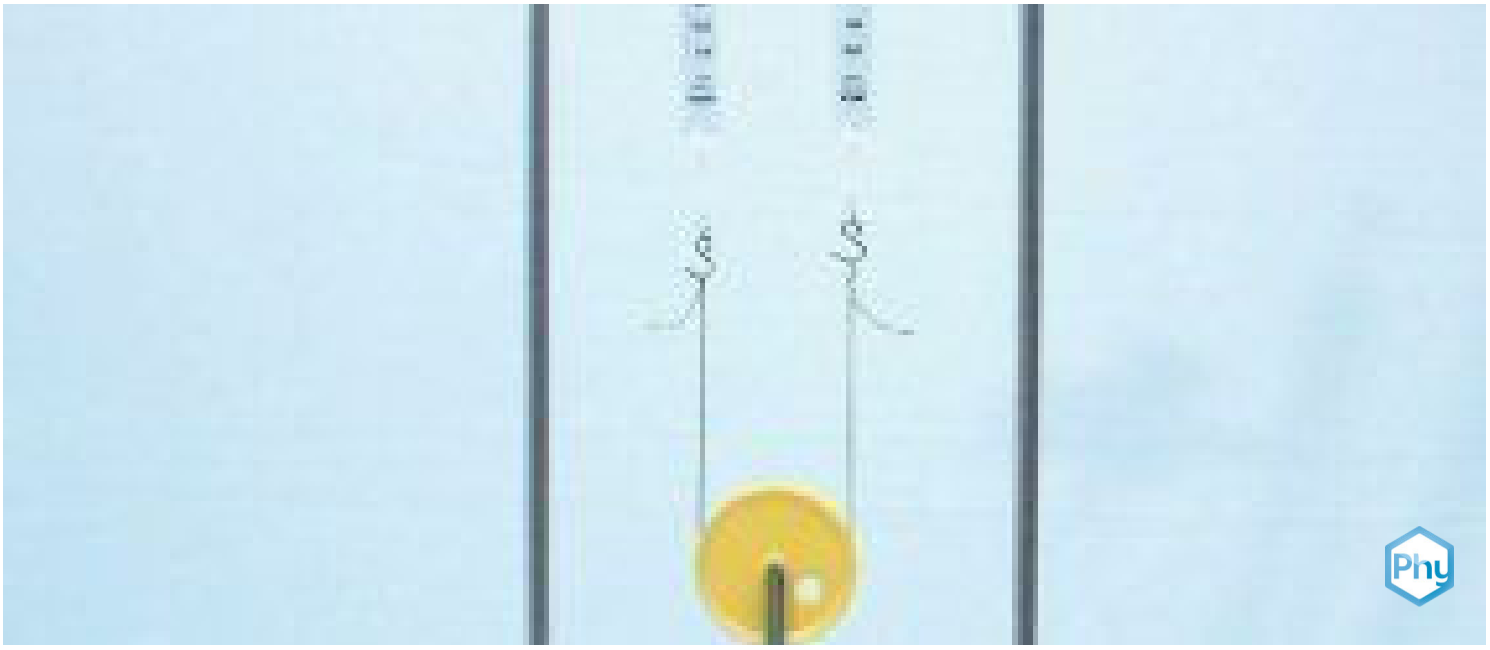
Force and displacement on a free pulley



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/5f9d962ee9913500039a886a

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Teacher information

Application

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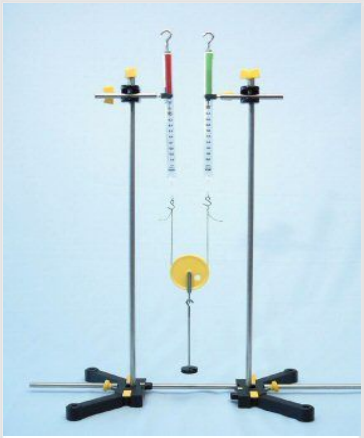

Test set-up for determining the force on a loose pulley

In this experiment, the forces acting on a rope which is laid around a deflection pulley are brought into balance.

