Hooke's law

Physics > Mechanics > Forces, work, power & energy

Difficulty level	Group size	Preparation time	Execution time
medium	-	10 minutes	20 minutes

This content can also be found online at:

http://localhost:1337/c/647303b8acbc1d0002da9699

Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

General information

Application

Spring

For all elastically deformable bodies and in particular for elastic springs, the change in length is proportional to the acting force:

F ~ s or **F/s = constant** or **F = D * s**

This relationship is called Hook's law, which was discovered by Robert Hooke. One can thus determine the spring constant of a spring; the so-called hardness.

Robert-Bosch-Breite 10
37079 Göttingen
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Fax: 0551 604 - 107
info@phywe.de
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Other information (1/2)

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Prior knowledge

The students should know $F_G = m \cdot g$.

Principle

It is to be shown that Hooke's law applies to the loading of coil springs and that the elongation of the springs depends on the acting force and on the hardness of the springs.

Other information (2/2)

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Learning objective

In this experiment, the students should learn that deformation is a characteristic property of every spring, with which a fundamental law (Hooke's law) can be observed. The students should understand the statement of Hooke's law, i.e. the proportionality between force and deflection within the elasticity range of an elastic body, by measuring two coil springs with different spring constants.

Tasks

- Understanding the relationship F ~ s
- Measurement of the 2 different spring constants

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Safety instructions

The general instructions for safe experimentation in science lessons apply to this experiment.

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Equipment

Position	Material	Item No.	Quantity
1	PHYWE Demo Physics board with stand	02150-00	1
2	Hook on fixing magnet	02151-03	1
3	Torsion dynamometer	03069-03	1
4	Scale for demonstration board	02153-00	1
5	Helical spring, 3 N/m	02220-00	1
6	Helical spring, 20 N/m	02222-00	1
7	G-clamp	02014-01	2

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Set-up and Procedure

Set-up

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- Place hook with holding magnet on the upper edge of the demo board and hang the soft coil spring on the hook with 3 N/m
- Place the dynamometer just below the coil spring, hook the cord onto the coil spring and turn the dynamometer so that the cord is as short as possible and the spring is slightly pretensioned.
- Place the scale vertically so that the lower edge of the coil spring is exactly at the height of the O-mark.
- Bring the pointer of the force gauge to zero and lock the scale (Fig. 1).

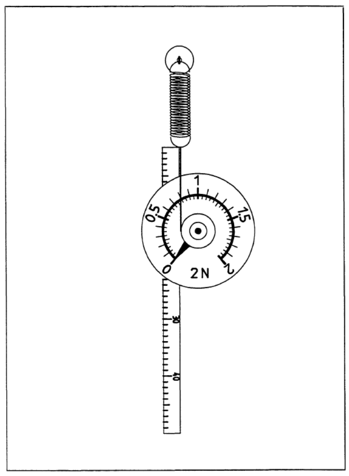

Figure 1

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Procedure

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- Move the dynamometer downwards until it indicates 0.2 N; measure the resulting elongation s and enter it in table 1.
- Increase the tensile force in further steps by 0.2 N each time (if the dynamometer is at the lower edge of the board, turn the dynamometer slightly if necessary and thereby wind up the string to achieve F = 0.8 N), measure the respective elongation and note it in table 1.
- Carry out the test with the hard coil spring with 20 N/m in the same way (up to F = 1.2 N) and enter the measured values in Table 2.

Evaluation (1/3)

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The graphical representation of the measured values (Fig. 2) results in a straight line in each case. So the following applies: F ~ s

This is synonymous with $F/s = constant$ as can be confirmed by quotient formation (see Table 1 or 2, last column). The deformation (elongation) of the helical spring is equal to the deforming force **proportional**.

Both results differ in that the same forces cause more than 6 times as much elongation in the first coil spring examined as in the second.

Tabelle 1 (weiche Feder)

F/N	s/cm	s/m	$\frac{F/s}{N/m}$
0	0	0	-
0,2	6,6	0,066	3,0
0,4	12,8	0,128	3,1
0,6	19,2	0,192	3,1
0,8	25,5	0,255	3,1

Tabelle 2 (harte Feder)

F/N	s/cm	s/m	$\frac{F/s}{N/m}$
0	0	0	-
0,2	1,0	0,010	20,0
0,4	2,0	0,020	20,0
0,6	3,0	0,030	20,0
0,8	4,1	0,041	19,5
1,0	5,0	0,050	20,0
1,2	6,0	0,060	20,0

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Evaluation (2/3)

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It is said that the springs have a different hardness and this is expressed by the spring constant D = F / s . The measurement results in a spring constant of about 3.1 N/m for the soft spring examined first, and about 20 N/m for the hard, second spring (cf. material list).

The relationship F ~ s is called Hooke's law. With F / s = D you get Hooke's law in the form F = D * s.

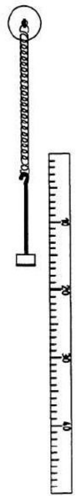

Fig. 2

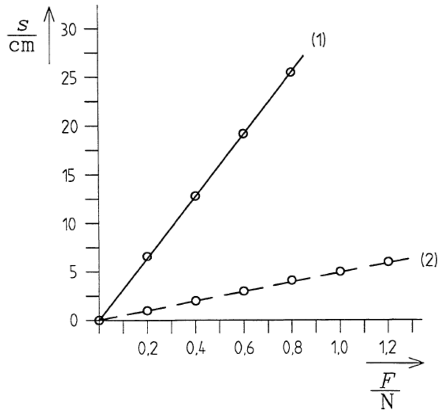

Fig. 3

Evaluation (3/3)

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Care must be taken during measurements to minimise parallax errors when reading the values for 5 and when adjusting the pointer on the force gauge. Elastic bodies are characterised by the fact that after being deformed by a force, they return to their original shape when no force is applied. Their deformation is therefore reversible, but only if the force does not exceed a specific value. The linear relationship F ~ s or F = D * s, which was recognised by Robert Hooke, is a special case for elastic deformations, because there are bodies made of substances that also show non-linear force-deformation behaviour in the elastic range. In such cases, F = D * s only applies to the so-called proportionality range.

In this experiment, the coil spring was stretched with a force gauge in order to be able to directly determine the relationship between deflection and force. It is also possible to stretch the coil spring by attaching mass pieces (Fig. 3). Then the respective weight force must be calculated for the evaluation.

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