Double-sided lever (Item No.: P1253100)

Curricular Relevance

Area of Expertise: Physik → **Education Level:** Klasse 7-10 → **Topic:** Mechanik → **Subtopic:** Kräfte, einfache Maschinen → **Experiment:** Zweiseitiger Hebel

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	10 Minutes	20 Minutes	1 Student

Additional Requirements:

Experiment Variations:

Keywords:

Principle and equipment

Principle

Demonstrate that a double-sided lever is in equilibrium when the product of the applied force and the force arm is the same on both sides.

Equipment

Position No.	Material	Order No.	Quantity
1	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 demonstration board	02153-00	1
5	Weight holder for slotted weights	02204-00	1
6	Slotted weight, black, 10 g	02205-01	2
7	Slotted weight, silver bronze, 10 g	02205-02	2
8	Slotted weight, black, 50 g	02206-01	1
9	Slotted weight, silver bronze, 50 g	02206-02	2
10	Lever	03960-00	1
11	Pointer for demonstration lever	03963-00	1
12	Marker, black	46402-01	1

Set-up and procedure

Set-up

- Place the axle on fixing magnet onto the upper part of the demonstration board and slip the lever's middle hole onto the axle.
- Using the white board pen, draw a vertical line downwards from the axle.
- Attach the pointer for demonstration lever to the lever (in the following its tip lies directly on the vertical line when the lever is in equilibrium).

Procedure

- Place the dynamometer onto the board, and measure the weight- in the following termed F_1 for the weight holder and all of the slotted weights. Enter F_1 in the upper part of Table 1.
- Hook the traction cord of the dynamometer in the hole at the #10 index mark on the right side, and the weight holder with the slotted weights at #10 index mark on the left side.
- Move the dynamometer until the lever is horizontal and the traction cord is perpendicular to it (Fig. 1).

