

Teachers' Guide

Objectives of the lesson

Cognitive objectives

- Students describe how the pulleys work
- Students observe objects of their everyday world that contain pulleys
- Students explain the advantages and disadvantages of the places we use the pulleys (few pulleys/greater applied force/short rope length vs many pulleys/lower applied force/long rope length)

Emotional objectives

- Students are encouraged to make hypotheses and experiment
- Students are willing to make assumptions and verify them with their observations, and if they are wrong to make new assumptions

Psychomotor objectives

- Students collaborate with each other to achieve the objectives of the activity
- Students can communicate effectively with their groups and in the plenary discussion, develop their critical thinking skills and be creative when they are asked to solve a problem
- Students develop fine motor skills through their own constructions
- Students present their results and compare it with the ones from the other groups

Introduction to the activity

In the introductory discussion you will discuss about a pulley is, how it works, its applications from the ancient times and the contemporary ones. Mention that we can use more than one pulley, building a system of pulleys. Then, a lower force is applied, but the length of the rope is bigger. Finally, mention the driver pulley and the driven one. Remind your students that we used these terms in gears.

Simple machine

The lesson is devoted to the pulleys. Pulleys are circular disks that rotate around the axes that pass through their center, perpendicular to their plane. Along its circumference there is a groove through which the rope passes. A belt is a continuous "cord" (elastic or not) that connects the two pulleys. Pulleys are used for lifting weights and are divided in two types: the fixed and the free ones. The first is steadily placed at one point and changes the direction of the applied force, while the second moves. One end of the rope is fixed, while the

applied force is applied to the other. For heavy weight lifting, we use a system of more than one pulleys (fixed or free). In this case, we use a longer length of rope, but the applied force is less.

Refer to the driver and the driven pulley, in the case of a pulley system, connected with a belt. The belt needs to be stretched (be careful not to break it), because if it isn't the pulleys cannot rotate. If its shape is like 0, the two pulleys rotate towards the same direction, whereas if its shape is like an 8, they rotate towards the different direction.

Building

You will do a series of constructions, focusing on studying one or more properties of the pulleys each time.

Beware! The rubbers of your set need to be stretched, but not too much to risk breaking them. If you don't have the yellow rubbers, adjust the place of the second pulley and use the rubbers you have.

If the pulleys don't move, loosen the connection of the wheels to their axles.

Help your students pass the rubbers in the groove and take care not to break the rubbers.

Answers to the worksheet

1. The pulley connected to the crank is the driver pulley and the other one is the driven. The two pulleys rotate towards the same direction and have the same speed, because for one rotation of the crank, there is one rotation of the pointer. This is explained because the two pulleys (wheels) have the same (have the same radius).
2. The two pulleys move towards the same direction, due to the connection with the belt, but they don't have the same speed. We can see that the smaller pulley moves faster. More specifically, for one rotation of the crank, the pointer does 3 rotations.

This happens because the driven pulley is smaller than the driver one. (Obviously, the small pulley has a radius 3 times lower than the bigger one).

Our conclusion is that if a smaller pulley is connected to a bigger one, then the small pulley will have greater speed.

3. In this case you just change place of the two pulleys. We see that the small pulley rotates faster than then bigger one. We measure that for one rotation of the pointer, three rotations of the crank are needed.

So, our conclusion is that our previous conclusion applies either to the driver or the driven pulley.

4. The pulleys move towards the different direction, since we have changed the shape of the belt (8 shape). The two pulleys are similar, so the move with the same speed, and 1 rotation of the cranks leads to 1 rotation of the pointer.

5. Here we use the two small pulleys, that they are on a different level: the driver pulley rotates in the horizontal level and the driven pulley in the perpendicular level. The speed of the two pulleys is the same, as we can notice from the crank and the pointer. (you can use the words across and down from the crosswords).
6. As for the first pointer we meet from the crank, we need 3 rotations of the crank (as we saw in the previous question). The big wheel is connected with an axle to the small wheel, which is connected to with a belt to the second big wheel. The small and the big wheel that are connected to the axle have the same speed (the speed the axle is rotated with). For one rotation of the second pointer, the crank needs to rotate 9 times.
7. We notice that the two big wheels rotate with the same speed and the small ones with the triple speed (for one rotation of the pointer, three rotation of the crank are needed. If this doesn't happen, there is friction in the pulleys and the axles, or the rubbers are not stretched). All the pulleys move towards the same direction. If you want, try to connect a rubber-belt in an 8-shape and observe the different direction of the driven pulley connected to it.

If you still have time, let your students work on their own construction, that needs to contain pulleys. You can open the presentation for inspiration photos of objects with pulleys.