Block and tackle with four pulleys (Item No.: P1001100)

Curricular Relevance

Area of Expertise: Physik
Education Level: Klasse 7-10
Topic: Mechanik
Subtopic: Kräfte, einfache Maschinen
Experiment: Flaschenzug mit 4 Rollen

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	10 Minutes	20 Minutes	2 Students

Additional Requirements:

- Scissors
- Felt-tip pen

Experiment Variations:

Keywords:

Task and equipment

Information for teachers

Additional Information

Using a block and tackle as an example, the students should observe that the force, which is necessary to lift a given load, decreases in direct correlation with the number of pulleys.

1. They should determine how much larger the weight force of the load is compared to the force which is necessary to maintain equilibrium, and whether there is a connection between this and the number of pulleys of a block and tackle.
2. They should investigate whether the load distance differs from the force distance and form the product $F \times s$. Additionally, they should be able to say whether the number of pulleys is important here, too.

Remarks

1. The term "(slotted) weight" is incorrect inasmuch as we are dealing with a mass which becomes a weight (or more precisely a "weight force") under the influence of gravity. The term "mass piece" used here is better.
2. Physically speaking, the product $F \times s = W$ represents work. In this context one can introduce the terms "lifting work" and the "laws of conservation of force" in preparation for experiment Work on an inclined plane (P1001400).
3. In industrial versions of a block and tackle, the pulleys are arranged not in vertical pairs but rather in horizontal ones. For this type of arrangement the names "shells" or "blocks" are used.

Block and tackle with four pulleys (Item No.: P1001100)

Task and equipment

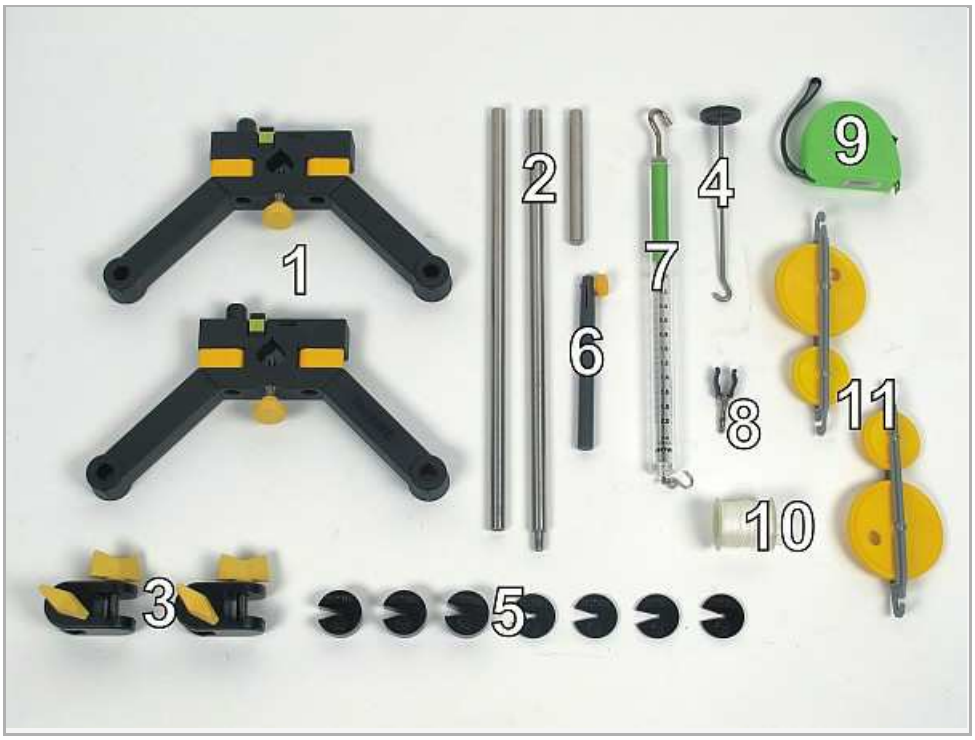
Task

How can heavy loads be lifted more easily?

A block and tackle consists of a combination of one fixed and one movable pulley or several fixed and movable pulleys. In this experiment a block and tackle with 2 fixed and 2 movable pulleys will be investigated.

You will determine experimentally how much force is required to lift a load with the block and tackle. Then you will investigate how long the force distance must be to lift a load a specific distance (this is called the load distance).

