Double-sided lever (Item No.: P1000600)

Curricular Relevance

Area of Expertise: Physics
Education Level: Age 14-16
Topic: Mechanics
Subtopic: Forces, simple machines
Experiment: Double-sided lever

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	10 Minutes	10 Minutes	2 Students

Additional Requirements:

Experiment Variations:

Keywords:

Task and equipment

Information for teachers

Additional Information

On a double-sided lever the students should verify the law “force × force arm = load × load arm" and be able to present it as a formula.
In a supplementary problem the term moment of rotation can be treated and the law of the lever presented in the form “Sum of all moments of rotation = 0”.

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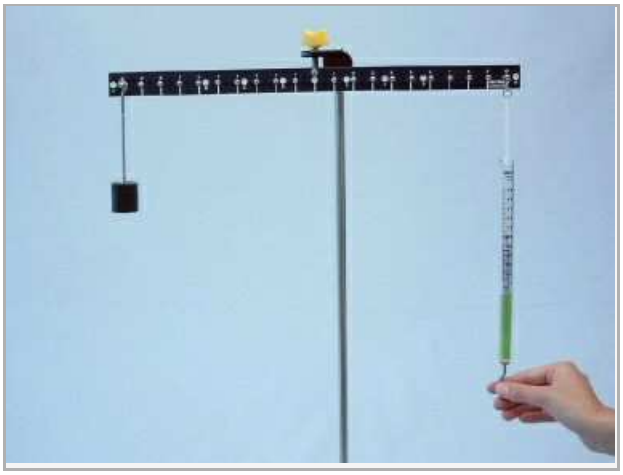
Task and equipment

Task

How does a double-sided (class 1) lever work?

Load one side of the lever with a mass which acts on different points on the lever. With a spring balance on the other end bring the lever into a horizontal position. Measure the forces and the lengths involved.
Load one side of the lever with a mass. With a spring balance which acts on different points on the other side bring the lever into a horizontal position. Perform again measurements of the lengths and masses involved.



Equipment

Position No.	Material	Order 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 for slotted weights	02204-00	2
6	Slotted weight, black, 10 g	02205-01	4
6	Slotted weight, black, 50 g	02206-01	1
7	Spring balance,transparent, 2 N	03065-03	1
8	Holding pin	03949-00	1

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Set-up and procedure

Set-up

First screw the split support rod together (Fig. 1). Set up a stand with the support base and the support rod (Fig. 2 and Fig. 3).

Fig. 1

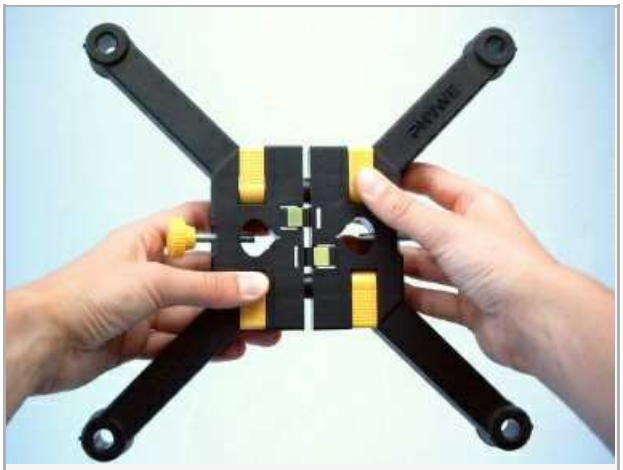

Fig. 2

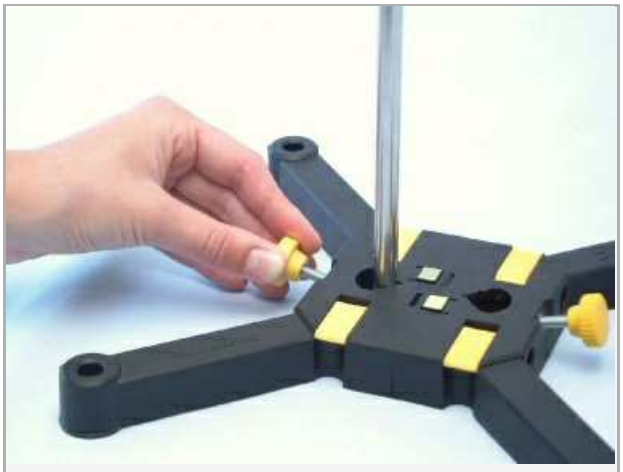

Fig. 3

Attach the bosshead to the support rod. Clamp the lever with the holding pin, so that the holding pin is exactly in the lever's centre. After that, insert the holding pin into the bosshead (Fig. 4). Set the spring balance to zero before making the "upside down" measurement (Fig. 5).

