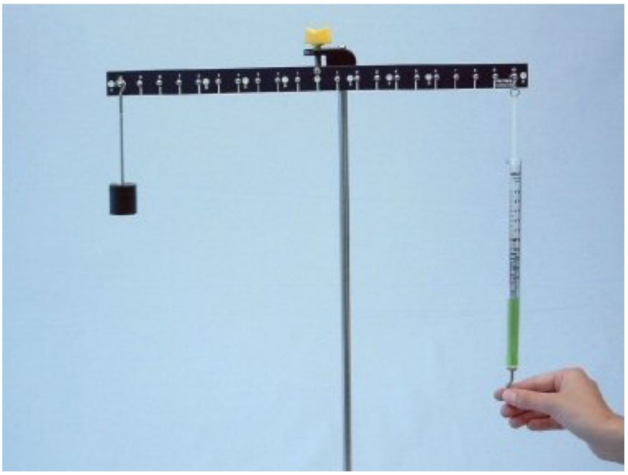
3.2 Double-sided (class 1) lever

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.



Use the space below for your own notes.

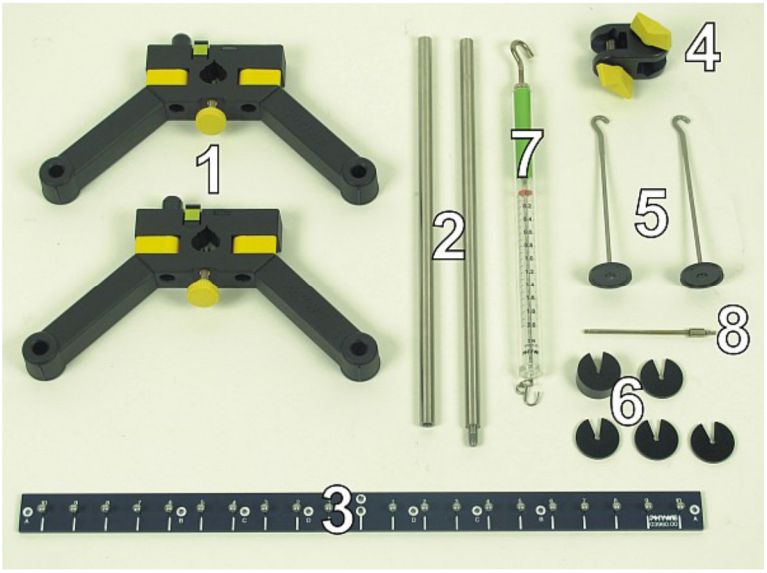
Material

Material from "TESS advanced Physics Set Mechanics 1, ME-1" (Order No. 15271-88)

Position No.	Material	Order No.	Quantity
1	Support base, variable	02001-00	1
2	Support rod, split in 2 rods, *l* = 600 mm	02035-01	1
3	Lever	03960-00	1
4	Bosshead	02043-00	1

5	Weight holder for slotted weights, 10 g	02204-00	2
6	Slotted weight, black coloured, 10 g	02205-01	4
6	Slotted weight, black coloured, 50 g	02206-01	1
7	Spring balance, transparent, 2 N	03065-03	1
8	Holding pin	03949-00	1

Material required for the experiment



Setup

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

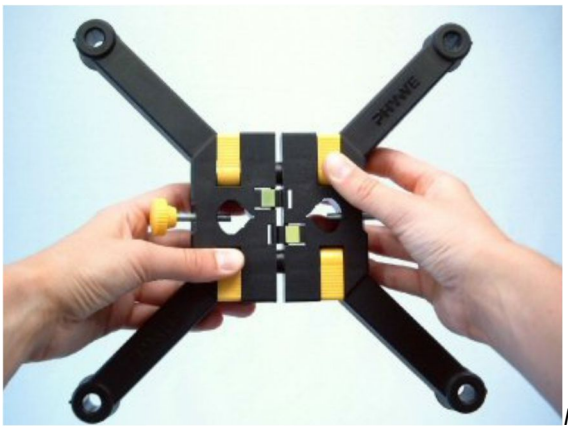


Fig. 2

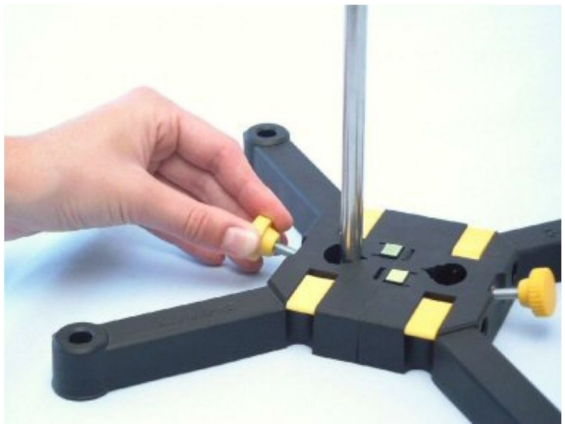


Fig. 3

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).

