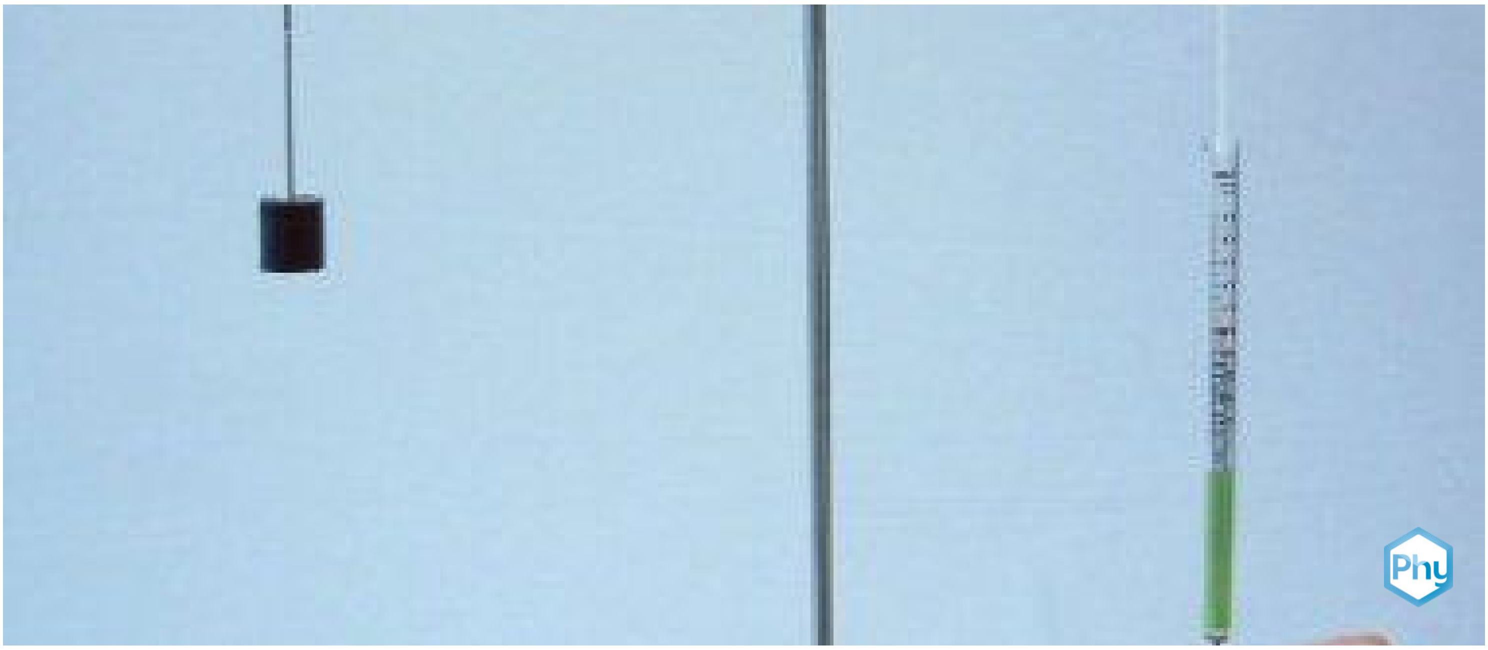
Double-sided lever



Physics | Mechanics | Forces, work, power & energy

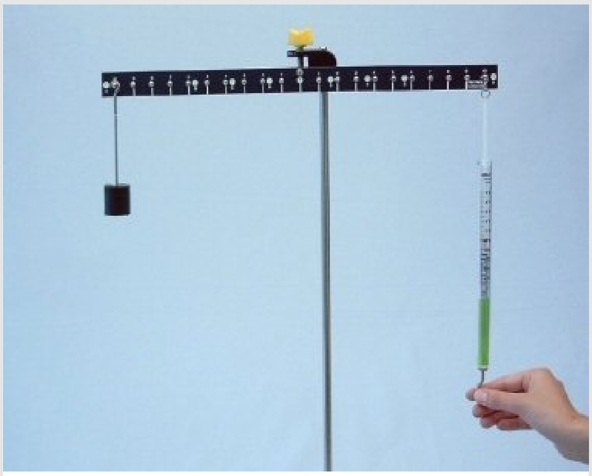
Difficulty level	Group size	Preparation time	Execution time
medium	2	10 minutes	10 minutes

This content can also be found online at:

http://localhost:1337/c/5ef9e2a346e83e000319c0cb

Teacher information

Application



Experimental setup double sided lever

The students have already determined various forces in previous experiments and got a feeling for the balance of forces. Now the students are to be taught that forces via a lever also result in moments.

