SINUS - Thüringen

Steigerung der Effizienz des mathematisch-naturwissenschaftlichen Unterrichts

Documentation for the teaching material »Buoyancy Force«

School:	Staatliche Regelschule Waltershausen (grades 5 – 10)
Grade:	5
Subject:	Human-Nature-Technology
Authors:	Tom Höpfner, Jörg Triebel
Target:	Topic Lifting force
Organization form/time needed:	Pair and group work (see tasks and protocol)
Evaluation of the students' performances:	Assessment and grading of the students' results possible by the teacher (e. g. protocol)
Material Requirements:	See realization
Methodical Indications:	After the introduction of the term »force« with the differentiation to everyday speech, the application of the measuring device is discussed followed by the clarification of the interaction of forces, where three variants are available.
Students' Materials:	See realization
Literature:	Internet research allowed

Didactic variations and the courage to realize ideas

With the new subject Human-Nature-Technology (MNT) for grades 5/6 in Thuringia, new educational paths become necessary to address issues, for example the issue of buoyancy force, age-specifically.

Buoyancy is a very interesting topic, because properties such as swimming, sinking and rising in all its technical and biological applications are based on the principles of interaction between weight and buoyancy force.

With a reasonable conceptual construct a lot of well observed phenomena can be explained.
Therefore, the concepts of force and buoyancy rightly have their place in module 3 of the new curriculum MNT.
However, in the planning stage of this issue, there are a few important aspects to consider that are easily underestimated as a teacher for chemistry, biology and physics.

Thus, the term force is:

- a completely new size for the student,
- an »abstract« size, because it is not directly observable, but can only be interpreted by its effect,
- a vector quantity that causes different effects with different directions,
- characterized by the interaction between weight and buoyancy force, that determine the movement direction of the body (swimming, floating, sinking, rising, falling, sliding).

Technical and biological systems manipulate one or both forces to influence the movement direction of the body.
The following suggestions intend to demonstrate possibilities on how this topic can be familiarized to ten- and eleven-year old students.

After the introduction of the term »force« with the differentiation to everyday speech, the application of the measuring device is discussed followed by the clarification of the interaction of forces, where three variants are available.

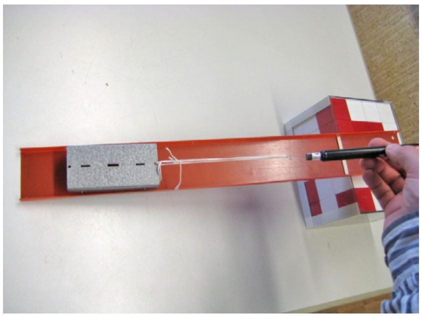
In the beginning, pictures of bodybuilders are shown along with the question: »Which of them is the strongest?«.
The students quickly guess that this question cannot be answered just by looking at the photo. This is a nice crossover to introduce the properties of forces. Examples (some pictures) from the world of sports are suitable to demonstrate the acting of forces.

Unfortunately, in everyday speech the term »force« is often used wrong. By giving several terms like muscular strength, whitening power, engine power, weight force, or power of thoughts, the students should decide with their knowledge which of the forces own the worked out properties and which are no forces at all.

The application of the measuring device demands carefulness and methodical capability of the students during the experiment.
After the first exercises with the spring scale, the following problems that had to be worked on by experiments are especially suitable.

Task 1

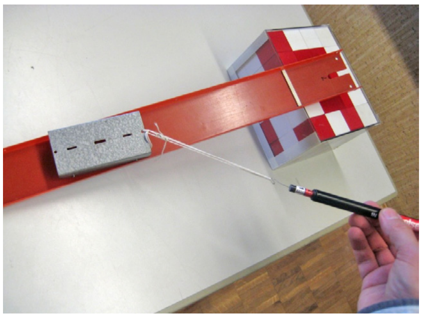
What force is needed to pull a wagon on an incline?



Hint:
Pull very slowly and evenly!

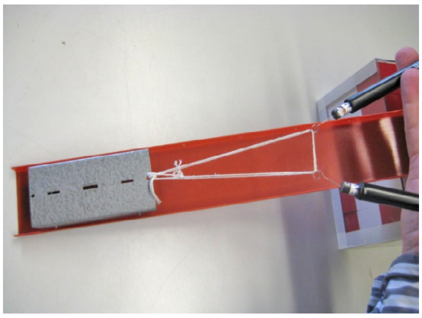
Task 2

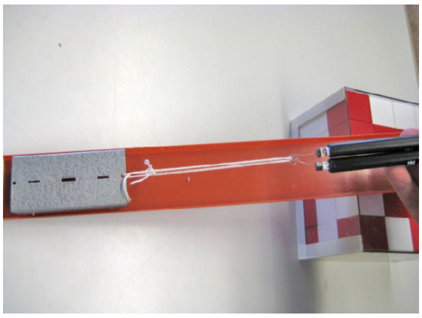
Is more or less force needed to pull the car diagonally to the top?



Task 3

Two students pull the car together up an incline.
How should the students go up to save power?



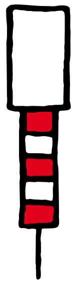


The interaction of forces (and here especially the approach to the topic buoyancy) could be from the effect of falling bodies on the one hand.

Handling the measuring device

- What measuring device to use?
- Problems
- Exercises to handle the spring scale

**Measure the weight of various pieces of mass.
Can you recognize a rule?**



mass in g	10	20		
weight in N				

mass in g	10	20	30	40	50
weight in N					
force arrow					

The interaction of forces (and here especially the approach to the topic buoyancy) could be from the effect of falling bodies on the one hand.

