Bending of a leaf spring

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:

http://localhost:1337/c/5f8eec175e5c1a00035cb625

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

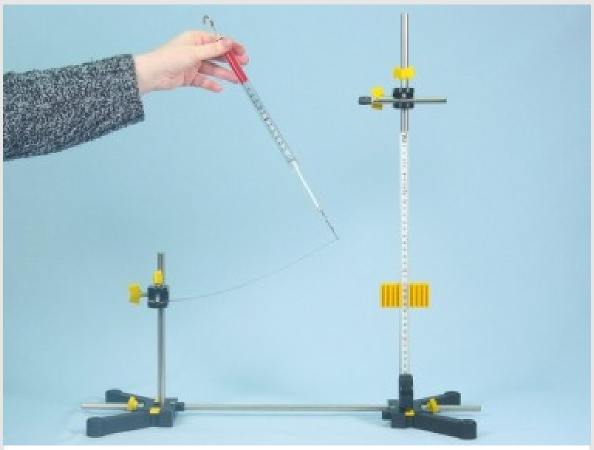
Teacher information

Application

In this experiment, a leaf spring is to be clamped horizontally and loaded with a force at the outer end. The applied force results in a bending moment M_b which stresses the spring. The bending moment is greatest at the point of loading 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 acting force F and lever arm l:

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



Experiment set-up

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

Other teacher information (1/2)

PHYWE

Prior knowledge

Students should have a basic understanding of forces. Ideally, the students should have previously done the experiment on Hook's Law and know the concept of spring constant and the relationships between the deflection of a spring under a certain force.

Scientific principle

For the characteristic values of leaf springs similar linear relationships apply as for coil springs.

Note: This test can be used as a preparation for experiments on the parallelogram of forces.

Other teacher information (2/2)

PHYWE

Learning objective

Students should study the behaviour of leaf springs under load and learn how to determine the spring constant of a leaf spring.

Tasks

1. The students should examine the behaviour of a leaf spring under load and determine its spring constant D.
2. In the same test set-up, the tensile force at constant deflection is to be determined at different angles and an interpretation of the result attempted.

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

Safety instructions

PHYWE

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

PHYWE

Student Information

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Motivation

PHYWE

Springboard

As you know, springboards in diving reinforce the dynamic impulse during the jump, allowing for a higher jump and a faster turn.

There are various applications where a leaf spring is used instead of a coil spring, as leaf springs are usually cheaper for the same spring effect.

In this experiment you will investigate the properties of a leaf spring.

Tasks

PHYWE

In this experiment you will learn the basic relationships between load and spring constant of the leaf spring. Proceed as follows:

1. Examine the behaviour of a leaf spring under load and determine the spring constant D.
2. Determine the force at constant deflection but at different angles.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Equipment

Position	Material	Item No.	Quantity
1	Support base, variable	02001-00	1
2	Support rod, stainless steel, l = 250 mm, d = 10 mm	02031-00	1
3	Support rod, l = 600 mm, d = 10 mm, split in 2 rods with screw threads	02035-00	2
4	Boss head	02043-00	2
5	Leaf spring	02228-00	1
6	Spring balance,transparent, 1 N	03065-02	1
7	Spring balance holder	03065-20	1
8	Glass tube holder with tape measure clamp	05961-00	1
9	Measuring tape, l = 2 m	09936-00	1
10	Fishing line, l. 20m	02089-00	1
11	Support rod with hole, stainless steel, 10 cm	02036-01	1

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Additional equipment

PHYWE

Position	Equipment	Quantity
1	Scissors	1

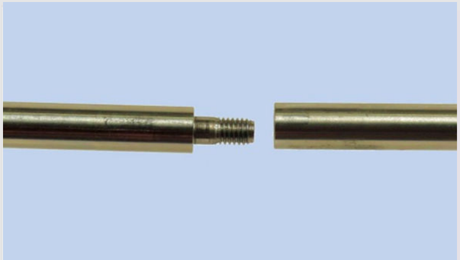
Set-up (1/5)

PHYWE

Connect the divided support rods to form a long support rod with a length of 600 mm.

Attach the two support base halves to the two ends of the long support rod.

By raising the locking levers you fix the support rod in the support base.



Support rods with thread

Mounting the feet

Fixing the stand rod

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Set-up (2/5)

PHYWE

Now insert one support rod each (right: 600 mm, left: 250 mm) vertically into the feet, screw it tight and attach a boss head each to the two vertical supportrods.

Insert the force gauge holder (clamp with plug) into the short rod.

