Sliding weight balance (Item No.: P1253700)

Curricular Relevance

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

Difficulty

Easy

Preparation Time

10 Minutes

Execution Time

10 Minutes

Recommended Group Size

1 Student

Additional Requirements:

- Set of precision weights, 1... 50 g (44017-00)
- Various objects
- Adhesive strips of paper, approx. 2 cm wide, approx. 40 cm long
- Scissors

Experiment Variations:

Keywords:

Principle and equipment

Principle

Construct a model of a sliding weight balance and use it to determine the masses of objects.

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	Scale for demonstration board	02153-00	1
4	Pointers f. Demonst.Board, 4 pcs	02154-01	1
5	Weight holder for slotted weights	02204-00	1
6	Slotted weight, black, 10 g	02205-01	4
7	Slotted weight, black, 50 g	02206-01	2
8	Slotted weight, silver bronze, 50 g	02206-02	2
9	Weight, 150 g, for 11060.00	11060-01	1
10	Balance pan, plastic	03951-00	1
11	Lever	03960-00	1
12	Fish line, l. 100m	02090-00	1
13	Marker, black	46402-01	1
Additional Material:			
14	Set of precision weights, 1... 50 g	44017-00	1
15	Various objects		
16	Adhesive strips of paper, approx. 2 cm wide, approx. 40 cm long		
17	Scissors		

Set-up and procedure

Set-up

- Paste the upper part of the lever over with an approximately 32 cm long piece of adhesive strip. From the remainder of paper strip cut out an arrow that is similar to the pointer for the demonstration board and paste it onto the back of the lever in such a manner that it extends a sufficient distance beyond the end of the lever (cf. Fig. 1).
- Make a loop of approximately 10 cm of fish line.
- Place the axle on fixing magnet onto the demonstration board and fix the lever onto the axle by means of the hole at point B.
- Hang the balance pan with the additional weight (150 g) at the #10 index mark on the left end. Hang the weight holder which is loaded with a 50-g slotted weight over the right arm of the lever with the aid of the loop, and move it until the lever remains in a horizontal position.

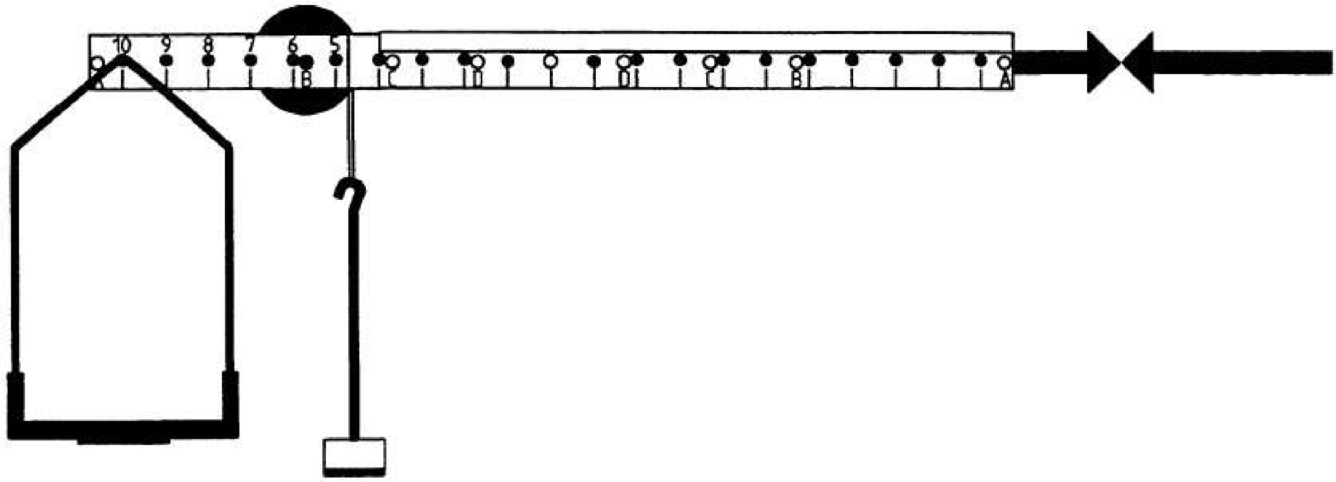

Fig. 1

Procedure

- Mark the position with the pointer for demonstration board, which points at the arrow pasted to the lever when the balance is balanced out (cf. Fig. 1). Mark the position of the loaded weight holder, which functions as the sliding weight, on the paper (right side of lever). This determines the zero point of the scale for the sliding weight balance. Measure the distance *l* between the zero point and the fulcrum (from the middle of the axle) and record its value in Table 1.
- Hold the lever tightly, place a 10-g slotted weight onto the balance pan and move the sliding weight until the balance is in equilibrium, i.e. the two arrow heads are (as nearly as possible) exactly opposite one another. Mark the position on the scale where the sliding weight is now located. Measure the distance between this location and the fulcrum and record it.
- Increase the load of the balance pan up to 200 g in 10-g steps and proceed in the same manner as above for each step.
- Remove the slotted weights from the balance pan and now determine the weight of appropriate objects (measuring range 200 g) (cf. Table 2).

