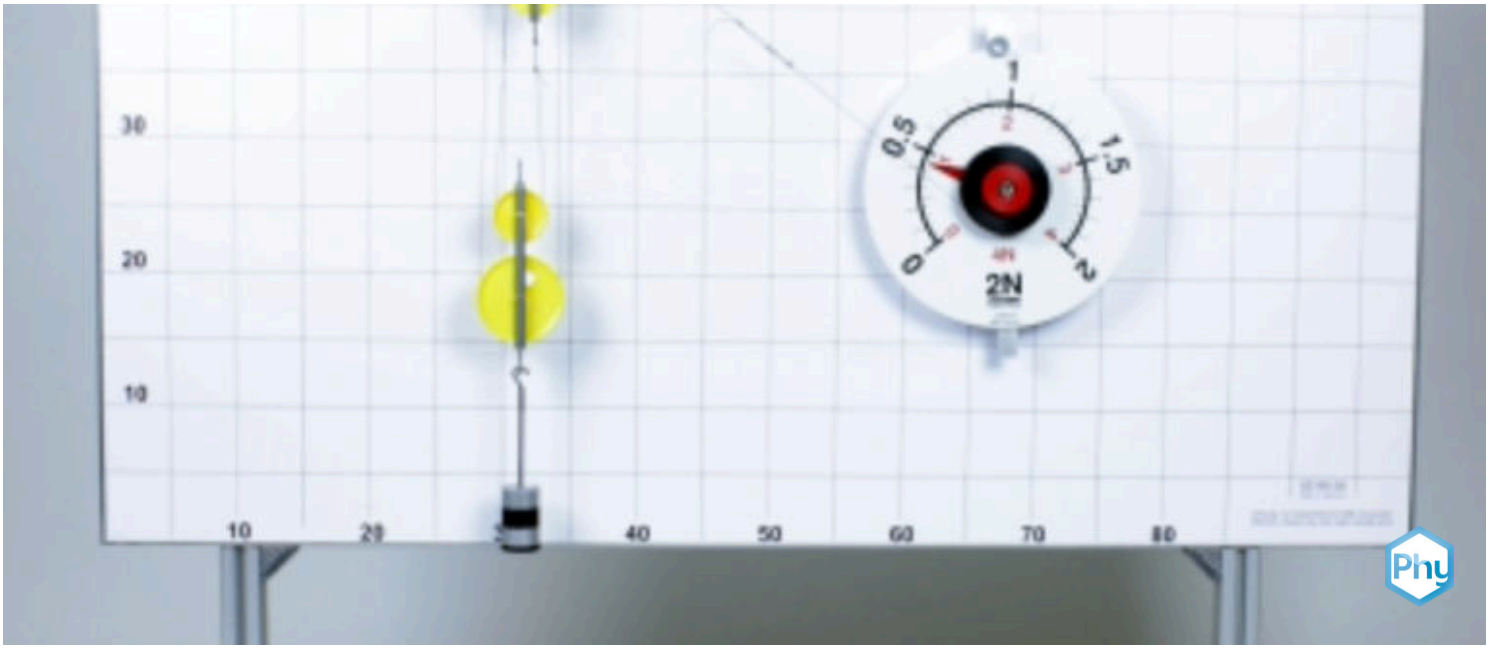
Block and tackle



P1254000

Physics > Mechanics > Forces, work, power & energy

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

This content can also be found online at:

http://localhost:1337/c/66431bc5e0f582000285b2ae

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General information

Application

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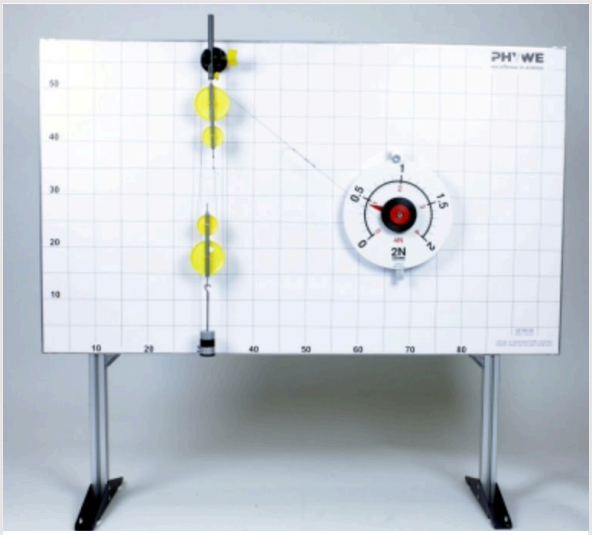

Fig. 1: Experimental setup

A block and tackle, or just tackle, is a machine that reduces the amount of force to be applied, e.g. for moving loads. The tackle consists of fixed and loose pulleys and a rope.