Mounting the foot

Fastening the boss head

Holder in tripod rod

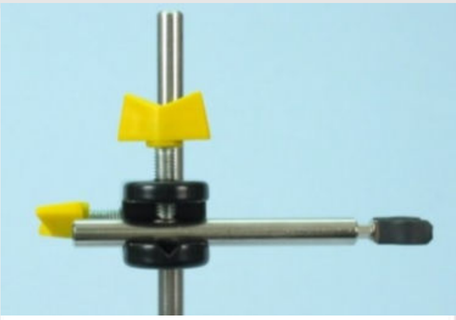
Set-up (3/5)

PHYWE

Clamp the short support rod with the clamp then into the boss head on the 600 mm support rod.

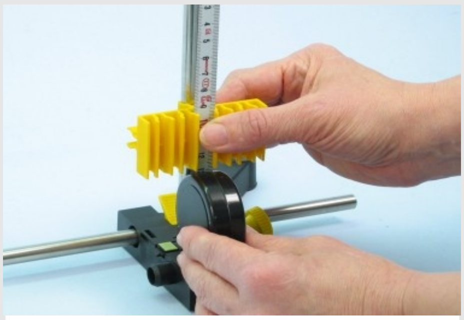
Now fix the extended measuring tape in the middle of the glass tube holder.

Then plug both onto the 600 mm support rod.



Holder on support

Measuring tape in glass tube holder



Glass tube holder on support

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

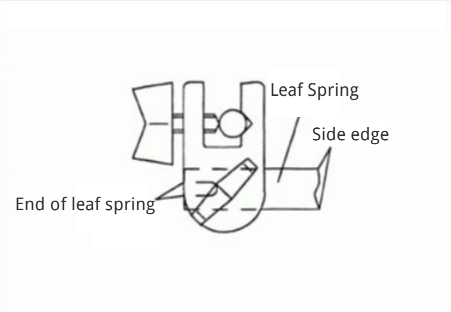
info@phywe.de
www.phywe.de

Set-up (4/5)

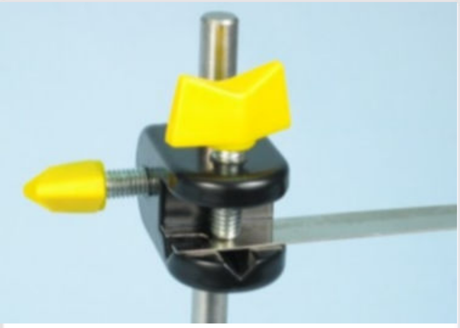
PHYWE

Attach the leaf spring to the short support rod using the boss head so that the rear end edge is flush with the boss head.

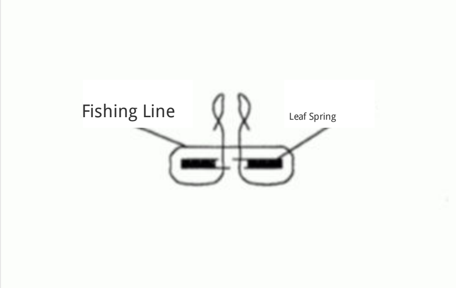
Take an approx. 12 cm long piece of fishing line and place it as a loop around the front end of the leaf spring as shown.



Leaf spring in boss head



Leaf spring in boss head



Created loop with the help of fishing line

Set-up (5/5)

PHYWE

Connecting force gauge and leaf spring

Finally, move the support base halves so that the leaf spring and the tape measure are approximately as far apart as shown in the figure.

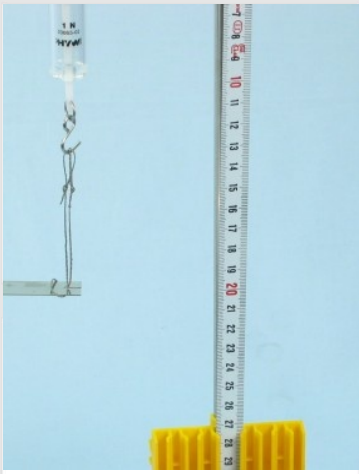
The tape measure should be close enough to the leaf spring to be able to read the length reliably, but also far enough away so that the leaf spring is not blocked or obstructed.

Then knot the two ends of the fishing line into a loop and hang the loop on the dynamometer. Fix the spring gauge in the holder provided.

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

Procedure (1/3)

PHYWE



Adjusting the measuring tape

Adjust the measuring tape so that a certain mark (e.g. 20 cm) is at the height of the unloaded leaf spring.

