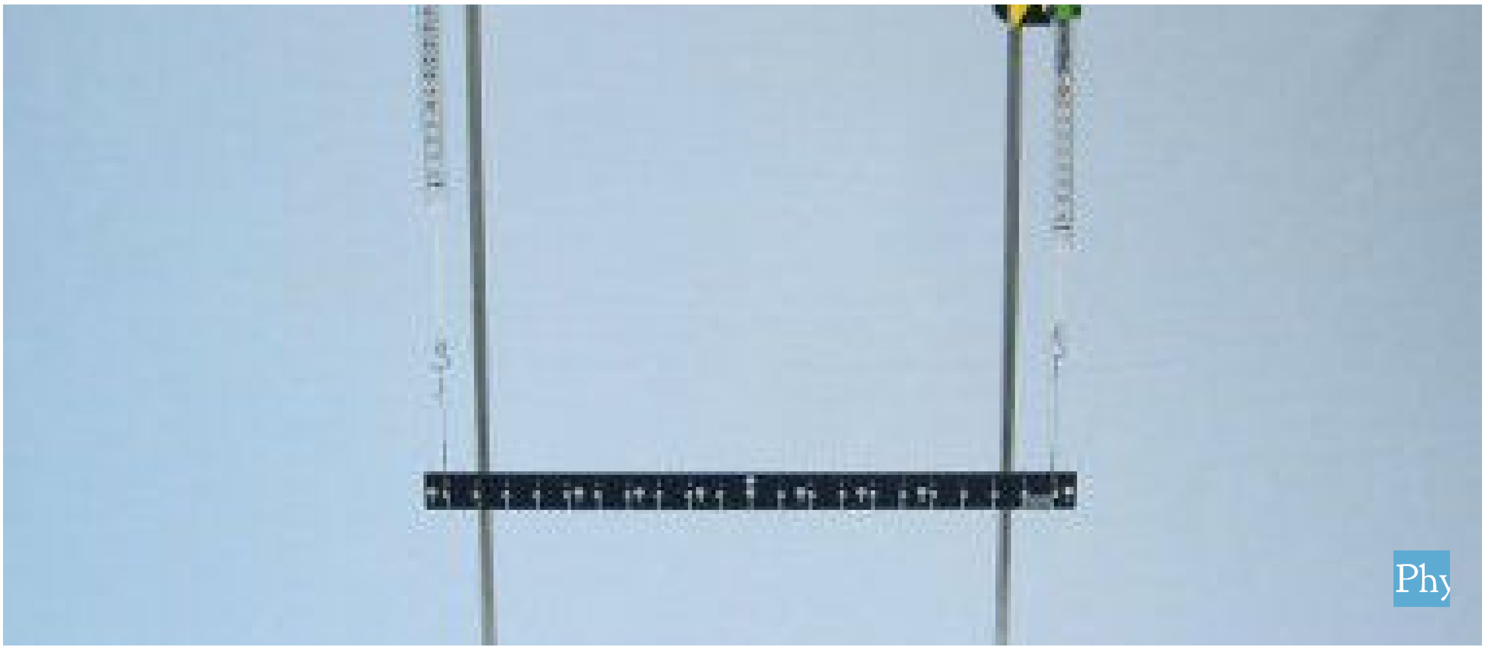
Reaction forces for an unloaded beam



Physics | Mechanics | Forces, work, power & energy

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

Teacher information

Application

Test setup for determining the support reactions of the unloaded beam

If a beam is supported by means of two supports at its ends, the support reactions in both bearings are equal if the mass of the beam is constant over its cross-section and the beam is not subjected to external loads. In the normal case - the statically determined case - a beam is supported by means of a classic fixed/loose bearing arrangement. In this case, the fixed bearing can transmit two bearing reactions and is therefore a bivalent bearing, whereas the floating bearing carries one bearing reaction and is a monovalent bearing.

The degree of freedom of the locating bearing is therefore 1 and that of the floating bearing is 2.

PHYWE excellence in science
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 excellence in science

Prior

Before carrying out this experiment, it is advisable that the students have already acquired basic knowledge about 'force and counterforce' and have experience in measuring forces and their effects. In addition, it would be an advantage if the students have already learned about the processes and moments at a lever.

