## Model 2
Pulley block

The students are supported in individual tasks by the provision of construction instructions (see appendix) for the construction and solution of the tasks. For tasks where this is useful, this is indicated at the beginning of the solution sheet.
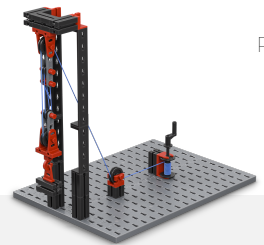
Note on the history of technology: The date of the invention of the pulley is unknown. The oldest known descriptions of pulleys come from the Roman Marcus Vitruvius Pollo (c. 80-15 BC), who described the engineering knowledge of his time in his "Ten Books on Architecture." These descriptions also include corrugated wheels, which were used in Roman construction cranes.

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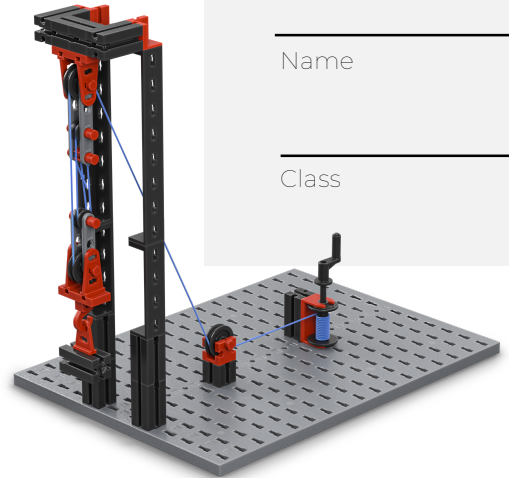
THEMATIC TASK

1. The exact number of crank turns depends on the thickness of the rope drum, i.e., the amount of rope already wound onto it. Without a pulley, it takes a good three turns; in case a), approximately six and a half; in case b), just under 10; and in case c), 13.

2. The force amplification is inversely proportional to the required rope length. Case a) doubles the force, case b) triples it, and in case c) it is quadrupled. The force amplification can be counted by the number of rope loops.

3. This also explains the term "factor pulley": the number of pulleys used is the factor of force amplification.

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EXPERIMENTAL TASK

1. The force amplification of the corrugated wheel corresponds to the ratio of the long lever to the radius of the rope drum. If the rope is wound directly onto the drum (diameter 0.7 cm) and the hand grips the center of the locking adapter, the amplification in case a) is 4.5/0.35 ≈ 12.85 and in case b) 6/0.35 ≈ 17.14.

   As the amount of rope wound increases, the radius of the rope drum increases, thereby reducing the force amplification. When comparing the wave wheel with the crank, however, it must be taken into account that the crank already provides a force amplification of approximately 1.2/0.35 ≈ 3.42.

2. The "distance" that must be traveled when turning the wave wheel increases proportionally with the force amplification. (This is easy to understand, since the circumference of a circle is $U = 2 \pi r$, meaning that multiplying the radius by the same factor is included in the calculation of the circumference.)
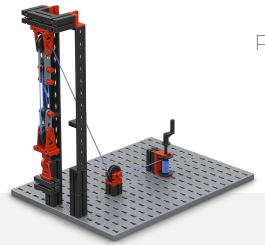
Distance is "exchanged" for force amplification. This means:

- The distance by which the rope is pulled in is smaller than the distance by which the force is moved on the locking adapter.

- The greater the force amplification, the longer the distance that the lever arm of the locking adapter has to travel. This is a direct consequence of the law of conservation of energy:

$$Arbeit = Kraft * Weg$$

3. A large force amplification can be achieved quickly and easily with the cogwheel. On the pulley block, however, a large number of additional pulleys are required. If the pulleys of the factor pulley block are arranged one below the other, the lifting distance is shortened. However, this can be avoided by arranging the pulleys in parallel. The additional rope length required must, however, fit on the rope drum. The advantage of this is that the weight to be lifted is distributed across the rope slings, meaning that a more stable pull rope is not required for heavier weights.

   The lever on the bevel wheel and the pull rope, on the other hand, must absorb the entire increased force or the weight to be lifted and must therefore be designed to be stronger for heavier weights. A longer lever on the bevel wheel also requires a correspondingly larger, round running surface around the bevel wheel. Since the pulling force on the rope drum increases with the weight to be lifted, a bevel wheel should also have a ratchet.

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Comparison of impeller and pulley:

Rotor:

Advantages:

- Simple design.
- Good for small mechanical systems.

Disadvantages:

- Limited force amplification (depending on the ratio of the radii).
- Amplification comes at the expense of a long travel distance.

Pulleys:

Advantages:

- Can achieve significantly greater force amplification (due to the number of rope deflections).
- Efficient for heavy loads

Disadvantages:

- More complex construction.
- Dependent on rope friction, which causes energy losses.

Easier to achieve:

For smaller amplifications, the bevel gear is easier and quicker to use.

For high force amplification, the pulley block is more efficient, but requires more effort in construction and maintenance.

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APPENDICES

Model 2: Construction manual for pulley block with rope winch, construction manual for pulley block with corrugated wheel, construction manual for pulley block with motor

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