Fixed pulley (Item No.: P1253800)

Curricular Relevance

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

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Easy	10 Minutes	10 Minutes	1 Student

Additional Requirements:

Experiment Variations:

Keywords:

Principle and equipment

Principle

Investigate the advantages which a fixed pulley has in the performance of mechanical work and which correlation exists between force and distance in this case.

Equipment

Position No.	Material	Order No.	Quantity
1	Demo Physics board with stand	02150-00	1
2	Torsion dynamometer	03069-03	1
3	Clamp on fixing magnet	02151-01	1
4	Fish line, l. 100m	02090-00	1
5	Rod for pulley	02263-00	1
6	Scale for demonstration board	02153-00	1
7	Pointers f. Demonst.Board, 4 pcs	02154-01	1
8	Pulley,movable,dia.65mm,w.hook	02262-00	1
9	Weight holder for slotted weights	02204-00	1
10	Slotted weight, black, 50 g	02206-01	1
11	Slotted weight, silver bronze, 50 g	02206-02	2

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Set-up and procedure

Set-up

Place the scale on the left side of the demonstration board. Position the clamp on fixing magnet with the rod and the pulley next to it at the upper edge (Fig. 1).

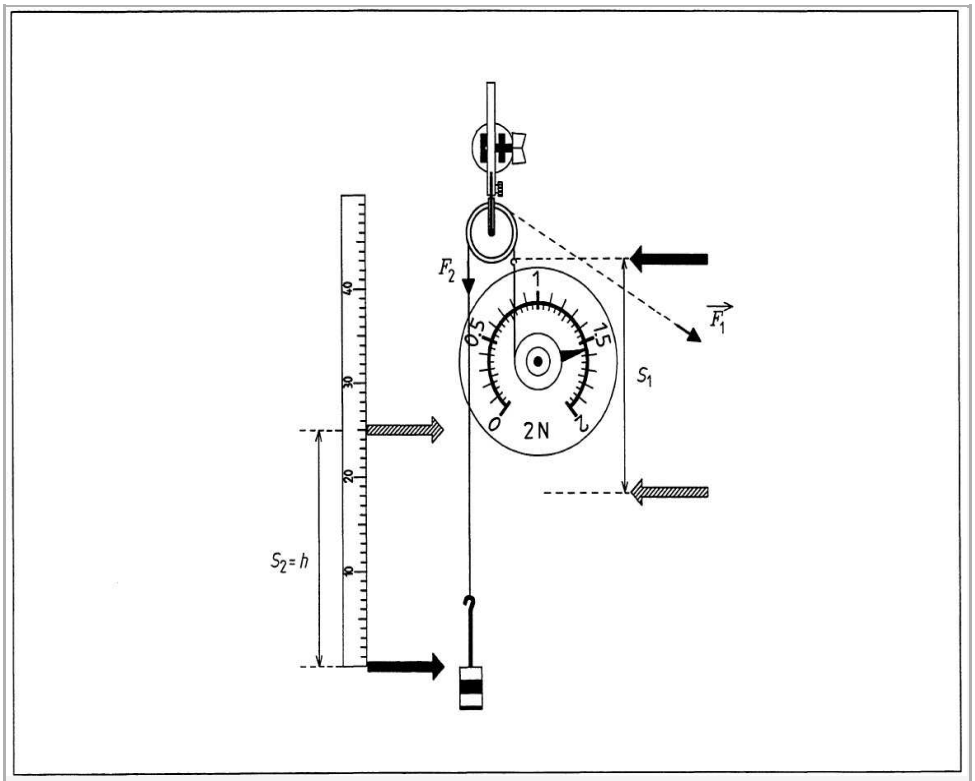

Fig. 1

Procedure

- Place the dynamometer below the pulley on the lower part of the demonstration board. Hang the weight holder which is loaded with three 50 g slotted weights onto the dynamometer. Measure $F_G = F_2$ for the loaded weight holder. Record the value for F2 under (1).
- Move the dynamometer slowly and uniformly upwards (to the position corresponding to that in Fig. 1), and measure the force F required for the performance of lifting work. Record F (2).
- Lay a piece of cord (fish line) approximately 50 cm long with loops at its ends over the pulley. Hook the loaded weight holder and the traction cord into the loops (cf. Fig. 1). Record the force F_1 required at equilibrium of the pulley and make a statement concerning this under (3).
- Mark the position of the weight holder with an arrow and place the second arrow of the same colour somewhat higher, e.g. 25 cm.
- Mark the position of the hook on the traction cord of the dynamometer with one of the different coloured arrows.
- Move the dynamometer uniformly downwards until the weight holder has been raised to the desired height $h = s_2$ Observe the dynamometer while doing so, and measure the force F_1 required for the performance of the lifting work. Record F_1 and F_2 as well as $s_2 = h$ under (4).
