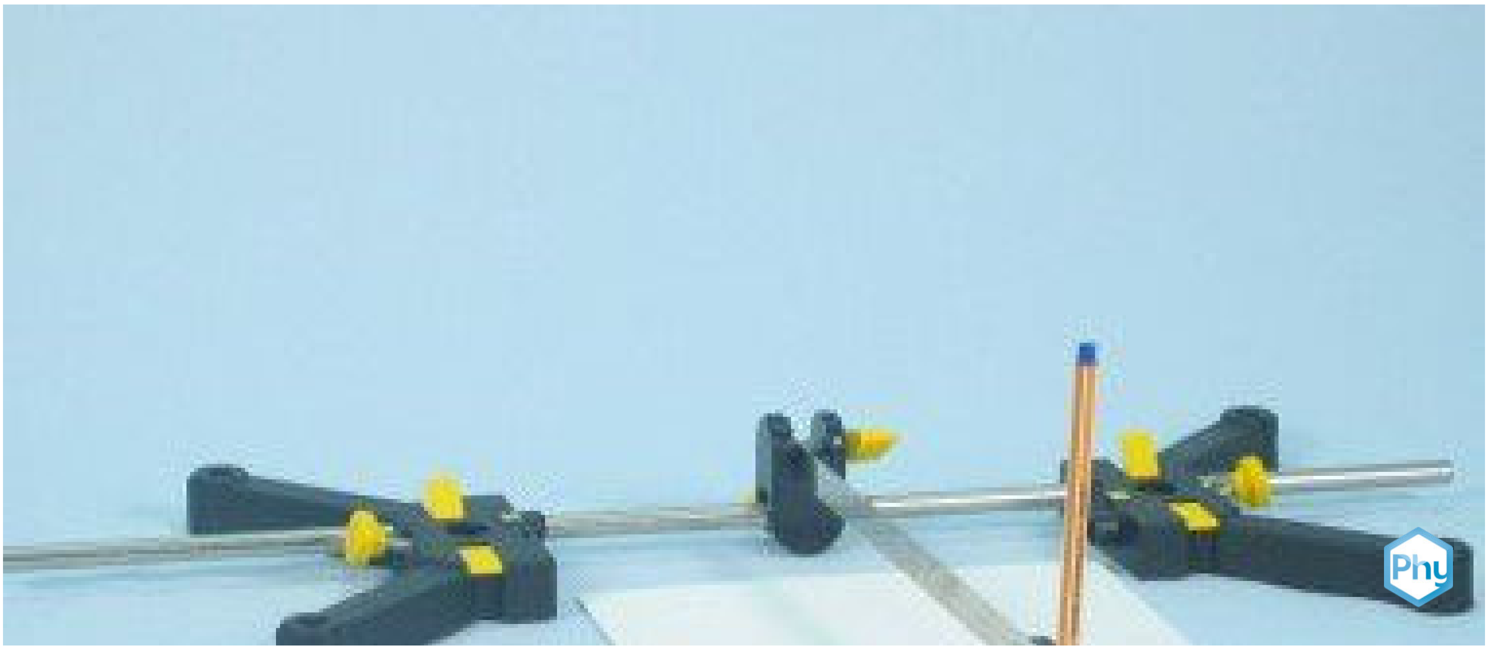
Displacement-time recording



Physics › Mechanics › Vibrations & waves

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

This content can also be found online at:

http://localhost:1337/c/5fda7ea6b5c96200036a66ec

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Teacher information

Application

Experimental setup for the graphical investigation of the leaf spring

There is a certain analogy between the oscillation of a leaf spring and that of the thread pendulum.

The duration of an oscillation T is significantly dependent on the length of the leaf spring l and is also equal to the reciprocal of the frequency of the oscillation.

The frequency f in turn results in the quotient of natural angular frequency ω and 2π.

$$f = \frac{\omega}{2\pi} \quad [\frac{1}{s} \triangleq s^{-1} \triangleq Hz]$$

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Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
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Other teacher information (1/3)

Prior knowledge

Ideally, the students should already have dealt with the thread pendulum, the so-called mathematical pendulum, and understood how it works.

