Hooke's law (Item No.: P0999100)

Curricular Relevance

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

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

Additional Requirements:

Experiment Variations:

- Demonstration experiment: Hooke's law (P1251800)

Keywords:

Hooke's law, elastic deformation, spring, force measurement, spring characteristic

Information for teachers

Introduction

Application
Hooke's law can be applied to determine the mass of a body. If a body is suspended from a spring, the extension of the spring, which results from the stress that is applied by the body, and the spring constant can be used to determine the weight of the body (i.e. the force on the body due to gravity). The mass of the object can be determined by way of the relationship $m = \frac{F_w}{g}$.

Spring balance


Experiment set-up

Educational objective
The aim of this experiment is to demonstrate to the students that deformation is a characteristic of all springs based on which a fundamental law (Hooke's law) can be observed. In order to study and comprehend Hooke's law, i.e. the proportionality between

force and extension within the elastic range of an elastic body, the students will perform measurements on two helical springs with different spring constants.

Task

1. Increase of the stress on a spring and determination of the resulting extension.
2. Determination of the weight of the objects that apply stress to the spring.
3. Check based on two different springs to see whether there is a relationship between stress and extension.

Prior knowledge
The students should be already familiar with the relationship $F_\mathrm{w} = m \cdot g$.

Principle
Hooke's law: The elastic deformation is proportional to the applied stress.

Equipment

Position No.	Material	Order No.	Quantity
1	Support base, variable	02001-00	1
2	Support rod, l = 600 mm, d = 10 mm, split in 2 rods with	02035-00	1
3	Boss head	02043-00	1
4	Weight holder for slotted weights	02204-00	1
5	Slotted weight, black, 10 g	02205-01	4
5	Slotted weight, black, 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

Safety information

For this experiment, the general notes and instructions concerning safe experimentation in science classes apply.

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Hooke's law **(Item No.: P0999100)**

Introduction

Application and task

Can forces deform solid bodies?

Application

Hooke's law can be applied to determine the mass of a body. If a body is suspended from a spring, the extension of the spring, which results from the stress that is applied by the body, and the spring constant can be used to determine the weight of the body (i.e. the force on the body due to gravity). The mass of the object can be determined by way of the relationship

$$m = \frac{F_{\mathrm{w}}}{g}.$$

Task

1. Increase the stress on a spring and determine the resulting extension.
2. Determine the weight of the objects that apply stress to the spring.
3. Use two different springs in order to check whether there is a relationship between stress and extension.

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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