Then pull the force gauge vertically upwards (parallel to the support rod) in steps of 0.1 N one after the other until a maximum force of 1.0 N is reached. Read for each of these ten forces F the deflection Δl and enter the measured values in Table 1 of the protocol.

Loading of the leaf spring

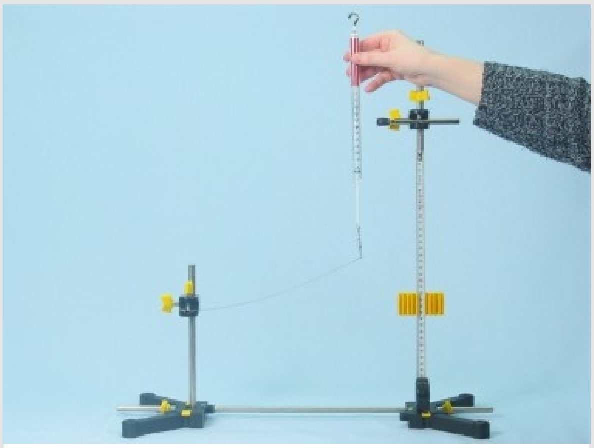
Procedure (2/3)

PHYWE

Now select a specific force, e.g. 0.6 N.

First determine the change of the end position of the leaf spring as described above Δlbut hold the dynamometer freely in your hand.

Note the measured deflection in Table 2 in the protocol.



Loading of the leaf veins

PHYWE

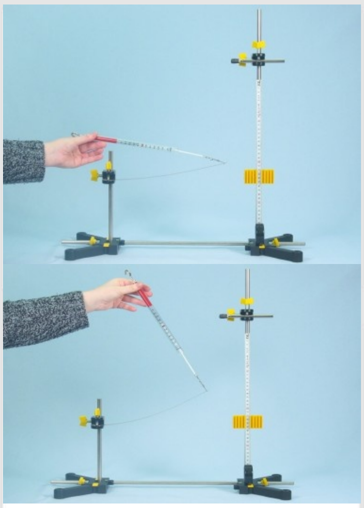
Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Procedure (3/3)

PHYWE



Variations of the load angle

The measured deflection should now be kept constant in the following.

Then change the angle of the force gauge relative to the leaf spring (with the same deflection): To do this, pull once parallel to the table surface and once at an angle of approx. 45° to the table surface.

In both cases, read the resulting indicated force F and also enter the values in Table 2 in the protocol.

PHYWE

Report

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Table 1

PHYWE

$F[N]$	$\Delta l[cm]$	$D[N/m]$	$F[N]$	$\Delta l[cm]$
0,1			0,6	
0,2			0,7	
0,3			0,8	
0,4			0,9	
0,5			1,0	

Write down your measured values for the first test part and calculate the spring constant $D = F/\Delta l$ for the first five values (0,1 N to 0,5 N).

Table 2

Write down your measurements for the second part of the experiment.

Deflection: $\Delta l =$ ___ m (constant)

Pulling direction:	$F[N]$
Vertical (90°)	
Diagonal (45°)	
Parallel (0°)	

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Table 2

PHYWE

Write down your measurements for the second part of the experiment.

Deflection: $\Delta l =$ ______ m (constant)

Pulling direction:	$F[N]$
Vertical (90°)	
Diagonal (45°)	
Parallel (0°)	

Task 1

PHYWE

Determine the mean value of the spring constant D for the first 5 measured values.

$D =$ ______ N/m

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Task 2

PHYWE

Why were only the first 5 measured values used in the calculation of the mean value for the spring constant?

- No more values were used, because with the 5 values a sufficiently accurate result can already be achieved.
- If further measured values were used for calculation, these would no longer lie on the linear course of the spring constant.

Check

Task 3

PHYWE

At which angle is the force required for the deflection smallest?

- The force is lowest at an angle of 90° (perpendicular to the leaf spring).
- The force is lowest at an angle of 0° (parallel to the leaf spring).
- The force is lowest at an angle of 45° (diagonal to the leaf spring).

Check

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Task 4

PHYWE

Can you give a reason for the question on the previous page?

- [ ] The force required is lowest when the load is below 0°, as here the force pulls in the direction in which the spring bends at the end.
- [ ] The force required is lowest when the load is under 90°, as the total force acts in the direction of the spring deformation.
- [ ] The force required is lowest when the load is applied at 90°, as in the other two directions only the vertical component of the force effect is decisive.

Check

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de