The tackle can effectively reduce the amount of force to be applied, which is why it is often used as part of a larger mechanism, such as a crane.

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Other information (1/2)

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Prior knowledge

The students need prior knowledge of the block and tackle. It is necessary that the students are already familiar with the basics of fixed and loose pulleys.

Principle

The aim is to investigate the advantages of a tackle when carrying out mechanical work and the relationships between forces and distances in relation to the number of load-bearing rope sections.

Other information (2/2)

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Learning objective

The aim is for students to understand the principle and function of the tackle as an example. Students are supposed to understand why the use of tackles significantly reduces the force required.

Tasks

The students are supposed to measure, record and compare the weight force F_G, tractive force F_1, pulling distance s_2 and load path s_1. Afterwards, the students can deduce relationships between forces and distances depending on the number of load-bearing rope sections.

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Safety instructions

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The general safety instructions for experimentation in science lessons apply.

Theory (1/2)

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A tackle is a machine that reduces the amount of force to be applied, e.g. to move loads. The tackle consists of fixed and loose pulleys and a rope.

There is the principle of the block and tackle:

1. $F_Z = 1/n \cdot F_L$

2. $s_Z = n \cdot s_L$

3 The golden rule of mechanics applies to blocks and tackles, as it does to all force-forming devices: What is saved in force must be added in distance.

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Theory (2/2)

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$W_Z = W_L$

$F_Z \cdot s_Z = F_L \cdot s_L$

F_Z= tractive force; (F_L \) = force through the load

s_Z= pulling distance; (s_L \) = load path

W_Z= required work; W_L = work on the load

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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	Rod for pulley	02263-00	1
10	Block and tackle, with 4 pulleys	02265-00	1
11	Marker, black	46402-01	1
12	Screw clamp	02014-01	2

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Setup and procedure

Structure and procedure (1/2)

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- Load the weight holder with three 50g slotted weights.
- Place the dynamometer on the demo board and determine the weight force $F_G = F_2$ for the loaded weight holder, including a block and tackle with 2 pulleys; note F2 (1)
- Place the clamp on fixing magnet with the rod for pulley on the demo board top left.
- Place the cord for the tackle over the pulleys and set up the experiment as shown in Fig. 2 (length of the cord with two loops approx. 160 cm); Compare F_1 with F_2 (2)

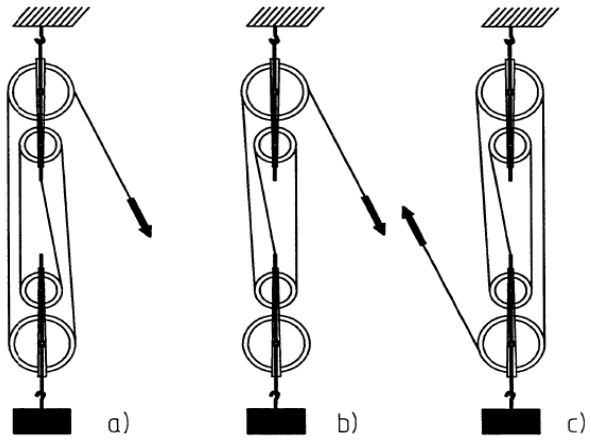

Fig. 2: Experimental setup

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Structure and procedure (2/2)

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- Mark the position of the weight holder (top point of the hook) and the dynamometer (hook of the pull cord - see Fig. 2) with arrows of different colours.
- Slowly and evenly move the dynamometer towards the bottom right-hand corner of the demo board; measure and record the force. (3)
- Mark the current position of the hook on the weight holder and the hook on the pull cord with arrows of the respective colour.
- Draw the path (lifting height) s_2 for the load and force path s_1 on the demo board; measure and note down s_1 and s_2 (3)
- Repeatedly lift the dynamometer and perform the lifting work with differently directed forces $\overrightarrow{F_1}$; observe the dynamometer and note down the observations. (4)

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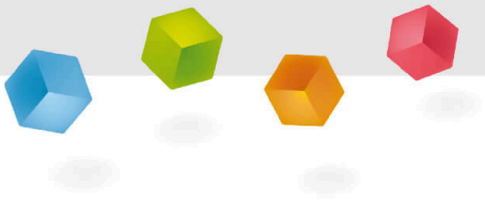

Report

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Observation

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(1) $F_G = F_2 = 1,78N$

(2) $F_1 = 0,44N$

$F_1 = F_2/4$

(3) $F_1 = 0,47N$

$s_1 = 60cm$

$s_2 = 15cm$

(4) F_1 always has the same value of 0.47 N.