Furthermore, the students should learn that the respective moments can also be in balance, just like with a balanced beam balance.

Levers are used every day without us often being aware of it. A few examples are any kind of pliers, wrenches, wheelbarrows, but also door handles, water taps or the brake or pedals on a bicycle.

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)

Prior knowledge

Since this experiment is about determining moments resulting from forces, the students should already have acquired a basic understanding of forces and their determination.

Scientific Principle

If the sum of the moments of a lever mounted in any pivot point is zero, the product of the forces and their lever arms acting on this lever is equal:

$$\Sigma M_{PivotPoint} = 0$$

Note: During experimental verification, slight deviations in the masses may cause the lever not to remain exactly horizontal.

Other teacher information (2/2)

Learning objective

The students should be able to work out the law

$$\text{"} force \cdot forcearm = load \cdot loadarm \text{"}$$

on a two-sided lever and to represent it in words and a formula.

Tasks

The students measure different combinations of force, force arm, load and load arm on a double sided lever.

In an additional task the concept of torque can be treated and the lever law can be represented in the form "sum of all torques = zero".

$$\Sigma M = 0$$

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 to be applied to this experiment.

PHYWE

Student Information

Motivation

PHYWE

Seesaw

As everyone knows, bobbing only makes sense if there are people sitting on both sides who weigh about the same. If this is not the case, you have to improvise and the heavier person has to push himself off the floor much harder.

However, an alternative would be for the heavier person to slide closer to the fulcrum. The reason for this is the so-called law of leverage. This means that the torques, i.e. the interplay of weight force and lever length, should ideally balance out on both sides.

In this experiment you will learn what the law of leverage is with a two-sided lever.

Tasks

PHYWE

Work out the principle of the two-sided lever:

- Load one side of the lever with a mass and bring it into a horizontal position with a force gauge on the other side.
- First vary the position of the mass and then that of the dynamometer.
- Measure the respective forces and lengths.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Material

Position	Material	Item No.	Quantity
1	Support base, variable	02001-00	1
2	Support rod, stainless steel, l = 600 mm, d = 10 mm	02037-00	1
3	Lever	03960-00	1
4	Boss head	02043-00	1
5	Weight holder, 10 g	02204-00	2
6	Slotted weight, black, 10 g	02205-01	4
7	Slotted weight, black, 50 g	02206-01	1
8	Spring balance,transparent, 2 N	03065-03	1
9	Holding pin	03949-00	1

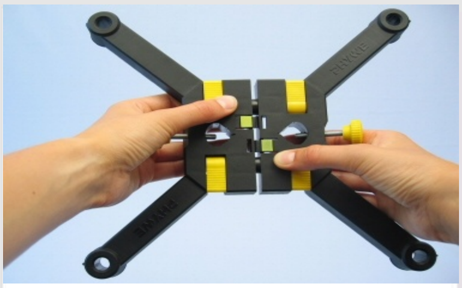
PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

Set-up (1/2)

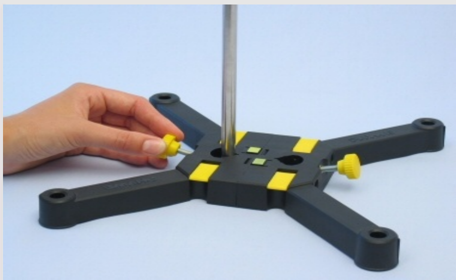
PHYWE

Build a tripod with the tripod foot and the tripod rod and attach the boss head to the tripod rod.

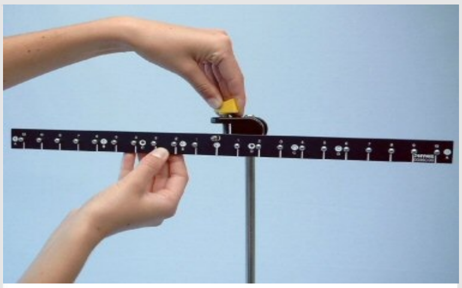
Insert the retaining pin in the middle of the lever and fix the retaining pin with the lever in the boss head.



