Learning about: Pulley Drives

Pulley drive systems

Recently my friend Stan moved to a new apartment at the second floor. All of their belongings were put into the apartment through the windows, using a special lift, because they were too big for placing them in the building's elevator! Stan was very impressed with this machine, so he built one using his Engino package!

Discover:

- What is a pulley and how does its diameter relate to lifting speed and force?
- What is a compound pulley system and what are its benefits?

Level Of Difficulty ★★★★★

Materials Needed:
- Engino® Simple Machines (STEM40) or Pulley Drives (STEM03).
- Small weight (e.g. rubber).

Procedure:

1. Find the instructions online and build the **material lift** model. As for the string, first tie it on the black axle, wrap it around the top pulley, then go all the way down and wrap it around the low pulley. Then, bring it up again at the middle pulley (close to the top one) and tie it with a knot, by passing it through the holes of the pulley.

2. Place your platform on the lowest point and put some weight as a load. Turn the handle (crank) and measure how many revolutions are needed in order for the platform to reach the highest point. Complete the next table for **case 1**.

3. For **case 2,** untie the string from the black axle and tie it on the small pulley.

4. For **case 3**, tie the string on the medium pulley. Once finished with the measurement, compare in each case the amount of effort needed for lifting (easy, medium or difficult).

5. For **case 4**, remove the pulley of the platform (indicated with *number 1* in the next picture) and replace it with the other orange pulley indicated with *number 2*. Keep the string tied on this pulley, so that the platform now is raised directly by the string.

6. Tie the string directly on the axle as in case 1 and put the same load as before. Turn the crank of the model and measure how many revolutions you make until the platform is totally lifted. Complete **exercises 3**, **4** and **5**.

1. Write your measurements about the crank's revolutions for each case. Then compare the amount of effort needed to lift the load, using the words **easy**, **medium** and **difficult**.

string wrapped around	crank's revolutions	force (Difficulty in rotation)
Case 1: black Axle	27	*easy*
Case 2: small Pulley	12	*medium*
Case 3: medium Pulley	5	*difficult*

2. Look at the answers in the table above. What is the relationship between the number of crank's revolutions needed to lift the weight and the size of the pulleys used to wrap the string? Give a brief explanation.

The smaller the size of the pulley the more revolutions are needed for the weight to be lifted. The axle has smaller radius than the pulleys, so more revolutions are required, but with less force.

3. How many crank revolutions are needed to lift the load in case 4: 15

4. In cases 1 and 4 the string is tied on the black axle but the number of revolutions and the force needed are different. How can you explain this?

In case 4 the load is lifted directly by the string and does not pass through a series of pulleys like in case 1. So, there is no M.A. in case 4, thus more effort is needed, but less distance is travelled.

5. Complete the paragraph below using some of the words.

faster, longer, shorter, force, pulleys, levers, more difficult, bigger, smaller

The ***faster*** a weight is lifted the ***more difficult*** it is to raise it. We can use a combination of ***pulleys*** to reduce the ***force*** needed to lift a load but we must use a ***longer*** piece of string as it must travel a ***bigger*** distance.

Learning about: Pulley Drives

Transfer of motion

Stationary bikes are a great way to work out if a normal bike is not available. They are usually found in gyms, next to the treadmills. Do you know how a stationary bike actually works? Let's carry out the following experiment and find out.

Discover:

- How can we change the direction of rotation of a pulley system?

Level Of Difficulty ★★★★★

Materials Needed:
- Engino® Simple Machines (STEM40) or Pulley Drives (STEM03).

Procedure:

1. Find the instructions online and build the **stationary bike** model.

2. Turn its pedals with your hand. What do you observe? Draw two arrows on the picture of **case 1** on your right, to show the direction of rotation of each pulley. Make the arrow of the faster pulley bigger.

3. Now, change the rubber band so as to create an X shape as shown in the picture of **case 2**. You will need to disassemble the pulleys from the main structure in order to take the rubber band out and reposition. Try to turn the pedals again. What do you observe? Draw two arrows in the picture of case 2 to show the direction of rotation of each pulley. Make the arrow of the faster pulley bigger.

Engino® "stationary bike" model

1. Draw arrows for the crank and the pulleys, for both cases below, showing the direction of rotation. Make the fastest pulley's arrow green and the slowest red.

case 1

standard belt drive

case 2

crossed belt drive

2. Can you describe what happens when you turn the pedals in case 1?

*In case 1, motion is transferred from one pulley to the other and the **direction of rotation** of both pulleys **is the same**. The bigger pulley rotates slower than the small one, so the output speed is reduced.*

3. Can you describe what happens when you turn the pedals in case 2?

*In case 2, motion is transferred from one pulley to the other and the **direction of rotation** of both pulleys **is opposite**. The output speed is reduced again.*

4. Complete the conclusion below using the words in the grey box.

distant, vertical, motion, pulleys, belt, reverse, axle, belt drive, more

In order to simply transfer the ***motion*** from one ***axle*** to another, we need at least two ***pulleys*** and a ***belt drive*** We can also transfer the motion to a ***distant*** point if we connect ***more*** pulleys together. Furthermore, by using the ***belt*** in a way that it creates an X shape, we can ***reverse*** the direction of rotation. In addition, pulleys can transfer rotation to axles that are ***vertical*** between them.

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