Evaluation (1/3)

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A block and tackle with 4 pulleys is in equilibrium when the tractive force is 1/4 of the weight force of the load:

$F_1 = F_2/4.$

This is because the weight force for the load is distributed over 4 load-bearing rope sections, as the tackle has 2 loose pulleys.

For a loose pulley, the equilibrium condition

$F_1 = F_2/2.$

is found. Using 3 loose rolls

$F_1 = F_2/6$ would apply

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Evaluation (2/3)

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for n loose rolls

$F_1 = F_2/n.$

The number of load-bearing rope sections is important for the tackle!

When performing mechanical work (lifting work in the experiment), F_1 must be greater than required for equilibrium, because during movement the tractive force F_1 also has to compensate for the frictional forces that always occur at the bearings of the pulleys.

The measurements also show that

$s_1 = 4s_2.$

Evaluation (3/3)

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The following applies to the work:

Work required $= F_1 \cdot s_1 = 28Ncm = W_1$,

Work performed $= F_2 \cdot s_2 = 27Ncm = W_2.$

The work required W1 is slightly greater than the work performed W_2.

If the frictional force can be kept negligible in comparison, the following applies:

$F_1 \cdot s_1 = F_2/4 = F_2 \cdot s_2$ or $W_1 = W_2$

To summarise, the following applies to a block and tackle with 2 loose pulleys: The required tractive force is 1/4 of the weight force for the load; in return, but the force path is 4 times greater than the path of the load (the lifting height). You cannot save labour with a clock and tackle, but you can make mechanical work much easier, especially as the direction in which the tractive force acts is arbitrary.

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Remarks

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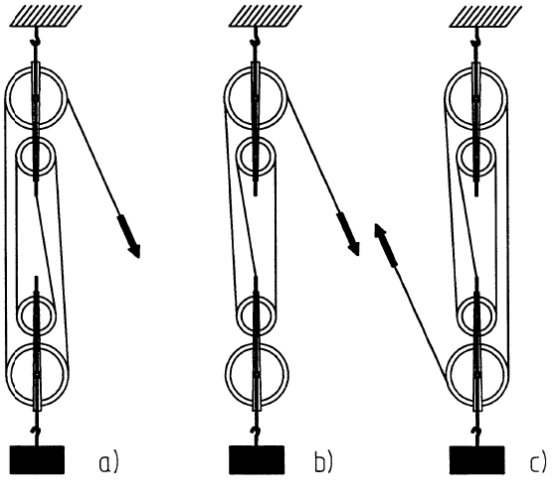

Fig. 3

It must be made clear that the force to be applied to a tackle is not determined by the number of pulleys, but by the number of load-bearing rope sections. Fig. 3 shows how this can be further clarified - if necessary, also as an experiment: With the same tackle $F_1 = F_2/4$ or $F_1 = F_2/3$ or $F_1 = F_2/5$ can apply, depending on whether the rope guide is selected according to case a) or b) or c).

If the tackle with 6 pulleys (order no. 02264-00) is available, it can also be demonstrated that with 3 loose pulleys and 6 load-bearing ropes $F_1 = F_2/6$ applies.

Task

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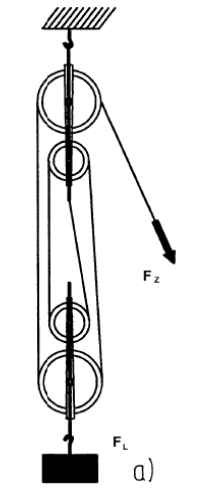

Fig. 4

Given are $F_L = 50N$.

How many loose pulleys are there? Can you still calculate F_Z?

- n = 2 ; F_Z = 25 N
- n = 4 ; F_Z = 25 N
- n = 4 ; F_Z = 12,5 N
- n = 2 ; F_Z = 12,5 N

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Slide	Score / Total
Slide 18: Number of loose pulleys	0/1

Total score 0 / 1

Show solutions Repeat

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