Hoist formed from a free and a fixed pulley

Physics | Mechanics | Forces, work, power & energy

Difficulty level	Group size	Preparation time	Execution time
medium	2	10 minutes	20 minutes

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Teacher information

Application

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Test setup of the pulley block

Physically, the work W is defined as an integral of force $\vec{F}$ from point 1 to point 2.

$$W = \int_{1}^{2} \vec{F} \cdot d$$

$vecs$

Now, assuming that the force $\vec{F}$ acts in such a constant way, the work can be expressed in a simplified way as the product of the force F and the way s.

$$W = F \cdot s$$

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Other teacher information (1/2)

Prior knowledge

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 the forces and paths on a fixed/loose pulley.

Scientific principle

Due to the previously described relationship between force F and way s with regard to the work to be done W the force required to lift a mass can be halved if the distance travelled is doubled. The pulley block makes use of this simple principle.

Other teacher information (2/2)

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Learning objective

Using the example of a simple pulley block, the students should realise that the force required to lift a given load can be halved in relation to the weight of the load using an arrangement of two pulleys. However, a longer distance must be applied for this.

Tasks

1. Set up a pulley block and understand how it works.
2. Lift different loads by means of the pulley block and determine the magnitude of load and force for each.
3. Lift a load and determine the necessary path of load and force.

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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, while the rope can be pulled with less force, the rope's travel distances become longer.

In this experiment you will learn about the forces at work and the ways of a pulley block.

Tasks

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- Build a simple pulley block from a loose and a fixed pulley and familiarize yourself with its mode of operation.
- Lift different loads with the pulley block and determine the load and force values.
- Lift a load with the pulley block and determine the paths of load and force.

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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	Weight holder, 10 g	02204-00	1
6	Slotted weight, black, 10 g	02205-01	4
7	Slotted weight, black, 50 g	02206-01	3
8	Pulley,movable,dia.65mm,w.hook	02262-00	1
9	Pulley,movable,dia.40mm,w.hook	03970-00	1
10	Rod for pulley	02263-00	1
11	Spring balance,transparent, 2 N	03065-03	1
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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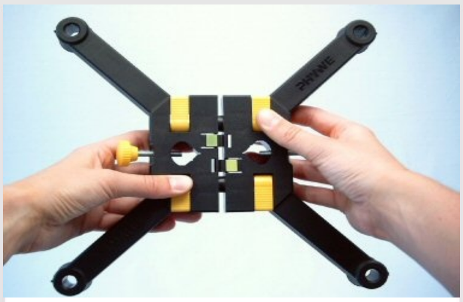
First screw together the parts of the stand rod and put the two stand foot halves together.

Push the 25 cm tripod rod through the hole in the tripod base and fix it with the lever.

Fix the long stand rod vertically in the stand foot.

Screwing the support rods



Mounting the half of the tripod foot

Fasten the support rods in the foot

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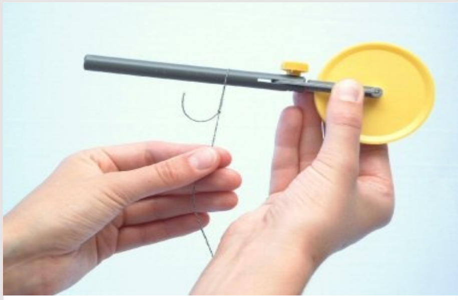
Set-up (2/3)

Cut a piece of string about 120 cm long with a loop at each end.

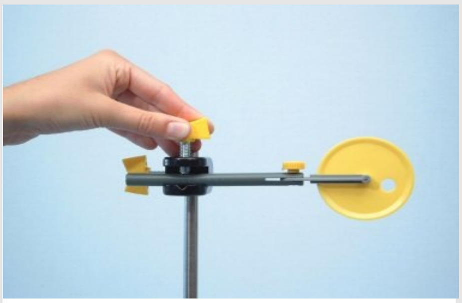
Attach the pulley ($d = 65\,cm$) to the "Pulley-Handle" and attach one end of the cord to the handle.

Now clamp the handle to the long support rod using the double sleeve.

