2.4 Hooke's law

Task

Can forces deform solid bodies?

In this experiment the deformation which is caused by the weight of "mass pieces" on two helical springs is measured. The deformation is a characteristic feature of each spring, nevertheless one can observe that a fundamental law is ruling here. It is the goal of this experiment to verify this law - Hooke's Law.

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, split in 2 rods, *l* = 600 mm	02035-00	1
3	Bosshead	02043-00	1
4	Weight holder for slotted weights, 10 g	02204-00	1
5	Slotted weight, black coloured, 10 g	02205-01	4
5	Slotted weight, black coloured, 50 g	02206-01	3
6	Helical spring 3 N/m	02220-00	1
7	Helical spring, 20 N/m	02222-00	1
8	Holding pin	03949-00	1
9	Glass tube holder with tape measure clamp	05961-00	1
10	Measuring tape, *l* = 2 m	09936-00	1

Material required for the experiment

Setup

First screw the split support rods together (Fig. 1). Set up a stand with the support base and the support rod as you can see in Fig. 2 and Fig. 3.

Fig. 1

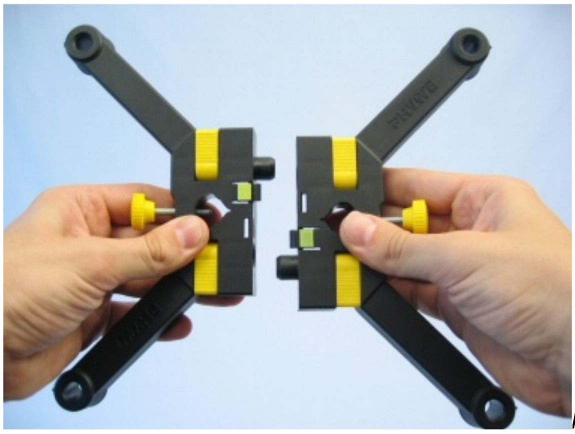


Fig. 2

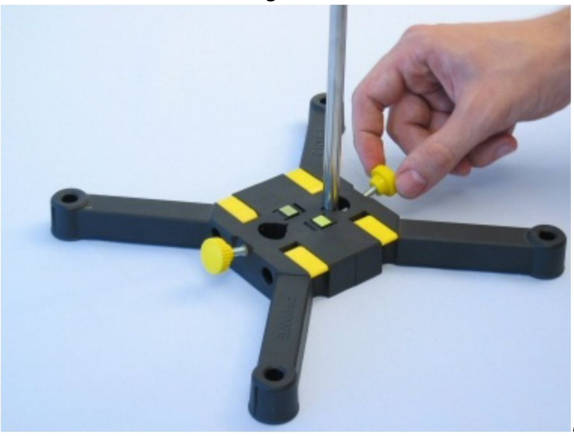


Fig. 3

Clamp the extended measuring tape in the glass tube holder (Fig. 4) and clamp both on the base of the support rod (Fig. 5).


Fig. 4

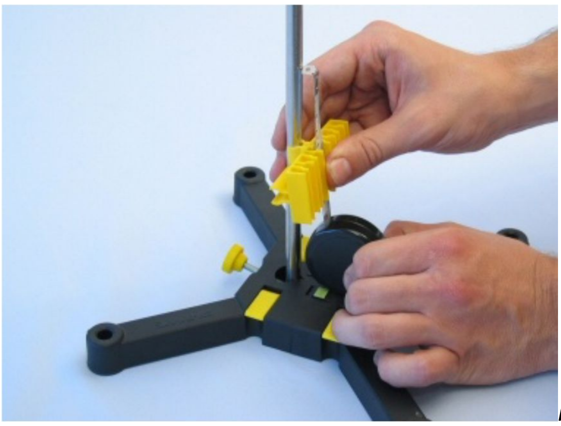


Fig. 5

Fix the holding pin in the bosshead (Fig. 6) and hang the helical spring 1 in it (Fig. 7).

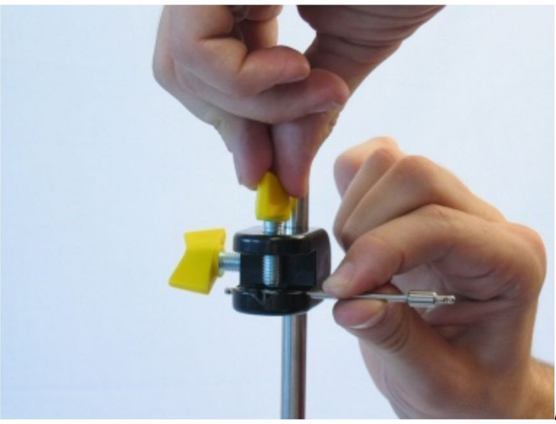


Fig. 6


Fig. 7

Adjust the length of the measuring tape so that its zero mark is exactly at the same level as the lower end of the helical spring. See Fig. 8 and Fig. 9.

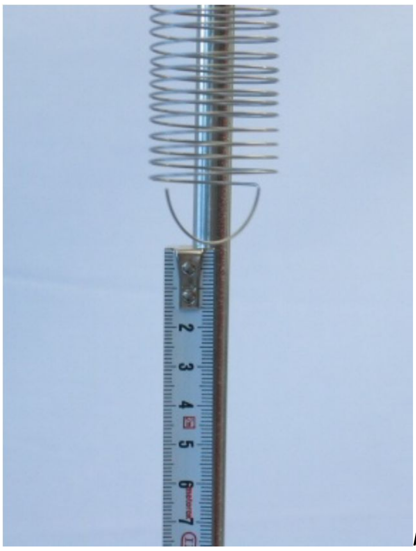


Fig. 8


Fig. 9

Action

- Hang the weight holder (m = 10 g) on the hooked end of the spring and record the extension Δl (Fig. 10).
- Increase the mass by 10 g increments to a total of 50 g and read the corresponding changes in length Δl.
- Record all the values for the mass m and the extension l in Table 1 on the Results page.
- Calculate the weight (force) $F_g = m \times 0.00981$ N/g. You can see the values in as a graph.