This phenomenon is based on the fact that the forces in a rope are equal at both ends when the rope is tensioned over a frictionless pulley. Since the forces caused by friction are negligible in the context of this experiment, the pulley can be considered almost frictionless here.

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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. Ideally, students should already have a basic understanding of forces and ways of moving on a fixed roller.

Scientific

The frictional force acting between the rope and pulley F_F is neglected in the context of this experiment.

Consequently, the forces acting in the sum of the forces in the vertical direction F_y is zero.

$$\Sigma F_y = 0$$

Other teacher information (2/2)

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Learning

The students should learn which forces act on a loose pulley and how these forces are related to the resulting distances.

Tasks

1. The forces acting on a loose pulley, which occur at the two suspensions when the pulley is loaded with different masses, shall be determined.
2. The point of application of the force (the force path) should be changed and the effect on the load (the load path) should be investigated. From the measured values, the relationships that apply to the loose pulley are to be derived.

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Safety instructions

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

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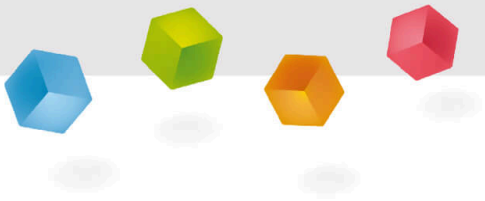

Student Information

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Motivation

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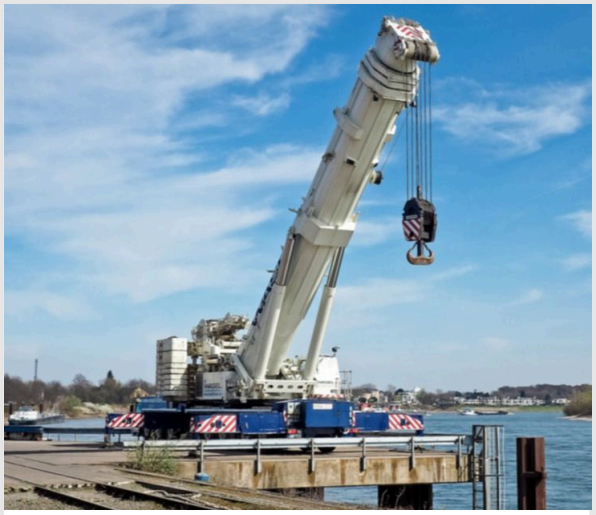

Crane with pulley block

Deflection pulleys are often used wherever heavy loads have to be lifted. The reason for this is that the ropes to which the load is attached can often only carry a certain, smaller load in order to be flexible enough to be wound onto a winch.

By deflecting at several fixed and loose pulleys (e.g. on a crane with pulley block) the load is distributed over several sections of the rope. As a result, lifting usually takes longer, since the rope can be pulled with less force, but the rope's travel distances become longer.

You will learn in this experiment the forces at work and the ways of the loose pulley.

Tasks

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- On a loose pulley you will determine the forces that occur on the two suspensions when you load the pulley with different masses.
- You will also change the point of application of the force and examine the effect on the load. This way you will find out the relationships that apply to the loose pulley.

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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	Weight holder, 10 g	02204-00	1
6	Slotted weight, black, 10 g	02205-01	4
7	Slotted weight, black, 50 g	02206-01	1
8	Pulley,movable,dia.65mm,w.hook	02262-00	1
9	Spring balance,transparent, 1 N	03065-02	1
10	Spring balance,transparent, 2 N	03065-03	1
11	Spring balance holder	03065-20	2
12	Measuring tape, l = 2 m	09936-00	1
13	Fishing line, l. 20m	02089-00	1

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Additional equipment

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Position	Equipment	Quantity
1	Scissors	1

Set-up (1/3)

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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.

