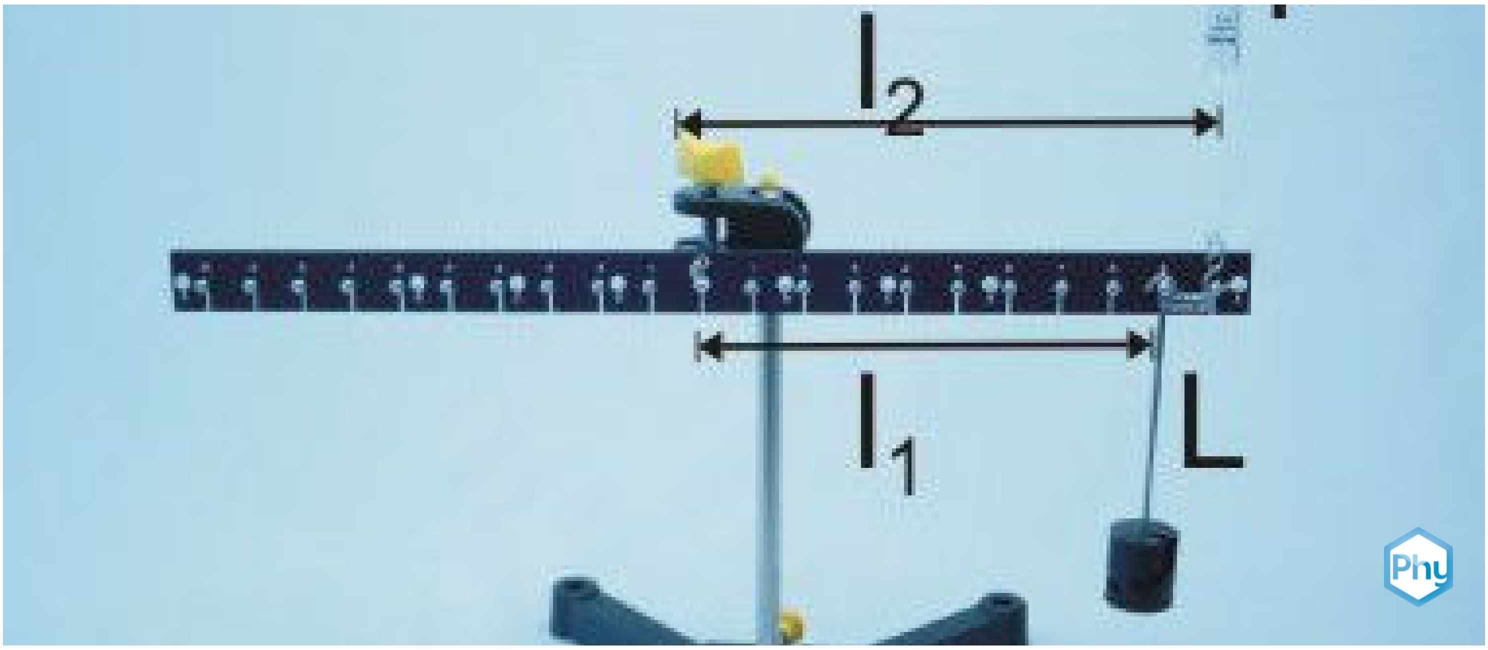
One-sided lever



Physics > Mechanics > Forces, work, power & energy

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

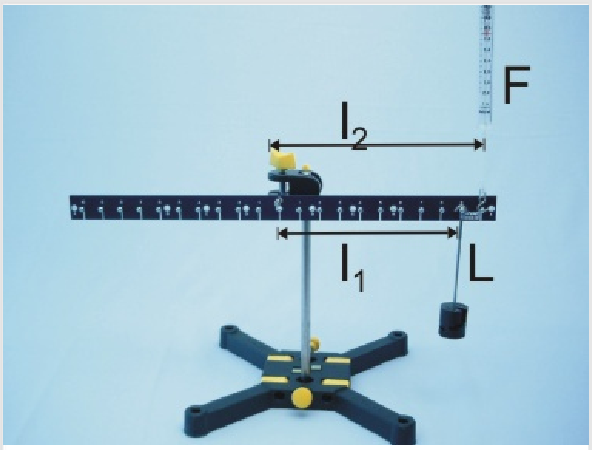
This content can also be found online at:

http://localhost:1337/c/5efb4779080b8d00038726ee

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

Teacher information

Application



Experimental set-up of a one-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
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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.

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

$$" \; force \cdot forcearm = load \cdot loadarm \; "$$

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

Tasks

The students measure different combinations of crater, force arm, load and load arm on a one-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".

$$\Sigma\, M \;=\; 0$$

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37079 Göttingen

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Fax: 0551 604 - 107

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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

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Motivation

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Bottle opener

Leverages accompany us every day at any time and everywhere. Examples of levers in everyday life include pliers and scissors, door handles and water taps, brakes and pedals on bicycles, and tools such as crowbars, spanners and bottle openers. Without all these levers we would normally be lost.