Last Name:	First Name:	Class:
	Employee:	Date:

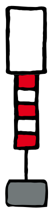
Protocol

■ Does the buoyancy force depend on the material?

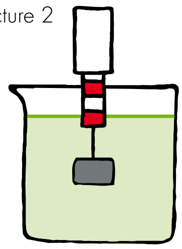
Task:	Steffi says: »The buoyancy force must depend on the material, because only in that way it can be explained, that a stone sinks and a piece of wood floats« Decide if Steffi is right by calculating the buoyancy force of three cubes of different materials.
Preliminary considerations:	■ Look at how to determine the buoyancy force of a body. ■ Only use cubes of the same size. ■ Always write down the material.

Experimental setup:

Picture 1



Picture 2



Required Equipment and Tools:
(Take out the required equipment from the experimental setup!)

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TIPS:
Never dip the spring scale into water!
Only use equal cubes.

Procedure:	■ Measure the weight in the air with the spring scale and write the result into the table. ■ Gauge the weight in the water with the spring scale and write the result into the table. ■ Draw in the forces F_{Air}, F_{Water} and define F_{Lift} (Pay attention to the length of the arrows!). ■ Complete the table and the solution sentence.

Results:

Material:		Material:		Material:	
F_{Air} =		F_{Air} =		F_{Air} =	
F_{Water} =		F_{Water} =		F_{Water} =	
F_{Lift} =		F_{Lift} =		F_{Lift} =	

Analysis:

The buoyancy force is ....

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	Employee:	Date:

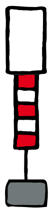
Protocol

The buoyancy

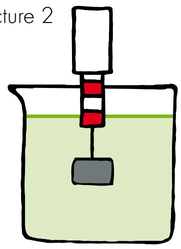
Task:	Martin says: »If I'm lying in the tub, I am much lighter!« Find out whether the claim can be true.
Preliminary considerations:	▪ Forces are measured in Newton. ▪ Forces have a direction and an amount. ▪ Therefore, an arrow is drawn indicating a force. ▪ The longer the arrow, the greater the force.

Experimental setup:

Picture 1



Picture 2



Required Equipment and Tools:
(Take out the required equipment from the experimental setup!)

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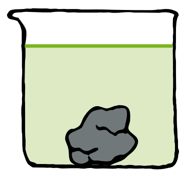
TIPS:
Never dip the spring scale into water!
Always note down the number of the stone!

Procedure:	▪ Pick a stone, and note the number of the stone. ▪ Determine the weight in air and in water and note the values. ▪ Draw both force arrows and determine the difference. ▪ Complete the formulas. ▪ Check your formulas with a different body.

Results:

Stone Number: ....

In the air
the weight force is: ....



In the water
the weight force is: ....

Force arrows: ....

Difference of the forces: ....

Analysis:

If the bodies are immersed in water ....

Martina's claim ....

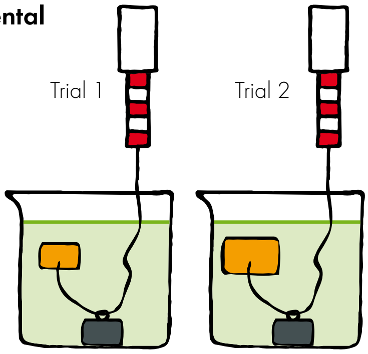
Last Name:	First Name:	Class:
	Employee:	Date:

Protocol

The buoyancy force

Task:	Martin says: »A small piece of cork floats just like a big piece. Therefore, I need the same strength to push both pieces under water.« Find out whether the claim can be true.
Preliminary considerations:	■ Forces are measured in Newton. ■ Forces can be measured by a spring scale.

Experimental setup:



Required Equipment and Tools:
(Take out the required equipment from the experimental setup!)

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TIP:
Never dip the spring scale into water!

Procedure:	■ Pick a small and a large piece of cork. ■ Pull the small piece of cork under the water and measure the power. ■ .... ■ ....

Results:
The small piece of cork needs .... to be pulled under water.
The big piece of cork needs .... to be pulled under water.

Analysis:

Match the sentence parts to a formula!
The more larger strength you a floating water need push body is the to it under.

Delete wrong parts of sentences.

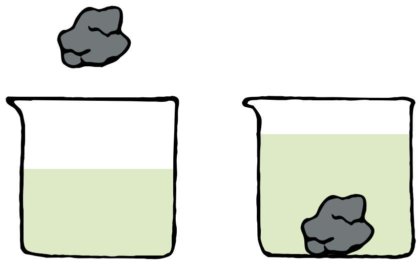
Small swimming bodies are pulled under water
- with less force.
- with the same force like big bodies.
- with big force.

Martin's claim ....

As a second option, you can explore why a body floats, by investigating floating bodies with different dimensions (e.g. cork pieces of different size).
However, you can also approach the problem a third way through thought experiments.

■ Illustration of the interaction between buoyancy and weight

With the help of an observation task, the students recognize that the water level has increased, because the stone pushes the water upward.



If the stone lifts the water up, the water pushes down.
You have to imagine it like this:

Now the student is asked the following questions:
»Who wins the competition? How will the the stone move?«
It quickly becomes clear that you have to compare the weights of stone and water to come up with a statement. This completes the thought experiment.

This demonstrates especially the high level of abstraction in processing of the subject but also the interaction of buoyancy and weight.