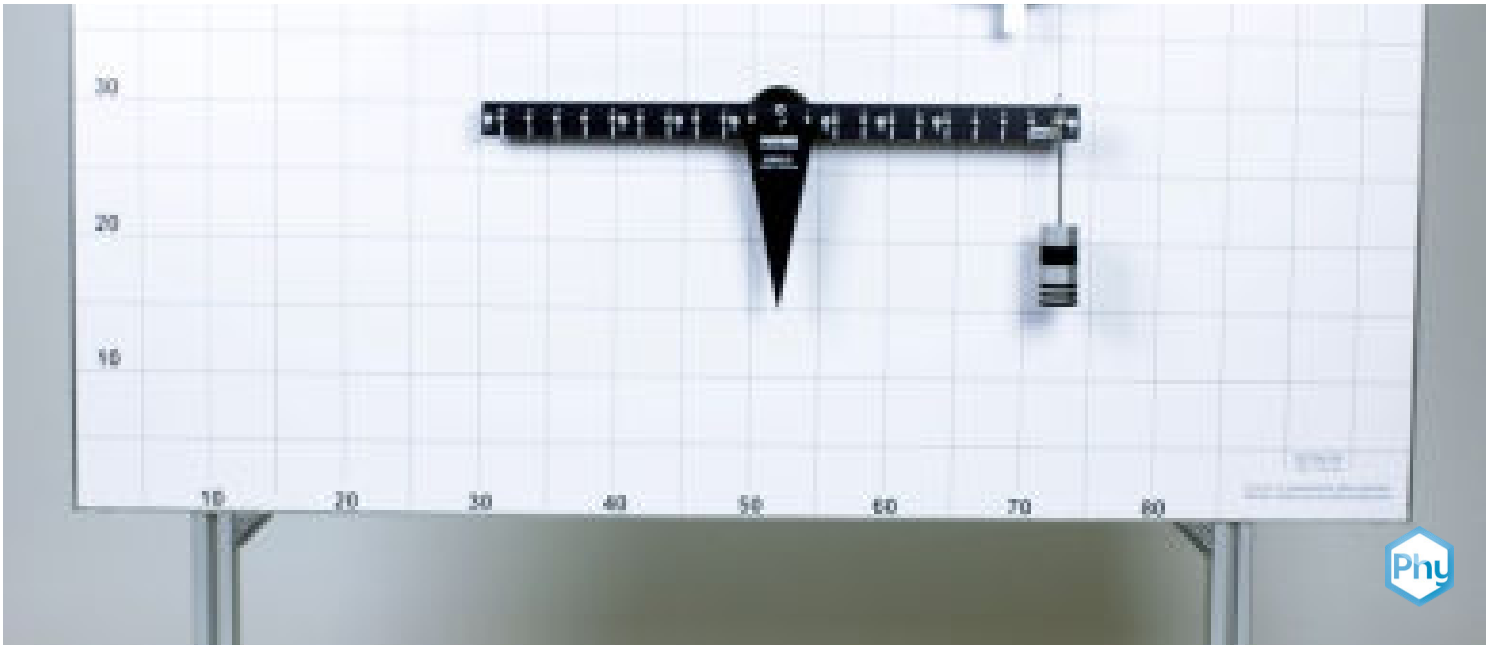
One-sided lever



P1253200

Physics > Mechanics > Forces, work, power & energy

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

This content can also be found online at:

http://localhost:1337/c/661fa4c0665a4b0002c3f539

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General information

Application

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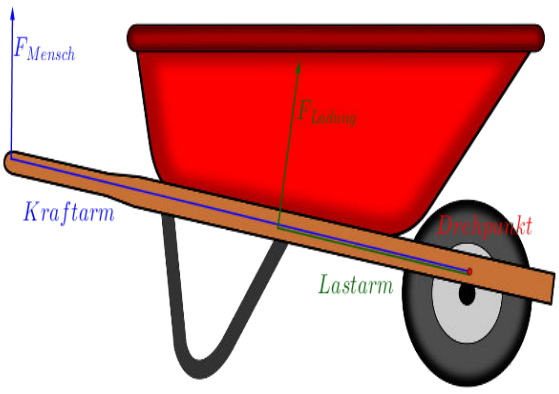

Fig. 1: One-sided lever using the example of a wheelbarrow

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

With a one-sided lever, force is applied on the same side on which the action takes place.

