RESCUE RAPUNZEL

CHALLENGE ACTIVITY

Rapunzel is tired of always letting down her hair to bring things into her tower. She needs your help to design and build a pulley. That way, when she wants something, she can pull it up to her tower, saving her hair and her headaches.

Today, your challenge is to construct a pulley that can lift a bucket (container or tray) into the tower so that Rapunzel does not have to use her hair.

Here are a few rules and requirements for your design:

- You may not use more than 6 feet of string
- You must attach the device to the top of the tower
- You must attach the device to the bucket (container or tray)
- Your pulley should be able to lift a bucket (container or tray) holding at least 10 pennies a distance of at least 10 inches.

Video link:

GETTING READY

Summary:
Have you ever wanted to lift a heavy object from the ground to a place high up, like your treehouse, or a 2nd floor window? Engineers use pulleys to raise heavy objects, taking advantage of gravity to help lift the object. Cranes, elevators and flagpoles are all examples of pulleys. In this activity, you will create your own pulley to learn how they are used to easily change direction of a force to make it easier to move a heavy object.

Active Time:
- 30-45 minutes

Total Project Time:
- 30-45 minutes

Key Concepts:
Work, Force, Simple Machines, Pulleys

MATERIALS

You will need:

- Rescue Rapunzel Log Book pages (download or use your own notebook)
- A small bucket or container (such as a yogurt container, small box, aluminum pie plate)
- Thread, string, yarn, ribbon or thin rope (at least 3 feet long)
- A wheel (such as a metal washer, button, tape roll, old CD, ribbon/thread spool**)**
- Pencil, stick, straw or chop stick
- Tape

- Ruler or yard stick
- Scissors
- Paper
- Clips (such as paper clips, binder clips, clothespins)
- 10 pennies or coins

BACKGROUND

Work, in scientific terms, is defined as force times distance.

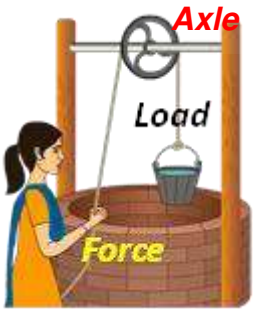
Work = Force x Distance

Force is when you give an object energy causing it to move, stop moving, or change direction. Some forms of force are pushing, pulling or lifting. If you want to move a book from one side of a desk to the other, you must do **work** to move it. You can push the book, pull it, or lift. In each case, you are applying **force** for a certain distance (the length of the desk).

Imagine that you want the same amount of **work** to get done using less **force**. In this example, you still want the book to move from one side of the desk to the other, but you don't want to push as hard. If you use half as much **force** to push the book, then you will have to push the book twice as far to do the same amount of **work**. Or, you could use a **simple machine** to make up the difference in the force you are applying.

Simple machines make work easier. A **pulley** is one type of simple machine. **Pulleys** often help people lift heavy objects. A simple **pulley** is made of a wheel with a rope looped over it. The wheel is fixed in one spot and the rope moves over it. The weight is attached to the one end of the rope. To make the pulley lift the object, a **force** is applied to the free end of the rope.

An example of a simple pulley is seen below in this picture of a well. A bucket of water can easily be lifted from the well. The bucket is tied to the end of the rope, and the **force** is applied when the person on the other end of the rope pulls the rope downward. This **force** turns the wheel with the rope and the heavy bucket is pulled up. **Work** is being done to move the bucket from the bottom of the well to the top.



INSTRUCTIONS

You are free to try and test as many different designs of your pulley to find the one that works best (can pull up more weight, or pull the weight a longer distance up to the tower). Plan your idea, draw your designs, build, test, re-build.

Follow these instructions to get started.

1. Attach a small container (examples: cup, yogurt container, aluminum pie plate, jar lid) to the end of a piece of string, ribbon or rope.
2. Thread the string through a metal loop (examples: metal washer, old CD, button hole) or over a wheel (examples: thread spool).
3. Attach the metal loop or the wheel to the top of your tower. If using a wheel, you may need to stabilize it by using an axle (a central rod or shaft for a rotating wheel). Use a chopstick, straw, pencil or similar item, pushed through the center hole of the spool so that it can still spin, but can be held in one place more easily.

The rest is up to you to imagine.

EXPLORE

As you plan your design, think about:

 How will you attach the pulley to your tower? You can use the seat of a chair, the top of a low table or bench, the top of a box, or anything sturdy as your tower.

 How long does the string/rope need to be?
Consider the distance that the bucket must travel from the ground to the tower, over the pulley and then back to the ground.

 What happens if you use a thicker or thinner string/rope?
Try using different materials for your rope such as ribbon or fishing line.

 How can you change your design so that it can lift more weight or lift it a longer distance?

EXPLAIN

The key concept of a pulley is that it re-directs **force**. In your design, instead of pushing a heavy object UP, you attached it to a rope and pulley above you and you pulled DOWN. You re-directed the force applied from UP to DOWN. Pulling down allowed you also to use the naturally existing force of gravity (the force that pulls on objects, and it is what keeps our feet on the ground on Earth) to help you. Gravity is already helping pull the rope down and you are pulling in that same direction. As a result, it feels easier to pull the heavy down rather than up.

However, it is important to understand that the pulley makes it FEEL easier to move the heavy object. It FEELS easier to pull down on the rope. But this is just a body sensation. It is not a scientific measurement of the actual **work** being done. You still need the same amount of **force** to move the heavy object the same distance. Remember that **work** equals the amount of **force** applied over a certain distance. The difference is that you changed the direction of the force to move the weight.

Learn more about inventing and find more activities on our website: www.fuelthespark.org.