Beam balance (Item No.: P1000500)

Curricular Relevance

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

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

Additional Requirements:

Experiment Variations:

Keywords:

Task and equipment

Information for teachers

Additional Information

In Experiment Weight (force; P0999000) the students determine the mass of different objects with a spring balance (dynamometer). They measured the force with a mass experiences under the influence of the earth's gravity. In contrast to this, measurements with the beam balance determine the mass of an object by comparing it with a defined mass from a weight set. At the same time this means that the earth's acceleration of gravity plays no role for this type of measurement. A beam balance always provides correct results, e.g., even on the moon.

In this experiment the students should determine the mass of different objects with a beam balance; in additional they should perform a tare measurement; and they should improve the reading accuracy to the extent that, by interpolating the scale, they determine intermediate weights which the weight set cannot provide because of its graduation.

In a supplementary problem the sensitivity of a beam balance should be determined and its dependence on different loads established.

Suggestion

To avoid parallax errors when reading the balance the students should be sure that they are looking at the scale perpendicularly when reading it.

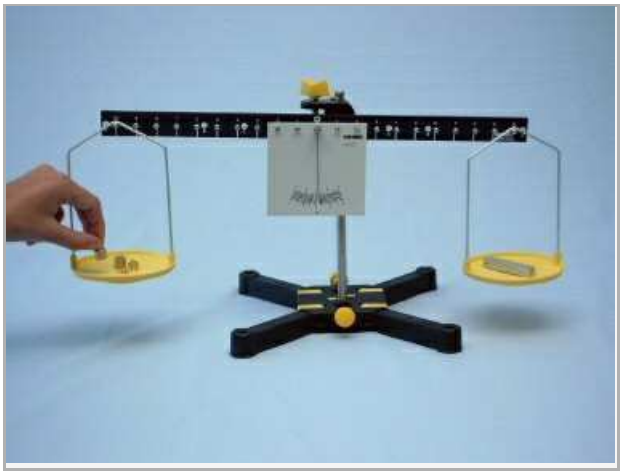
Beam balance (Item No.: P1000500)

