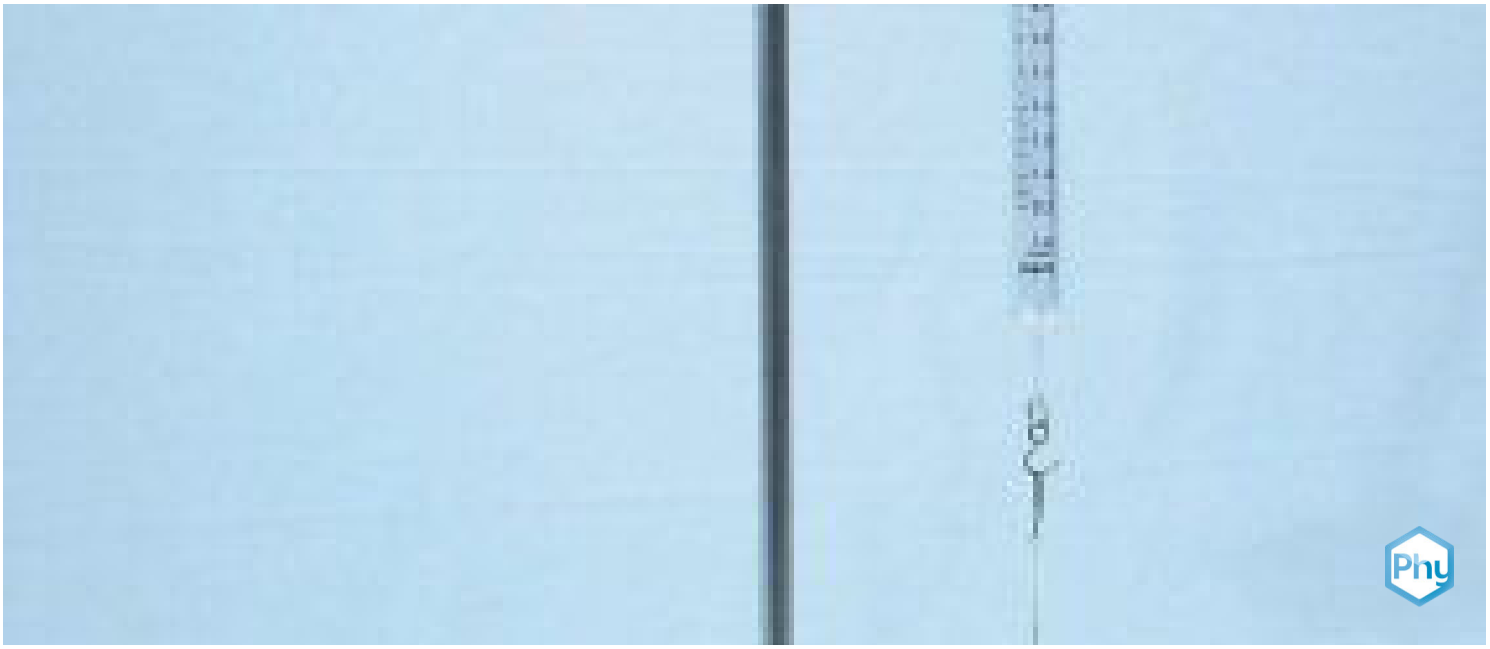
Finding the density of solid bodies by measuring the buoyancy



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/5faffdc6a79804000390faca

PHYWE

Teacher information

Application

PHYWE

Experimental set-up for determining the density of a body by means of its buoyancy force

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

Using the density of water ρ_W and the mass m_W of the displaced water volume can then be determined by V_K of the immersed body.

From the weight force $F_{W,A}$ and the acceleration of gravity g the mass of the body can be m_B and finally determine the density from the quotient of mass and volume ρ_B of the body.

$$\rho_B = \frac{m_B}{V_B} \left[\frac{kg}{m^3}\right]$$

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Other teacher information (1/2)

PHYWE

Prior

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

Scientific

A buoyancy force acts on a body immersed in water F_B. This results from the difference of its weight in air and in water. From this, the mass of the displaced water can be calculated and then (using the known density of water) the volume of the body.

If you then determine the quotient of mass and volume of the immersed body, you obtain its density.

Other teacher information (2/2)

PHYWE

Learning

The students should learn which method in combination with simple equations can be used to determine the (average) density of any solid body experimentally.

Tasks

1. Determining the Bouyancy force F_B of the body from the difference between the two weight forces in air and in water.
2. Determining the density of the body ρ_B from its buoyancy and the volume of the displaced water.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

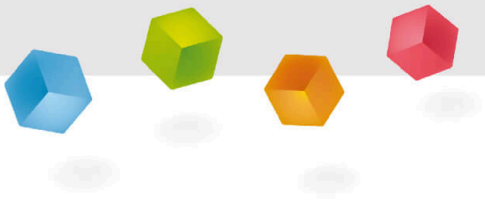
info@phywe.de
www.phywe.de

Safety instructions

PHYWE

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

PHYWE



Student Information

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Motivation

PHYWE

Ship floating in the sea

Due to the Archimedean principle it is possible that hot air balloons fly or ships float on the water. For this purpose, the vehicles are constructed so 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 bottom, but its weight force is reduced by the opposite buoyancy force.

In this experiment you 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.

Tasks

PHYWE

To examine a solid body, you can sink it into a container filled with water and draw conclusions about its density.

