Block and tackle (Item No.: P1254000)

Curricular Relevance

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

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	10 Minutes	20 Minutes	1 Student

Additional Requirements:

Experiment Variations:

Keywords:

Principle and equipment

Principle

Investigate the advantages which a block and tackle provides in the performance of mechanical work and the correlations between forces and distances as a function of the number of supporting ropes.

Equipment

Position No.	Material	Order No.	Quantity
1	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 for slotted weights	02204-00	1
7	Slotted weight, black, 50 g	02206-01	1
8	Slotted weight, silver bronze, 50 g	02206-02	2
9	Rod for pulley	02263-00	1
10	Block and tackle, with 4 pulleys	02265-00	1
11	Marker, black	46402-01	1

Set-up and procedure

- Load the weight holder with three 50-g slotted weights.
- Place the dynamometer onto the demonstration board and determine the weight $F_G = F_2$ for the loaded weight holder including a block with two pulleys. Record F_2.
- Place the clamp on fixing magnet with the rod for pulley in it onto the upper left-hand corner of the demonstration board.
- Thread the cord for the block and tackle around the pulleys and set-up the experiment according to Fig. 1. The length of the cord with two loops is approximately 160 cm.

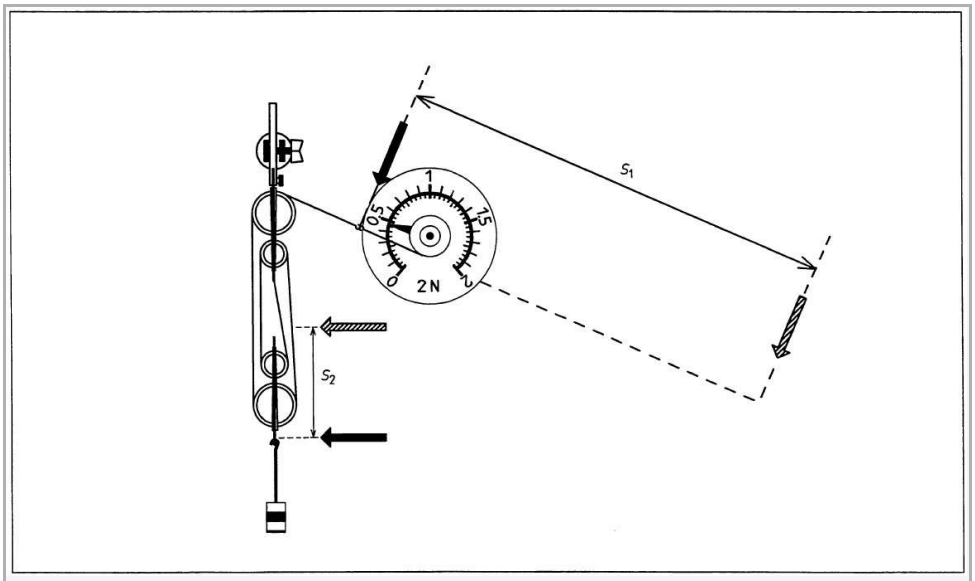

Fig. 1

- Measure the force F_1 required for equilibrium on the block and tackle and record it under (2).
- Compare F_1 with F_2 (2).
- Mark the position of the weight holder (highest point on the hook) and of the dynamometer (hook on the traction cord - cf. Fig. 1) with arrows of different colours.
- Move the dynamometer slowly and uniformly in the direction of the lower right-hand corner of the demonstration board. Measure force F1 and record it under (3).
- Mark the current position of the weight holder's hook and the hook on the traction cord with arrows of colour corresponding to the above use.
- Mark the distance (lifting height) s_2 for the load and the force distance s_1 on the demonstration board. Measure s_1 and s_2 and record them under (3)
- Raise the dynamometer repeatedly, and while doing so perform lifting work with differently oriented forces $\overrightarrow{F_1}$ - Note your observation under (4).

Observation and evaluation

Observation

(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, i.e. 0.47 N.

Evaluation

A block and tackle with 4 pulleys is in equilibrium when the tractive force is equal to 1/4 of the load's weight:
$F_1 = F_2/4$.