Set-up and procedure

Set-up

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

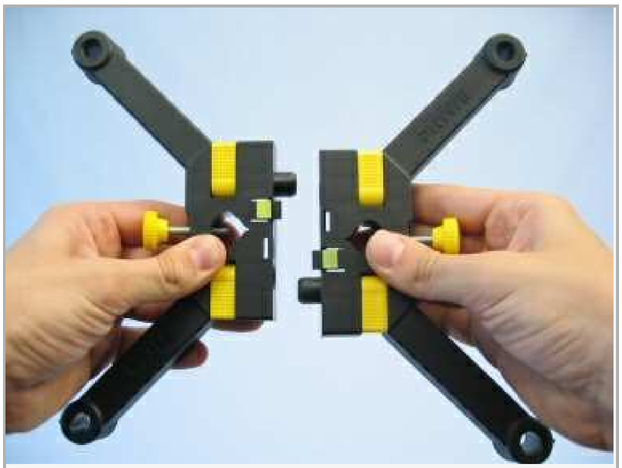


Fig. 2

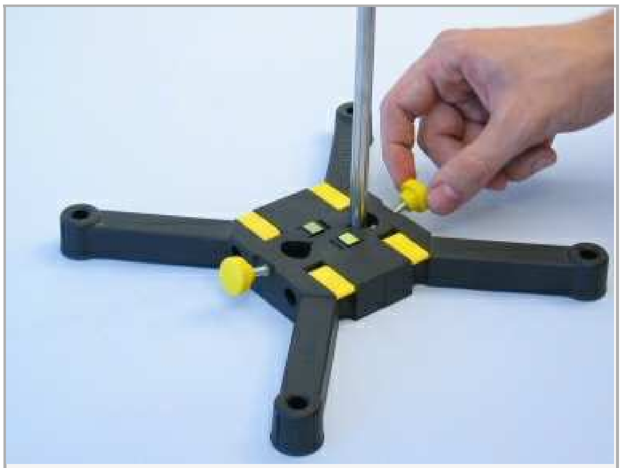


Fig. 3

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

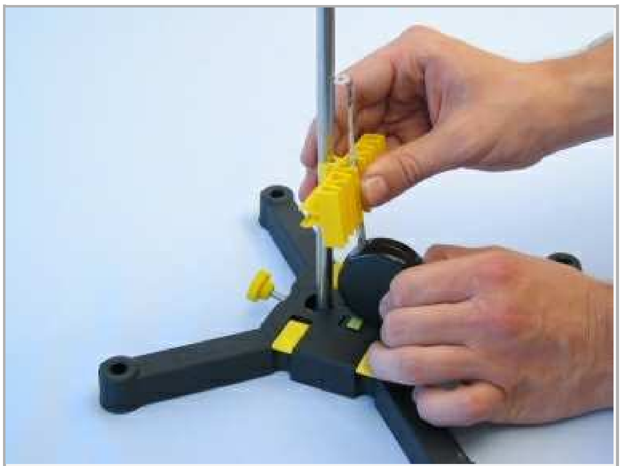


Fig. 5

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

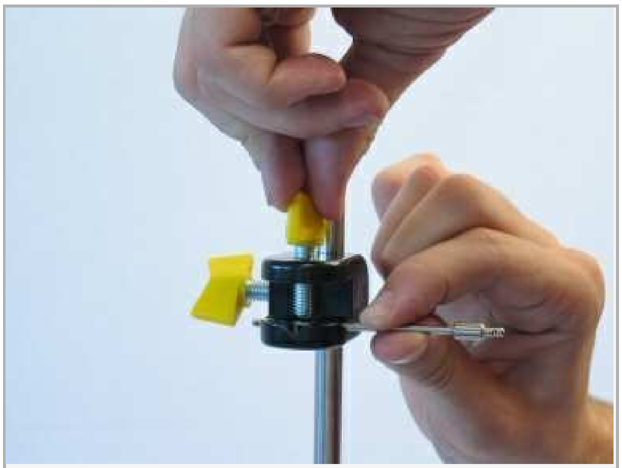


Fig. 6


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

Procedure

- 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 Δl in Table 1 in the experiment report.
- Calculate the weight (force) $F_g = m \times 0.00981$ N/g and also note these values in Table 1.

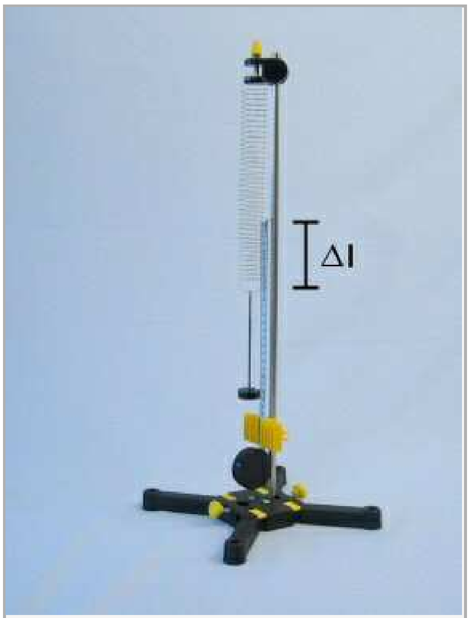


Fig. 10

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.
- 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 in the experiment report and calculate the weight (force), too.