To do this, process the following steps:

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

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

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	1
3	Support rod with hole, stainless steel, 10 cm	02036-01	1
4	Boss head	02043-00	2
5	Spring balance,transparent, 2 N	03065-03	1
6	Spring balance holder	03065-20	1
7	Aluminium column	03903-00	1
8	Steel Column nickel-plated	03913-00	1
9	Beaker, 100 ml, plastic (PP)	36011-01	1
10	Beaker, 250 ml, plastic (PP)	36013-01	1
11	Fishing line, l. 20m	02089-00	1

PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

Additional equipment

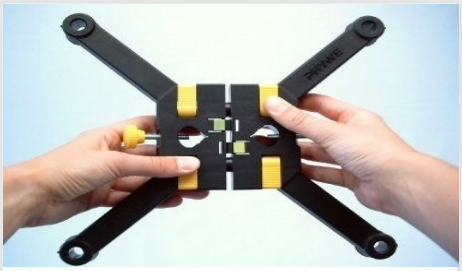
Position	Equipment	Quantity
1	Scissors	1

Set-up (1/3)

Plug the two halves of the tripod foot together.

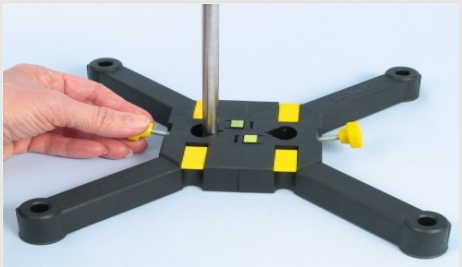
Then screw together the divided stand rod to a long one.

Fix the long stand rod vertically in the stand foot.



Assembling the tripod base

Screwing the stand rod



Assembling the tripod

PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

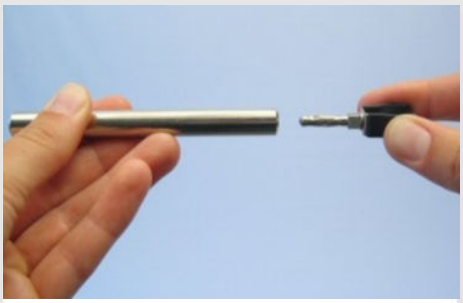
Set-up (2/3)

PHYWE

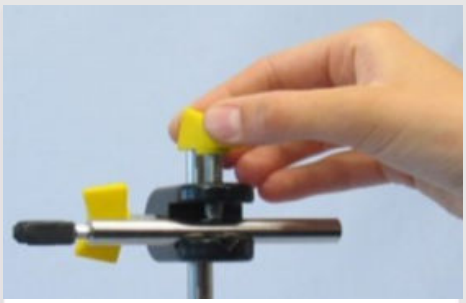
Insert the two dynamometer holders into the 100 mm tripod rods with hole.

Attach the double sleeves to the long support rods and clamp the force gauge holders into them.

Insert the two force gauges and adjust them in the position of use with the screw.



Insert the force gauge holder into the stand rod



Fixing the support rods to the double socket

Inserting and adjusting the force gauges

Set-up (3/3)

PHYWE

Fasten fishing line to the clamp holder

Pull a piece of fishing line through each of the holes on the iron and aluminium column and use it to form loops for hanging.

Remove both screws from the clamp holder and also provide them with a loop of fishing line.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Procedure (1/2)

PHYWE

Determination of the weight forces in air $F_{W,Air}$

- Hang the aluminium column, the iron column and the double socket one after the other on the dynamometer and read the weight forces $F_{W,Air}$.
- Place the large beaker filled with water under the tripod, immerse the three bodies one after the other in the water and let the weight forces $F_{W,Water}$ off.
- Write down all your measured values in the table in the protocol.

Determination of the weight forces in water $F_{W,Water}$

Procedure (2/2)

PHYWE

Disassembling the tripod base

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

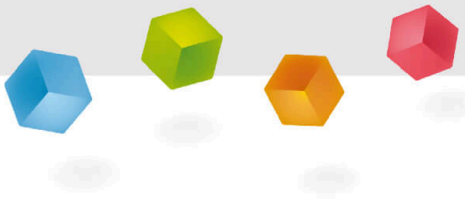
PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

PHYWE



Report

Table

PHYWE

Take your readings for $F_{W,A}$ and $F_{W,W}$ in the table and calculate the buoyancy force F_B than their difference. Then calculate the mass of the displaced water m_W from the buoyancy F_B and the acceleration of gravity g and then taking into account the density of water ($\rho_W = 1\ \frac{g}{cm^3}$) the volume V_B of the body. Calculate the mass m_B of the body from the weight force $F_{W,A}$ in air and the acceleration of gravity g to finally determine its density $\rho_B = m_B / V_B$.

Body	$F_{W,A}\ [N]$	$F_{W,W}\ [N]$	$F_B\ [N]$	$m_W\ [g]$	$V_B\ [cm^3]$	$m_B\ [g]$	$\rho_B\ [\frac{g}{cm^3}]$
Aluminium column							
Iron column							
Clamp Holder							

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Task 1

PHYWE

Which of the following statements is correct?

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

Check

Task 2

PHYWE

Which of the following statements is correct?

- [ ] The density of the aluminium column is the smallest
- [ ] The density of the clamp holder is the smallest
- [ ] The density of all three bodies is greater than that of water
- [ ] The density of the iron column is highest
- [ ] The density of the clamp holder is the greatest.

Check

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Task 3

PHYWE

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

○ True ○ Wrong

Check

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

○ True ○ Wrong

Check

Slide	Score / Total
Slide 18: Buoyancy forces of the bodies in comparison	0/2
Slide 19: Density of the bodies in comparison	0/3
Slide 20: Multiple tasks	0/2

Total amount 0 / 7

Solutions Repeat Exporting text

PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de