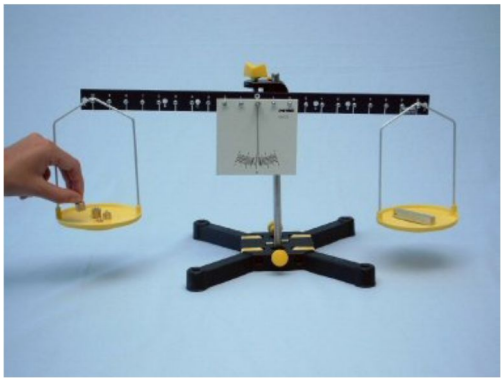
3.1 Beam balance

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.



Use the space below for your own notes.

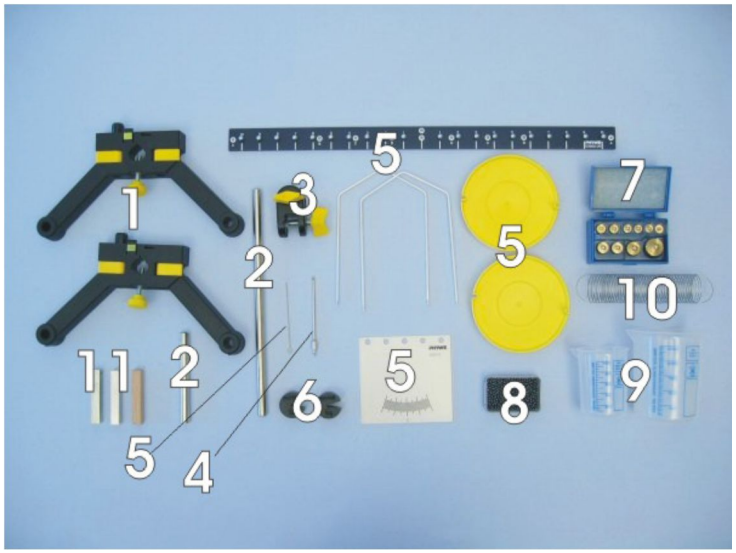
Material

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 with hole, stainless steel, 100 mm	02036-01	1
2	Support rod with hole, stainless steel 18/8, *l* = 250 mm, *d* =10 mm	02031-00	1
3	Bosshead	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 coloured, 50 g	02206-01	2
7	Set of precision weights, 1g...50g, in case	44017-00	1
8	Lead shot, *d* = 3 mm, 120 g	03990-00	120 g
9	Beaker, plastic, short form, 100 ml	36011-01	1
9	Beaker, plastic, short form, 250 ml	36013-01	1
10	Helical spring 3 N/m	02220-00	1

11	Iron column, nickel-plated	03913-00	1
11	Wood column	05938-00	1
11	Aluminium column	03903-00	1

Material required for the experiment



Setup

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

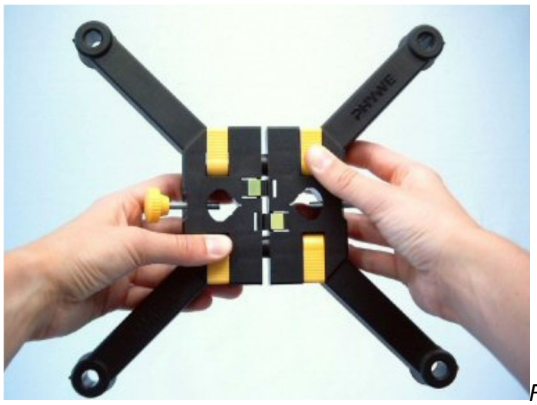


Fig. 1

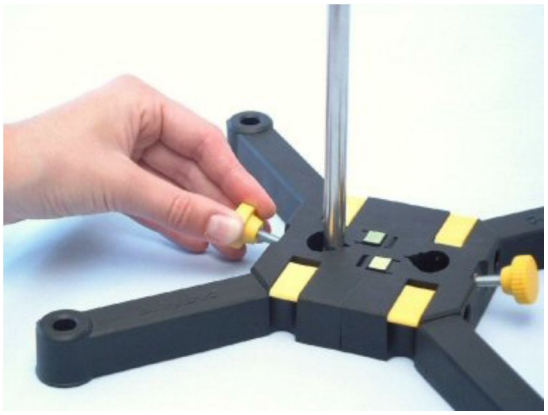


Fig. 2

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).

