Force and displacement on a free pulley (Item No.: P1000900)

Curricular Relevance

Area of Expertise: Physik
Education Level: Klasse 7-10
Topic: Mechanik
Subtopic: Kräfte, einfache Maschinen
Experiment: Kräfte und Wege an der losen Rolle

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 determine the forces which occur on both supporting lines of a movable pulley when it is loaded with various masses.
2. Further, they should change the point of impact of the force (the force distance) and examine the effect on the load (load distance). From the measuring results they should derive the equations which are valid for movable pulleys.

Remark

The term “(slotted) weight" is incorrect inasmuch as we are dealing with a mass which becomes a weight (in reality “a weight-force") under the influence of the earth’s gravity. The term “mass piece" used here is better.

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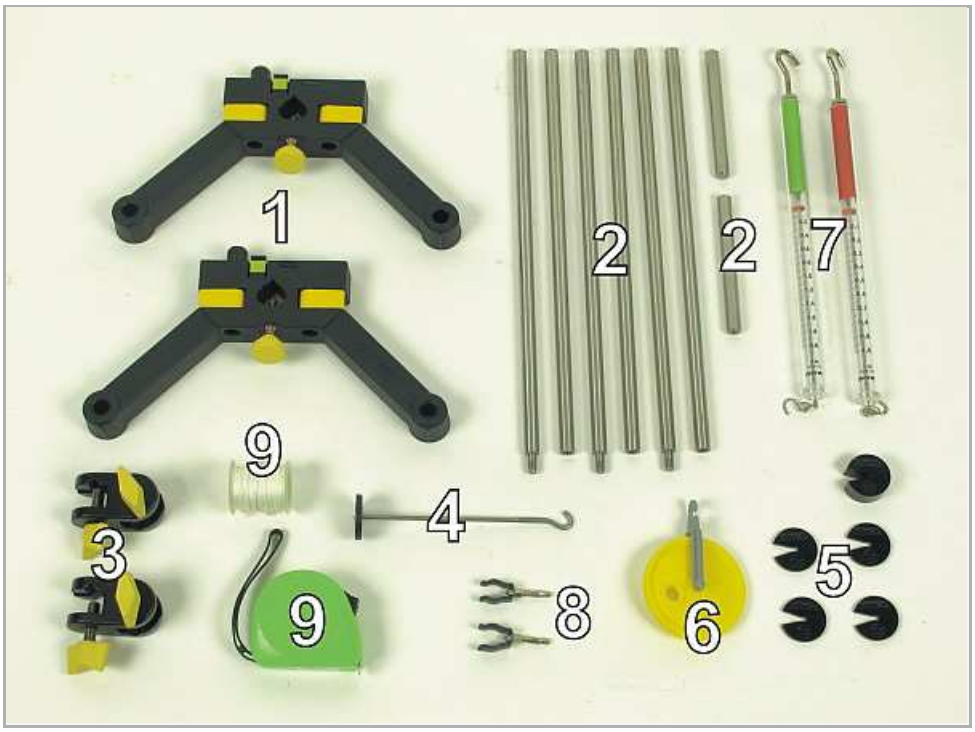
Task and equipment

Task

Which forces and distances occur on a free pulley?

You will see which forces occur on both supporting lines of a movable pulley when you load it with various masses. Furthermore, you will change the point of impact of the load. By doing this, you will derive the equations which are valid for movable pulleys.

Equipment



Position No.	Material	Order No.	Quantity
1	Support base, variable	02001-00	1
2	Support rod with hole, stainless steel, 10 cm	02036-01	2
2	Support rod, stainless steel, l = 600 mm, d = 10 mm	02037-00	3
3	Boss head	02043-00	2
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	1
6	Pulley,movable,dia.65mm,w.hook	02262-00	1
7	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	Measuring tape, l = 2 m	09936-00	1
9	Fishing line, l. 20m	02089-00	1

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Set-up and procedure

Set-up

Part 1

First screw the splitt support rods together (Fig. 1). Connect the two halves of the support base with one of the 60 cm support rods and tighten the locking levers (Fig. 2). Set the other two 60 cm support rods into the support base halves, tighten them with the locking screws (Fig. 3).

Fig. 1

Fig. 2

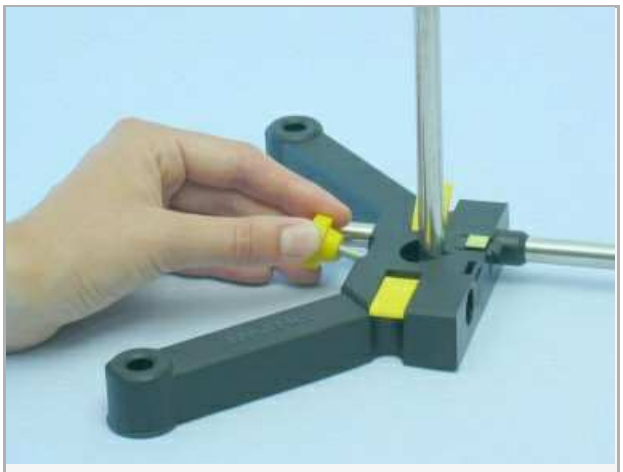

Fig. 3

Insert the spring balance holders into the short rods (Fig. 4). Fix the bossheads at the 60 cm support rods and clamp the short support rods in the bossheads. Clamp the two spring balances into place and adjust them to zero by using the screw (Fig. 5).


Fig. 4


Fig. 5

Connect the two spring balances with a piece of fish line which is about 35 cm long. Hang the movable pulley on the line and attach the weight holder to the pulley's hook (Fig. 6).