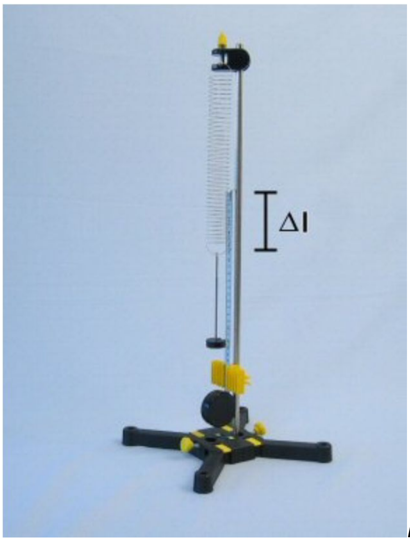


Fig. 10

For fixing the slotted weight to the weight holder, you should slip the slotted weight over the top end of the weight holder (Fig. 11).


Fig. 11

- Exchange the helical spring 1 for the helical spring 2 . Move the measuring tape up or down until its zero mark is even with the lower end of the spring.
- Hang the weight holder with a 10 g mass piece (sum = 20 g) on the spring's hook and note the extension Δl. Determine the corresponding extensions in length.
- Increase the mass in 20 g increments up to a total of 200 g and determine the corresponding extensions in length.
- Record theses values in Table 1 on the Results page and calculate the weight (force), too.

In order to disassemble the support base you should press the yellow button (Fig. 12).

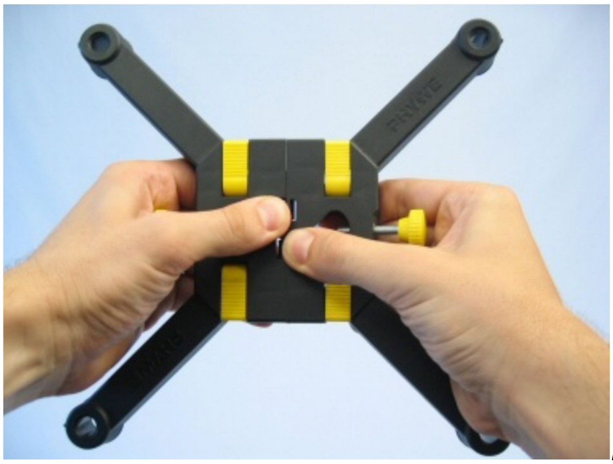


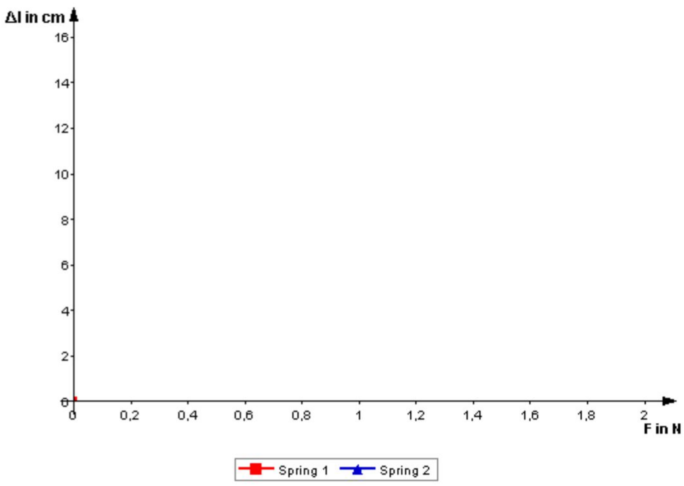
Fig. 12

Results

Table 1

Mass *m* in g	Weight (force) F_g in N	Deflection of Spring 1 Δ*l* in cm	Deflection of Spring 2 Δ*l* in cm
10			
20			
30			
40			
50			
60			
80			
100			
120			
140			
160			
180			
200			

Chart 1



Evaluation

Question 1:

What interrelationship can be seen in the plotted values (graphs)? What is the difference between the two helical springs?

Question 2:

Which object is deformed by the slotted weights (mass pieces)?

Question 3:

Do the values for the two springs lie in one straight line?

Question 4:

Is the extension Δl of the two springs proportional to the weight (force) F_g and thus to the mass m?

Question 5:

Determine the proportionality factor (k) from the two curves:

1. $k_1 = \Delta l_1 / F_{g1}$; $k_1 =$ ______ m/N

2. $k_2 = \Delta l_2 / F_{g2}$; $k_2 =$ ______ m/N

Additional Tasks

The two helical springs differ in their proportionality factors k. Their reciprocal $1/k$ is called the spring constant D or deforming force:

$D = 1/k = F/\Delta l$

The spring constant is characteristic for a given spring.

Question 1:
Calculate the spring constant. Which of the two springs has the larger spring constant?

Question 2:
What is the effect of this larger spring constant?

Question 3:
Do your measurements agree with the declared spring constants in the material list?

Question 4:
Are the deviations larger than ±10 %?