Scientific principle

The period of oscillation T of the leaf spring is significantly dependent on the length of the leaf spring l and the mass m with which the leaf spring is weighted. The following applies:

$$T = f(l, m)$$

Other teacher information (2/3)

Learning objective

The students should learn that the duration of an oscillation can be determined not only with the help of a stopwatch, but also by graphically recording the oscillation.

Tasks

The students are to record the oscillations of a leaf spring at different masses and pendulum lengths on a piece of drawing paper and determine the respective oscillation period from the graphical representation of the oscillations.

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Robert-Bosch-Breite 10
37079 Göttingen
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Other teacher information (3/3)

Notes:

- Since the paper has to be pulled under the swinging leaf spring pendulum at the same time and the time required for this has to be measured, two pupils should always carry out the experiment together.
- For the third measurement, an oscillation was selected which can no longer be measured with the hand-held stopwatch, but which can still be evaluated well with the aid of the displacement-time recording.

Safety instructions

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

Robert-Bosch-Breite 10
37079 Göttingen

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info@phywe.de
www.phywe.de

Student Information

Motivation

Diving board

As you know, diving boards amplify the dynamic momentum during the jump, allowing for a higher jump and a faster turn.

There are various other applications in which leaf springs are used. For example, in the undercarriages of trains to increase the ride comfort for passengers.

In this experiment you will investigate the vibration behaviour of a leaf spring using a graphical recording.

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

Draw the oscillations of a leaf spring at different masses m and pendulum lengths l on a piece of drawing paper.

From the graphical representation of the oscillations, determine the respective oscillation period T.

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Equipment

Position	Material	Item No.	Quantity
1	Support base, variable	02001-00	1
2	Support rod, l = 600 mm, d = 10 mm, split in 2 rods with screw threads	02035-00	1
3	Boss head	02043-00	1
4	Holding pin	03949-00	1
5	Leaf spring	02228-00	1
6	Leaf spring attachment	02228-05	1
7	Slotted weight, black, 10 g	02205-01	2
8	Slotted weight, black, 50 g	02206-01	1
9	Measuring tape, l = 2 m	09936-00	1
10	Digital stopwatch, 24 h, 1/100 s and 1 s	24025-00	1

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Additional equipment

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Position	Equipment	Quantity
1	Felt-tip pen	1
2	White paper	DIN A4

Set-up (1/2)

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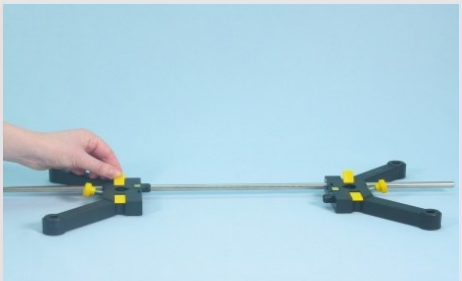
Screw the split 600 mm support rod together.

Connect the two halves of the support base to the support rod (600 mm) and tighten the levers.

Clamp the boss head to the support rod

Screwing the support rod



Connecting the support base halves

Fastening the boss head

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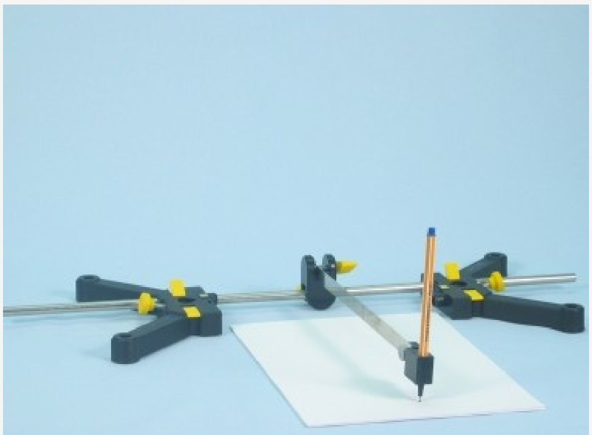
Set-up (2/2)



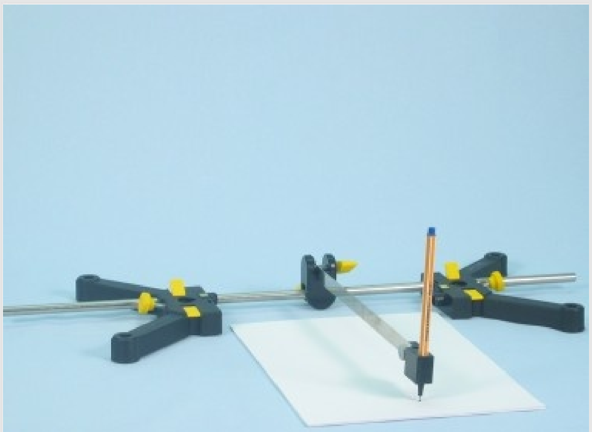
Adjusting the distance and mounting the pin

Adjust the distance between the two halves of the stand so that the sheet of paper can pass easily between them without jamming.

