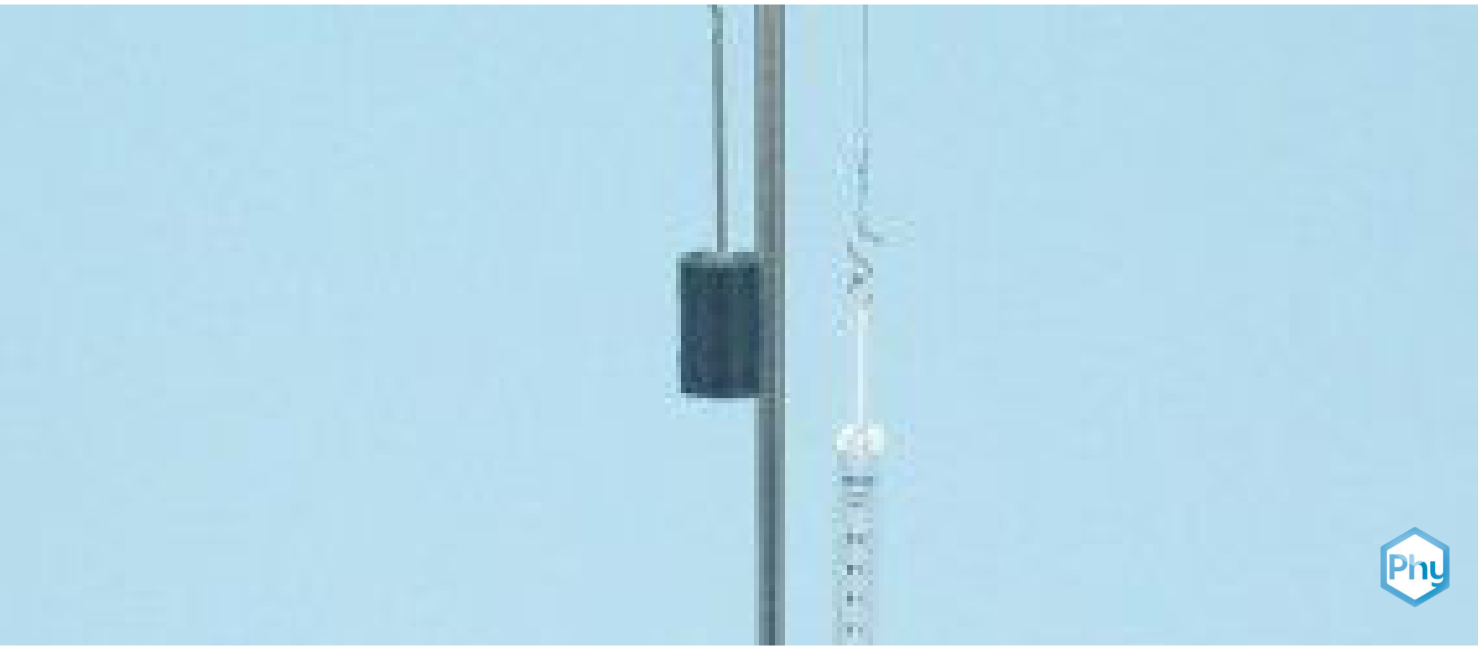
Forces and paths at the step wheel



Physics | Mechanics | Forces, work, power & energy

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

This content can also be found online at:

http://localhost:1337/c/5f9daccce9913500039a88d4

Teacher information

Application

Experimental set-up for the step wheel

The step wheel is - as the name suggests - a wheel with a heel. This shoulder, also called step, has a smaller diameter than the actual wheel.

If you now apply a load to the heel, it creates a moment around the center of the wheel. In the static case, this moment is counteracted by a moment resulting from the counteracting force and the radius of the wheel.

The sum of the moments would therefore be zero according to the laws of statics.

$ \Sigma\,M_i=0=Load \cdot load arm force\cdot force arm $

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)

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Prior

Students should have a basic understanding of forces and be able to determine the weight of a body using a spring force meter. In addition, they should already have developed basic knowledge of the origin and effect of moments.