Observations and evaluation

Observations

Table 1

m/g	l/cm	m/g	l/cm
0	1.2	110	17.3
10	2.7	120	18.6
20	4.2	130	20.1
30	5.6	140	21.5
40	7.1	150	23.1
50	8.5	160	24.5
60	9.9	170	26.0
70	11.4	180	27.4
80	12.8	190	28.9
90	14.3	200	30.4
100	15.7		

Table 2

Object on the balance pan	Distance of the sliding weight from fulcrum l/cm	Position of the sliding weight on the scale in the range of	Mass of object m/g
Weight set	22.2	140 ... 150	141
Shaft without magnet	5.2	20 ... 30	27

Evaluation

The double-sided, unequal-armed lever is in equilibrium when the clockwise and counterclockwise moments of rotation (torques) counterbalance each other.

In this experiment the acting forces are the weight of objects. Therefore, one can compare weights and thus masses with the device which is termed a sliding weight balance.

Through the comparison of the unknown mass of an object with the known mass of standardised mass pieces (weights) one can determine the unknown mass.

On the sliding weight balance, equilibrium is achieved by changing the power arm of the sliding weight to the required length. Each length of the power arm corresponds to a specific mass of the body which is to be weighed. By proceeding according to this principle, one can calibrate the sliding weight balance.

Remarks

The calibration of the sliding weight balance in 10-g steps provides a great many gradations on its scale but is very time consuming. One could also proceed in larger steps (each 20 g or each 50 g in size) and subsequently perform a finer subdivision of the scale.

The most rational procedure would be to determine only the zero point and the end point (200 g) of the scale using measurements, and then to subdivide the scale linearly as finely as desired. This procedure is possible because a change in the counterclockwise force acting about the test object's weight (force) F_G (on the left arm of the balance) requires a proportional change in the length of the right power arm in order to restore the equilibrium of the balance:

$\Delta F_G \;\; \Delta l$ or $\Delta l \;\; \Delta m$ (cf. Fig. 2).

The counterclockwise moment increases proportionally to the mass of the test object (for a constant lever arm; the clockwise moment, proportionally to the length of the power arm (for constant force).

The determination of the masses of the test objects (cf. Table 2) is only as exact as the smallest-selected gradations of the scale. If the mass is to be determined as exactly as possible, one measures the
length *l* of the lever arm required for equilibrium in each case and then calculates the mass using a known pair of measured values (e.g. 100 g = 15.7 cm). Otherwise, one can interpolate and obtain a good approximation of the mass. This latter method corresponds better to practical use of the balance.

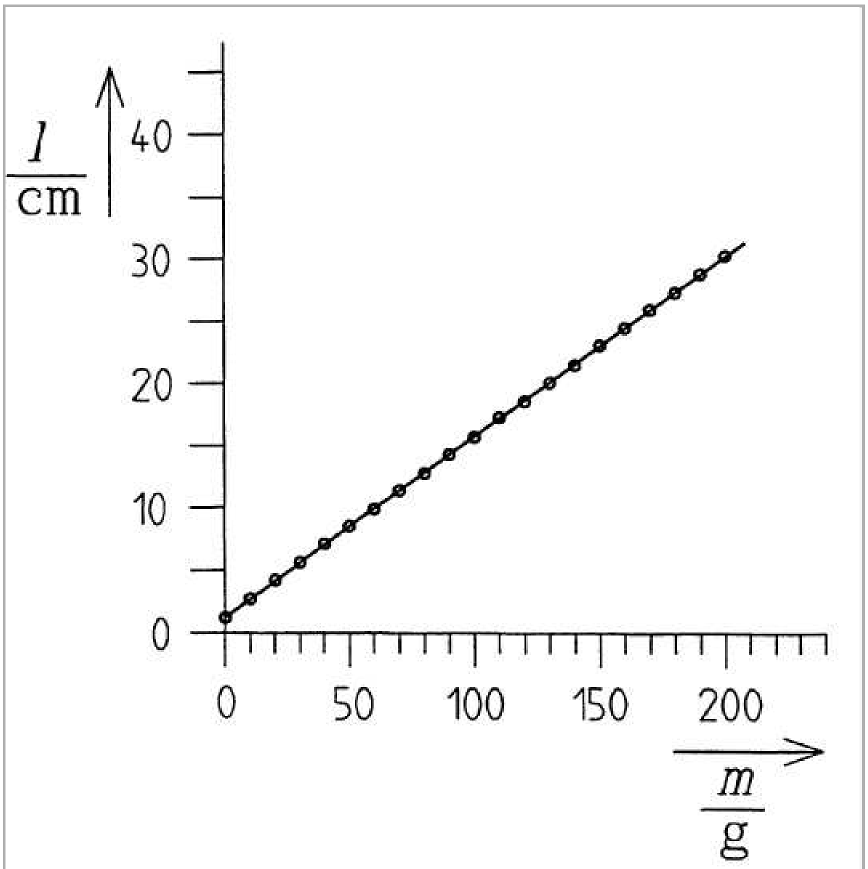

Fig. 2