Bending of a leaf spring with SMARTsense (Item No.: p0999269)

Curricular Relevance

Area of Expertise:	Education Level:	Topic:	Subtopic:	Experiment:
Physics	Age 14-16	Mechanics	Forces, simple machines	Bending of a leaf spring with SMARTsense

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

Additional Requirements:

- tablet PC with measureAPP
- pair of scissors

Experiment Variations:

Keywords:

distortion of a spring, restoring force, spring constant

Teachers information

The students are to examine the behaviour of a leaf spring under load, present the measurement results in the form of a graph and, in particular, determine the spring constant *D*.

Notes on set-up and procedure

- The force sensor must be tared – this is carried out automatically when the sensor is switched on or off.
  Alternatively: Select "set to zero" in the measure App and click save.
- Pay attention to the correct height of the force sensor: The height of the free end of the leaf spring is reduced with each increase in displacement. If the height of the force sensor is not correspondingly re-adjusted, the measurement results will be falsified. The height of the force sensor usually requires re-adjustment after the following displacements: 5 cm, 8 cm, 10 cm, 12 cm, 13 cm, 14 cm, 15 cm.

Evaluation

Fitting curve:
Using the fitting tool in the "measure" App, a fitting curve can be put through the first 5 measurement points. For that it is important, that the first measurement equals 1 cm displacement, the second measurement equals 2 cm and so on. The linear equation can be read off directly.

Fig. 6: Measured values and fitting function

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Overview

Introduction

How does a leaf spring behave?

Have you ever wondered how it is possible to coil the cable of a vacuum cleaner with a single touch of a button? The mechanism works with two balance springs which wind up and unwind against each other moving two cylinders which then coil the cable. A balance spring is a spiral coiled leaf spring. Within this experiment you will investigate the properties of such a leaf spring. The metal is not as winded as for a balance spring but the properties are pretty similar. It distorts when a force is applied. As soon as the application of force ends, the distortion goes back. This is characteristic for elastic distortions. You now want to figure out how the distortion depends on the applied force.

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Equipment

Position No.	Material	Order No.	Quantity
1	Cobra SMARTsense-Force	12904-00	1
2	Support base variable	02001-00	1
3	Support rod with hole, stainless steel, 10 cm	02036-01	1
4	Support rod, stainless steel, l = 250 mm, d = 10 mm	02031-00	1
5	Support rod, stainless steel, l = 600 mm, split in 2 rods with screw threads	02035-00	2
6	Boss head	02043-00	2
7	Leaf spring	02228-00	1
8	Glass tube holder with tape me	05961-00	1
9	Measuring tape, l = 2 m	09936-00	1
10	Fishing line, l. 20 m	02089-00	1
Additional materials:			
11	Tablet PC with "measure" App		1
12	Scissors		1

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Tasks

Displace a leaf spring from its rest position and measure the restoring force with a force gauge. Evaluate the measurement results in a graph (restoring force against displacement).

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Setup and procedure

Setup

- Set up the experiment as shown in Fig. 1. Firmly connect the left foot of the stand to the horizontal rods by means of the yellow eccentric element. Also ensure that the leaf spring is correctly fastened in the bosshead (Fig. 2).
- Connect the leaf spring to the hook of the force sensor by means of an approx. 5 cm–10 cm long loop as shown in Fig. 3. Now move the bosshead with leaf spring to the right until the loop is tautened and the leaf spring is minimally bent in the direction of the force sensor by the loop.
- Position the measuring tape so, that the “0 cm end” is exactly at the left side of the boss head with the leaf spring!

