Archimedes' principle

Physics | Mechanics | Mechanics of liquids & gases

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

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Teacher information

Application

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Determination of the amount of water displaced by a mass

According to the Archimedean principle, the following statement applies:

"The static lift F_A of a body in a medium is as great as the weight of the medium displaced by the body."

Conversely, this means that a body of a certain mass m_K and a lower density than water into a container filled with water, displaces exactly the amount of water that corresponds to its weight. I.e. the weight force F_G of the body corresponds to the product of volume V_W and density ρ_W of the displaced water with the acceleration of gravity g:

$$F_G = m_K \cdot g = V_W \cdot \rho_W \cdot g \; [N] \quad \Rightarrow \quad m_K = V_W \cdot \rho_W \; [kg]$$

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Other teacher information (1/2)

Prior knowledge

Students should already have gained a basic understanding of the weight force of bodies. The students should also know the density of water.

Scientific principle

A body immersed in a resting fluid displaces a certain amount of the fluid. This amount of fluid corresponds exactly to the weight of the immersed body if the density of the body is less than the density of the fluid. If the density is higher, the displaced volume is equal to the volume of the body and the weight force is reduced by the opposite buoyancy force, which is equal to the weight force of the displaced fluid.

Other teacher information (2/2)

Learning objective

The students should be able to use the weight force F_G of a body first in air and then in water. From the difference they should determine the buoyancy force F_A calculate. In a second test they shall determine the mass of water displaced during immersion, calculate its weight force from this and compare it with the buoyancy force.

Tasks

Comment:

The term "(slot)weight" is incorrect in that it refers to a mass which only receives a "weight", i.e. a weight force, under the influence of the acceleration due to gravity. The expression "piece of mass" is better.

Hint:

Stead of the beam balance, another balance with a weighing capacity of 100 g and a division of 1 g (or better) can be used.

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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

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Motivation

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 ground, but its weight force is reduced by the opposite buoyancy force.

In this experiment you will learn to what extent the weight force is reduced by the buoyancy force and what the relationship is between the amount of water displaced and the weight force of the body in question.

Tasks

Does a force act on a body when immersed in water?

- Determine the weight of a body first in air and then in water.
- Determine the amount of water displaced when the body is immersed and its weight.

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Equipment

Position	Material	Item No.	Quantity
1	Weight holder, 10 g	02204-00	1
2	Slotted weight, black, 10 g	02205-01	4
3	Slotted weight, black, 50 g	02206-01	2
4	Spring balance,transparent, 2 N	03065-03	1
5	Overflow vessel 250 ml	02212-00	1
6	Beaker, 100 ml, plastic (PP)	36011-01	1
7	Graduated cylinder, 50 ml, plastic	36628-01	1
8	Pipette with rubber bulb	64701-00	1
9	Balance pan, plastic	03951-00	2
10	Lever	03960-00	1
11	Pointer for lever	03961-00	1
12	Plate with scale	03962-00	1
13	Support base, variable	02001-00	1
14	Support rod, stainless steel, l = 250 mm, d = 10 mm	02031-00	1
15	Boss head	02043-00	1
16	Holding pin	03949-00	1
17	Set of precision weights,1g-50g	44017-01	1

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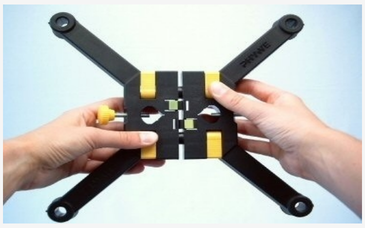
Set-up (1/4)



Connecting the tripod foot

Mounting the support rod

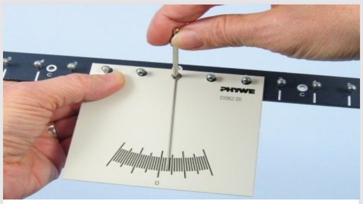
Build a tripod with the tripod foot, the tripod rod and the double socket.

First connect the two halves of the tripod foot to form a tripod foot.

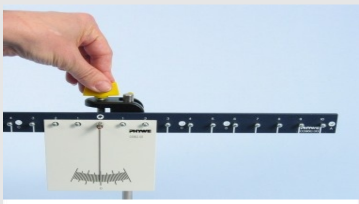
Then screw the stand rod into the stand foot and mount the double socket.

Attaching the double socket to the stand rod

Set-up (2/4)



Fasten scale to the beam balance



Fasten the retaining bolt in double socket

Fasten the plate with scale together with the pointer using the retaining bolt in the middle of the beam scale.