Attaching the pulley to the handle



Attaching the cord



Clamp the handle in the support rod

Set-up (3/3)

Experiment set-up

Complete the pulley:

Use the small pulley ($d = 40\,mm$).

Thread the loose end of the string first through the small pulley and then through the large pulley.

Adjust the force gauge upside down to zero in the operating position.

Hang the end of the cord last to the dynamometer 2 N and fix it to the tripod rod 25 cm.

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Procedure (1/4)

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Loading the loose pulley

- Determine the weight force $F_{W,Pulley}$ of the loose pulley and note the value over table 1 in the protocol.
- Then hang so many weights from the weight plate on the loose pulley that the load is 50 g, 100 g, 150 g and finally 200 g in succession. Determine the respective forces for each mass F at the loose rope end and enter the measured values in Table 1.
- To hang the slotted weights on the weight plate, slide them over the top of the weight plate.

Procedure (2/4)

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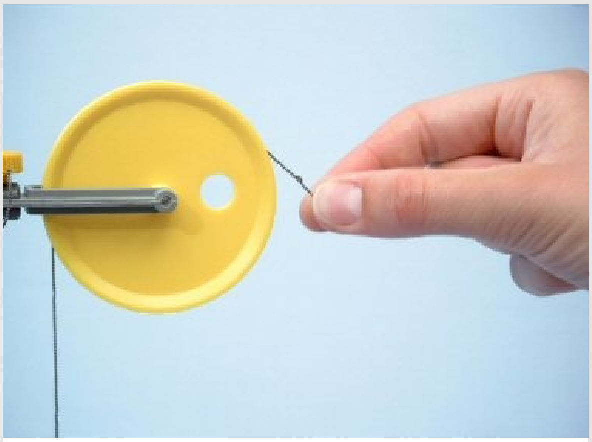

Remove the dynamometer from the pulley

- Take a load of 100 g and remove the dynamometer.
- Let the load rest on the table surface and tighten the cord.
- Adjust the height of the fixed pulley so that its marking point points to the right.
- Tie a knot in the cord at the point of the mark on the fixed pulley.

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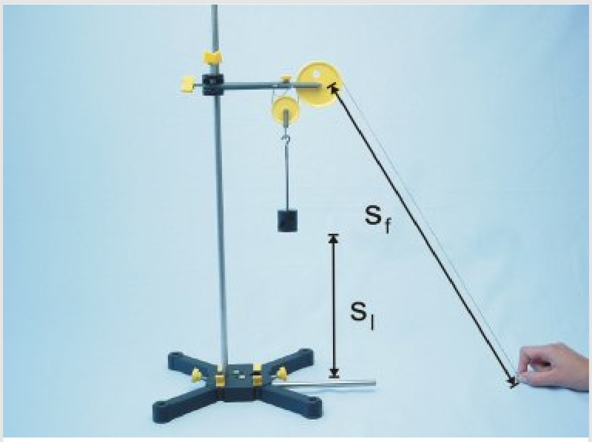
Procedure (3/4)



Measuring the distances travelled

- Pull down the loose end of the string as far as possible diagonally and measure the length of the string s_f between the marker knot and the right side of the fixed pulley.
- Also measure the track s_l around which the load was lifted.
- Note the measured values in the protocol.

Procedure (4/4)

Disassembling the tripod base

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

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Report

Table 1

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Enter the values for the measured force F into the table and calculate the total weight of the load F_W from the sum of the calculated weight force F_m of the masses and the loose pulley $F_{W,Pulley}$.

$m\ [g]$	$F\ [N]$	$F_m\ [N]$	$F_W\ [N]$
50			
100			
150			
200			

Enter the weight here $F_{W,Pulley}$.