A distinction is made in particular between one-sided and two-sided levers. The bottle opener shown here is an example of a one-sided lever.

In this experiment you will learn the connections with the law of leverage in relation to the one-sided lever.

Tasks

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Work out the principle of one-sided leverage:

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

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Material

Position	Material	Item No.	Quantity
1	Support base, variable	02001-00	1
2	Support rod, stainless steel, l = 250 mm, d = 10 mm	02031-00	1
3	Boss head	02043-00	1
4	Lever	03960-00	1
5	Spring balance,transparent, 2 N	03065-03	1
6	Weight holder, 10 g	02204-00	2
7	Slotted weight, black, 10 g	02205-01	4
8	Slotted weight, black, 50 g	02206-01	1
9	Holding pin	03949-00	1

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Set-up (1/2)

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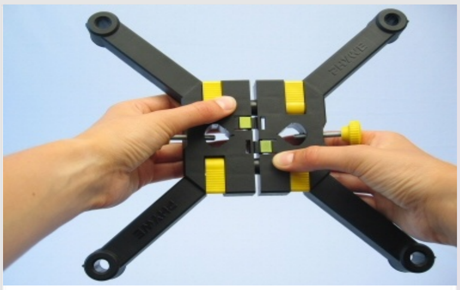
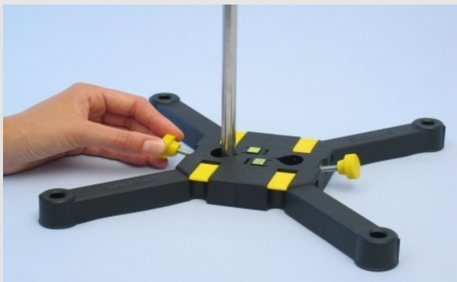
Build a tripod with the tripod foot and the tripod rod and attach the boss head to the tripod rod.

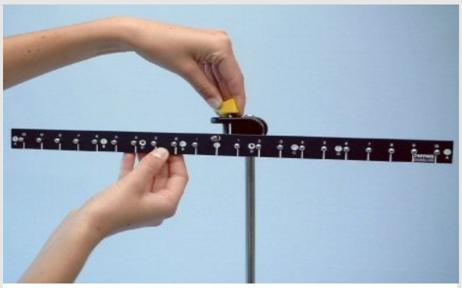
Insert the retaining pin in the middle of the lever and fix the retaining pin with the lever in the boss head.



Mounting the foot



Tripod base with tripod rod



Fixing the lever with the help of the boss head

Set-up (2/2)

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Adjustment of the spring balance

Adjust the spring balance to zero with the screw before the measurements.

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Procedure (1/4)

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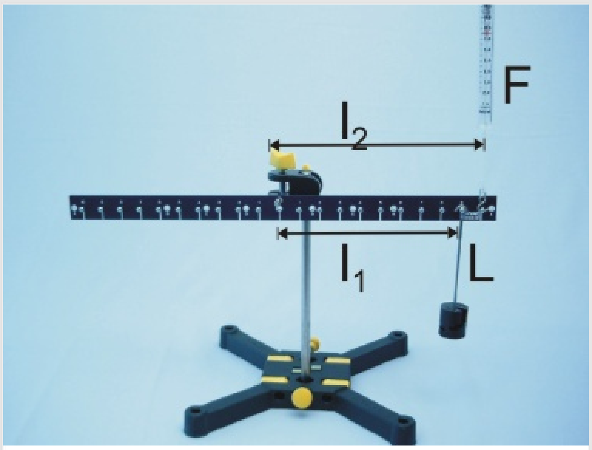

Dispensing the lever with load (100 g) using the force gauge

- Hang the weight plate with a total mass of $m_{total1} = 100\ g$ on the right side of the lever at mark 9.
- To hang the slotted weights on the weight plate, slide them over the top of the weight plate.
- Place the lever horizontally by means of the dynamometer at mark 10 right (pulling direction upwards).
- Note the measured value for the force in Table 1 in the report.

