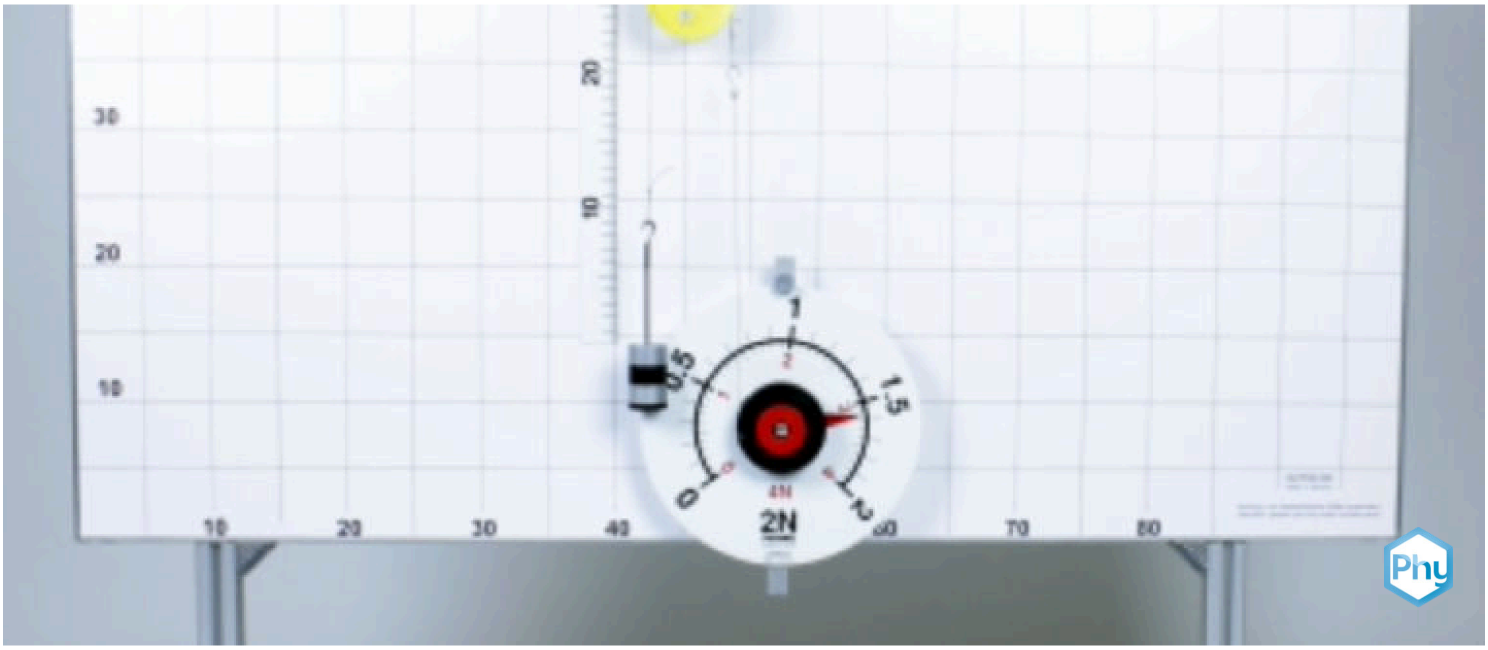
Fixed pulley



P1253800

Physics > Mechanics > Forces, work, power & energy

Difficulty level	Group size	Preparation time	Execution time
easy	-	10 minutes	10 minutes

This content can also be found online at:

http://localhost:1337/c/6641c041b9e82b00020835c6

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General information

Application

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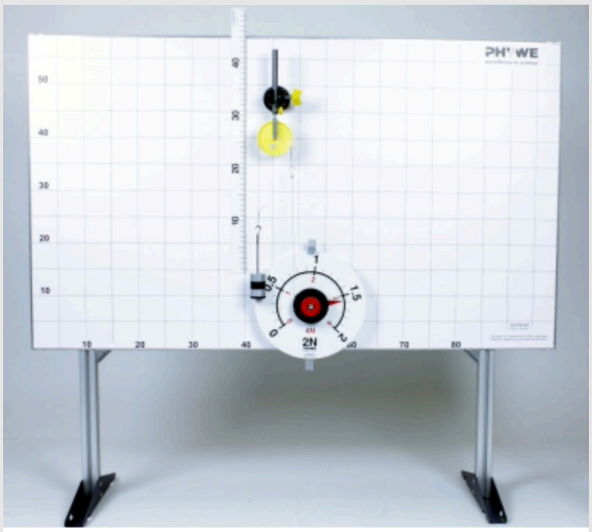

Fig. 1: Experimental setup

A pulley is a force transducer and machine element consisting of a wheel that is mounted on an axle with as little friction as possible. The fixed pulley is attached to a point and is used to lift and move a load.