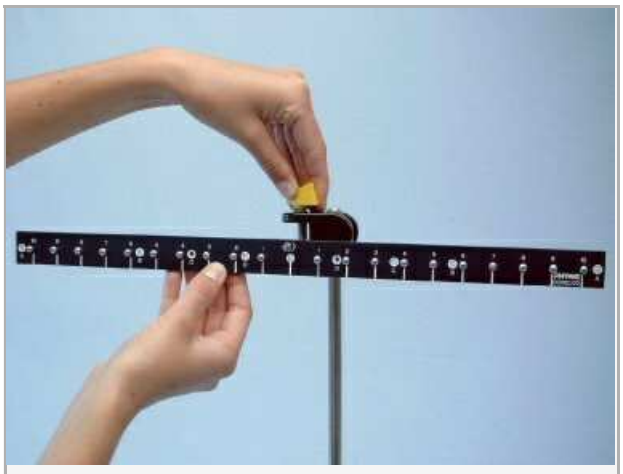

Fig. 4

Fig. 5

Procedure

- Hang the weight holder with a total mass of $m_{tot.}$ = 100 g on the left side of the lever at the 10 mark.
- Hang the spring balance on the right side of the lever at the 10 mark and pull the lever into a horizontal position with it (Fig. 6).
- Read the indicated value and record it in Table 1 in the report.

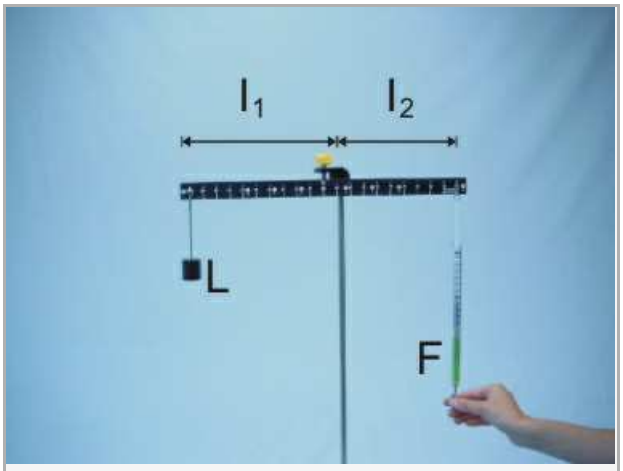

Abb. 6

- Move the load successively to the 8, 6, 4 and 2 marks on the left side and measure the force *F* for each position (Fig. 7).
- Record all the values in Table 1.

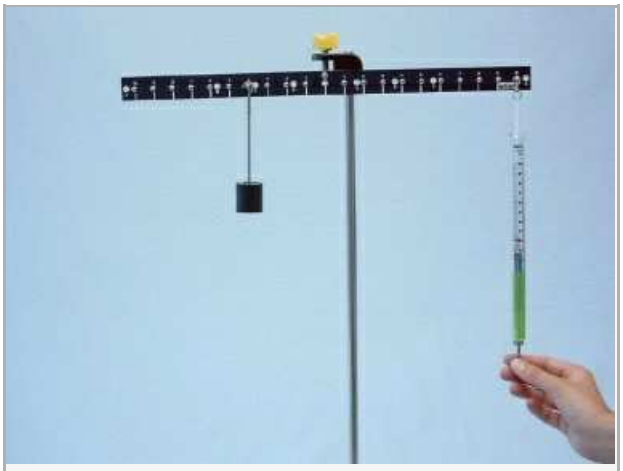

Abb. 7

- Hang the weight holder with a total mass of $m_{tot.}$ = 40 g on the left side of the lever at the 10 mark.
- Hang the spring balance on the right side of the lever at the 10 mark and pull the lever into a horizontal position with it. Read the indicated value and record it in Table 2 in the report.
- Move the spring balance successively to the 8, 6, 4 and 2 marks on the right side and measure the force *F* for each position (Fig. 8). Record all the values in Table 2.

Abb. 8

In order to disassemble the support base you should press the yellow buttons (Fig. 9).