$F_{W,Pulley} = N$ ☐

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Table 2

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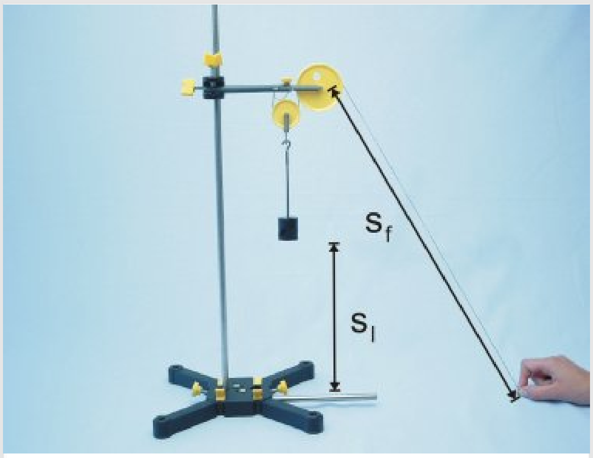
Enter your measured values from the 2nd part of the experiment (without force gauge) here. For this purpose, use the data from the first part of the experiment for $m = 100\,g$ certain forces. The product of path and force is called work.

$s_l = cm$	
$s_f = cm$	
$s_l \cdot F_W = Ncm$	
$s_f \cdot F = Ncm$	



Determination of the distances covered

Task 1

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Experiment set-up

Compare F_W with F. What do you find?

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

Check

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Task 2

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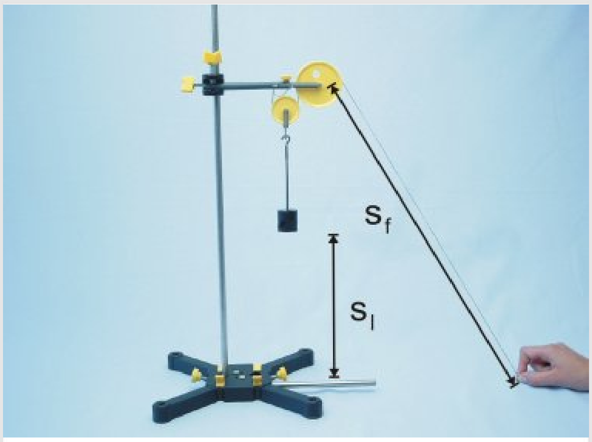

settlement of s_l and s_f

Compare s_l with s_f. What relationship can you see between the two?

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

Check

Task 3

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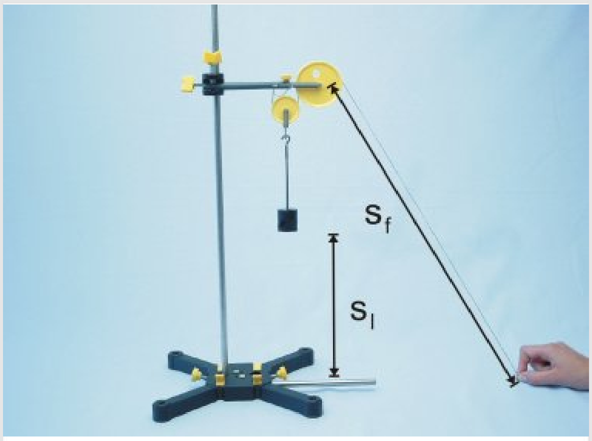

settlement of $s_l \cdot F_G$ and $s_f \cdot F$

Compare the products $Load \cdot Loadpath$ and $Force \cdot Forcepath$ with each other. What relationship can you discern between the two?

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

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Task 4

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Experiment set-up

Can force be saved with a simple pulley block?

- No, with the help of a pulley block, the force required to lift a load becomes greater. However, the work is reduced.
- Yes, the force required to lift a load can be reduced by using a pulley block. However, the overall work remains the same.
- No, when lifting a load with a pulley block the required force remains the same. However, the work is reduced.

Check

Task 5

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Experiment set-up

What about the distance you had to travel with the string?

- Due to the pulley block, the distance that had to be covered to lift the load becomes longer.
- Due to the pulley block, the distance that had to be covered to lift the load was reduced.

Check

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Slide	Score / Total
Slide 21: settlement of \(F\) and \(F_G\)	0/1
Slide 22: settlement of \(s_l\) and \(s_f\)	0/1
Slide 23: Comparison of the way-force products	0/1
Slide 24: Power saving	0/1
Slide 25: Change in distance travelled	0/1

Total amount 0 / 5

Solutions Repeat Exporting text

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