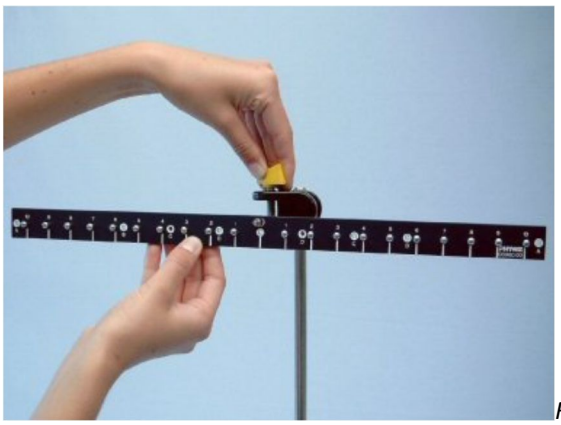


Fig. 4


Fig. 5

Action

- 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 on the Results page.

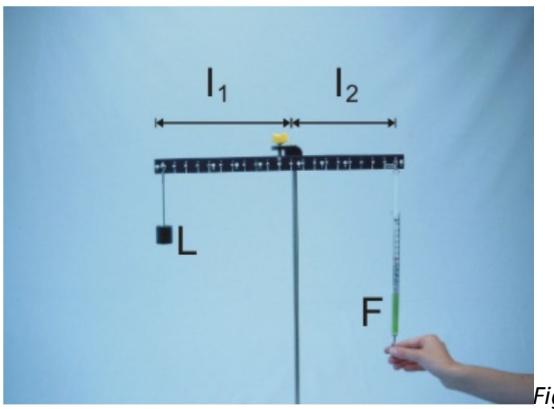


Fig. 6

- 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.

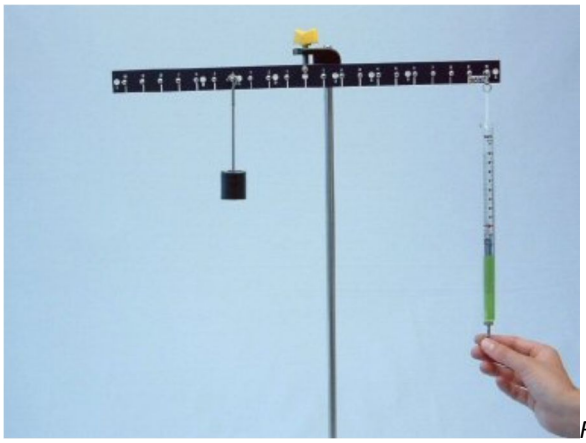


Fig. 7

- 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 on the Results page.
- 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.

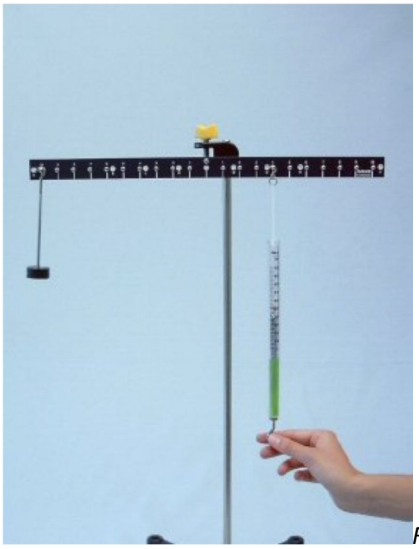


Fig. 8

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

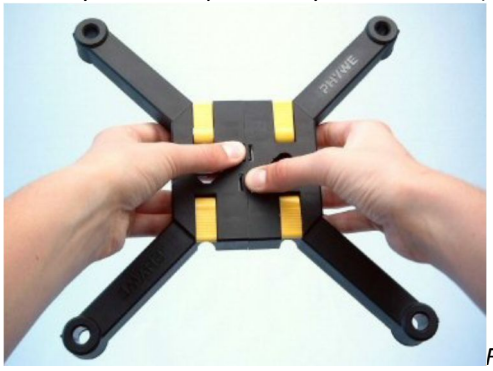


Fig. 9

Results

Table 1

$m_{tot.}$ = 100 g, L = ☐ N

Mark No.		F in N	l_1 in cm	$L \times l_1$ in Ncm	l_2 in cm	$F \times l_2$ in Ncm
Left	Right					
10	10					
8	10					
6	10					
4	10					
2	10					

Table 2

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

Mark No.		F in N	l_1 in cm	$L \times l_1$ in Ncm	l_2 in cm	$F \times l_2$ in Ncm
Left	Right					
10	10					
10	8					
10	6					
10	4					
10	2					

Evaluation

Question 1:

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

Question 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 Action page) and add these values to the tables (Results page).

Question 3:

Calculate the products $L \times l_1$ und $F \times l_2$ and record these values in the tables, too.

Question 4:

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

Question 5:

Express the observed facts in words and as a formula:

Question 6:

Examine Table 3:
How does the force change under the given conditions? Does it become larger or smaller?
Complete the table.

Table 3

Load *L*	Load arm l_1	Force arm l_2	Force *F*
Constant	**Smaller**	**Constant**	
Constant	**Constant**	**Smaller**	
Smaller	**Constant**	**Smaller**	

Question 7:

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?

Additional Tasks

Question 1:

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

Question 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?

Question 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?

Question 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?