Procedure (2/4)

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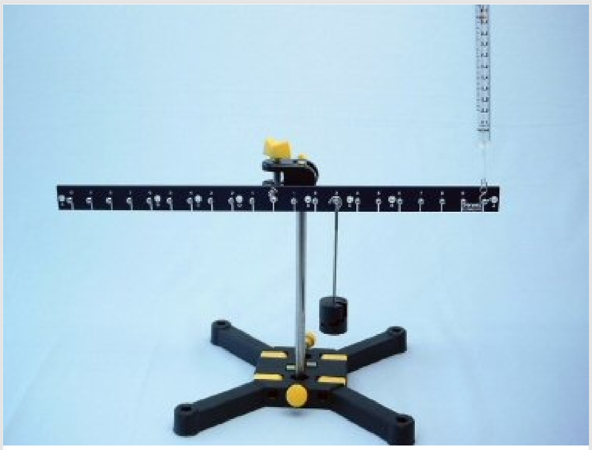

Variation of the load position

- Now hang the mass one after the other at marks 7, 5, 3 and 1 (still on the right) and for each of these positions read off the force F necessary to balance the load.
- Note all measured values in Table 1 in the report.

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Procedure (3/4)

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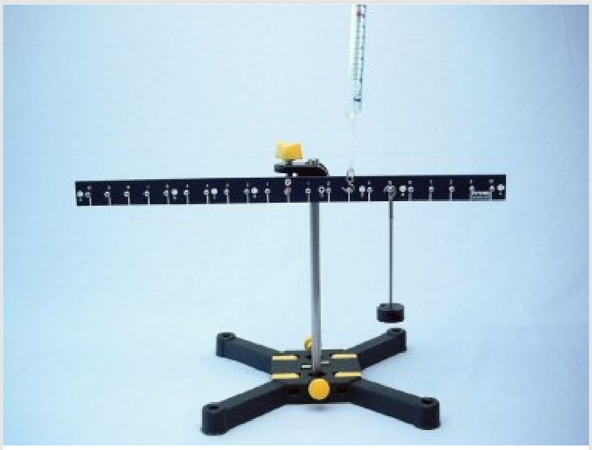

Variation of the position of the spring balance at lower load (40 g)

- Now hang the weight plate with a mass of F at the mark 5 on the right.
- Place the lever with the dynamometer horizontally at the mark 10 right (pulling direction upwards).
- Bring the dynamometer to marks 8, 6, 4 and 2 on the right hand side one after the other and measure the force $m_{total2} = 40\ g$ for each position of the dynamometer.
- Note all values in Table 2 in the report.

Implementation (4/4)

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Disassembling the tripod base

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

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Report

Task 1

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Calculate the weight force from the mass $m_{total1} = 100\ g$ and enter it as load m_{total1}:

N F [ ] $L =$

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37079 Göttingen

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Table 1

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Marker no..:

Mass spring balance	$L[N]$	$F\ [N]$	$l_1\ [cm]$	$L \cdot l_1\ [Ncm]$	$l_2\ [cm]$
9 10					
7 10					
5 10					
3 10					
1 10					

Task 2

PHYWE

Calculate the weight force from the mass $m_{total2} = 40\ g$ and enter it as load m_{total2}:

N $F \cdot l_2\ [N$ [ ] $L =$

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Table 2

PHYWE

Marker no..:

Mass spring balance	$L[N]$	$F\ [N]$	$l_1\ [cm]$	$L \cdot l_1\ [Ncm]$	$l_2\ [cm]$
5 10					
5 8					
5 6					
5 4					
5 2					

Task 3

PHYWE

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

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

Check

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Task 4

PHYWE

What formula can be used to describe this situation?

- $F_{load} \cdot l_{load} \neq F_{springbalance} \cdot l_{springbalance}$
- $F_{load} \cdot l_{load} = F_{springbalance} \cdot l_{springbalance}$
- $F \cdot l_2\ [Ncm]$

Check

Task 4

PHYWE

What formula can be used to describe this situation?

- $F_{load} \cdot l_{load} \neq F_{springbalance} \cdot l_{springbalance}$
- $F_{load} \cdot l_{load} = F_{springbalance} \cdot l_{springbalance}$
- $F \cdot l_2\ [Ncm]$

Check

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Table 3

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Load $\frac{F_{load}}{l_{load}} =$	Load arm L	Force arm l_1	Force l_2
constant	smaller	constant	
constant	constant	smaller	
smaller	constant	constant	

Look at the table:

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

Task 5

PHYWE

Apply a load of 30 g to the lever on the right at mark 6.

Also hang the dynamometer on this mark and bring the lever in horizontal position.

What is the indicated force?

F [ ] $F =$

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Task 6

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Assume that one side of the lever is loaded with several loads $L_2 \ = \ (L_{11} \cdot l_{11} + L_{12} \cdot l_{12} + \ \ldots) \ / \ l_2$ on different load arms $L_{11}, \ L_{12}, \ \ldots.$

What is the required force $l_{11}, \ l_{12}, \ \ldots$ on the force arm L_2 on the same side to compensate for this?

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

Check

Task 7

PHYWE

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

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

- When a greater moment acts downwards on the lever.
- When an equal momentum acts on the lever in both directions (up and down).
- When a greater moment acts upwards on the lever.

Check

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Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de