Task and equipment

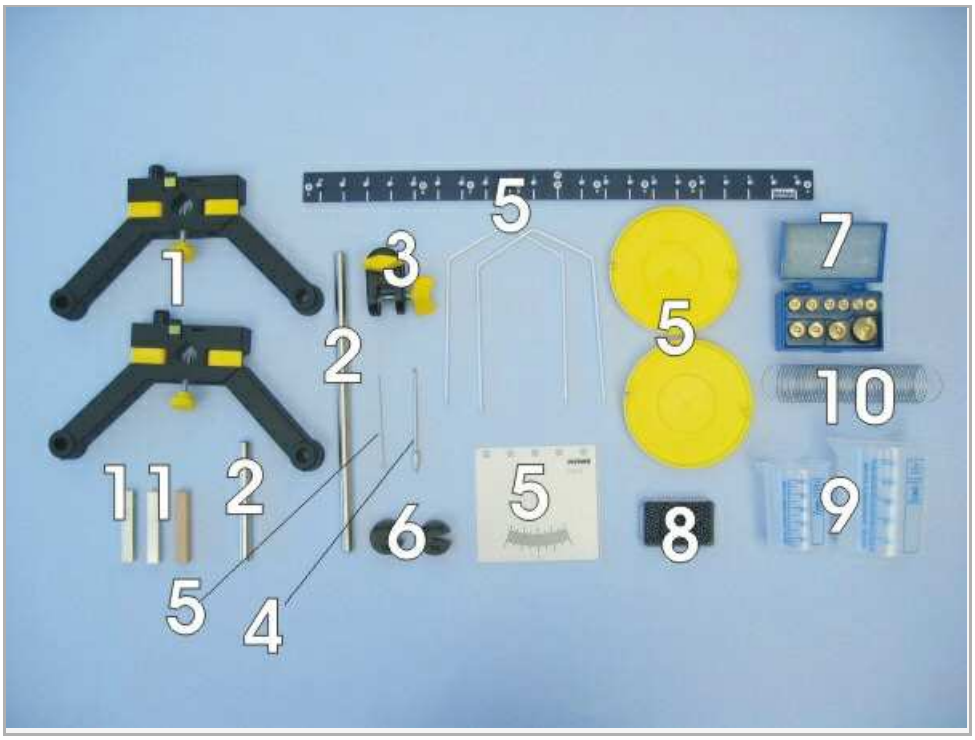
Task

What does one measure with a beam balance?

1. Determine the mass of different objects by comparing them with the mass pieces of a weight set.
2. Determine the mass of a liquid in a container.
3. Improve the accuracy of your readings by interpolating of the scale's divisions.



Equipment



Position No.	Material	Order No.	Quantity
1	Support base, variable	02001-00	1
2	Support rod with hole, stainless steel, 10 cm	02036-01	1
2	Support rod, stainless steel, l = 250 mm, d = 10 mm	02031-00	1
3	Boss head	02043-00	1
4	Holding pin	03949-00	1
5	Balance pan, plastic	03951-00	2
5	Lever	03960-00	1
5	Pointer for lever	03961-00	1
5	Plate with scale	03962-00	1
6	Slotted weight, black, 50 g	02206-01	2
7	Set of precision weights,1g-50g	44017-00	1
8	Steel pellets, d = 2 mm, 120 g	03990-00	1
9	Beaker, low form, plastic, 100 ml	36011-01	1
9	Beaker, 250 ml, low form, plastic	36013-01	1
10	Helical spring, 3 N/m	02220-00	1
11	Steel Column nickel-plated	03913-00	1
11	Wood column	05938-00	1
11	Aluminium column	03903-00	1

Set-up and procedure

Set-up

Set up a stand with the support base and the support rod (Fig. 1 and Fig. 2).

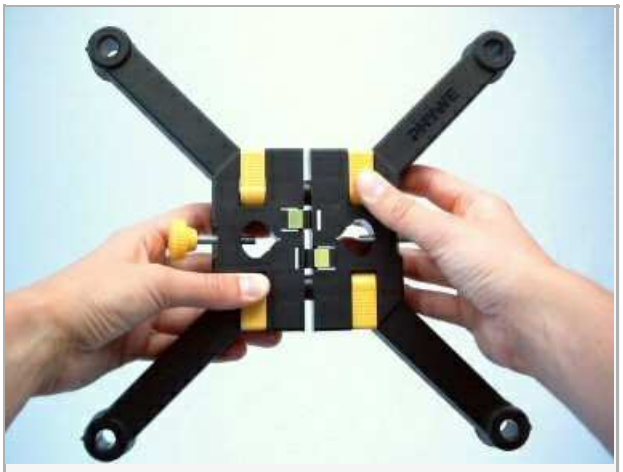


Fig. 1

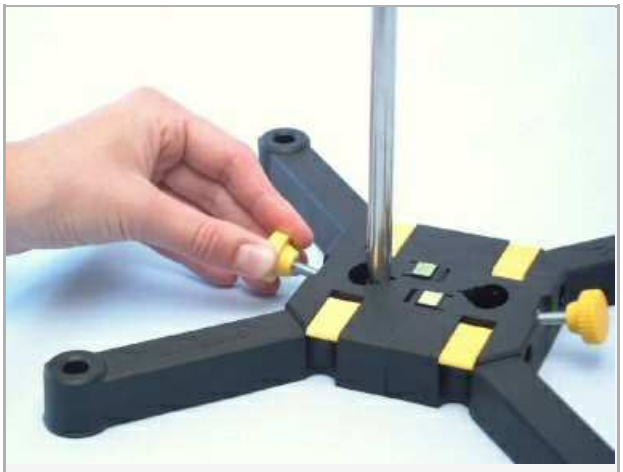


Fig. 2

Put the plate with scale in the middle of the lever, then, put the holding pin in the hole of the pointer and in the hole of the lever (Fig. 3). Attach the bosshead to the support rod and fix the holding pin in it (Fig. 4).