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Set-up (2/3)

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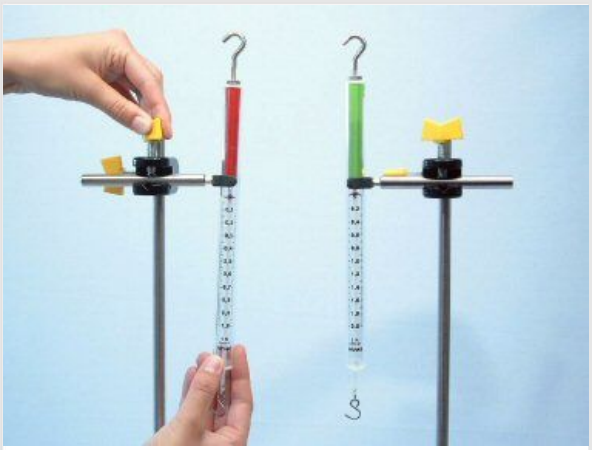
Insert the two remaining long tripod rods into one half of the tripod foot and fix them.

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

Set-up (3/3)

PHYWE



Attaching and adjusting the force gauge

Attach the double sleeves to the two vertical, long support rods at the upper end and clamp the short rods into the double sleeves with the force gauge holders.

Now clamp the two force gauges and adjust them to zero with the screws.

Prepare a piece of fishing line of about 35 cm length and knot one loop at each end.

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Procedure (1/3)

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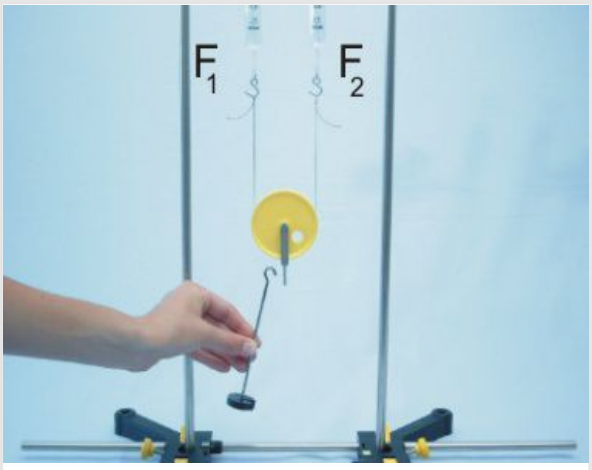
Determination of F_W of the pulley

- Determine the weight force F_W of the pulley with the dynamometer 1 N and note the value.
- Connect the two dynaometers with the fishing line and hang the loose pulley into the line.

Procedure (2/3)

PHYWE



Determination of F_1 and F_2

- Attach the weight plate to the hook on the pulley.
- Load the pulley successively with weights so that the total mass is equal to the masses given in Table 1 m and measure the forces F_1 and F_2.
  - $m_{total} = 20g,\ 40g,\ 60g,\ 80g,\ 100g$
- Note your measurement results in the table.

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Procedure (3/3)

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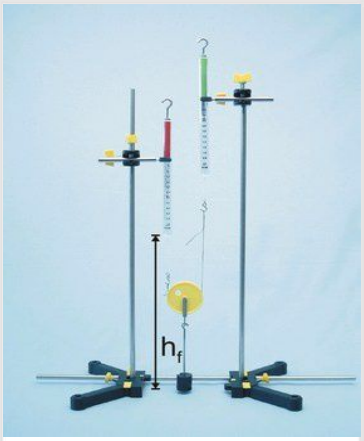

Variation of the force gauge position and load path

- Now clamp the force gauge 1 N so that the load is only just above the table top, load the roller with a total mass $m = 100\,g$ and read the readout of both force gauges F_1 and F_2 again.
- Measure the height h_f of the dynamometer 1 N above the table surface (the height h_l of the load above the table surface is 0).
- Pull the dynamometer 1 N higher step by step, so that the load is lifted by about 2 cm at a time.
- For each position of the load, read its height h_l above the table surface and the height h_f of the dynamometer 1 N. At each step, observe the measured values for F_1 and F_2. Enter all measured values in Table 2 in the protocol.

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Report

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Table 1

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Enter your measured values in the table.

$m\,[g]$	$F_1\,[N]$	$F_2\,[N]$	$F_W\,[N]$	$F_1 + F_2\,[N]$
20				
40				
60				
80				
100				

$F_{W,Pulley} = N$ ____

Calculate F_W according to the formula

$$F_W = m \cdot g + F_{W,Pulley}$$

with: $g = 9,81 \frac{m}{s^2}$

Additionally calculate the sum of F_1 and F_2.

