column is greater than that of the iron column.
- [ ] The buoyancy forces of all three bodies are approximately equal
- [ ] The buoyancy force of the two columns is approximately equal.

Check

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Task 3

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Which of the following statements is true?

- [ ] The density of all three bodies is greater than that of water
- [ ] The density of the double socket is smallest
- [ ] The density of the iron column is the greatest
- [ ] The density of the double socket is the greatest.
- [ ] The density of the aluminum column is the smallest

Check

Task 4

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To determine the density of a body, it is sufficient to determine the weight force in air and in water, if one knows the density of water and the prevailing acceleration due to gravity.

- ○ True
- ○ Incorrect

Check

The buoyant force of a body immersed in water results from the weight force of the water displaced by the body. Furthermore, the buoyancy force is the difference between the weight force of a body in air and in water.

- ○ True
- ○ Incorrect

Check

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Slide	Score / Total
Slide 20: The course of the calculation	0/7
Slide 21: Comparison of buoyancy forces of the bodies	0/2
Slide 22: Density of the bodies in comparison	0/3
Slide 23: Multiple tasks	0/2

Total 0 / 14

Solutions | Repeat | Export text

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