Then fix the retaining bolt in the double socket.

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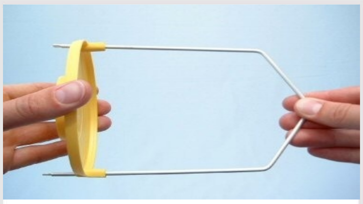
Set-up (3/4)



Assembling the weighing pans

Taring the balance

Put the pans together and hang them on the ends of the beam balance.

Adjust the pointer so that it points exactly to the zero mark.

Set-up (4/4)

Filling the overflow vessel with water

Fill the overflow vessel with water until it runs straight into the beaker.

Wait until no more water drips out, then dry the beaker carefully.

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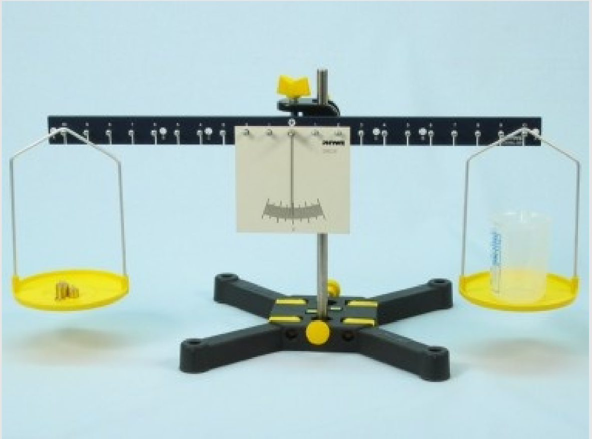
Procedure (1/4)

- Determine the mass m_0 of the dry beaker with the beam balance and note the value in the protocol.



Balanced beam scales:

Determination of the mass of the empty cup

Procedure (2/4)

Determination of the weight forces in air

- Determine the weight in air for the masses 50 g, 100 g and 150 g with the dynamometer $F_{G_{iL}}$.
- Note the measured values in the table in the protocol.

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Procedure (3/4)

Determination of the weight forces in water

- Place the well-dried beaker under the maximum-filled overflow vessel and immerse the weight plate with the pieces of mass for the total masses of 50 g, 100 g and 150 g completely in the overflow vessel one after the other.
- Read the value for the weight in water $F_{G_{iW}}$ for the masses.
- Wait until no more water drips out and then determine the mass of the displaced water including the beaker m_1 with the beam balance.
- Enter all measured values in the table.
- Note: Make sure for each total mass that the beaker is dry and the overflow vessel is filled to the maximum.

Procedure (4/4)

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

Disassembling the tripod base

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Report

Table

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Enter them in the appropriate fields.

Determine the buoyancy forces of the masses: $F_A = F_{G_{iL}} - F_{G_{iW}}$

$m_0 =$ ______ g

Determine the mass of the overflowed water: $m_W = m_1 - m_0$

Calculate the associated weight forces from this: $F_W = m_W \cdot g (g = 9,81 m/s^2)$

m [g]	$F_{G_{iL}} [N]$	$F_{G_{iW}} [N]$	$F_A [N]$	$m_1 [g]$	$m_W [g]$	$F_W [N]$
50						
100						
150						

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Task 1

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Compare the results for F_A with those of F_W. What do you find?

- ○ F_W is greater than F_A.
- ○ F_A is greater than F_W.
- ○ F_A and F_W are the same size.

Check

Task 2

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With which two methods can the buoyancy force F_A determine?

- ☐ The buoyancy force can be determined directly by measuring the mass in water in terms of its weight.
- ☐ One can determine the buoyancy force by building the difference of the weight forces in air and water.
- ☐ One can determine the buoyancy force by determining the weight of the displaced water.

Check

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Task 3

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How does the buoyancy force affect a submerged body?

- ○ It counteracts its weight and thus makes it appear lighter.
- ○ It has no effect on the body.
- ○ It works together with its weight and makes it appear heavier.

Check

Task 4

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When does a body swim, when does it sink?

- ☐ A body floats when it is gently laid on the water.
- ☐ A body always floats when its average density is lower than that of water.
- ☐ A body always floats when the effective buoyancy force is greater than its weight in water

Check

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Slide	Score / Total
Slide 20: settlement of \(F_A\) and \(F_W\)	0/1
Slide 21: Determination of the buoyancy force	0/2
Slide 22: impact of \(F_A\)	0/1
Slide 23: buoyancy	0/2

Total amount 0/6

Solutions Repeat Exporting text

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