This due to the fact that the weight of the load is divided among 4 load-bearing segments of rope since the block and tackle has 2 moveable pulleys. For one moveable pulley, the equilibrium condition was found to be
$F_1 = F_2/2$

For the use of three moveable pulleys
$F_1 = F_2/6$

would be valid; for n moveable pulleys,
$F_1 = F_2/n$

The important factor on a block and tackle is the number of load-bearing segments of rope!

For the performance of mechanical work (in this experiment lifting work) F_1 must be greater than that required for equilibrium because during movement the tractive force F_1 , must also compensate the frictional forces which always occur on the bearings of the pulleys.

In addition, the measurements show that
$s_1 = 4s_2$.

For work, the following is true:
$expendedwork work = F_1 * s_1 = 28Ncm = W_1$,
$performed work = F_2 * s_2 = 27Ncm = W_2$.

The expended work W_1 is somewhat larger than the performed work W_2.

If the frictional force can be neglected in comparison $F_2 = F_G$ the following is true:
$F_1 * s_1 = F_2/4 = F_2 * s_2$ or $W_1 = W_2$

In summary, the following is true for a block and tackle with 2 moveable pulleys. On the one hand, the required tractive force is equal to 1/4 of the load's weight. On the other hand, the force distance is 4 times as large as the load distance (the lifting height). One cannot avoid work with a block and tackle, but it does make the performance of mechanical work substantially easier, especially since it makes no difference in which direction the tractive force acts.

Remarks

The fact that the force which is expended on a block and tackle is not a function of the number of pulleys, but rather that the number of load-bearing rope segments is the determining factor, must be made extremely clear. Fig. 2 indicates how this aspect can be further illustrated -also experimentally if necessary. For the same block and tackle F_1 can be $F_1 = F_2/4$ oder $F_1 = F_2/3$ or $F_1 = F_2/5$ depending on whether path of the rope is selected according to case a), b), or c).

If the block and tackle with 6 pulleys (Order no.: 02264.00) is available, it can additionally be demonstrated that for three

moveable pulleys with 6 loadbearing rope segments $F_1 = F_2/6$ is valid.

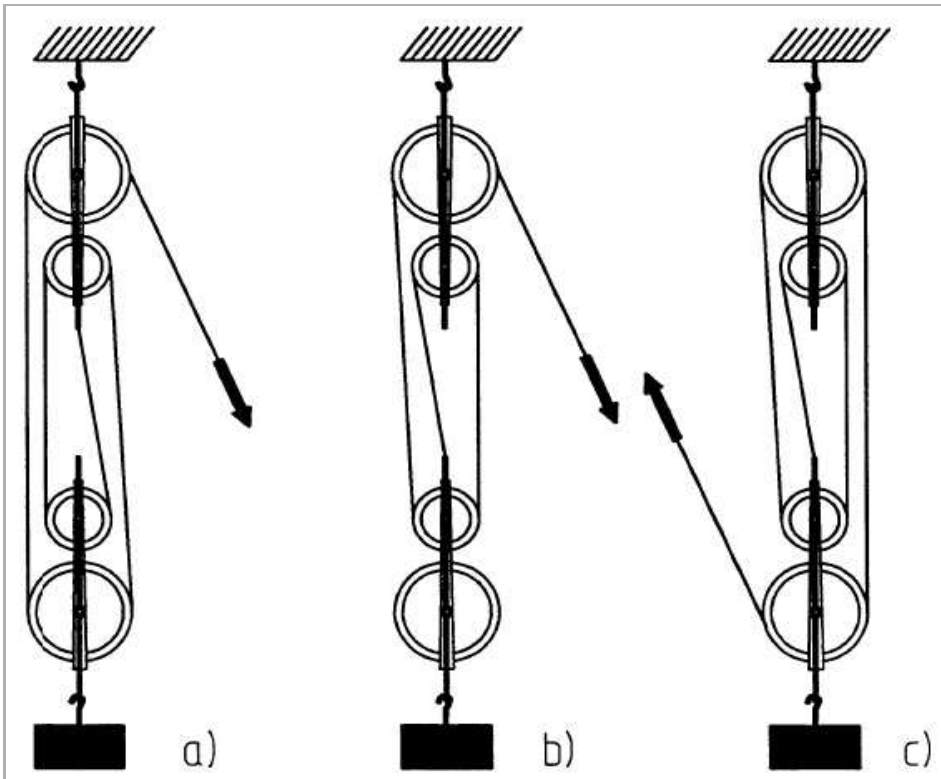

Fig. 2