Scientific

If a beam is supported at both ends and no load is applied to it, the support reactions in the bearings A and B the same size. Each of them has only one vertical component, if the beam was stored completely horizontal. These components A_y and B_y then each correspond to half the load resulting from the beam's own weight.

Other teacher information (2/2)

PHYWE excellence in science

Learning

The experiment is intended to show the students which forces act in the supports of a symmetrically supported beam. Furthermore, it should give them a feeling for the effect these forces can have.

Tasks

1. Determine the supporting forces of an unloaded beam with symmetrical suspension of the beam.
2. Determine the supporting forces of an unloaded beam with an asymmetrical suspension of the beam.

Note: Make sure that the beam itself is hooked into the loops and not just the marker pins.

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

Safety instructions

PHYWE excellence in science

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

PHYWE excellence in science

Student Information

PHYWE excellence in science

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Motivation

Framework of a high-rise building

Beams, girders and other load-bearing elements are a central component of many structural engineering structures. Properly designed, they are capable of bearing very heavy loads or distributing them to the so-called supports (support points) of the beam.

One thinks, for example, of the steel beams used in a high-rise building, crossbeams in the roof truss of a pitched roof or as suspension for swings, but also of the axles of trains or trucks.

In this experiment, you examine the bearing forces of an unloaded beam as a function of the suspension.

Tasks

Determine the forces generated in the supports of the beam. These forces are also known as the support reaction.

Determine the bearing forces of an unloaded beam:

1. symmetrical suspension of the beam.
2. asymmetrical suspension of the beam.

excellence in science
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 = 600 mm, d = 10 mm	02037-00	3
3	Support rod with hole, stainless steel, 10 cm	02036-01	2
4	Boss head	02043-00	2
5	Lever	03960-00	1
6	Spring balance,transparent, 1 N	03065-02	1
7	Spring balance,transparent, 2 N	03065-03	1
8	Spring balance holder	03065-20	2
9	Fishing line, l. 20m	02089-00	1

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

Additional equipment

PHYWE excellence in science

Position	Equipment	Quantity
1	Scissors	1

Set-up (1/4)

PHYWE excellence in science

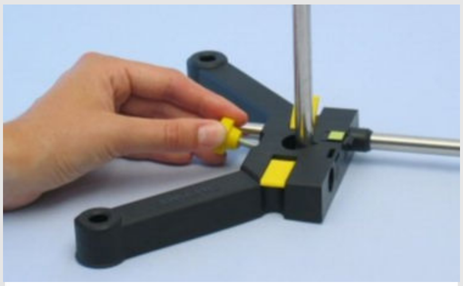
First, screw the divided support rods together to form long support rods.

Connect the two halves of the tripod foot with a long tripod rod and attach the locking levers.

Insert the two remaining long tripod rods into one half of the tripod foot and fix them.

Connecting the support rods

Connecting the tripod feet



Fixing the support rods

PHYWE excellence in science

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

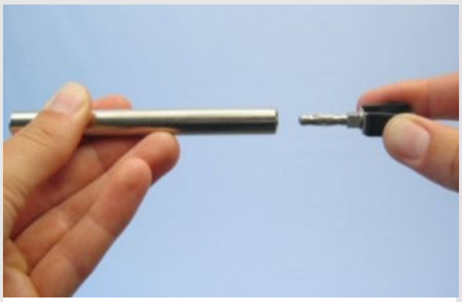
Set-up (2/4)

PHYWE excellence in science

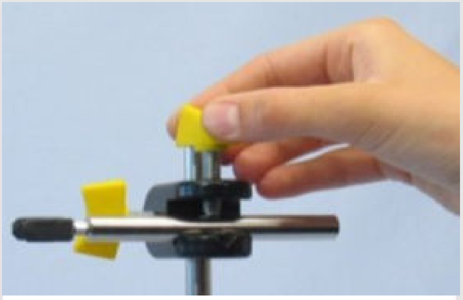
Insert the two dynamometer holders into the 100 mm tripod rods with bore hole.

