Force and displacement on a step wheel (Item No.: P1001200)

Curricular Relevance

Area of Expertise: Physik
Education Level: Klasse 7-10
Topic: Mechanik
Subtopic: Kräfte, einfache Maschinen
Experiment: Kräfte und Wege am Stufenrad

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	10 Minutes	10 Minutes	2 Students

Additional Requirements:

- Scissors

Experiment Variations:

Keywords:

Task and equipment

Information for teachers

Additional Information

1. The students should measure the forces which maintain equilibrium with different load masses on a step wheel.
2. They should measure the force and the length of the load arms of a step wheel, and calculate the products load × load arm and force × force arm.

From their measuring results they should conclude that, under static conditions, a step wheel works like a lever and that the aforementioned products should be equal – as it is the case for a lever.

Remarks

1. The term "(slotted) weight" is incorrect inasmuch as we are dealing with a mass which becomes a weight (more precisely, a "weight force") under the influence of gravity. The term "mass piece" used here is better.
2. Physically speaking, the product F x s = W represents work. In this cWork on an inclined planeontext one can introduce the terms "lifting work" and the "laws of conservation of forces" in preparation for experiment Work on an inclined plane (P1001400).

Force and displacement on a step wheel (Item No.: P1001200)

Task and equipment

Task

How does a step wheel work?

First, you will determine the force which is necessary to maintain a hanging load in equilibrium on a step wheel. You will change the load several times.
Then you will measure the load and force arms of the step wheel, form the product of the load × load arm and force × force arm and compare them with each other.

Equipment

Position No.	Material	Order No.	Quantity
1	Support base, variable	02001-00	1
2	Support rod, l = 600 mm, d = 10 mm, split in 2 rods with	02035-00	1
2	Support rod, stainless steel, l = 250 mm, d = 10 mm	02031-00	1
3	Boss head	02043-00	1
4	Weight holder for slotted weights	02204-00	1
5	Slotted weight, black, 10 g	02205-01	4
5	Slotted weight, black, 50 g	02206-01	3
6	Spring balance,transparent, 2 N	03065-03	1
7	Vernier calliper, plastic	03011-00	1
8	Fishing line, l. 20m	02089-00	1
9	Wheel and axle	02360-00	1
10	Shaft, dia.12mm, l.45mm	02353-00	1
Additional material			
	Scissors		

Set-up and procedure

Set-up

Set up a stand with the support base (Fig. 1), the 250 mm support rod (Fig. 2) and the 600 mm support rod (Fig. 3-4). Clamp the bosshead on the long support rod (Fig. 5).