Scientific

According to the laws of mechanics, a system is at rest when the sum of all forces and moments is zero. This special case is a fundamental component of statics. In this experiment, the sum of the moments at the step wheel is to be brought into equilibrium.

$\Sigma \,M=0$

Other teacher information (2/2)

PHYWE

Learning

Using the example of a stepped wheel, the students are to determine that the same mechanical laws apply here as in the static case of the lever.

Tasks

1. On a step wheel, those forces are measured which, with different masses as load, create an equilibrium

   ab.

2. The force and load arm should be measured at the step wheel and the products $Last \cdot Lastarm$ and $Kraft \cdot Kraftarm$ can be formed.

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Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Safety instructions

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

Student Information

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Motivation

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Gear change of a bicycle

Anyone who has ever ridden up a steep mountain on a bicycle will appreciate the gear shift on the bike. Here the force to be applied is significantly reduced.

The front and rear gearwheels together form a so-called stepped wheel, in which the pedaling force and the pedaling speed can be adapted to the given requirements by selecting the appropriate diameter. Other everyday examples of the use of the stepped wheel include vehicle transmissions.

In this experiment you will learn the mode of operation of a step wheel.

Tasks

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Examine the forces and moments acting on a step wheel. Proceed as follows:

- Use a step wheel to determine the force required to adjust the balance for different attached loads.
- Measure the load and force arm of the step wheel, form the products $Last \cdot Lastarm$ respectively $Kraft \cdot Kraftarm$ and compare them with each other.

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Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
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info@phywe.de
www.phywe.de

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	Support rod, stainless steel, l = 250 mm, d = 10 mm	02031-00	1
4	Boss head	02043-00	1
5	Wheel and axle	02360-00	1
6	Weight holder, 10 g	02204-00	1
7	Slotted weight, black, 10 g	02205-01	4
8	Slotted weight, black, 50 g	02206-01	3
9	Spring balance,transparent, 2 N	03065-03	1
10	Shaft, dia.12mm, l.45mm	02353-00	1
11	Vernier calliper, plastic	03011-00	1
12	Fishing line, l. 20m	02089-00	1

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Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
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info@phywe.de
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Additional equipment

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Position	Equipment	Quantity
1	Scissors	1

Set-up (1/4)

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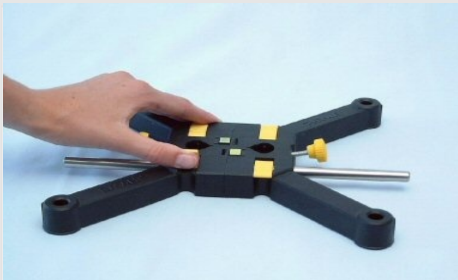
Put the two-part tripod base together and fix the 25 cm long tripod rod horizontally in it.

Then screw the two-part stand rod to a long stand rod.

Insert the 60 cm long tripod rod vertically into the tripod base and fix it with the screw.



Tripod foot with tripod rod

Support rods with thread

Attaching the stand rod

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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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Set-up (2/4)

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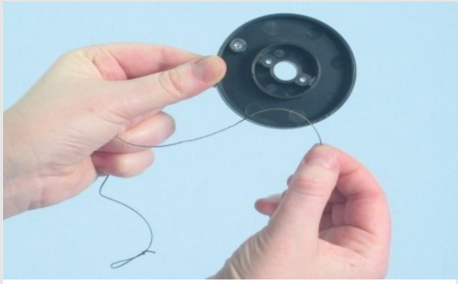
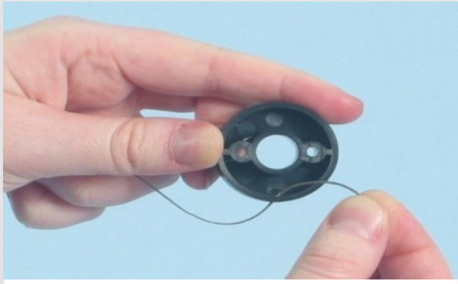
Pull a string through each of the two discs of the step wheel.