Mounting the foot



Tripod foot with tripod rod



Fixing the lever with the help of the boss head

Set-up (2/2)

PHYWE

Adjustment of the force gauge

Adjust the spring balance upside down to zero before the measurements.

(upside down: zero point of the scale below)

PHYWE

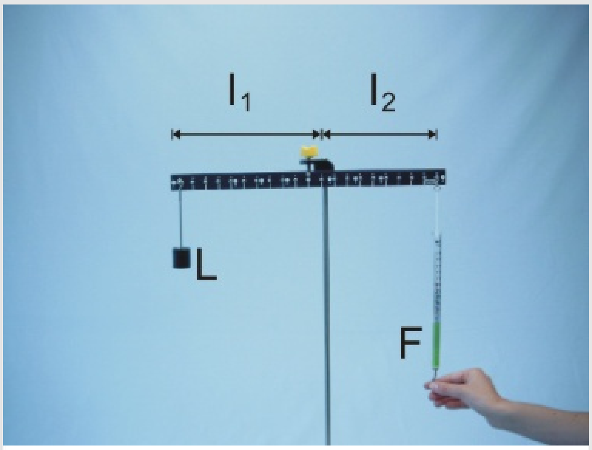
Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Procedure (1/4)

PHYWE

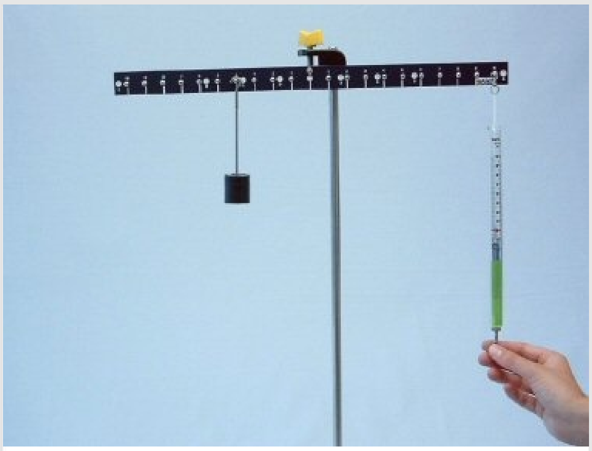


Lever loaded with load (100 g) and force

- Hang the weight plate with a total mass of $m_{ges1} = 100\ g$ on the left side of the lever at the mark 10.
- Hook the dynamometer at the mark 10 on the right side of the lever and set the lever horizontally.
- Read the displayed measured value for the force and note it in Table 1 in the report.

Procedure (2/4)

PHYWE



Changed load position

- Now hang the load on the marks 8, 6, 4 and 2 (still on the left) one after the other and measure the force for each of these positions that is necessary to balance the lever.
- Note all values also in table 1.

PHYWE

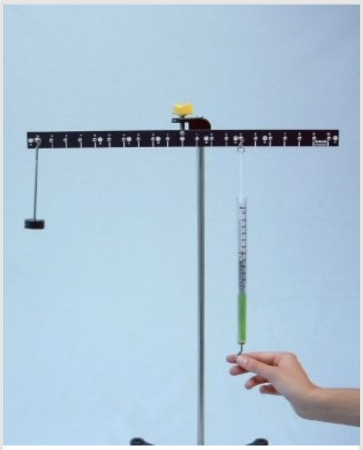
Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Procedure (3/4)