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Other information (1/2)

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Prior knowledge

No prior knowledge required.

Principle

The aim is to prove that equilibrium prevails on a one-sided lever if the products of two opposing forces acting in opposite directions are equal to their lever arms.

Other information (2/2)

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Learning objective

The experiment is designed to help students understand where the equilibrium is with a one-sided lever.

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 equilibrium of a one-sided lever.

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Safety instructions

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The general safety instructions for experimentation in science lessons apply.

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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 demonstration lever	03963-00	1
12	Marker, black	46402-01	1
13	Screw clamp	02014-00	2

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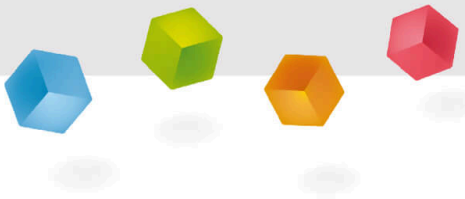

Setup and procedure

Setup

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

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Procedure (1/2)

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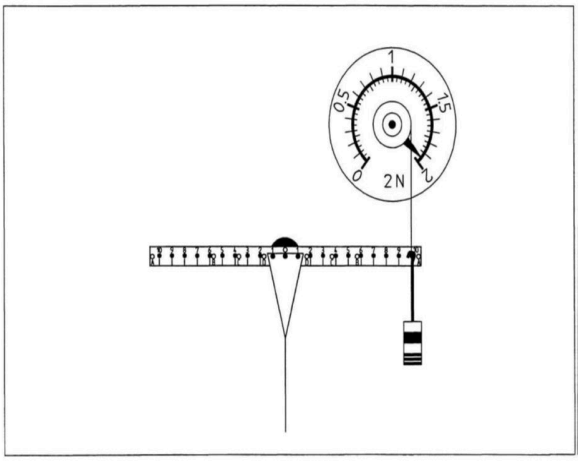

Fig. 2: Beam balance with weight and dynamometer

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

Procedure (2/2)

- Note down the reading for F_2 on the dynamometer and in Table 1.
- Shorten lever arm I_1 step by step, measure and note the force required to balance the lever in each case F_2 (see specifications in Table 1, upper part).
- Remove two 50 g slotted weights from the weight holder, measure and record the weight force F_1 again.
- Hook the weight holder at mark no. 9, on the right, and leave it there in the following.
- Shorten lever arm I_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 for each case.

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Evaluation

Evaluation (1/4)

Table 1 is completed by the specific values for I_1 and I_2.

(The distance between the marks is 2 cm.)

After calculating the products $F \cdot I$ can be recognized:

$$\vec{F_1} \cdot \vec{I_1} = \vec{F_2} \cdot \vec{I_2}$$

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Evaluation (1/4)

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Evaluation (2/4)

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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

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Evaluation (3/4)

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A one-sided lever is in equilibrium if the products of the oppositely directed forces acting on it and their lever arms are equal. The lever arms are the distances between the points of application of the forces and the centre of rotation of the lever.

The lever is rotatable in its centre so that the weight forces of the two halves of the lever balance each other out (better: their torques). The students must be made aware of this so that they do not get the wrong idea of a one-sided lever.

It is advisable to cover the free (left) side of the lever with white paper so that the image of the one-sided lever is clear from the outset.

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

(see next page)

Evaluation (4/4)

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In the case of equilibrium, the sum of the torques on the one-sided lever is zero. For two forces the following applies:
$| \vec{M} | = \vec{F_1} \cdot \vec{I_1} + \vec{F_2} \cdot \vec{I_2} = 0$

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

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

$| \vec{M} | = M = | \vec{F} \cdot \vec{I} | = F \cdot I$ applies, otherwise it's $M = F \cdot I \cdot \sin\alpha$.

$I \cdot \sin\alpha$ as the effective length of the lever arm or effective lever length.

The terms load and load arm were deliberately avoided, as the load is not a physical quantity.

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Task 1

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In the case of equilibrium, the sum of the torques on the one-sided lever is zero.

○ True ○ False

Check

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