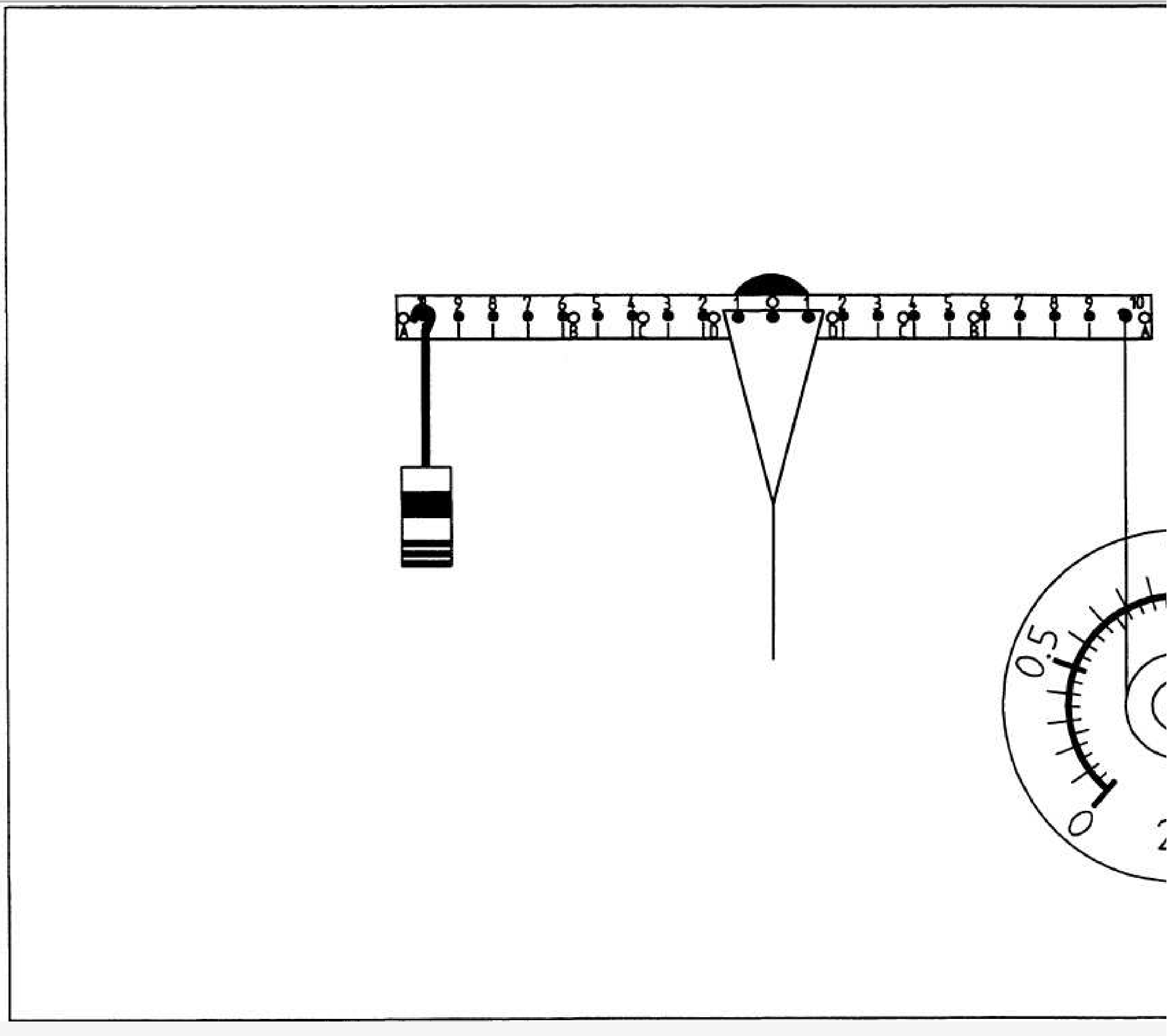

Fig. 1

- Read F_2 on the dynamometer and record its 1 value in Table 1.
- Shorten the power arm l_1 progressively and in each case measure the force F_2 required for the maintenance of equilibrium and record it (cf. given values in Table 1, upper part).
- Remove two 50-g slotted weights from the weight holder, measure the weight F_1 and record it.
- Hook the weight holder into the hole at the #9 index mark, and leave it there in the following steps.
- Progressively shorten the power arm l_2 To do this, hook the traction cord of the dynamometer into the holes at the #10, #9, ... , #6 index marks (cf. Table 1, lower part), Measure F_2 in each case and record the respective values.

Observation and evaluation

Observation

Table 1

Left side of the lever				Right side of the lever			
Index mark no.	l_1/m	F_1/N	$\frac{F_1 * l_1}{N * cm}$	Index mark no.	l_2/m	F_2/N	$\frac{F_1 * l_1}{N * cm}$
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	1.95	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

Evaluation

The distances between the index marks is 2 cm. Record the resulting I_1 und I_2 in Table 1.

After calculation of the products $F * I$ the following can be seen:

$$F_1 * I_1 = F_2 * I_2$$

A double-sided lever is in equilibrium when the product of the forces acting to the left and to the right of the fulcrum and their respective power arms are equal. In this context, the distance between the points of application of the forces and the fulcrum of the lever is termed the power arm.

Remarks

The F_1 forces were chosen to utilise nearly the entire measuring range of the dynamometer. The pointer for the demonstration lever suggests the association with an application of the lever, the beam balance. If one does not want to bring this association to the students' minds at this time, ignore it as this point and draw a horizontal line along the lower edge of the lever. If the term torque can be introduced at this time, generalise the determined law to the momentum theorem:

$$\vec{M} = \overrightarrow{F_1} * \overrightarrow{I_1} + \overrightarrow{F_2} * \overrightarrow{I_2} = 0 .$$

where the clockwise and counterclockwise torques have different signs:

$$\overrightarrow{F_1} * \overrightarrow{I_1} = -\overrightarrow{F_2} * \overrightarrow{I_2} .$$

For the case in which $\vec{F}$ and $\vec{I}$ form an angle of 90°, the following is true:

$$\left|\vec{M}\right| = M = \left|\vec{F} * \vec{I}\right| = F * I ,$$

However, the general case is as follows:

$$M = F * I * \sin\alpha .$$

$I * \sin\alpha$ is also termed the effective length of the power arm or the effective lever length (cf. Fig. 2).

The unit of M is the newton-meter (Nm), i.e. the same unit used to express mechanical work. This correspondence is often a source of irritation for the students.

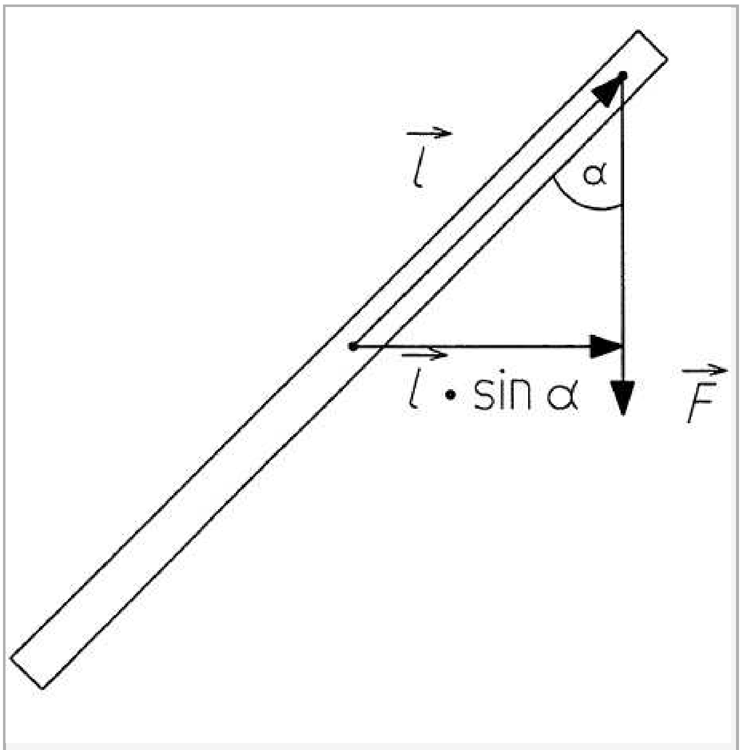

Fig. 2