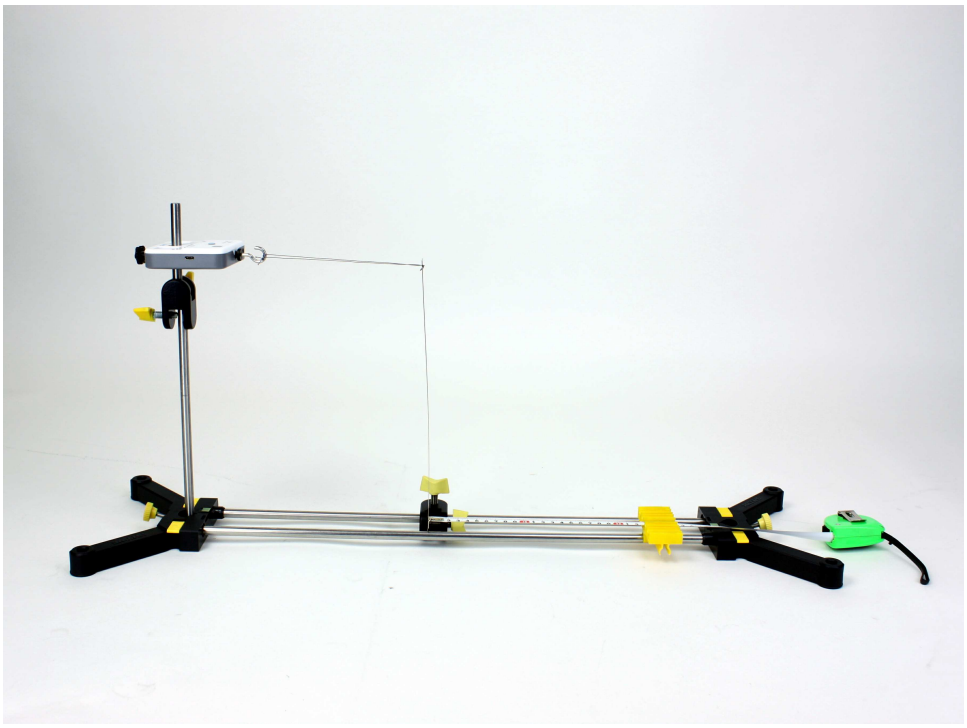

Fig.1: Set-up

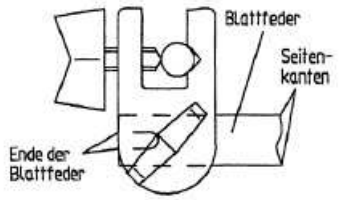

Fig. 2: Fastening the leaf spring in the boss head

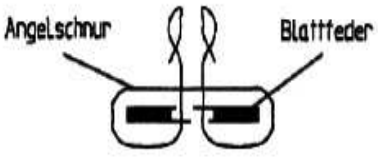

Fig. 3: Fastening the fish line on the leaf spring

Procedure

- Turn on the Cobra SMARTsense-Force sensor. Open the „measure“ app and select the force sensor.
- The force sensor is tared on being switched on, i.e. at the start a weight force of 0 N is shown. If this is not the case, choose "Set to zero" and the save the changes.
- Change the settings to "Point by point measurement".
- Now move the bosshead with the leaf spring 1 cm to the right and start the measurement. Hence the first measurement equals 1 cm displacement. Before each taken measurement point, move the bosshead 1 cm further.
- Repeat this procedure until the displacement has reached a total of 15 cm. Then stop the measurement and save it. Pay attention hereby prior to each measurement that the hook of the Cobra4 Sensor-Unit Force 40 N is at approximately the same height as the free end of the leaf spring! If necessary, appropriately re-adjust the height of the force sensor.

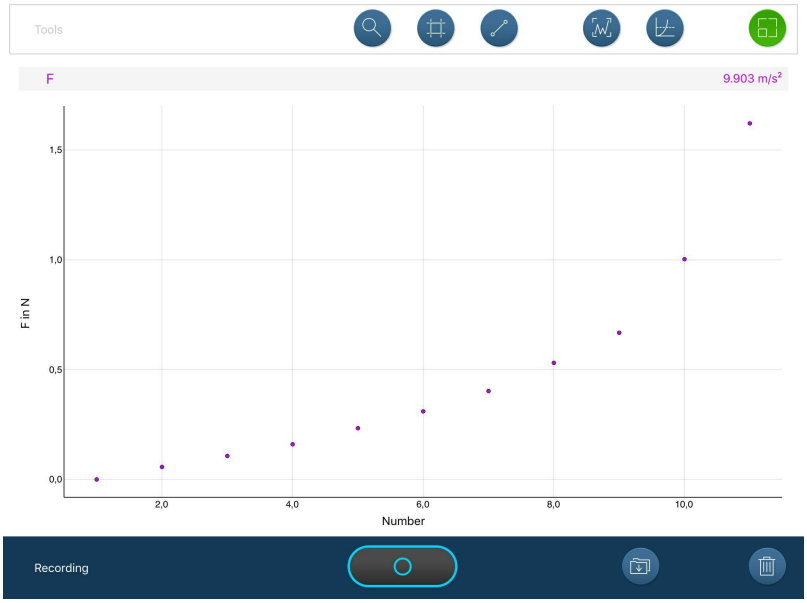

Fig. 4: Exempary measurement

Observation and results

Evaluate your data with the report. Your observations are the measurement you took.

Fig. 5: Data fitting

Report: Bending of a leaf spring with SMARTsense

Results - Question 1

When you look at the first measured values, you will notice that they lie approximately on a straight line. Using the fitting tool in the app, you can put a fitting curve through the first 5 measurement points. The linear equation is displayed.

What is the Slope of the line?

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Results - Question 2

When you make the fitting line long enough it soon becomes obvious that the data does not follow the linear plot. From which displacement on does the straight line clearly
deviate from the measured values?

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Results - Question 3

The spring constant *D* of a leaf spring is defined as the quotient of the force *F* that perpendicularly pulls the end of the leaf spring and the corresponding displacement Δs:

$D := F/\Delta s$

What connection is there between the spring constant “D” and the slope that you have determined?

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Results - Question 4

Why were only the first five values used?

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