Equipment



Position No.	Material	Order No.	Quantity
1	Support base, variable	02001-00	1
2	Support rod, stainless steel, l = 600 mm, d = 10 mm	02037-00	1
2	Support rod with hole, stainless steel, 10 cm	02036-01	1
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	3
6	Rod for pulley	02263-00	1
7	Spring balance,transparent, 2 N	03065-03	1
8	Spring balance holder	03065-20	1
8	Measuring tape, l = 2 m	09936-00	1
10	Fishing line, l. 20m	02089-00	1
11	Pulleys, double in line	02266-00	2
Additional material			
	Scissors		1
	Felt-tip pen		

Set-up and procedure

Set-up

- Before you set up the experiment, determine the weight (force) F_r of a double pulley with the spring balance (Fig. 1) and record the value in the report.

Fig. 1

- Screw the splitt 600 mm support rod together (Fig. 2). Set up a stand with the support base (Fig. 3), the 600 mm support rod (Fig. 4) and the bosshead (Fig. 5).
- Fix the pulley into the pulley rod (rod for pulley) (Fig. 6) and attach the rod to the bosshead.

Fig. 2

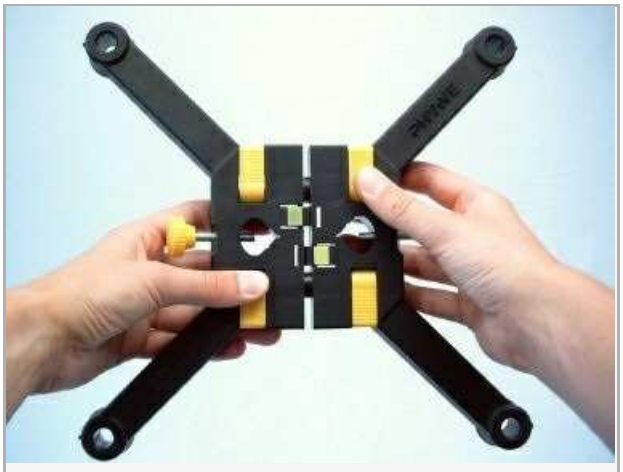


Fig. 3

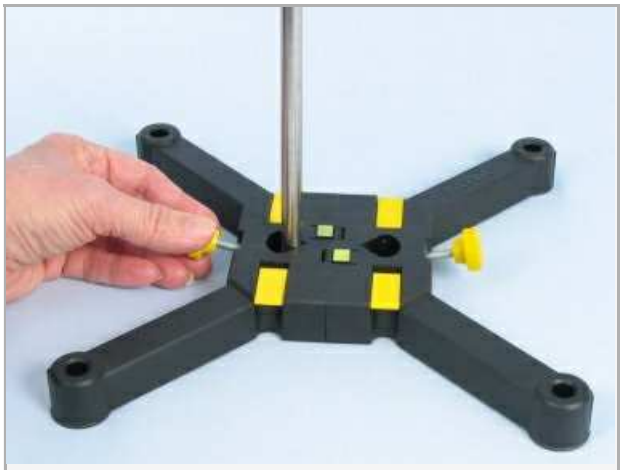


Fig. 4


Fig. 5


Fig. 6

- Fix a second bosshead to the lower part of the 600 mm support rod (Fig. 7).
- Insert the spring balance holder into the short rod (Fig. 8) and clamp the latter into the bosshead (Fig. 9).


Fig. 7


Fig. 8

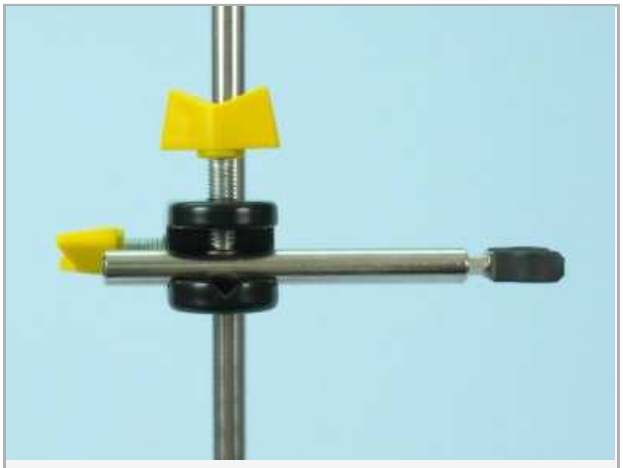


Fig. 9

- Attach a piece of fish line of approx. 110 cm length to the hook of the upper, fixed pulley (Fig. 10).
- Thread the line through the 4 pulleys as shown in Fig. 11 - 14.

