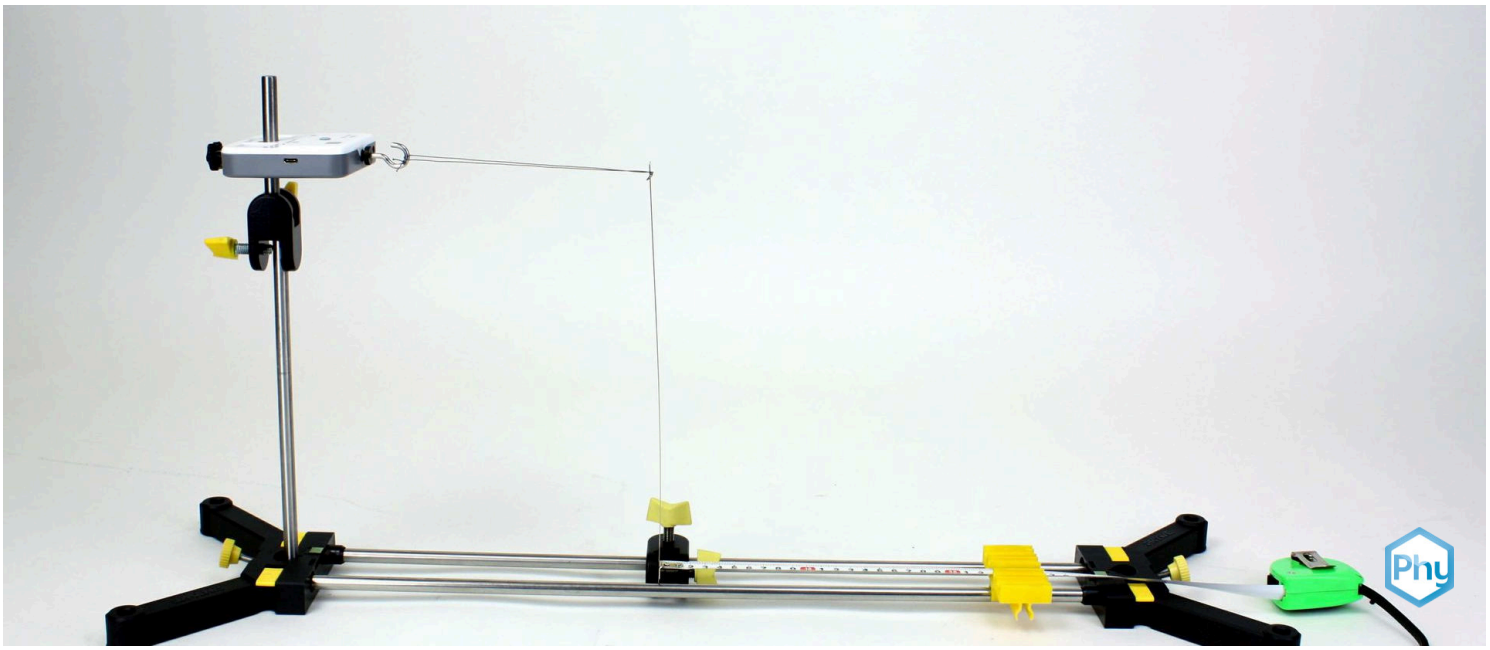
Bending of a leaf spring with Cobra SMARTsense



Physics > Mechanics > Forces, work, power & energy

Difficulty level	Group size	Preparation time	Execution time
easy	2	10 minutes	10 minutes

This content can also be found online at:

https://www.curriculab.de/c/604f1a2e3b95820003807eff

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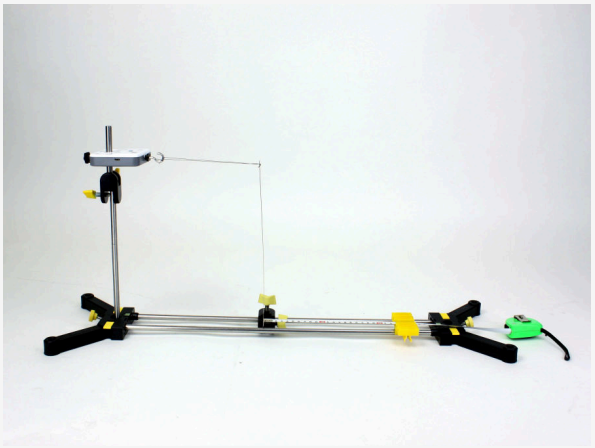
Teacher information

Application



Experiment set-up

In this experiment, a leaf spring is to be clamped horizontally and a force applied at the outer end. The applied force then results in a bending moment M_b which stresses the spring. The bending moment is greatest at the loading point and decreases towards the support of the leaf spring until it finally becomes zero in the bearing itself.