Secure the line with a knot to prevent slipping.

Insert the shaft from the front through the step wheel.



Pull the cord through the disc



Secure the cord against slipping

Mount the shaft in the step wheel

Set-up (3/4)

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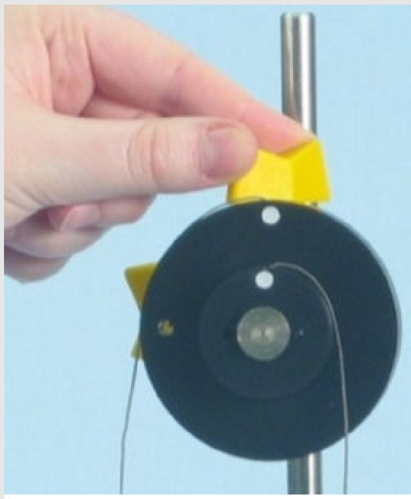
Mounting the double socket on the stand rod

Now mount the double socket at the upper end of the long tripod rod.

Clamp the shaft together with the step wheel into the double socket.



Fastening the shaft and step wheel in the double socket

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Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Set-up (4/4)

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Attaching the force gauge

Use the crank to fix the two discs against each other (both white points and thus the exit points of the cords together at the top).

Put both cords in opposite directions once around the respective disk of the step wheel. Make sure that the cords lie in the groove of the wheel.

Attach the dynamometer to one fishing line and the weight plate to the other. The line to the dynamometer should run over the larger disc. Adjust the dynamometer upside down to zero without load.

Hook the hook of the dynamometer into the short stand rod at the stand foot.

Procedure (1/2)

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Determination of F

- Load the weight plate with four 10 g weights ($m_{ges} = 50\ g$).
- Miss the power Fwhich is necessary to adjust the balance.
- Increase the mass successively to 100 g, 150 g and 200 g and repeat the measurements.
- Determine the length of the load arm l_l and the power arm l_f with the caliper gauge (radius of the respective disc).
- Write down all measurement results in the table in the protocol.

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Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Procedure (2/2)

Disassembling the tripod base

- To disassemble the tripod base, press the buttons in the middle and pull both halves apart.

Report

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

Table

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Carry the values of the force F into the table. Calculate the weight force F_G from the masses m and add the values to the table. Calculate the products $F_G \cdot l_l$ and $F \cdot l_f$ and enter the results in the table. Enter your values for l_l and l_f one.

$m\ [g]$	$F\ [N]$	$F_G\ [N]$	$F_G \cdot l_l\ [Ncm]$	$F \cdot l_f\ [Ncm]$
50				
100				
150				
200				

$l_l = cm$

$l_f = cm$

Task 1

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Test setup for determining the acting force

Compare the results of the products with each other.

What do you find?

- $F_G \cdot l_l > F \cdot l_f$
- $F_G \cdot l_l < F \cdot l_f$
- $F_G \cdot l_l = F \cdot l_f$

Check

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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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Task 2

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Test setup for determining the acting force

What can you deduce from this?

- The acting moments are always the same when the system is in balance.
- No correlation can be inferred.
- The moment acting due to the load is always greater than the moment resulting from the force acting on the force gauge.

Check

Task 3

PHYWE

Test setup for determining the acting force

What is the relationship between the displayed value of the force gauge and the weight force, i.e. F/F_G?

- $F/F_G = l_l/l_f$
- $F \cdot F_G = l_l \cdot l_f$
- $F/F_G = l_f/l_l$

Check

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Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
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Slide	Score / Total
Slide 19: Comparison of the moments	0/1
Slide 20: Conclusion for the moments	0/1
Slide 21: ratio F/F_G	0/1

Total amount 0/3

Solutions Repeat Exporting text

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