- Mark the current position of the hook on the traction cord of the dynamometer with the fourth arrow (in Fig. 1 indicated by a hatched arrow). Measure the distance s_1 which was covered under expenditure of the force F_1 and record it under (4).
- Lower the weight holder and raise it again. However, this time, allow $\overrightarrow{F_1}$ to act in a different (cf. indicated direction in Fig. 1) and observe the dynamometer; if necessary, repeat the procedure several times. Record your observation under (5).

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Observation and evaluation

Observation

1. $F_G = F_2 = 1.54N$
2. $F = 1.54N$

   Equilibrium exists 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

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

If lifting work is performed on a body without the use of a pulley, the tractive force is equal to the weight of the body. If the lifting work is performed with the aid of fixed pulley, a slightly larger force is required. This is due to the friction occurring on the axle of the moved pulley.

From the measured values the distances are obtained which were moved under the expenditure of the force F_1 ; $s_1 = s_2$,

$W_1 = F_1 * s_1 = 1,62N * 0.25m = 0,40Nm$

for the work performed:

$W_2 = F_2 * s_2 = 1.54N * 0,25m = 0,38Nm$

If the friction were to be reduced to the point where it would be negligible by using good bearings on the pulley, the following would be true: $W_1 = W_2$ i.e., the work expended is the same as the work performed, in this case the lifting work.

Therefore, no work can be avoided with a fixed pulley and the force which has to be expended is not reduced. Indeed, one must expend somewhat more work to overcome the friction which always occurs during movement. However, with a fixed pulley, one can change the direction of the forces. In practice, this is often a substantial advantage in the performance of mechanical work.

Remarks

If the moment of rotation (torque) has been previously discussed, the equilibrium conditions for the fixed pulley $F_1 = F_2$ can be clearly illustrated with the aid of Fig. 2. The force arms for $\overrightarrow{F_1}$ und $\overrightarrow{F_2}$ are equal in length (equal to the contact radius of the lines of action which are tangential to the circle). Thus, F_1 and F_2 are also equally large.

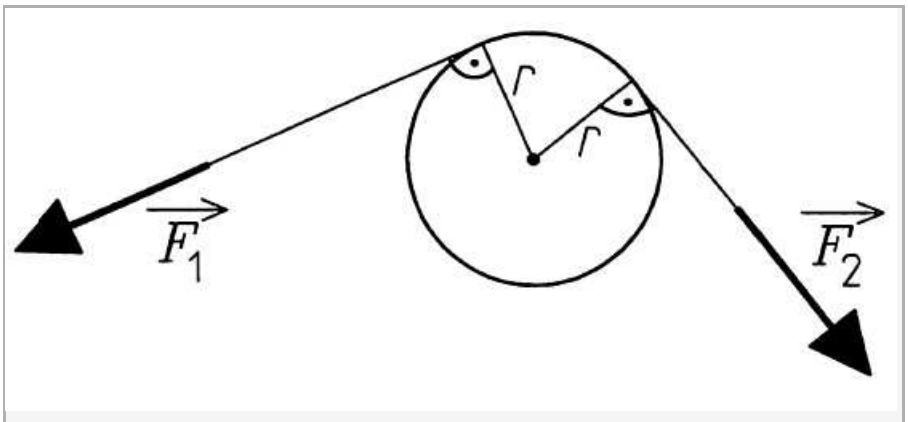

Fig. 2

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