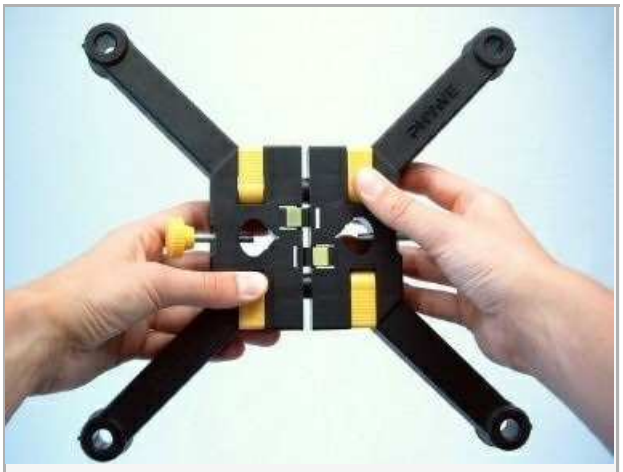
Fig. 1


Fig. 2


Fig. 3

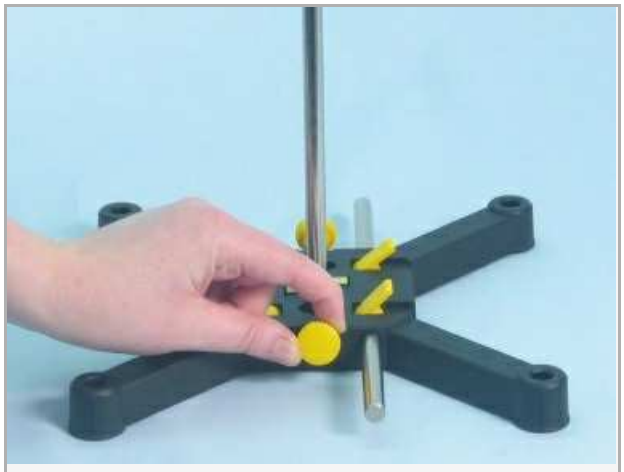
Fig. 4

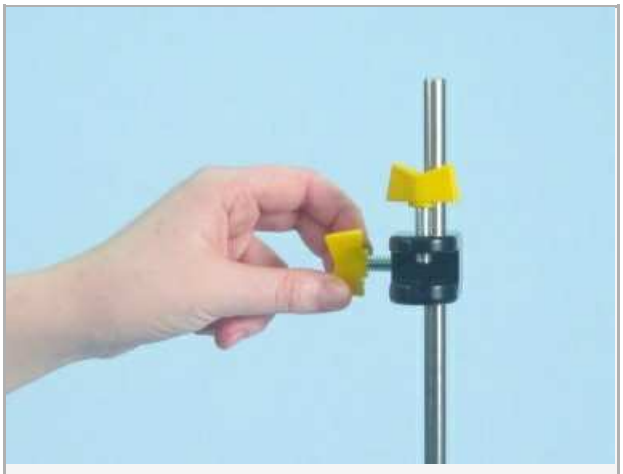
Fig. 5

Pull a piece of fish line through each of the step wheel's discs (Fig. 6, 7). Stick the axle through the step wheel (Fig. 8) and clamp

it in the bosshead (Fig. 8).