Attach the leaf spring attachment to the leaf spring and clamp the leaf spring together with the leaf spring attachment into the boss head.

Insert the felt pen into the hole of the leaf spring attachment. It should not sit too loosely, but still be movable. If necessary, wrap a short strip of paper or tape around the pen to give it a more stable hold.

Set-up (2/2)



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Procedure (1/4)

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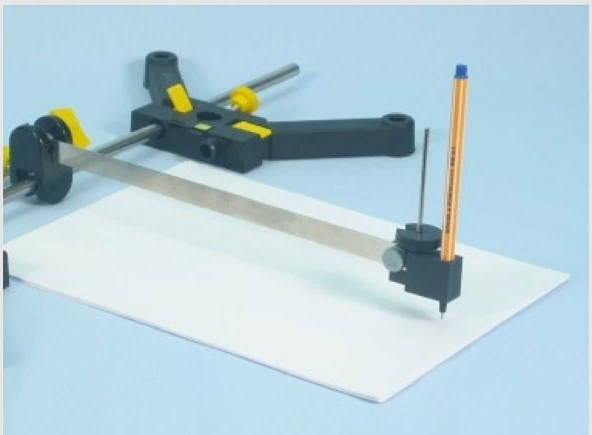

Experimental setup for the graphical investigation of the leaf spring

- Practice the recording process first!
- Attach the holding pin to the leaf spring attachment. (To increase the mass of the pendulum, you can place slotted weights on the holding pin).
- Deflect the spring and release it so that it swings.
- Pull the paper as evenly as possible from back to front under the vibrating spring. Make sure that the writing trace is even.

Procedure (2/4)

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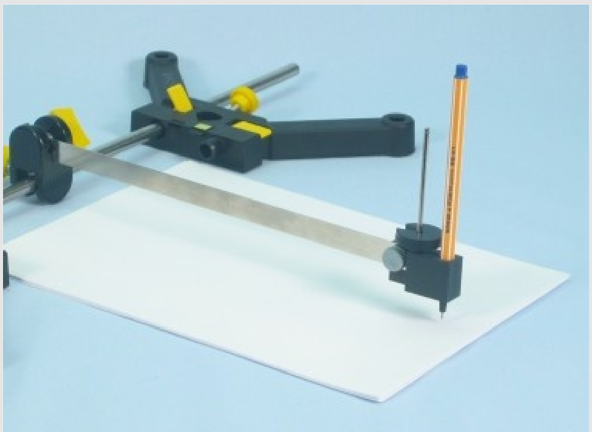

Experimental setup for the graphical investigation of the leaf spring

- If necessary you may need to adjust the position of the leaf spring in the clamping a little bit.
- Determine the time at the same time t, the paper must be completely under the pen.
- It makes the evaluation easier if you mark the position of the pen on the paper before starting the recording and only then let the leaf spring swing.
- Repeat the exercise until you are completely familiar with the graphical recording.

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Fax: 0551 604 - 107

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Procedure (3/4)

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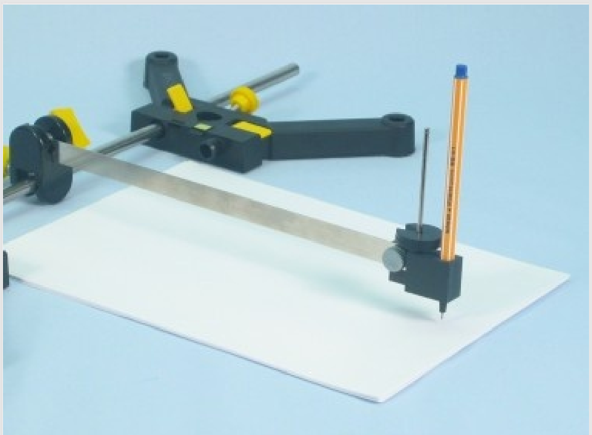

Experimental setup for the graphical investigation of the leaf spring

- Adjust the pendulum length of the leaf spring $l = 28\,cm$ and load the pendulum with an additional mass m_z From $20\,g$ (place slotted weights on the retaining bolt).
- Set the pendulum swinging and note the oscillations as you practiced. At the same time measure the time t the paper is pulled under the leaf spring.
- Repeat the measurement / recording.
- Note the measured time for both runs t in Table 1 in the report.