Fig. 10

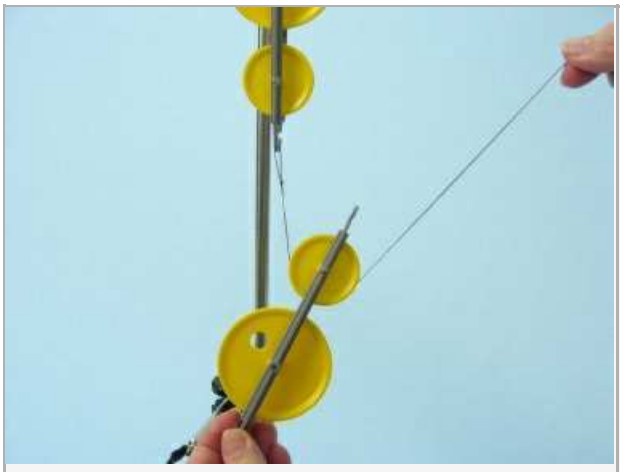


Fig. 11

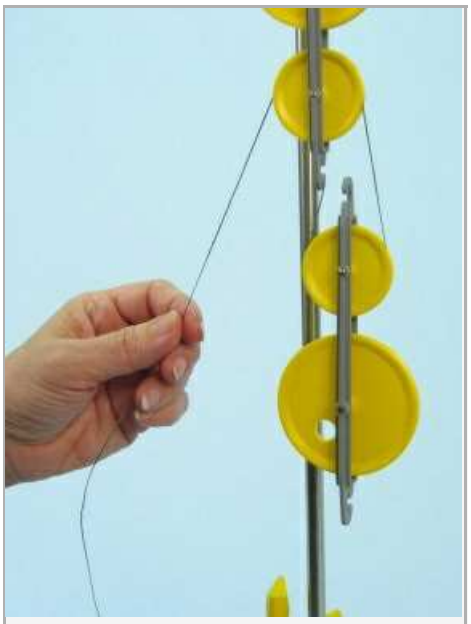


Fig. 12

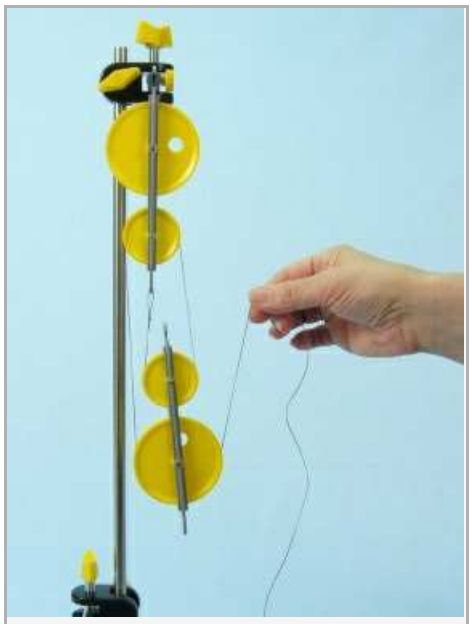


Fig. 13

Fig. 14

- Make a loop in the free end, hook the spring balance into it and clamp the spring balance into the spring balance holder as shown in Fig. 15.

Fig. 15

Procedure

Part 1

- Load the block and tackle with a mass of 50 g (weight holder and four 10 g mass pieces) (Fig. 16).

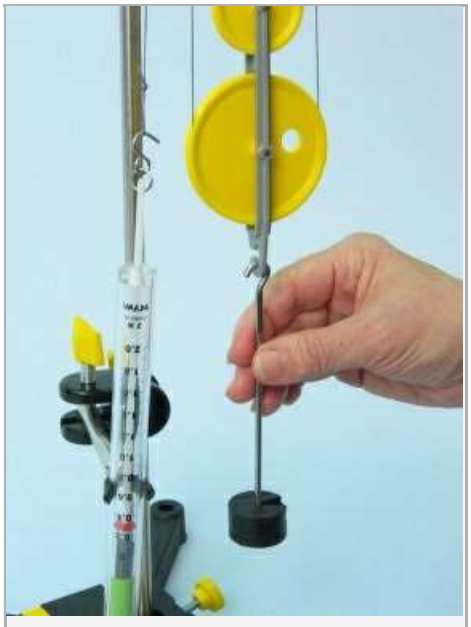


Fig. 16

- Read the force F on the spring balance and enter the value in Table 1 in the report.
- Repeat the force measurements with 100 g, 150 g and 200 g masses as loads.
- Record all the measured values in Table 1 in the report.