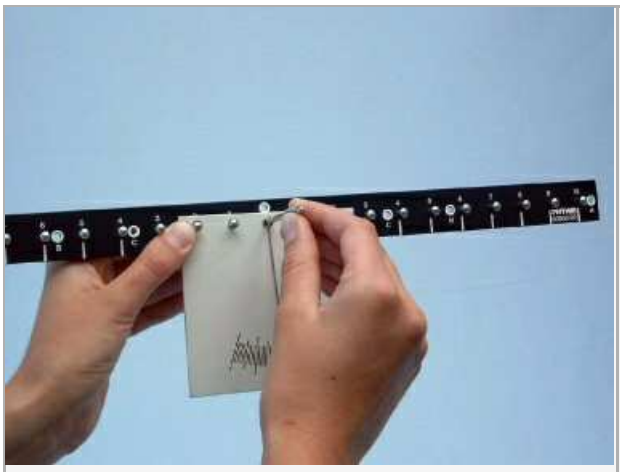


Fig. 3

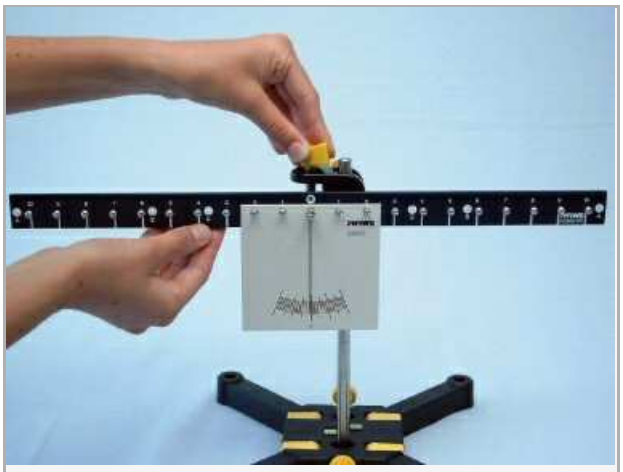


Fig. 4

Assemble the balance pans (Fig. 5) and hang each of them on the 10 mark of the lever (Fig. 6).

