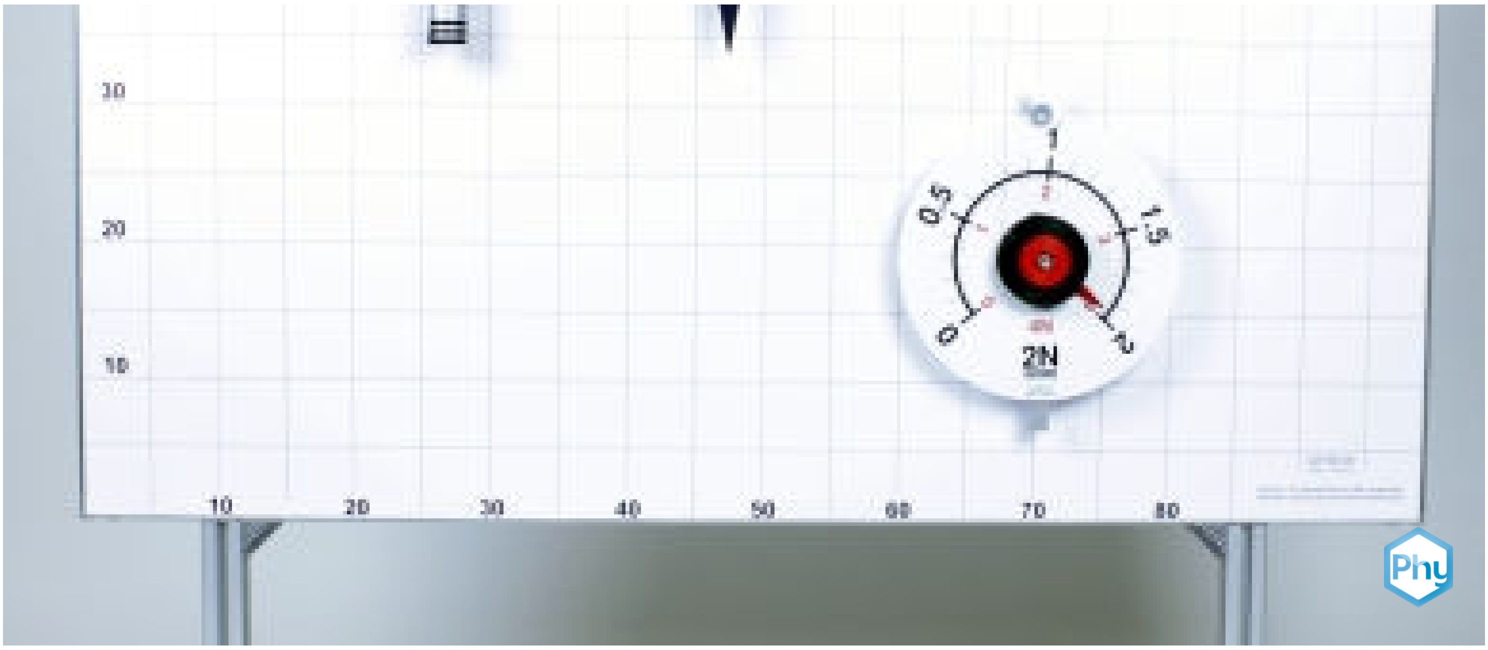
Two-sided lever



P1253100

Physics → Mechanics → Forces, work, power & energy

Difficulty level	Group size	Preparation time	Execution time
medium	-	10 minutes	20 minutes

This content can also be found online at:

http://localhost:1337/c/661cdb5c9cc71c0002761f33

General information

Application

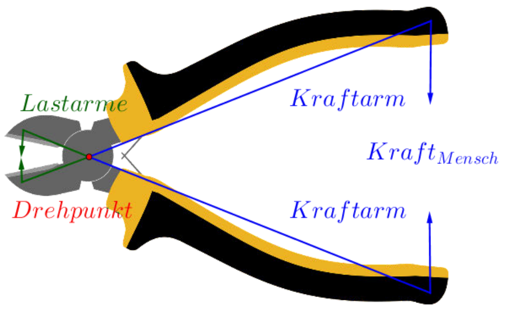


Fig. 1: Two-sided lever using the example of pliers

Levers are force-transforming devices. They are often used to generate larger forces with small forces

With a **two-sided lever** both forces act on different sides as seen from the axis of rotation.