The bending moment results from the product of the acting force F and the lever arm l:

$M_b = F \cdot l ~ [Nm]$

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Teacher information (1/2)

Prior knowledge

Students should have a basic understanding of forces. Ideally, the students have already carried out the experiment on Hooke's law and know the concept of the spring constant as well as the correlations between the deflection of a spring under a specific force effect.

Learning objective

The students are to investigate the behaviour or deformation of a leaf spring under load (by the acting force), present the measurement results in the form of a diagram and, in particular, determine the spring constant D.

Teacher information (2/2)

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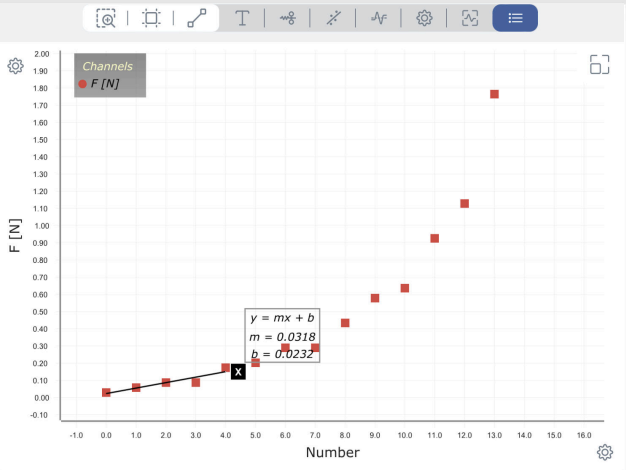
Scientific principle



Measured values and fit function

About the evaluation

Generate fit line:

Using the straight line tool of the app, a balance line can be laid through the first 5 measuring points. It is important that the first measurement actually corresponds to 1 cm deflection, the 2nd measurement to 2 cm and so on. The equation for the straight line can then be read directly in the output.

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Notes on procedure

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- The force sensor must be tared - this is done automatically when the sensor is switched on and off.

  Alternatively: Select the sensor in the app. Then select "Set to zero" and save.

- Attention must be paid to the correct height of the force sensor: The height of the free end of the leaf spring decreases with increasing deflection. If the height of the force sensor is not adjusted accordingly, the measurement results will be falsified. Usually the height of the force sensor should be adjusted according to the following deflections: 5 cm, 8 cm, 10 cm, 12 cm, 13 cm, 14 cm, 15 cm.

Safety instructions

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

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Student Information

Motivation

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https://www.youtube.com/watch?v=egwjc5axZjo

Have you ever wondered how it is possible to roll up the cord on a vacuum cleaner at the push of a button? The mechanism is called a scroll spring drive, where 2 spiral springs roll up and unroll against each other, moving 2 reels that wind up or unwind the power cable.

A spiral spring is a leaf spring that is rolled up in a spiral and thus very strongly bent. In this experiment, you will take a closer look at such a leaf spring.

Although it is not as strongly bent as a spiral spring, it still has similar properties.

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Equipment

Position	Material	Item No.	Quantity
1	Cobra SMARTsense - Force and Acceleration, ± 50N / ± 16g (Bluetooth + USB)	12943-00	1
2	Support base, variable	02001-00	1
3	Support rod, stainless steel, l = 250 mm, d = 10 mm	02031-00	1
4	Support rod, stainless steel, l = 600 mm, d = 10 mm	02037-00	2
5	Boss head	02043-00	2
6	Leaf spring	02228-00	1
7	Glass tube holder with tape measure clamp	05961-00	1
8	Measuring tape, l = 2 m	09936-00	1
9	Fishing line, l. 20m	02089-00	1
10	Support rod, stainless steel, l = 250 mm, d = 10 mm	02031-00	1
11	measureAPP - the free measurement software for all devices and operating systems	14581-61	1

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Task

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- Deflect a leaf spring from its resting position and measure the restoring force with a force gauge.
- Display the measurement results in a diagram.
- In doing so, contrast the restoring force and the deflection.