The fixed pulley is used in various areas, e.g. on a ski lift. There, the rope is pulled over a fixed pulley for the drag lift, and at construction sites, for example, full buckets are sometimes pulled up over a fixed pulley.

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Other information (1/2)

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Prior knowledge

Students need prior knowledge of "fixed pulleys".

Principle

The advantages of a fixed pulley in the performance of mechanical work and the relationship between forces and distance are to be investigated.

Other information (2/2)

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Learning objective

The aim of this experiment is for the students to understand through examples how the fixed pulley works.

Tasks

The task of this experiment is for the students to determine the force weight F_2, the force measured by the dynamometer F_1, pulling path s_1 and load path s_2 and compare them in order to discover the relationship between forces and distances.

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Safety instructions

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The general safety instructions for experimentation in science lessons apply.

Theory

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The fixed pulley is attached to a fixed point and is used to lift or move a load.

With a fixed pulley, only the direction of this force is changed, which is why they are also called deflection pulleys. The required tensile force is just as great as the force exerted by the load:

$$F_Z = F_L$$

And the tensile force and load path are the same size:

$$s_Z = s_L$$

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Equipment

Position	Equipment	Item no.	Quantity
1	PHYWE Demo Physics board with stand	02150-00	1
2	Clamp on fixing magnet	02151-01	1
3	Torsion dynamometer	03069-03	1
4	Scale for demonstration board	02153-00	1
5	Pointers f. Demonst.Board, 4 pcs	02154-01	1
6	Weight holder, 10g	02204-01	1
7	Slotted weight, silver-bronze, 50 g	02206-03	1
8	Slotted weight, silver-bronze, 50 g	02206-03	1
9	Pulley,movable,dia.65mm,w.hook	02262-00	1
10	Rod for pulley	02263-00	1
11	Fish line, l. 100m	02090-00	1
12	Screw clamp	02014-01	2

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Setup and procedure

Setup

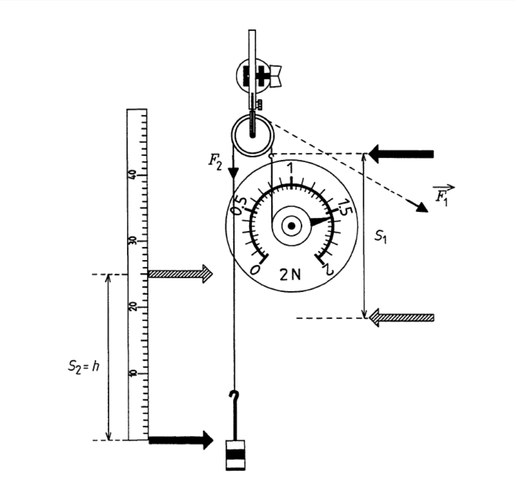

Fig. 2: Experimental setup

Apply the scale to the demo board on the left and place the clamp on fixing magnet with the handle and the pulley next to it on the upper edge (Fig. 2).

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Setup

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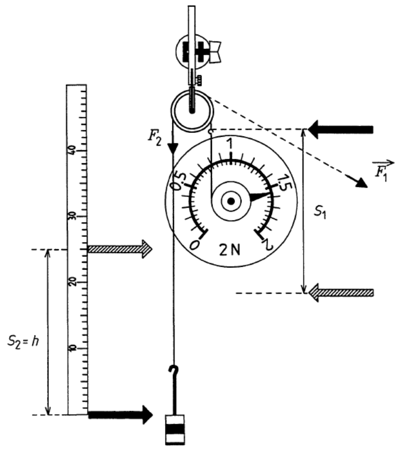

Fig. 2: Experimental setup

Apply the scale to the demo board on the left and place the clamp on fixing magnet with the handle and the pulley next to it on the upper edge (Fig. 2).

Procedure (1/2)

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- Attach the dynamometer underneath the pulley, on the lower part of the demo board, attach the weight holder loaded with three 50 g slotted weights and measure $F_G = F_2$ for the loaded weight holder; note the value for F_2 (1)
- Move the dynamometer slowly and evenly upwards (to the position shown in Fig. 2) and measure the force F required to perform the lifting work on the weight holder; note F (2)
- Place a cord about 50 cm long with loops at the ends over the pulley, hook the loaded weight holder and the pull cord of the dynamometer into the loops (see Fig. 2); note the force F_1 which is required when the pulley is in equilibrium, and the statement (3)
- Mark the position of the weight holder with an arrow and place a second arrow of the same colour slightly higher, e.g. 25 cm.