Enter the calculated values into the table.

Table 2

PHYWE

Note your measured values in the table and calculate the load paths from the height difference to the starting position for load and force s_l and s_f and complete the table.

Enter the values here again of both force gauges and the value for F_W for $m_{total} = 100\,g$.

$F_1 = N$ ____

$F_2 = N$ ____

$F_G = N$ ____

$h_l\,[cm]$	$h_f\,[cm]$	$s_l\,[cm]$	$s_f\,[cm]$
0			
2			
4			
6			
8			
10			

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Table 3

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Calculate the product in each case $F_W \cdot s_l$ and $F_f \cdot s_f$. Enter these results in the table.

$h_l\ [cm]$	$F_W \cdot s_l\ [Ncm]$	$F_f \cdot s_f\ [Ncm]$
2		
4		
6		
8		
10		

The following applies:

$F_f = F_1 = F_2$

Task 1

PHYWE

Compare this sum $F_1 + F_2$ to the weight force F_W which has mass and role. Which statement is true?

- ○ $F_1 + F_2 = F_W$
- ○ $F_1 + F_2 < F_W$
- ○ $F_1 + F_2 > F_W$

Check

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Task 2

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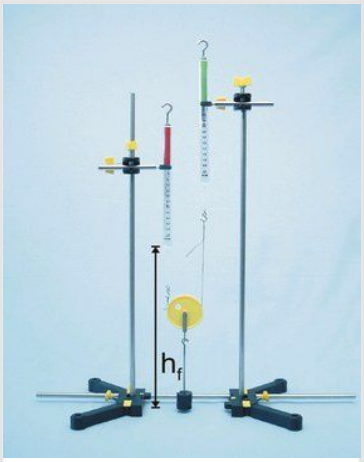


Experiment set-up

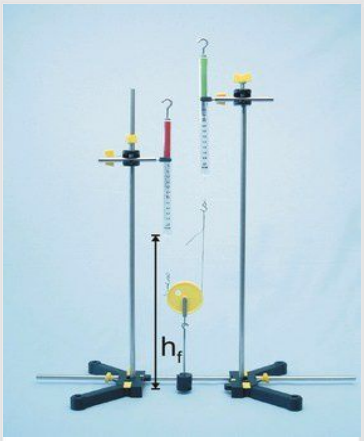
What relationship can you see when you look at the results?

- ○ $Load \cdot Loadpath = Force \cdot Forcepath$
- ○ $Load \cdot Loadpath < Force \cdot Forcepath$
- ○ $Load \cdot Loadpath > Force \cdot Forcepath$

Check

Task 3

PHYWE



Experiment set-up

What is the relationship between load path s_l and force path s_f?

- ○ $s_f = s_l$
- ○ $s_f = 2 \cdot s_l$
- ○ $s_l = 2 \cdot s_f$

Check

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Task 4

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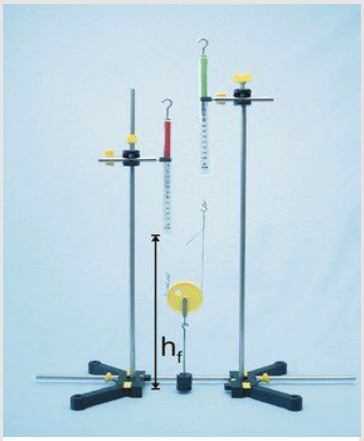

Experiment set-up

What is the relationship between the forces F_f and F_W?

- ○ $F_f = F_W$
- ○ $F_f = 2 \cdot F_W$
- ○ $F_W = 2 \cdot F_f$

Check

Slide	Score / Total
Slide 21: Comparison of the forces	0/1
Slide 22: Comparison of the products	0/1
Slide 23: relation between \(s_l\) and \(s_f\)	0/1
Slide 24: relation between \(F_f\) and \(F_G\)	0/1

Total amount 0/4

Solutions Repeat Exporting text

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