PHYWE

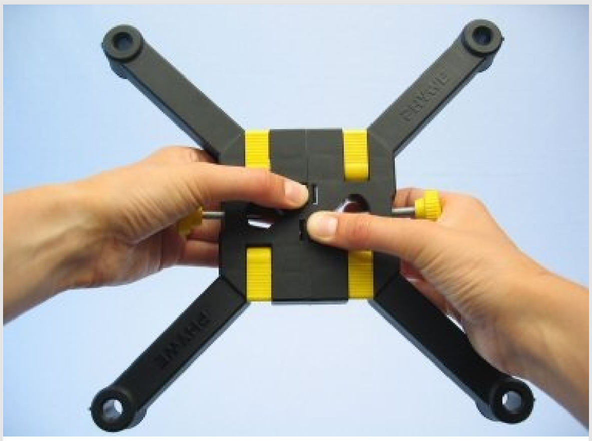


Lever loaded with load (40 g) and force

- Hang the weight plate with a total mass of $m_{ges2} = 40\ g$ on the left side of the lever at the mark 10.
- Suspend the spring balance on the right side of the lever at the mark 10, set the lever horizontally and read the displayed measurement.
- Then place the dynamometer at the marks 8, 6, 4 and 2 (right) one after the other. The position of the load remains unchanged this time. Measure the force for each position of the dynamometer.
- Note all values in Table 2 in the report.

Procedure (4/4)

PHYWE



Disassembling the tripod base

To disassemble the tripod base, press the inner buttons to release the locking hooks and pull the 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

Task 1

PHYWE

From the mass m_{ges1} calculate the weight force and enter it as load $L[N]$:

$m_{ges1} = 100\ g$

$L =$ ______ N

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Table 1

PHYWE

Marker no..:

left right	$F\ [N]$	$l_1\ [cm]$	$L \cdot l_1\ [Ncm]$	$l_2\ [cm]$	$F \cdot l_2\ [Ncm]$
10 10					
8 10					
6 10					
4 10					
2 10					
(load) (spring balance)					

Task 2

PHYWE

Calculate the weight force from the mass m_{ges2} and enter it as load $L[N]$:

$m_{ges2} = 40\ g$ $L =$ ______ N

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Table 2

PHYWE

Marker no..:

left right	$F\ [N]$	$l_1\ [cm]$	$L \cdot l_1\ [Ncm]$	$l_2\ [cm]$	$F \cdot l_2\ [Ncm]$
10 10					
10 8					
10 6					
10 4					
10 2					
(load) (spring balance)					

Task 3

PHYWE

Compare the products (torques) with each other. What do you take from this comparison?

- ○ The products always have the same value.
- ○ The values of the products do not match.

Check

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Task 4

PHYWE

What formula can be used to describe this situation?

- ○ $F_{Load} \cdot l_{Load} \neq F_{springbalance} \cdot l_{springbalance}$
- ○ $\frac{F_{Load}}{l_{Load}} = \frac{F_{springbalance}}{l_{springbalance}}$
- ○ $F_{Load} \cdot l_{Load} = F_{springbalance} \cdot l_{springbalance}$

Check

Table 3

PHYWE

Last L	Load arm l_1	Force arm l_2	Force F
constant	smaller	constant	
constant	constant	smaller	
smaller	constant	constant	

Consider the table: How does
the force change under the given conditions? Does it increase or decrease? Complete the table.

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

Task 5

PHYWE

Assuming a load m = 10 g hangs on the left side of the lever at the marks 4.

To which markings do you have to place a second load with m = 20 g on the right side of the lever to keep it horizontal?

- At marker 2.
- At marker 4.
- At mark 6.

Check

Task 6

PHYWE

The torque is defined as product "force times lever arm".

Under what conditions does the lever remain in the horizontal position?

- When a greater moment acts on the left side of the lever.
- When both sides of the lever apply an equal amount of torque.
- When a greater torque is applied to the right side of the lever.

Check

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Task 7

PHYWE

Assume that one side of the lever is loaded with several loads $L_{11},\ L_{12},\ \ldots$ on different load arms $l_{11},\ l_{12},\ \ldots$.

What is the required force L_2 on the force arm l_2 on the opposite side to compensate for this?

- ○ $L_2\ =\ (L_{11}\cdot l_{11} + L_{12}\cdot l_{12} +\ \ldots)\ /\ l_2$
- ○ $L_2\ =\ (L_{11}\cdot l_{11} + L_{12}\cdot l_{12} +\ \ldots)\ \cdot\ l_2$

Check

Slide	Score / Total
Slide 21: Comparison of the products	**0/1**
Slide 22: Formula	**0/1**
Slide 24: Understanding levers	**0/1**
Slide 25: Leverage law	**0/1**
Slide 26: Multiple load	**0/1**

Total amount **0/5**

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