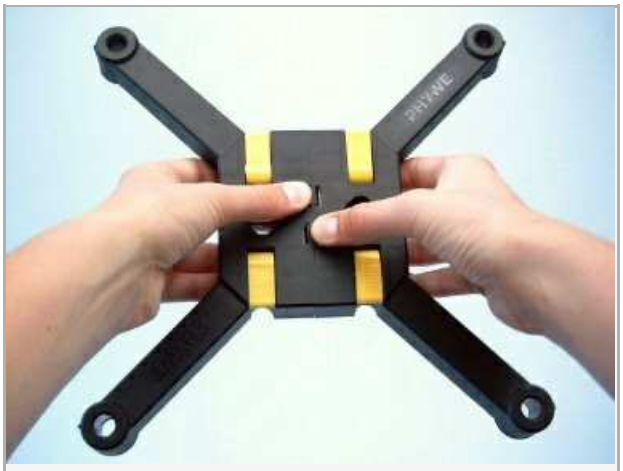

Abb. 9

Report: Double-sided lever

Results – Part 1

Part 1:

Using the mass $m_{tot.}$, calculate the weight (force) and record it as load L.

$m_{tot.}$ = 100 g, L = ... N

Results – Table 1

Enter measured value in the Table 1.

From the distance between the marks used (2 cm each), calculate the length of the load arm l_1 and the force arm l_2 in cm (see Fig. 5 on the procedure page) and add these values to the table.

Calculate the products $L \cdot l_1$ and $F \cdot l_2$ and record these values in the table, too.

Mark No.		F in N	l_1 in cm	$L \cdot l_1$ in Ncm	l_2 in cm	$F \cdot l_2$ in Ncm
left	right	1 ±0	1 ±0	1 ±0	1 ±0	1 ±0
10	10	1 ±0	1 ±0	1 ±0	1 ±0	1 ±0
8	10	1 ±0	1 ±0	1 ±0	1 ±0	1 ±0
6	10	1 ±0	1 ±0	1 ±0	1 ±0	1 ±0
4	10	1 ±0	1 ±0	1 ±0	1 ±0	1 ±0
2	10	1 ±0	1 ±0	1 ±0	1 ±0	1 ±0

Results – Part 2

Part 2:

Using the mass $m_{tot.}$, calculate the weight (force) and record it as load L.

$m_{tot.}$ = 40 g, L = ... N

Results – Table 2

Enter measured value in the Table 2.

From the distance between the marks used (2 cm each), calculate the length of the load arm l_1 and the force arm l_2 in cm (see Fig. 5 on the procedure page) and add these values to the table.

Calculate the products $L \cdot l_1$ and $F \cdot l_2$ and record these values in the table, too.

Mark No.		F in N	l_1 in cm		l_2 in cm	$F \cdot l_2$ in Ncm
left	right					
10	10	1 ±0	1 ±0	1 ±0	1 ±0	1 ±0
10	8	1 ±0	1 ±0	1 ±0	1 ±0	1 ±0
10	6	1 ±0	1 ±0	1 ±0	1 ±0	1 ±0
10	4	1 ±0	1 ±0	1 ±0	1 ±0	1 ±0
10	2	1 ±0	1 ±0	1 ±0	1 ±0	1 ±0

Evaluation – Question 1

Compare the products with each other, what do you conclude from this comparison?

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Evaluation – Question 2

Express the observed facts in words and as a formula:

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Evaluation – Table 3

Examine Table 3:

How does the force change under the given conditions? Does it become larger or smaller? Complete the table.

Load L	Load arm l_1	Force arm l_2	Force F
constant	smaller	constant	1
constant	constant	smaller	1
smaller	constant	constant	1

Evaluation – Question 3

Hang a weight m = 10 g on the left side of the lever at the 2, 4, 6, 8 and 10 marks. At which mark on the right side of the lever must a second weight m = 20 g be placed so that it remains horizontal?

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Evaluation – Additional Task 1

The product "$F \cdot l$ = force times lever arm" is called the moment of rotation. Can you state under which conditions the lever remains in a horizontal position?

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Evaluation – Additional Task 2

In which direction does a lever move under the influence of a moment of rotation which acts on the right side of the lever with force F at distance l_2 on the lever arm?

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Evaluation – Additional Task 3

How does a lever move under the influence of a moment of rotation with force F at distance l_2 on the lever arm on the left side of the lever?

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Evaluation – Additional Task 4

Load one side of the lever with several loads L_1, L_2 ... on different force arm lengths l_{11}, l_{12} ... How large is the required force on force arm l_2?

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