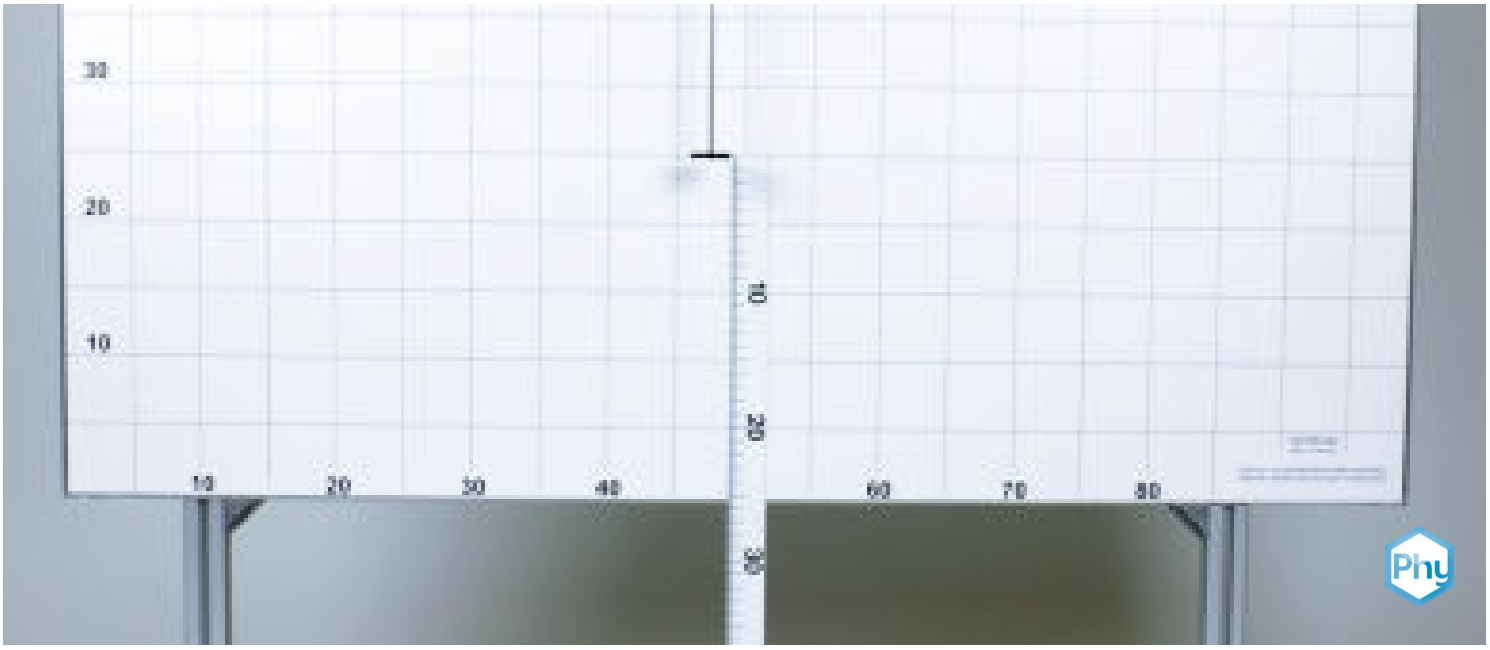
Extension of a rubber band and helical spring



Physics | Mechanics | Forces, work, power & energy

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

This content can also be found online at:

http://localhost:1337/c/64730045acbc1d0002da968b

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General information

Application

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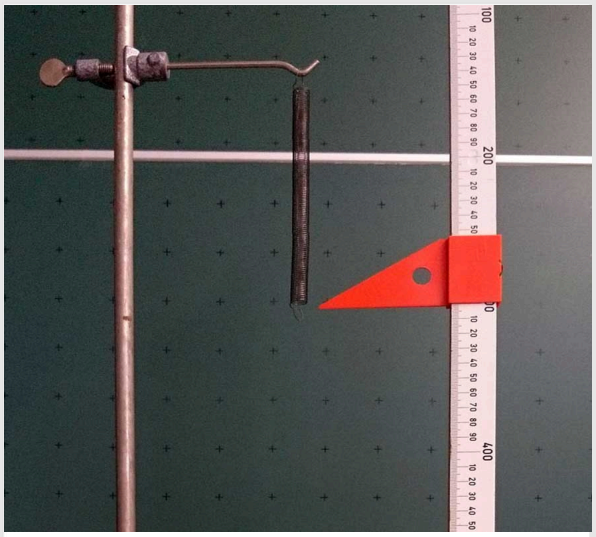