Set-up (1/5)

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For measurement with the **Cobra SMARTsense sensors** the **PHYWE measureAPP** is required. The app can be downloaded free of charge from the relevant app store (see below for QR codes). Before starting the app, please check that on your device (smartphone, tablet, desktop PC) **Bluetooth** is **activated**.

iOS

Android

Windows

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Set-up (2/5)

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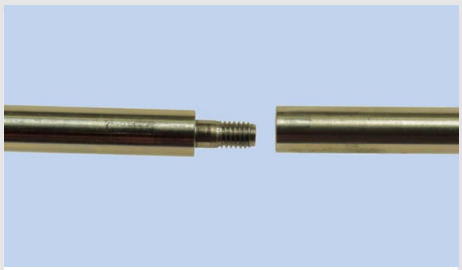
Connect the seperate tripod rods to form two long tripod rods, with a length of 600 mm each.

Attach the two tripod base halves to the two ends of the long tripod rods.

By raising the locking levers, the respective tripod rod is fixated in the tripod base.



Tripod rods with thread

Assembly of the bases

Fixing the stand rod

Set-up (3/5)

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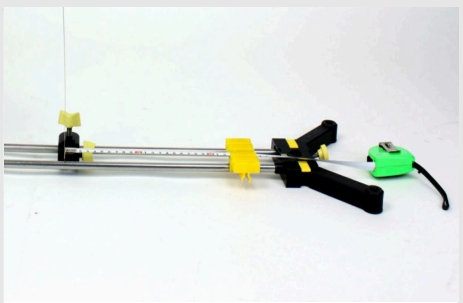
Now insert the short tripod rod vertically into a tripod base and screw it tight.

Attach a double socket to the center of one of the horizontal tripod rods.

Then attach the tape measure with the glass tube holder to the second horizontal rod.

Assembly of the base

Measuring tape in glass tube holder



Fasten tape measure

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Set-up (4/5)

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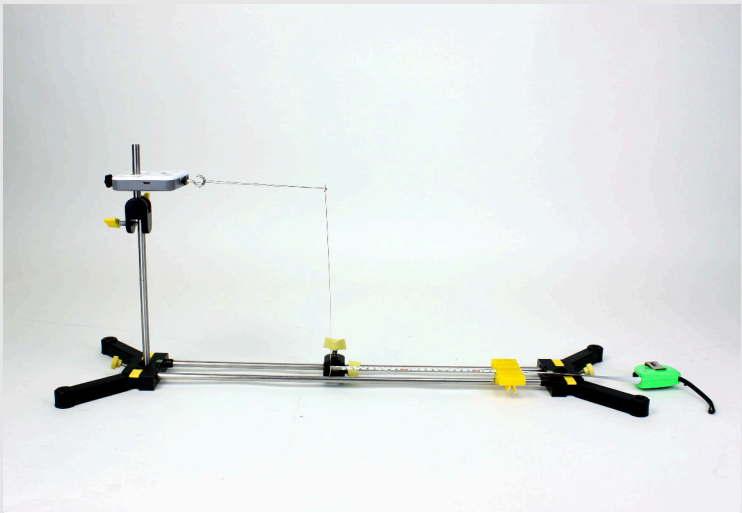

Experiment set-up

- Complete the experimental set-up as shown in the accompanying diagram.
- To do this, clamp the force sensor to the vertical tripod rod.
- Refer to the illustrations on the next page for securing the leaf spring in the double socket and for securing the fishing line to the leaf spring.

Set-up (5/5)

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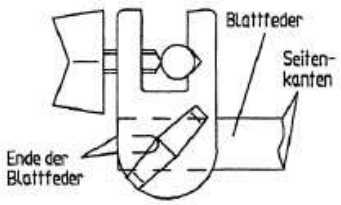
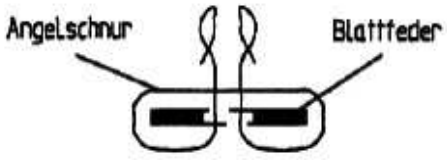


Assembly of leaf spring in double socket



Fastening fishing line to leaf spring

- Do make sure that the leaf spring is correctly attached to the double socket (top illustration). The leaf spring is clamped vertically upwards.
- Using an approx. 5 cm-10 cm long loop, connect the leaf spring to the hook of the force sensor according to the bottom illustration.
- Then move the double socket with the leaf spring to the right until the loop is taut and the leaf spring is minimally bent by the loop in the direction of the force sensor.
- Adjust the tape measure so that the "0 cm end" is just at the left side of the double socket with the leaf spring!