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Procedure (2/2)

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- Mark the position of the hook on the pull cord of the dynamometer with one of the differently coloured arrows.
- Move the dynamometer evenly downwards until the weight holder raised to the intended height $h = s_2$; observe the dynamometer and measure the force required to perform the lifting work F_1; note F_1 and F_2 and $s_2 = h$ (4)
- Mark the current position of the hook on the pull cord of the dynamometer with a fourth arrow (dotted line in Fig. 2); measure and note the path s_1 which was travelled with the application of force F_1 (4)
- Lower and raise the weight holder, but let $\overrightarrow{F_1}$ act in a different direction (see direction indicated in Fig. 2) and observe the dynamometer; repeat the process several times if necessary and note the observation (5)

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Report

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Observation

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1. $F_G = F_2 = 1,54N$

2. $F = 1,54N$

There is equilibrium when

3. $F_1 = 1,54N$

4. $F_1 = 1,54N = F_2$ $F_1 = 1,62N$

$F_2 = 1,54N$ $s_1 = 25cm$

$s_2 = 25cm$

5. F_1 always has the same value, regardless of the direction in which the force $\overrightarrow{F_1}$ acts.

Evaluation (1/2)

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A fixed pulley is in equilibrium when $F_1 = F_2$, i.e. if the tensile force is equal to the weight force of the load.

If lifting work is performed on a body without the use of a pulley, the tensile force is equal to the weight of the body. If the lifting work is performed with the aid of a fixed pulley, a slightly greater force is required. This is due to the friction that occurs on the axis of the moving pulley.

The measured values show the distances travelled using the force F_1:

$s_1 = s_2$

for the work involved:

$W_1 = F_1 \cdot s_1 = 1,62N \cdot 0,25m = 0,40Nm$

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Evaluation (2/2)

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for the work performed:

$W_2 = F_2 \cdot s_2 = 1,54N \cdot 0,25m = 0,38Nm$

If the friction were to be minimised to a negligible level through good pulley bearings, then the following would apply:

$W_1 = W_2$,

i.e. the work invested is equal to the work performed, in this case the lifting work.

So, the amount of work needed or the force to be applied can not be reduced with a pully. In fact, a little more is needed to overcome the friction that always occurs during movement. But with a fixed pulley, the direction of force can be changed, which in practice often means a considerable advantage in mechanical work.

Remarks

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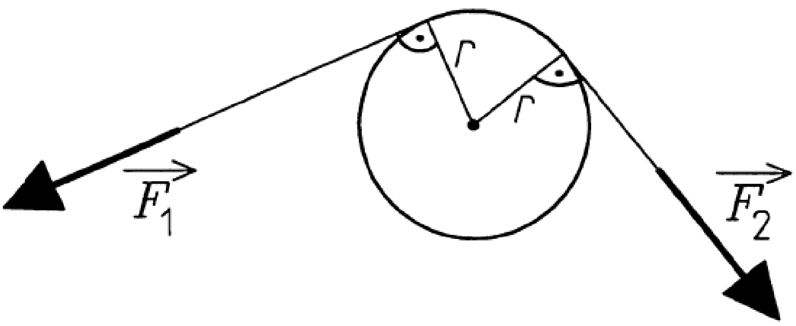

Fig. 3

The equilibrium condition for the fixed pulley, $F_1 = F_2$, can - if the torque has been covered - be directly visualised with the aid of Fig. 3: The force arms $\vec{F_1}$ for $\vec{F_2}$ and are of equal length (equal to the radius of contact of the lines of action tangential to the circle), i.e. also F_1 and F_2 are the same size.

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Task

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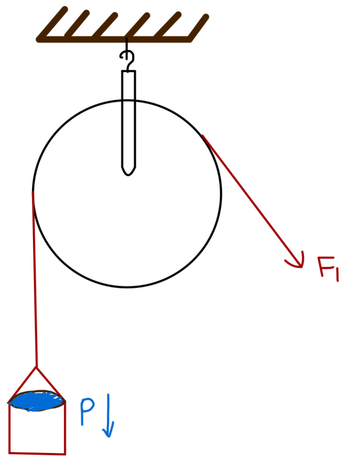

Fig. 4

Figure 4 illustrates the deflection of the force via a pulley.

How much force F_1 must be applied to lift the bucket of water whose weight is P = 50N?

- 50 N
- 60 N
- 30 N

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