Fig. 6

Part 2

Clamp the 1 N spring balance so that the mass is just above the table top (Fig. 7).

Fig. 7

Procedure

Part 1

- Determine the weight (force) F_r of the pulley with the 1 N spring balance and record the value in the input box above Table 1 (Fig. 8).
- Load the pulley with the masses m given in Table 1 and measure the forces F_1 and F_2 (Fig. 9).

Fig. 8

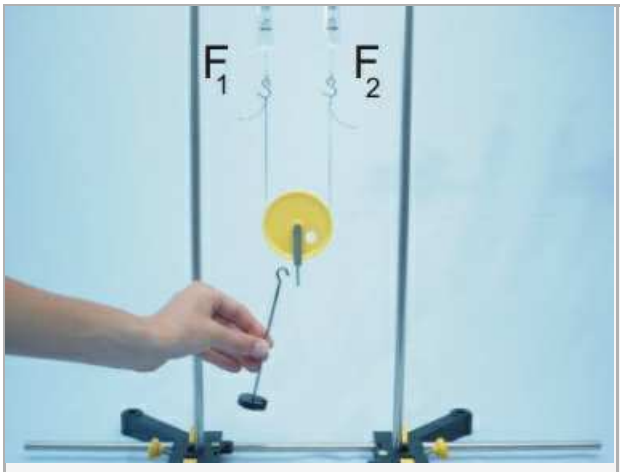

Fig. 9

Part 2

- Load the pulley with a total mass of m = 100 g and read the indicators of both spring balances F_1 and F_2 .
- Measure the 1 N spring balance's height h_f above the table top (Fig. 10); the height h_l of the load above the table top is 0.
- Move the 1 N spring balance progressively higher so that the load is about 2 cm higher with each step.
- At each new height of the load read its height h_l above the table top and the height h_f of the 1 N spring balance.
- You can also use the values for F_1 and F_2 from part 1. Record all the measured values in Table 2.

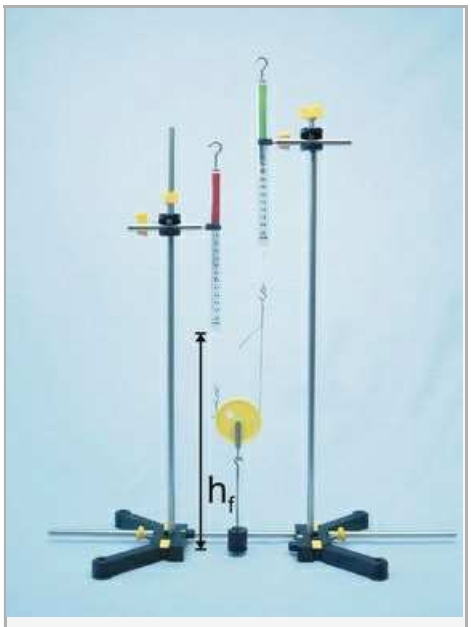

Fig. 10

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Report: Force and displacement on a free pulley

Results – Part 1

Enter the weight (force) here: F_r = ... N

Results – Table 1

Enter measured values in the Table 1.

Calculate F_g according to the above formula $F_g = m \times g + F_r$, with g = 9,81 m/s^2, and the sum of F_1 and F_2. Record all calculated value in Table 1.

m in g	F_1 in N	F_2 in N	F_g in N	$F_1 + F_2$ in N
20	0 ±0	0 ±0	0 ±0	0 ±0
40	0 ±0	0 ±0	0 ±0	0 ±0
60	0 ±0	0 ±0	0 ±0	0 ±0
80	0 ±0	0 ±0	0 ±0	0 ±0
100	0 ±0	0 ±0	0 ±0	0 ±0

Evaluation – Part 1

Compare this sum with the weight (force) F_g of the mass and the pulley.

Complete the following statement: $F_1 + F_2$ is ..... the weight (force) F_g.

Evaluation – Part 2

Enter measured values F_1 and F_2, calculate F_g according to the above formula $F_g = m \times g + F_r$ with $g = 9{,}81$ m/s^2 and enter the calculated value:

$m = 100$ g

F_1 = ...

F_2 = ...

F_g = ...

Results – Table 2

Enter the measured values in the table 2.

From the height difference of load and force calculate the load distance s_l and the force difference s_f. Add these values to table 2.

h_l in cm	h_f in cm	s_l in cm	s_f in cm
0	0 ±0	0 ±0	0 ±0
2,0	0 ±0	0 ±0	0 ±0
4,0	0 ±0	0 ±0	0 ±0
6,0	0 ±0	0 ±0	0 ±0
8,0	0 ±0	0 ±0	0 ±0
10,0	0 ±0	0 ±0	0 ±0

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Evaluation – Table 3

Form the product F_g x s_l and F_f x s_f where $F_1 = F_2 = F_f$. Record these results in the comparison table 3.

h_l in cm	$F_g \cdot s_l$ in Ncm	$F_f \cdot s_f$ in Ncm
2,0	0 ±0	0 ±0
4,0	0 ±0	0 ±0
6,0	0 ±0	0 ±0
8,0	0 ±0	0 ±0
10,0	0 ±0	0 ±0

Evaluation – Question 1

Which relationship do you notice while inspecting the products?

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Evaluation – Question 2

Which relationship exists between load distance s_l and force distance s_f?

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Evaluation – Question 3

Which relationship exists between force F_f and load F_g? Express the observed facts in words and as a formula.

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