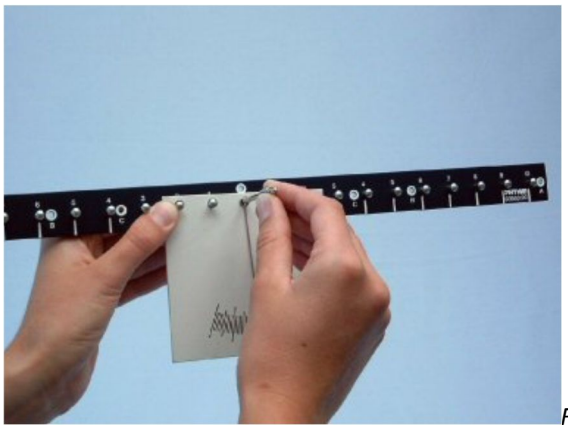


Fig. 3

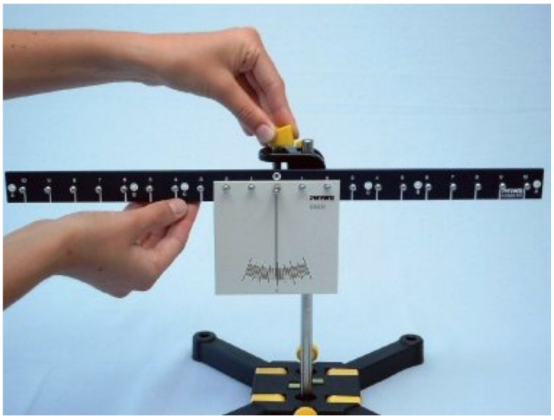


Fig. 4

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

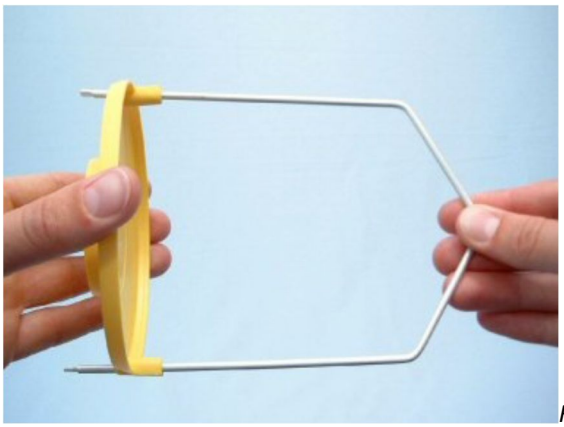


Fig. 5

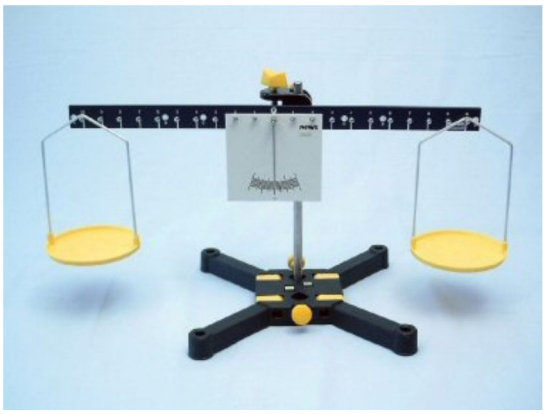


Fig. 6

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

Fig. 7

Action

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.

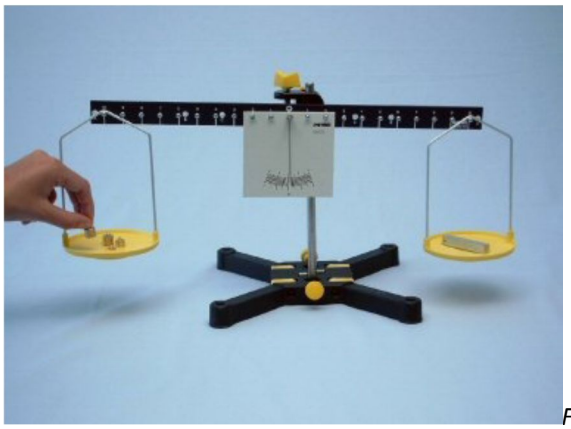


Fig. 8

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 on the Results page.

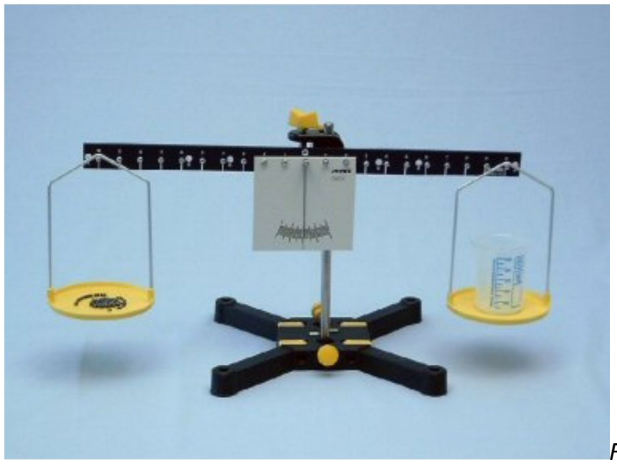


Fig. 9

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$_2$) on the Results page.

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

Fig. 10

Results

Part 1

Table 1

Object	*m* in g
Helical spring	
Iron column	
Aluminium column	
Wood column	
Beaker 250 ml	
Support rod 100 mm	

Part 2

Mass of the water in the beaker: m = ☐ g.

Part 3

m_1 = ☐ g; Deviation$_1$ = ☐ divisions

$m_2 = m_1 + 1$ g; Deviation$_2$ = ☐ divisions

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.

Evaluation

Question 1a:

What physical property can you measure with a beam balance?

Question 1b:

Would you get the same results on the moon?

Question 2:

What are the advantages of the tare measurements?

Additional Tasks

Sensitivity of the balance.

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.

Table 2

Position of the balance pans	Load g		Deviation [Div.]		Sensitivity in g/Div.
	Left	right	Left	Right	
10	1	0			
10	0	1			
7	1	0			
7	0	1			
10	50+1	50			
10	50	50+1			

Question 1:

Calculate the sensitivity of the balance in g/div. and add it in Table 2.

Question 2:

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

Question 3:

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

Question 4:

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

Question 5:

When is the sensitivity of the balance the largest?

Question 6:

What can the cause of this be?