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Procedure (1/2)

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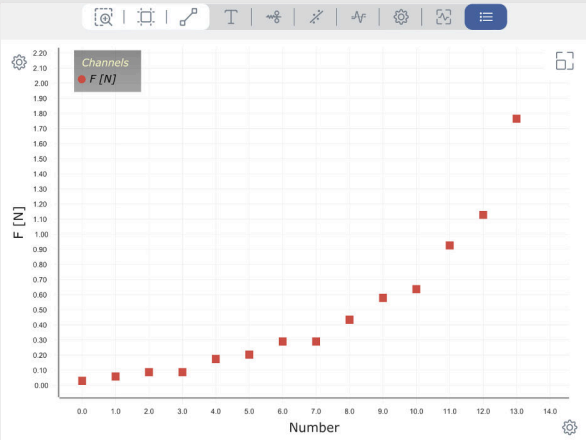

Example of measurement of the restoring force

- Turn on your Cobra SMARTsense Force Sensor. Open the measureAPP and select the force sensor as the sensor.
- When switched on, the force sensor is tared, i.e. at the start it shows a weight force of 0 N. Alternatively, the sensor must be tared manually in the start position. In this case, select "Set to zero".
- The measurement is performed as a point-by-point measurement. For this purpose, set "Measurement to keystroke".
- Now move the double socket with the leaf spring 1 cm to the right and start the measurement.

Procedure (2/2)

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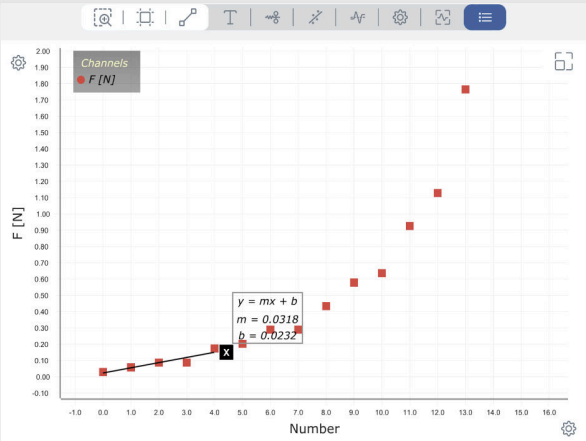

Regression line

- The first measuring point thus corresponds to 1 cm of deflection. Before each new measurement, the spring is pushed further by 1 cm.
- Proceed accordingly until the total deflection is 15 cm. Then finish the measurement and save it. Make sure that the hook of the force sensor is approximately at the same height as the free end of the leaf spring. You may have to adjust the height of the force sensor accordingly during the measurement.
- Evaluate your data with the help of the questions in the protocol. As an observation, use your measurement on the tablet.

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Report

Task 1

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When a force is applied to the metal plate, it deforms. When the force is removed, the deformation decreases. This is characteristic of...

- an elastic and inelastic deformation
- an inelastic deformation
- an elastic deformation

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Task 2

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Drag the words to the right places

For _____ deflections the course of the measured values deviates _____ from the linear course. This happens approximately from a deflection of _____.

Not needed: _____ (adjective), _____ (deflection).

large
7 cm
small
14 cm
increasingly

Check

Task 3

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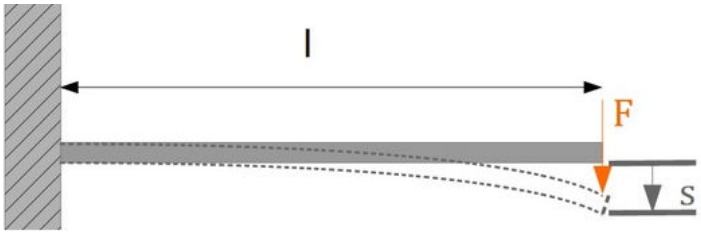
The spring constant D of a leaf spring is defined as the quotient of the force pulling perpendicularly to the end of the leaf spring F and the corresponding deflection Δs

$$D := F/\Delta s$$



What has the spring constant D to do with the straight line gradient that was determined?

- The spring constant D has nothing to do with the straight line gradient!
- The spring constant D equals the gradient of the straight line!
- The spring constant D equals the doubled straight line gradient!

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Slide	Score / Total
Slide 19: Type of deformation	0/3
Slide 20: Deviation of the measured values	0/5
Slide 21: Relationship of the straight line slope to the spring con...	0/2

Total 0 / 10

Solutions Repeat

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