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

Other information (1/2)

PHYWE

Prior knowledge

No prior knowledge required.

Principle

The aim is to demonstrate that a two-sided lever is in equilibrium if the product of the applied force and the lever arm is the same on both sides.

Other information (2/2)

PHYWE

Learning objective

The experiment is designed to help students understand when a two-sided lever is in equilibrium.

The relationship between force, length of the lever arms and torque is also shown.

Tasks

The students are supposed to carry out observations and measurements to determine the conditions for equilibrium with a two-sided lever.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Safety instructions

The general safety instructions for experimentation in science lessons apply.

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

Equipment

Position	Equipment	Item no.	Quantity
1	PHYWE Demo Physics board with stand	02150-00	1
2	Rod on fixing magnet	02151-02	1
3	Torsion dynamometer	03069-03	1
4	Scale for demo board	02153-00	1
5	Weight holder, 10 g	02204-01	1
6	Slotted weight, silver-bronze, 10 g	02205-03	2
7	Slotted weight, silver-bronze, 10 g	02205-03	2
8	Slotted weight, silver-bronze, 50 g	02206-03	1
9	Slotted weight, silver-bronze, 50 g	02206-03	1
10	Lever	03960-00	1
11	Pointer for demo lever	03963-00	1
12	Marker, black	46402-01	1
13	Screw clamp	02014-00	2

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

PHYWE

Setup and procedure

Setup

PHYWE

- Place the rod on the fixing magnet on the upper part of the demo board and place the lever in the centre on the rod.
- Draw a line vertically downwards from the axis with the marker.
- Attach the pointer for the demo levers (its tip lies exactly on the line drawn when the lever is balanced).

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Procedure (1/2)

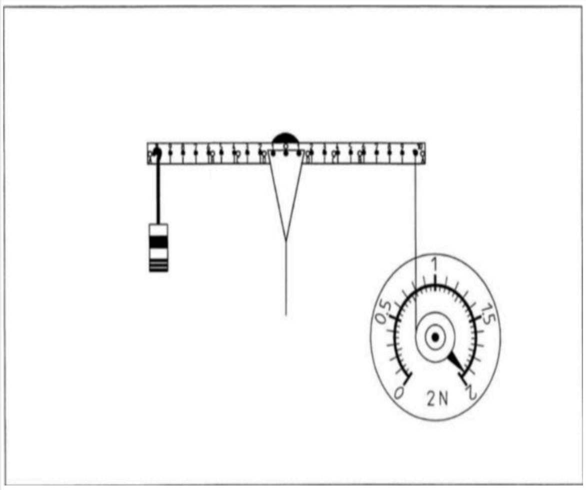


Fig. 2: Beam balance with weight and dynamometer

- Put on the dynamometer and measure the weight force - in the following called F_1 - for the weight holder with all slotted weights; note F_1 in Table 1, upper part.
- Hook the pull cord of the dynamometer on the right, at mark no. 10, and the weight holder with the slotted weights at no. 10, on the left.
- Move the dynamometer until the lever is horizontal and the pull cord is perpendicular to it (Fig. 2)
- Read F_2 on the dynamometer and note it in Table 1.

Procedure (2/2)

- Shorten the lever arm l_1 step by step; measure and record the force required to balance the lever in each case F_2 (see specifications in Table 1, upper part).
- Remove two 50g slotted weights from the weight holder, measure and record the weight force F_1.
- Hook the weight holder at mark no. 9, left, and leave it there for the following procedure.
- Shorten lever arm l_2 step by step; to do this, hook the pull cord of the dynamometer at marks no. 10, 9, ... , 6 (see Table 1, lower part), measure and note down F_2 each time.