Attach the double sleeves to the long support rods and clamp the force gauge holders into them.

Insert the two force gauges and adjust them in vertical position of use with the screw.



Insert the force gauge holder into the stand rod



Fixing the support rods to the double socket

Inserting and adjusting the force gauges

Set-up (3/4)

PHYWE excellence in science

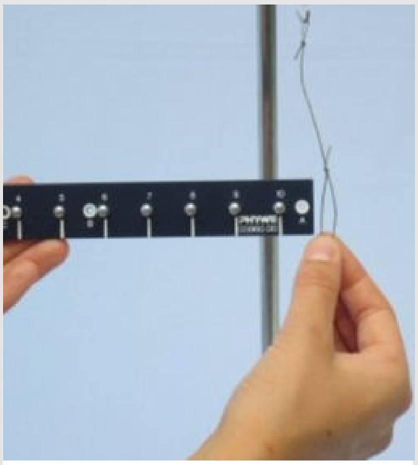
Fishing line on the power gauge hangers

Make 2 loops from the fishing line (thread length approx. 10 cm each) and hang them on the hooks of the dynamometer.

Slide the other loop of the fishing line over the ends of the bar up to the markings '10'.

Hint:

Make sure that one loop is large enough that you can move it over the marker pins on the bar.



Sliding the fishing lines over the beam

PHYWE excellence in science

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Set-up (4/4)

PHYWE excellence in science

Adjusting the tripod base distance

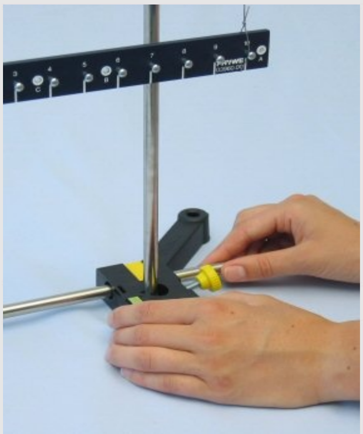
Your test setup should correspond to the adjacent figure.

First move the two halves of the tripod feet horizontally so that both loops with the force gauges hang vertically on the bar at the marks '10' on the right and left.

Finally, adjust the two force gauges with the double sleeves vertically so that the beam hangs horizontally.

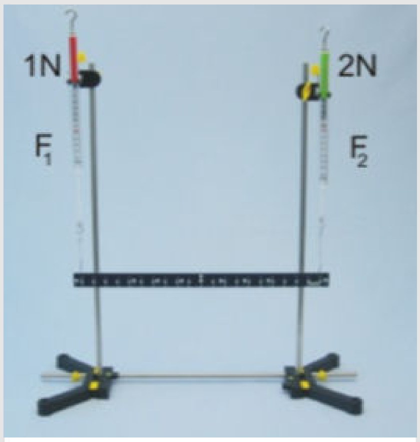
Procedure (1/4)

PHYWE excellence in science



Setting up the test setup

- Always make sure that the bar hangs horizontally before each measurement and always push the loops from the outside to the marker pins you are using.
- Adjust both tripod foot halves so that the force gauge and loops hang vertically.
- Read both force gauges when the loops are at the '10' mark on both sides. Carry the forces F_1 and F_2 in Table 1 on the results page.

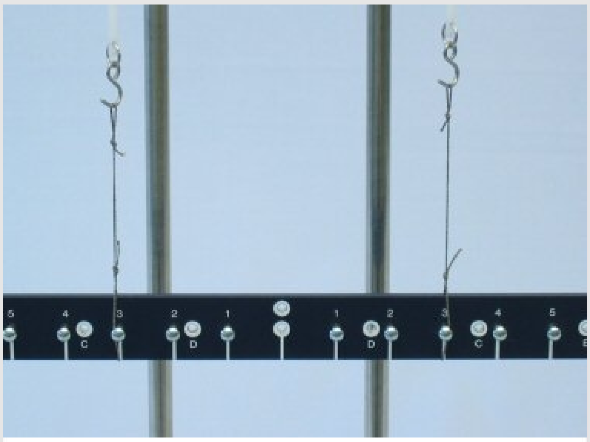


Measuring the forces F_1 and F_2

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

Procedure (2/4)

