Mechanics

Statics

Lever

LD
Physics
Leaflets

P1.2.3.1

One-sided and two-sided lever

Objects of the experiment

- Measuring the force F_1 for a one-sided and two-sided lever as a function of the load F_2.
- Measuring the force F_1 for a one-sided and two-sided lever as a function of the load arm x_2.
- Measuring the force F_1 for a one-sided and two-sided lever as a function of the power arm x_1.

Principles

A lever is defined as a rigid body rotating on a fixed pivot (often called the fulcrum) which can be used to raise and move loads. The segments from the pivot to the point of application of the force and to the load are termed the lever arms, specifically the power and load arms respectively. In a two-sided lever, the force *F1* and the load F_2 act in the same direction on opposite sides of the pivot; in a one-sided lever, the forces act in opposite directions on the same side of the pivot. The law of levers applies for both lever types:

$$F_1 \cdot x_1 = F_2 \cdot x_2$$

x_1: power arm, x_2: load arm

This law can be explained on the basis of the more general concept of equilibrium of angular momentums and forms the basis for all types of mechanical transmission of force.

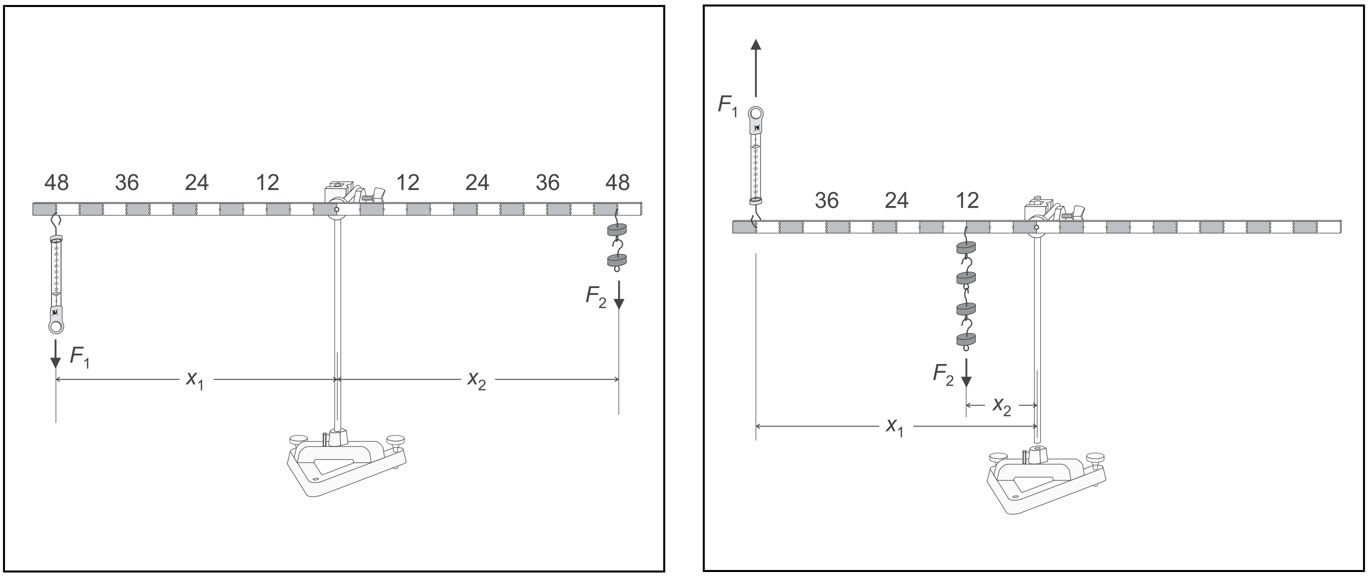
The first experiment examines the law of levers for one-sided and two-sided levers. The object is to determine the force F_1 which maintains a lever in equilibrium as a function of the load F_2, the load arm x_2 and the power arm x_1. The load is applied using multiple 50 g weights suspended one below the other. For the load

$$F_2 = m \cdot g$$

g: gravitational acceleration

of a weight, the value 0.5 N can be assumed with sufficient accuracy.