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

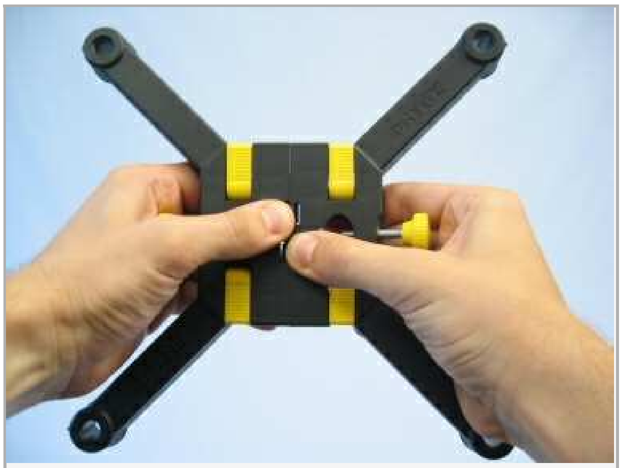


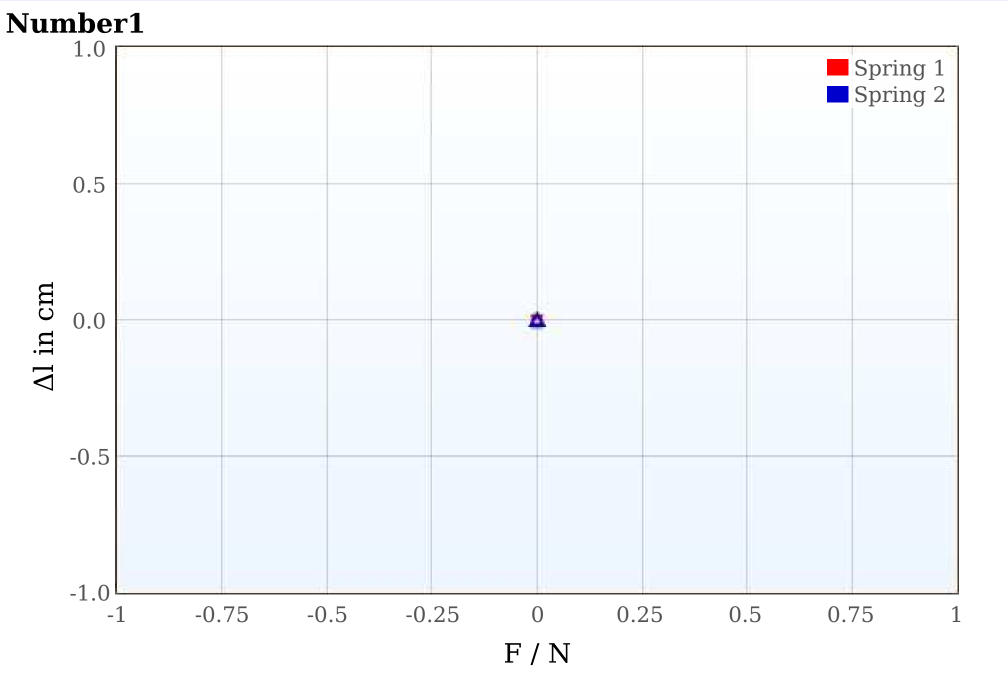
Fig. 12

Report: Hooke's law

Result - Table 1

Enter the measurement results into the table.

Mass *m* in g	Weight (force) F_W in N	Deflection of spring 1 Δl in cm	Deflection of spring 2 Δl in cm
0	0	0	0
10	1 ±0	1 ±0	
20	1 ±0	1 ±0	1 ±0
30	1 ±0	1 ±0	
40	1 ±0	1 ±0	1 ±0
50	1 ±0	1 ±0	
60	1 ±0		1 ±0
80	1 ±0		1 ±0
100	1 ±0		1 ±0
120	1 ±0		1 ±0
140	1 ±0		1 ±0
160	1 ±0		1 ±0
180	1 ±0		1 ±0
200	1 ±0		1 ±0



Evaluation - Question 1

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

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....

....

....

Evaluation - Question 2

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

- [ ] Yes, the measurement values for both springs are on a straight line.
- [ ] No, the measurement values for both springs are not on a straight line.
- [ ] No, the measurement values are on a straight line for only one spring.

Evaluation - Question 3

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

- [ ] No, there is no relationship between the extension and weight.
- [ ] Yes, the extension is proportional to the weight and, thereby, to the mass.
- [ ] Yes, there is a linear relationship between the extension and weight.
- [ ] Yes, there is a quadratic relationship between the extension and weight.
- [ ] No, the extension is proportional to the weight for only one of the two springs.

Evaluation - Question 4

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

1. $k_1 = \Delta l_1 / F_{w1}$; $k_1 =$ .... m/N
2. $k_2 = \Delta l_2 / F_{w2}$; $k_2 =$ .... m/N

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Evaluation - Question 5

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.

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

....

....

....

....

Evaluation - Question 6

What is the effect of this larger spring constant?

- ☐ The greater spring constant has no effect.
- ☐ The spring with the greater spring constant is stiffer, i.e. the extension is smaller with the same force applied.
- ☐ The spring with the greater spring constant is softer, i.e. the extension is greater with the same force applied.

Evaluation - Question 7

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

- ☐ Yes, they are exactly in line with the information in the list of materials.
- ☐ Yes, they are approximately in line with the information in the list of materials (deviation below 10%).
- ☐ No, they are not in line with the information in the list of materials.

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Evaluation - Question 8

During this experiment, we have found a law that describes the extension of a spring when a force is applied: $F = D \cdot \Delta l$. This law is known as ....

If a spring extends by 1 m due to a force that is applied, and if the spring has a spring constant of 30 N/m, a force of .... has been applied to the spring.

A force of 40 N is applied to a spring with an initial length of 4 m. The spring is now 5 m long. As a result, the spring constant of the spring is ....