PHYWE excellence in science

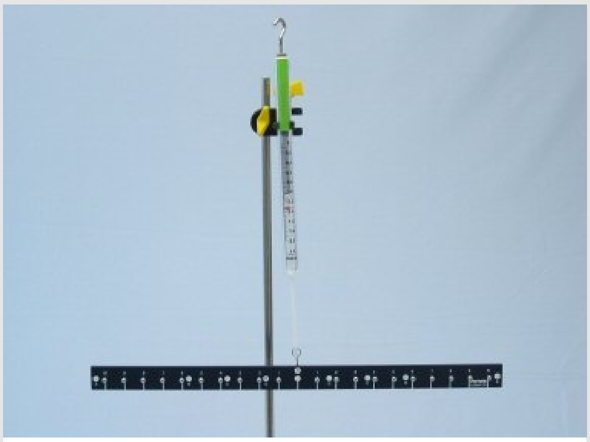


Variation of the support position

- Move the loops (and the tripod foot halves) one after the other both to the marks '6' and then to the '3'.
- Read the values of both force gauges and enter the measured values in Table 1.

Procedure (3/4)

PHYWE excellence in science



Determining the weight force F_G of the beam

- Determine the weight force F_G of the beam.
- To do this, hang the beam centrally on a 2 N dynamometer and note the measured value.

PHYWE excellence in science

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Procedure (4/4)

Variation of the position of the right support

- Return the bar to its initial position (marker '10').
- Now place the right-hand dynamometer on the marks 8, 6, 4, 2 and 0 one after the other, leaving the left-hand dynamometer at mark '10' in this series of measurements.
- Read both force gauges in each position and apply the forces F_1 and F_2 in Table 2 of the Protocol.

Report

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

Table 1

PHYWE excellence in science

Enter your measured values into the table and calculate the sum of the forces $F_{total} = F_1 + F_2$.

Additionally form the ratio of F_1 to F_2 and enter this in the table.

Marking No. left	right	$F_1\ [N]$	$F_2\ [N]$	$F_{total}\ [N]$	F_1 / F_2
10	10				
6	6				
3	3				

Enter the value for the weight force of the bar in the field. $F_W =$ ______ N

Table 2

PHYWE excellence in science

Enter your measured values into the table and calculate the sum of the forces $F_{total} = F_1 + F_2$.

Additionally form the ratio of F_1 to F_2 and enter this in the table.

Marking No. left	right	$F_1\ [N]$	$F_2\ [N]$	$F_{total}\ [N]$	F_1 / F_2
10	8				
10	6				
10	4				
10	2				
10	0				

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

Task 1

Compare the values for F_{total} with the weight of the beam F_W.

What do you find?

- $F_{total} < F_W$
- $F_{total} = F_W$
- $F_{total} > F_W$

Check

Task 2

Compare the proportions F_1/F_2 with the numbers for the markings (part 2).

Do you notice anything different?

- There is no typical pattern to be seen.
- The values change proportionally to each other.
- With increasing distance of the marking the ratio F_1/F_2 twice as strong.

Check

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

Task 3

PHYWE excellence in science

Instead of the marker numbers, can you specify a different (physical) quantity to which they correspond?

- ○ The markings can be adjusted with the acceleration of gravity g can be compared.
- ○ There is no comparable physical size.
- ○ The markings are comparable with the lever arm l.

Check

Task 4

PHYWE excellence in science

What is the meaning of the middle of the bar? What does it represent physically?

- ○ The centre of the bar represents its centre of gravity.
- ○ The middle of the bar has no physical reason whatsoever.
- ○ Its density is greatest in the middle of the bars.

Check

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

Slide	Score / Total
Slide 22: Comparison F_{total} & F_g	0/1
Slide 23: Comparison of F1/F2 with the support position	0/1
Slide 24: Marking number as physical quantity	0/1
Slide 25: Centre of gravity of the beam	0/1

Total amount 0/4

Solutions Repeat Exporting text

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