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

PHYWE

Evaluation

Evaluation (1/4)

PHYWE

Observation:

Marke Nr.	l1 / cm	F1 / N	(F1*l1) / (N*cm)	Marke-Nr.	l2 / cm	F2 / N	(F2*l2) / (N*cm)
10	20	1.95	39.0	10	20	1.96	39.2
8	16	1.95	31.2	10	20	1.55	31.0.
6	12	1.95	23.4	10	20	1.19	23.8
4	8	1.95	15.6	10	20	0.79	15.8
2	4	1.98	7.8	10	20	0.39	7.8
9	18	0.98	17.6	10	20	0.88	17.6
9	18	0.98	17.6	9	18	0.99	17.8
9	18	0.98	17.6	8	16	1.10	17.6
9	18	0.98	17.6	7	14	1.27	17.8
9	18	0.98	17.6	6	12	1.47	17.6

Table 1: Example measurements

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

Evaluation (2/4)

PHYWE

The distance between the marks is 2 cm. The resulting I_1 and I_2 are to be entered in Table 1.

After calculating the products $F \cdot I$ for the left and right lever side $F_1 \cdot I_1 = F_2 \cdot I_2$ can be recognised.

A two-sided lever is in equilibrium if the products of the forces acting to the left and right of the centre of rotation and their lever arms are equal. Here the lever arms are the distances between the points of application of the forces and the centre of rotation of the lever.

Evaluation (3/4)

PHYWE

The forces F_1 were selected in order to utilise the measuring range of the dynamometer as much as possible. The pointer for demo levers promotes the association with an application of the lever, the beam balance.

If the suggestion of this association is not desired at this point, leave the pointer out and draw a horizontal line behind the lower edge of the lever.

If the term torque can be used, the law found is generalised into the torque theorem:

At the two-sided lever, the sum of all torques is zero in the case of equilibrium.

The following applies with two forces:
$\vec{M} = \overrightarrow{F_1}\ \overrightarrow{I_1} + \overrightarrow{F_2}\ \overrightarrow{I_2} = 0$

Clockwise and anti-clockwise torques have different signs:
$\overrightarrow{F_1}\ \overrightarrow{I_1} = -\overrightarrow{F_2}\ \overrightarrow{I_2}$

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

Evaluation (4/4)

PHYWE

In the event that $\vec{F}$ and $\vec{I}$ form an angle of 90°, is

$| \vec{M} | = M = | \vec{F} * \vec{I} | = F \cdot I$

In the general case, however

$M = F \cdot I \cdot \sin\alpha$ is also known as the effective length of the force arm or effective lever length (see Fig. 2).

The unit of M is the Newton metre (Nm), i.e. the same as the unit for mechanical work, which is often a source of confusion for students.

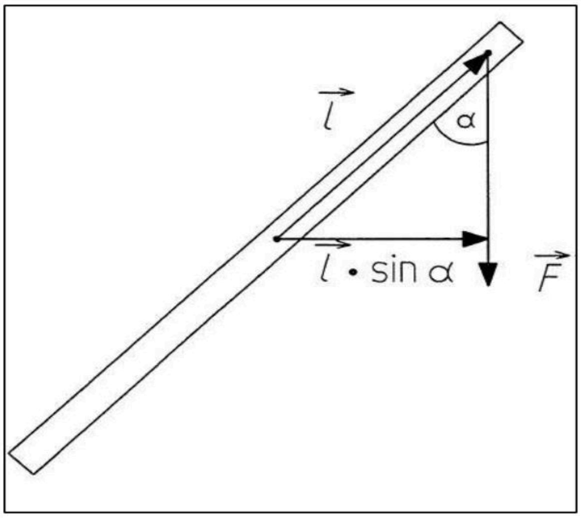


Fig. 3: Calculation of the lever arm

Task 1

PHYWE

What is the effective length of the lever arm or effective lever length?

- ○ $I \cdot \sin\alpha$
- ○ $I \cdot \cos\alpha$
- ○ $F \cdot I \cdot \sin\alpha$
- ○ $F \cdot \sin\alpha$

Check

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

Slide	Score / Total
Slide 16: Effective lever length	0/1

Total score 0 / 1

Show solutions

Repeat

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