Fig. 1 Experiment setup for verifying the law of levers for a one-sided (left) and two-sided (right) lever



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Apparatus

1 Lever, 1 m 342 60
1 Set of 12 weights, 50 g each 342 61

1 Dynamometer, 2 N 314 45
1 Dynamometer, 5 N 314 46

1 Stand base, V-shape, 20 cm 300 02
1 Stand rod, 47 cm 300 42
1 Leybold multiclamp 301 01

Setup and carrying out the experiment

a) Two-sided lever

Set up the experiment as shown in Fig. 1 (top).

a1) Measuring as a function of the load arm F_2:

– Suspend two, four and six weights at x_2 = 24 cm and attach a dynamometer 2 N at x_1 = 48 cm to determine the force F_1 required to maintain the lever in a horizontal position.

a2) Measuring as a function of the load arm x_2 :

– Suspend four weights at x_2 = 48, 36 and 24 cm and attach a dynamometer 2 N at x_1 = 48 cm to determine the force F_1 required to maintain the lever in a horizontal position.

a3) Measuring as a function of the power arm x_1 :

– Suspend four weights at x_2 = 48 cm and attach a dynamometer 5 N at x_1 = 48, 36 and 24 cm to determine the force F_1 required to maintain the lever in a horizontal position.

b) One-sided lever

Set up the experiment as shown in Fig. 1 (bottom).

b1) Measuring as a function of the load F_2:

– Suspend four, eight and 12 weights at x_2 = 12 cm and attach a dynamometer 2 N at x_1 = 48 cm to determine the force F_1 required to maintain the lever in a horizontal position.

b2) Measuring as a function of the load arm x_2 :

– Suspend four weights at x_2 = 12, 24 and 36 cm and attach a dynamometer 2 N at x_1 = 48 cm to determine the force F_1 required to maintain the lever in a horizontal position.

b3) Measuring as a function of the power arm x_1 :

– Suspend three weights at x_2 = 48 cm and attach a dynamometer 5 N at x_1 = 36, 24 and 12 cm to determine the force F_1 required to maintain the lever in a horizontal position.

Measuring example and evaluation

a) Two-sided lever

Table 1: Force F_1 as a function of the load F_2 (x_1 = 48 cm, x_2 = 24 cm)

$\frac{F_2}{\text{N}}$	$\frac{F_2 \cdot x_2}{\text{Nm}}$	$\frac{F_1}{\text{N}}$	$\frac{F_1 \cdot x_1}{\text{Nm}}$
1.0	0.24	0.5	0.24
2.0	0.48	1.0	0.48
3.0	0.72	1.5	0.72

Table 2: Force F_1 as a function of load arm x_2 (x_1 = 48 cm, F_2 = 2.0 N)

$\frac{x_2}{\text{cm}}$	$\frac{F_2 \cdot x_2}{\text{Nm}}$	$\frac{F_1}{\text{N}}$	$\frac{F_1 \cdot x_1}{\text{Nm}}$
24	0.48	1.0	0.48
36	0.72	1.5	0.72
48	0.96	2.0	0.96

Table 3: Force F_1 as a function of power arm x_1 (x_2 = 48 cm, F_2 = 2.0 N)

$\frac{x_1}{\text{cm}}$	$\frac{F_1}{\text{N}}$	$\frac{F_1 \cdot x_1}{\text{Nm}}$	$\frac{F_2 \cdot x_2}{\text{Nm}}$
24	4.0	0.96	0.96
36	2.75	0.99	0.96
48	2.0	0.96	0.96

b) One-sided lever

Tab. 4: Force F_1 as a function of the load F_2 (x_1 = 48 cm, x_2 = 12 cm)

$\frac{m_2}{g}$	$\frac{F_2}{\text{N}}$	$\frac{F_2 \cdot x_2}{\text{Nm}}$	$\frac{F_1}{\text{N}}$	$\frac{F_1 \cdot x_1}{\text{Nm}}$
200	2.0	0.24	0.5	0.24
400	4.0	0.48	1.0	0.48
600	6.0	0.72	1.5	0.72

Table 5: Force F_1 as a function of load arm x_2 (x_1 = 48 cm, F_2 = 2.0 N)

$\frac{x_1}{\text{cm}}$	$\frac{F_2 \cdot x_2}{\text{Nm}}$	$\frac{F_1}{\text{N}}$	$\frac{F_1 \cdot x_1}{\text{Nm}}$
12	0.24	0.5	0.24
24	0.48	1.0	0.48
36	0.72	1.5	0.72

Table 6: Force F_1 as a function of power arm x_1 (x_2 = 48 cm, F_2 = 1.0 N)

$\frac{x_1}{\text{cm}}$	$\frac{F_1}{\text{N}}$	$\frac{F_1 \cdot x_1}{\text{Nm}}$	$\frac{F_2 \cdot x_2}{\text{Nm}}$
12	4.0	0.48	0.48
24	2.0	0.48	0.48
36	1.25	0.45	0.48

Results

For one-sided and two-sided levers, the law of levers applies: “force x power arm = load x load arm”.

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