Rubber band vs. coil spring

In mechanics, a basic distinction is made between **Two types of deformation**:

1. the **elastic** and
2. the **plastic deformations**

In the case of elastic deformation, the material returns to its original state after deformation.

Plastic deformation results in a change of shape that is partly permanent.

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Other information (1/2)

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Prior knowledge

No prior knowledge is required for this experiment.

Principle

The difference between plastic and elastic deformation is to be demonstrated by stretching a rubber band and a coil spring step by step.

Other information (2/2)

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Learning objective

The difference between plastic and elastic deformation is to be determined by 2 test setups.

Tasks

- Determine load and relief of the coil spring
- Determine the elongation of the rubber band
- Note the measured values of both experiments in the tables

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Safety instructions

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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	Scale for demonstration board	02153-00	1
4	Helical spring, 20 N/m	02222-00	1
5	Weight holder, 10 g	02204-01	1
6	Slotted weight, silver bronze, 10 g	02205-03	2
7	Slotted weight, silver bronze, 10 g	02205-03	2
8	Slotted weight, silver bronze, 50 g	02206-03	1
9	Slotted weight, silver bronze, 50 g	02206-03	1
10	Rubber bands, 50 pieces	03920-00	1
11	G-clamp	02014-01	2

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Set-up and Procedure

Set-up (1/2)

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Experiment 1

- Place the hook with the magnet on the upper edge of the demo board and attach the rubber ring to the hook.
- Preload rubber ring with attached weight plate.
- Place the scale on the board so that the lower edge of the weight plate is level with the zero mark of the scale (Fig. 1).

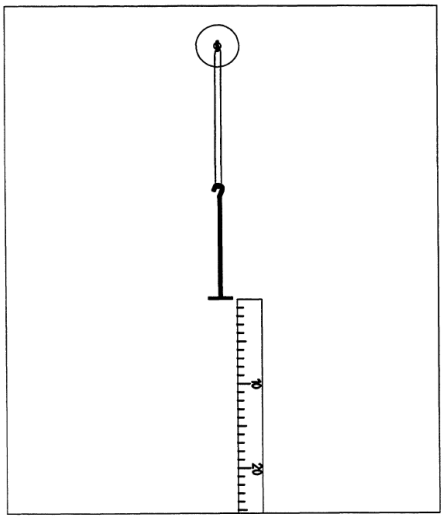

Figure 1

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Set-up (2/2)

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Experiment 2

- Now attach the coil spring to the hook with 20 N/m instead of the rubber band.

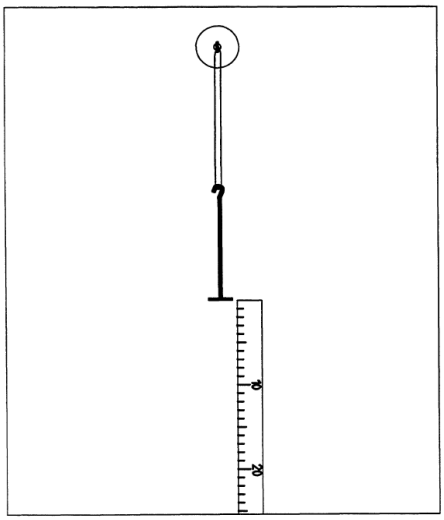

Figure 1

Procedure (1/2)

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Experiment 1

- Place all 5 slit weights of 10 g each on the plate, measure the resulting elongation and enter the measured value in Table 1.
- Place the 3 slit weights of 50 g each on the weight plate one after the other, measure the respective elongation and note it in Table 1 (Note: It is recommended to wait a little before reading the last measured value because the rubber band elongates slightly at higher loads).
- Reduce the load on the rubber band step by step (by 50 g each time), measure the respective elongation and enter it in table 1.