Procedure (4/4)

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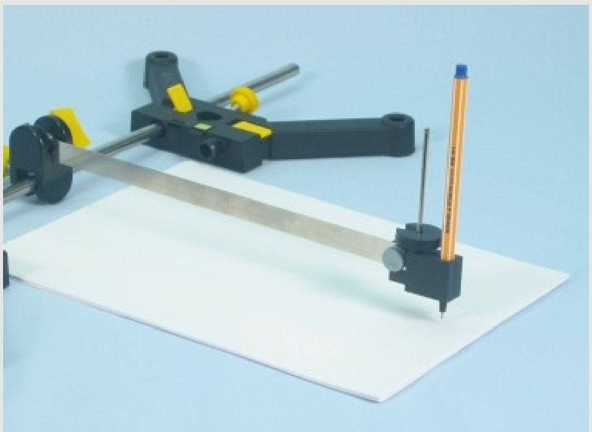

Experimental setup for the graphical investigation of the leaf spring

- Weigh down the pendulum with a total additional mass of $60\,g$ and repeat the experiment twice.
- Shorten the pendulum length to $l = 14\,cm$ and reduce the additional mass back to $20g$. Perform the experiment two more times.
- Note the total measurement time for all runs again t in Table 1 in the report.

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Report

Notes to Table 1

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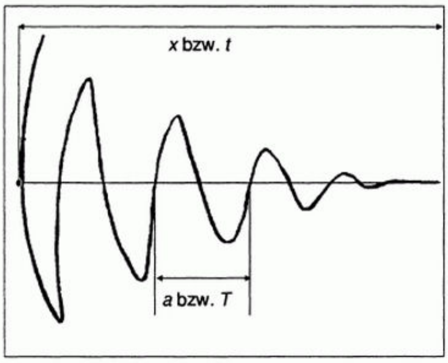
Write down your measurements in the table.

Mass of the leaf spring attachment including retaining bolt: $27\,g$.

- Determine the scale for the respective time axes of your results: Note the distance x and the duration t in Table 1 on the results page.
- Calculate the time t_1 (scaling factor) for a distance of $1\,cm$.
- Determine the period of oscillation T from the recorded diagrams: Determine the length a of an oscillation by averaging over several recorded oscillations. Then calculate from a with the help of the scaling factor t_1 the period of oscillation T.
- Note the values obtained in Table 1 on the results page.



Sample measurement result

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Table 1

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$l\,[cm]$	$m_z\,[g]$	$m\,[g]$	$t\,[s]$	$x\,[cm]$	$t_1\,[s]$	$a\,[cm]$	$T\,[s]$
28	20						
28	60						
14	20						

Task 1

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How does an increase in pendulum mass affect the period of oscillation of the leaf spring?

- ○ As the mass of the pendulum increases, the period of oscillation becomes longer.
- ○ The increase of the pendulum mass has no influence on the oscillation period.
- ○ As the mass of the pendulum increases, the period of oscillation becomes shorter.

Check

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Robert-Bosch-Breite 10
37079 Göttingen

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Task 2

How does a reduction in the length of the pendulum affect the period of oscillation of the leaf spring?

- ○ The reduction of the pendulum mass has no influence on the oscillation period.
- ○ As the length of the pendulum decreases, the period of oscillation becomes shorter.
- ○ As the length of the pendulum decreases, the period of oscillation becomes longer.

Check

Task 3

Which parameters of this experiment directly affect the accuracy of the measurements and were basically not considered here?

- ☐ The mass of the pin in the leaf spring attachment.
- ☐ The friction of the pen on the paper when writing the graphs.
- ☐ The uniformity with which the paper was drawn.

Check

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