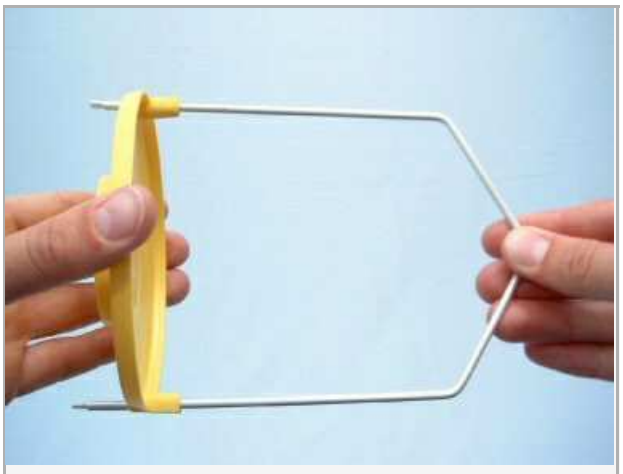


Fig. 5

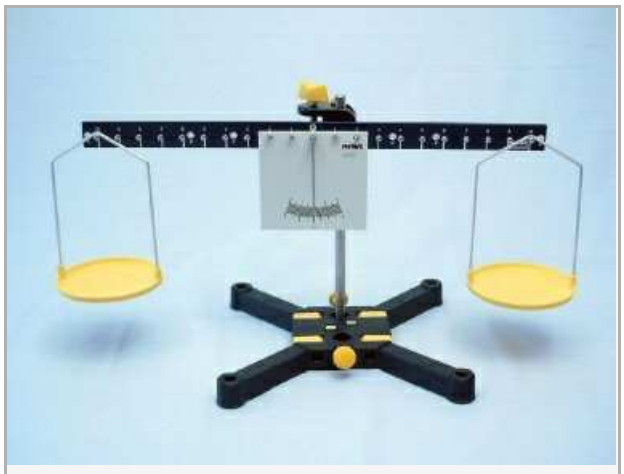


Fig. 6

Place the pointer in such a way, that it points exactly to the zero mark (Fig. 7).

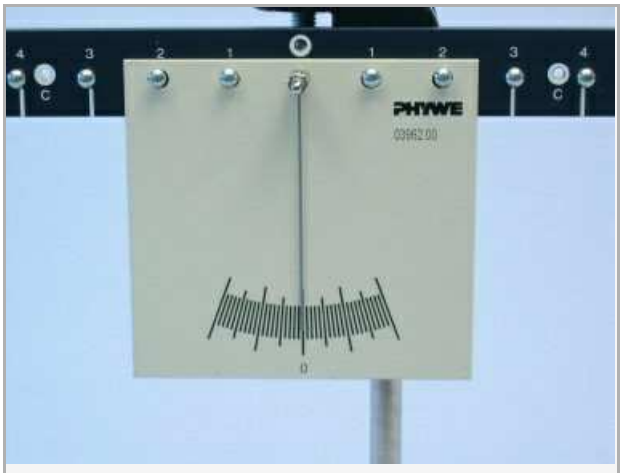


Fig. 7

Procedure

Part 1

Place several objects (see Table 1 on the Results page), one after another, on one of the balance pans and bring the balance into equilibrium by placing mass pieces from the weight set into the other pan (Fig. 8). Record the measured values in Table 1.

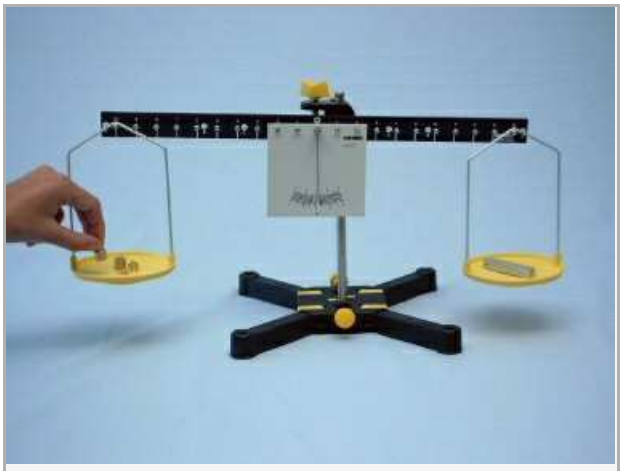


Fig. 8

Part 2

Place the 100 ml beaker on one balance pan and pour enough lead shot onto the other that the balance is in equilibrium (tare measurement) (Fig. 9). Fill the beaker half full with water and determine the mass of the water with the weight set. Record the result in the report.

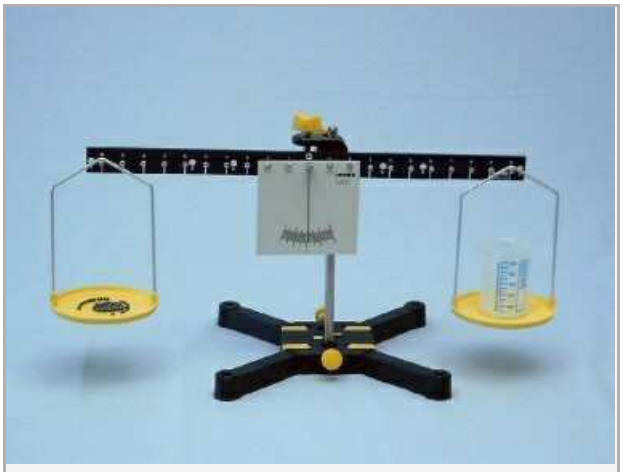


Fig. 9

Part 3

During the weighing in Part 1 it was not always possible to balance the scale exactly: the pointer sometimes did not point directly at the zero mark. The reading can be improved by doing the following:

- Lay the wood column into the left balance pan and determine its mass (m_1) as exactly as possible. The pointer should, however, still point to the right of the zero mark.
- Read the deviation (deviation$_1$) of the pointer and note the value; use (+) for a deviation to the right and (-) for one to the left.
- Place an additional 1 g mass piece on the right balance pan and read the deviation of the pointer - with sign! Record the deviation (deviation$_2$) in the report.

In order to disassemble the support base you should press the yellow buttons (Fig. 10).

Fig. 10

Report: Beam balance

Results – Table 1

Record all the measured values in Table 1.

Object	*m* in g
Helical spring	$\frac{1}{\pm 0}$
Iron column	$\frac{1}{\pm 0}$
Aluminium column	$\frac{1}{\pm 0}$
Wood column	$\frac{1}{\pm 0}$
Beaker 250 ml	$\frac{1}{\pm 0}$
Support rod 100 mm	$\frac{1}{\pm 0}$

Results – Part 2

Record the mass of the water in the beaker: m = ... g.

Results – Part 3

Calculate the displacement of the pointer for 1 g by the summation of displacements, neglecting of the algebraic signs::

m_1 = ... g; Deviation$_1$ = ...

$m_2 = m_1 + 1$ g; Deviation$_2$ = ...

Calculate the mass which corresponds to a deviation of 1 scale division:

1 division corresponds to ..... g.

Determine the deviation in grams and calculate the exact (corrected) mass m_k of the wood column:

Corrected mass of the wood column m_k = ... g.

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Evaluation – Question 1

a) What physical property can you measure with a beam balance?

b) Would you get the same results on the moon?

Evaluation – Question 2

What are the advantages of the tare measurements?

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Evaluation – Additional Task 1

The sensitivity of a balance is defined as the quotient of mass and deviation. To find it, the mass which causes a deviation of 1 scale division is determined.
Determine whether the sensitivity of the balance depends on

- the load of the balance pans,
- the length of the lever arms

by selecting the load and position of the balance pans as given in Table 2.

Position of the balance pans	Load g		Deviation [Div.]		Sensitivity in g/Div..
	left	right	left	right	$\frac{1}{\pm 0}$
10	$\frac{1}{\pm 0}$	$\frac{1}{\pm 0}$	$\frac{1}{\pm 0}$		$\frac{1}{\pm 0}$
10	$\frac{1}{\pm 0}$	$\frac{1}{\pm 0}$		$\frac{1}{\pm 0}$	$\frac{1}{\pm 0}$
7	$\frac{1}{\pm 0}$	$\frac{1}{\pm 0}$	$\frac{1}{\pm 0}$		$\frac{1}{\pm 0}$
7	$\frac{1}{\pm 0}$	$\frac{1}{\pm 0}$		$\frac{1}{\pm 0}$	$\frac{1}{\pm 0}$
10	50+1	$\frac{1}{\pm 0}$	$\frac{1}{\pm 0}$		$\frac{1}{\pm 0}$
10	$\frac{1}{\pm 0}$	50+1		$\frac{1}{\pm 0}$	$\frac{1}{\pm 0}$

Evaluation – Additional Task 2

Does the sensitivity depend on the load of the balance pans?

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Evaluation – Additional Task 3

Does the sensitivity depend on which side the load is placed?

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Evaluation – Additional Task 4

What effect do the shortened lever arms have on the sensitivity with the same (additional) load?

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Evaluation – Additional Task 5

a) When is the sensitivity of the balance the largest?

b) What can the cause of this be?

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