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Procedure (2/2)

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Experiment 2

- Determine the elongation 5 with gradual loading and unloading of the coil spring in the same way as for test 1 and enter the measured values in Table 2.

Evaluation (1/5)

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Attempt 1:

Table 1 and the graphical representation of the measured values in Figure 2 result in:

- The elongation 5 of the rubber is not directly proportional to the force causing the elongation.
- Rubber does not fully return to its original shape after the force is removed.

When a force acts on a body made of rubber, the result is a predominantly reversible change in shape (but there is no proportionality between the deformation and the force), which is accompanied by an irreversible change in shape (plastic deformation).

Tabelle 1 ($100g \mathrel{\hat{=}} 0{,}98N$)

m/g	F/N	Dehnung beim	
		Belasten s/cm	Entlasten s/cm
0	0	0	0,3
50	0,49	1,1	1,9
100	0,98	3,0	4,3
150	1,47	6,1	7,1
200	1,96	9,3	9,3

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Evaluation (2/5)

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Experiment 2:

Table 2 and the graphical representation of the measured values (Fig. 3):

- The elongation 5 of steel is proportional to the force that causes the elongation.
- Steel returns completely to its original shape after the force has ceased.

If a force acts on a body made of steel, then a completely reversible change in shape (elastic deformation) results.

Tabelle 2 ($100g \mathrel{\hat{=}} 0,98N$)

m/g	F/N	Dehnung beim	
		Belasten s/cm	Entlasten s/cm
0	0	0	0
50	0,49	2,6	2,6
100	0,98	5,2	5,2
150	1,47	7,6	7,7
200	1,96	10,2	10,2

Evaluation (3/5)

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The graphs in Figures 3 and 4 represent the s-F characteristics of the bodies that were deformed (in these cases stretched) by forces in Experiments 1 and 2.

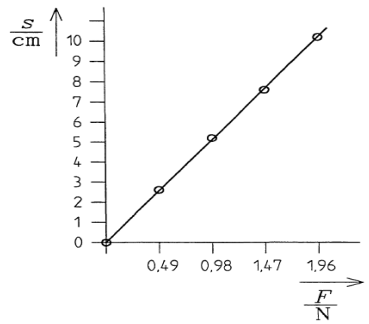

Figure 2

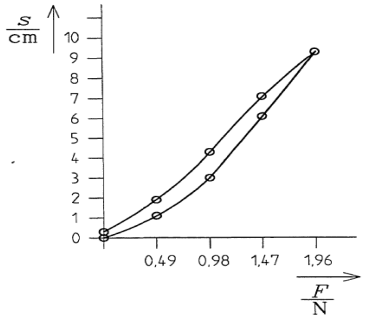

Figure 3

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Evaluation (4/5)

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If the elongation is accompanied by a plastic deformation, then the characteristics obtained for increasing (loading) and decreasing (unloading) force will differ; in the case of elastic deformations, for which s ~ F applies, the characteristic curves coincide.

The measured values determined in experiment 1 can only be regarded as examples, because they depend not only on the rubber ring used (age, shape, material), but also on how quickly the measured values are read after the respective changes in force. Especially with larger forces, rubber stretches a little further for a while. It is therefore advisable to wait a little (approx. 1 minute) before reading the measured value for the maximum elongation and to start relieving the elastic band immediately after reading it.

Evaluation (5/5)

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The proportionality between F and s applies to the spring only up to a characteristic limit force. The proportionality range is generally smaller than the elasticity range. If the elasticity range is exceeded when elastic bodies are deformed, plastic deformation also occurs here.

In these experiments, the weight force was chosen as the deforming force and it was assumed that the students would understand the connection between $100g = 0,98N$. But one can also speak of the relationship $1N = 100g$ and work with simpler numerical values in the tables and figures; this does not change the basic result of the experiments.

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