Part 2

- Exchange the 110 cm fish line by a piece of fish line of approx. 4 - 5 m length (Fig. 17). Make sure you thread the fish line through the 4 pulleys exactly the same way as in Part 1.
- Load the block and tackle with a total mass of 150 g. The load should rest on the floor (if the load does not reach the floor you will have to use a longer piece of fish line).

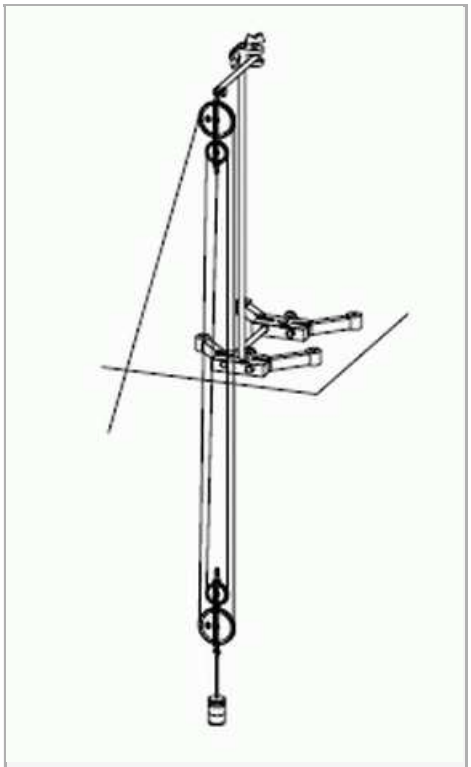


Fig. 17

- Mark the fish line at a certain point of the setup, e.g. the support base, with a marker (Fig. 18).

Fig. 18

- Pull the line until the load has reached the upper edge of the table top and attach it to the spring balance; then mark the line with the marking at the same point of the setup as before.
- Read the force *F* hat now can be seen on the spring balance (cp. part 1).
- Measure the length of the line between the two markings (force distance s_f) and the distance between the floor and the upper edge of the table top (load distance s_l).
- Record all the measured values in Table 2 in the report.

Report: Block and tackle with four pulleys

Results – Part 1

Enter the weight (force) F_r of the double pulley here:

F_r = ... N

Results – Table 1

Enter measured values in the table 1.

From the mass m and the weight force F_r of the double pulley, calculate the total weight (force) F_g and paste it into the table 1. Use the formula $F_g = m \times g + F_r$, where $g = 9.81$ m/s^2.

Form the quotients F_g / F and record the values in table 1, too.

m in g	F in N	F_g in N	F_g / F
50	1 ±0	1 ±0	1 ±0
100	1 ±0	1 ±0	1 ±0
150	1 ±0	1 ±0	1 ±0
200	1 ±0	1 ±0	1 ±0

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Evaluation Part 1 – Question 1

Is it easier to lift a load directly or with the help of a block and tackle?

Evaluation Part 1 – Question 2

How many fixed and how many movable pulleys does the block and tackle have?

Evaluation Part 1 – Question 3

Is there a correlation between the quotients F_g / F and the number of pulleys? If so, what is it?

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Results – Table 2

Enter measured values in the table 2.

The value for F_g can be taken from Table 1 or calculated using the formula $F_g = m \times g + F_r$. Add the value obtained to table 2.

Calculate the quotient s_l / s_f (load distance / force distance) and record the value in table 2, too.

m in g	F_g in N	s_l in cm	s_f in cm	s_l / s_f	F in N
150	1 ±0	1 ±0	1 ±0	1 ±0	1 ±0

Evaluation Part 2 – Question 1

What can you say about the force that is necessary to lift the load?

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Evaluation Part 2 – Question 2

Form the following products:

F x s_f = ... N cm

F_g x s_l = ... N cm

What do you notice?

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Evaluation Part 2 – Question 3

Is the following relation valid here, too?

load × load distance = force × force distance

Evaluation Part 2 – Question 4

On another block and tackle, the force necessary to lift the load is six times smaller than the weight force of the load.

What is the quotient force distance / load distance in this case?

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Evaluation Part 2 – Question 5

How many pulleys must such a block and tackle have?

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