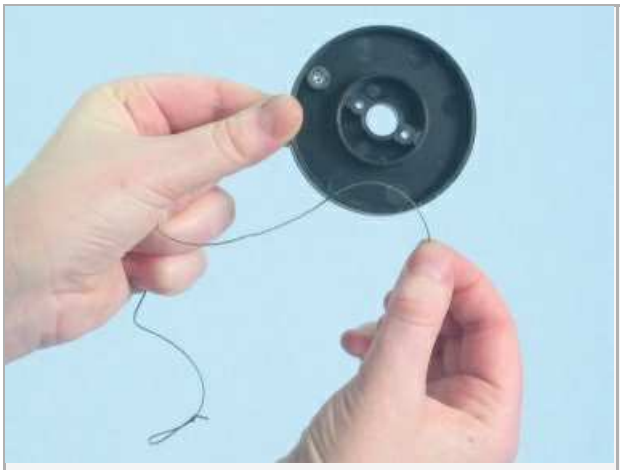

Fig. 6

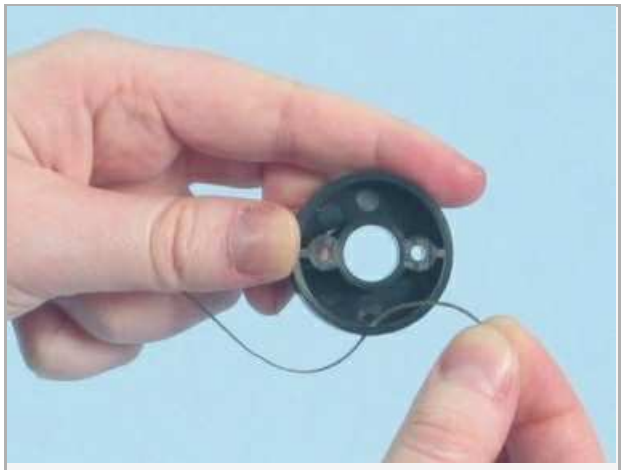

Fig. 7

Fig. 8

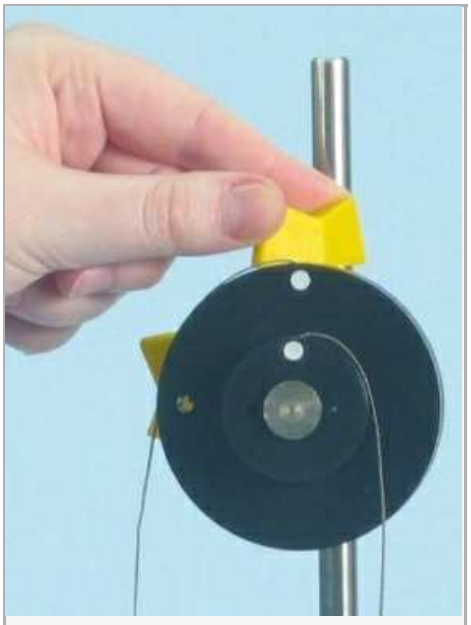

Fig. 9

Attach the spring balance to one end of the fish line, and the weight holder to the other end. Make sure that the part of fish line attached to the spring balance passes over the larger of the two discs (Fig. 10).

Hook the attachment hook of the spring balance on the 250 mm support rod in the support base (Fig. 10).

Fig. 10

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Procedure

- Load the weight holder with four 10 g mass pieces (m_{ges} = 50 g).
- Measure the force *F* which is necessary to maintain equilibrium. Record its value in Table 1 in the report.
- Repeat the measurements with masses of 100, 150 and 200 g (Fig. 11), again record the results in Table 1.

Fig. 11

- Determine the length of the load arm, l_l, and of the force arm, l_f, with the vernier caliper. Record these values above Table 1 (report).

In order to disassemble the support base, press the yellow buttons (Fig. 12).

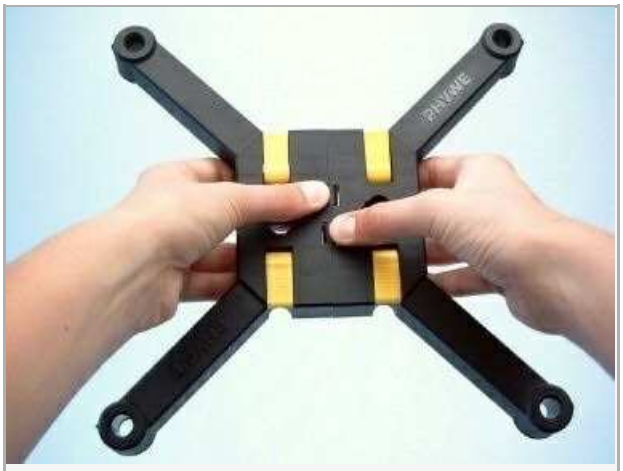

Fig. 12

Report: Force and displacement on a step wheel

Results – Table 1

Enter measured values for force F in the table.

Calculate the weight (force) F_g from the masses m and add the values to the table. ($F_g = m \times g$, where $g = 9.81$ m/s^2)

Calculate the products $F_g \times l_l$ and $F \times l_f$ and record the results in the table, too.

m in g	F in N	F_g in N	F_g x l_l in Ncm	F x l_f in Ncm
50	0	0	0	0
100	0	0	0	0
150	0	0	0	0
200	0	0	0	0
l_l	0			
l_f	0			

Evaluation – Question 1

Compare the results. What do you observe?

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Evaluation – Question 2

What can you conclude from this?

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Evaluation – Question 3

What is the ratio of the indicated value on the spring balance to the weight force, i.e. $F : F_g$?

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Evaluation – Question 4

What is the ratio of the two step wheel's discs' radii, i.e. $l_f : l_l$?

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Evaluation – Question 5

Are the two ratios equal?

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Evaluation – Question 6

Which device (that you know) can a step wheel be compared to?

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Evaluation – Additional Task 1

If the location of the load and of the spring balance are interchanged, what is the indicated value F on the spring balance (using m = 50 g)?

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