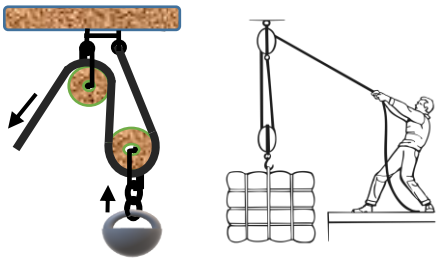
raft RESOURCE AREA FOR TEACHING

STEAM SCIENCE TECHNOLOGY ENGINEERING ARTS MATHEMATICS

LEARNING ACTIVITY

Muscle Multiplier

Make it Easier to Lift Heavy Objects with Your Bare Hands



Develop super strength! A single pulley can change the direction of lifting force. Two pulleys can make lifting easier. What will happen as more pulleys are added?

Activity Challenge

Build a simple pulley device that makes that makes it easier to lift heavy objects.

Preparation

1. This activity references the **Rapunzel's Tower Challenge** Learning Activity. The tower is optional. Use a doorknob, back of a chair, or other object about 2 ½ to 5 feet high from which to hang and test the pulleys.
2. Review the **Materials Needed** list and gather the supplies.
3. Make 2 pulleys. Refer to RAFT's **Build a Simple Pulley** Learning Activity Sheet and the diagrams on this sheet.

To Do

1. Hang 1 pulley from the top of the tower (or chair, doorknob, etc.). Holding one end of the rope, run the rope over the pulley and tie the other end to the basket's handle.
2. Try lifting different sets of items placed in the basket by pulling down on the on the free end of the rope down. The basket at the other end should lift. Record the length of the rope that was pulled to lift the basket of items to the top. How does the length of rope that was pulled compare to the length of the portion of the rope from the basket handle to the pulley?
3. Record the relative force needed to lift each basketful of items on a scale from 1 to 5 with 5 for the most force, and 1 for the least.
4. Make a second pulley and run the rope through the 2 pulleys as shown in the diagram at the top of the next page.

Materials Needed

- See Build a Simple Pulley Learning Activity Sheet for materials and instructions to construct the two pulleys needed for this activity
- See Rapunzel's Tower Challenge Learning Activity Sheet to build a platform to hang the pulleys from, or hang them from an alternative object, like the back of a chair or doorknob.
- String or rope at least 3 1/2 times longer than the height of the object you hang the pulley from.

Grade Range

3-5
6-8

Topics/Skills

Math: Measurement
Engineering Design

Learning Standards

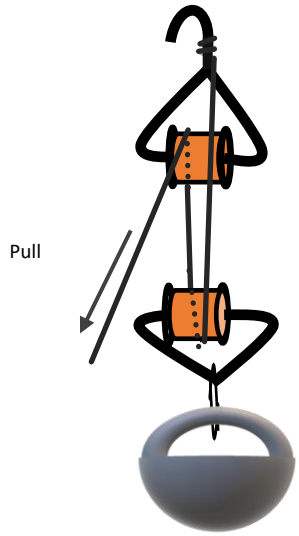
3-5 CCSS Math
3-5 Engineering Design

Duration

45 - 90 minutes

Prep Time

30 - 45 minutes



5. Try lifting different groups of items in the basket using two pulleys by pulling the rope down. As the rope rolls over the top pulley, it should lift the bottom pully as well as the basket of items attached to it. Record the length of rope you must pull to lift the basket to the top. How does the length of rope pulled compare to the height of the tower, (or back of chair, doorknob, etc.), and to the length of rope pulled using just 1 pulley in step 2?
6. Note the relative force needed to lift each set of items on a scale from 1 to 5 with 5 for the most force, and 1 for the least. Compare the results with what was recorded in step 3 for the identical groups of items.

Observations

- Was it easier to lift objects with the two-pulley system?
- What is the difference in the length of rope needed to raise the basket with one pulley and with two pulleys?
- What would change if a 3rd pulley was added? Draw a diagram of how to connect a 3rd pulley to make lifting even easier.

Extensions

- Research how weight is related to gravity.
- How are pulleys like seesaws when an adult is on one side and a child on the other? How can a child lift an adult?
- How are the scientific principles that govern pulleys used in other simple machines, like bicycles, walking up switchbacks on a hill, climbing stairs, changing a tire on a car, and using a pliers or scissors?

The Science Behind the Activity

For thousands of years, people have been using simple machines to get work done, and we still use the same simple machines today! A pulley is a grooved wheel with a rope wrapped around it. Pulleys make work easier by changing the direction of the force needed to do work by allowing a small force to exert a larger force. Multiple pulleys can be used like a lever to gain **mechanical advantage**, which is a way to reduce the amount of force needed to lift an object. For two pulley systems, the mechanical advantage is about a factor of 2 --- the force required to lift an object is ½ the weight of the object. But the rope must be pulled 2 times further than the height of the object being lifted. More pulleys can be added to the system to gain a bigger mechanical advantage at the cost of having to pull the rope even farther rope than the height that the weight was lifted.