

Simple Block and Tackle Pulley Demonstration

Introduction

How much easier is it to lift a heavy object using a pulley system? Use this simple broomstick-pulley system to effectively demonstrate why a block and tackle pulley system is so useful.

Concepts

- Pulleys
- Simple machines
- Mechanical advantage

Materials

- Broom handle (or dowel rod), 1 to 1½" diameter (or ¾" PVC pipe), 2–3 feet long, 2
- Rope, strong, 25 feet long
- Student volunteers, 3

Safety Precautions

Please follow normal laboratory safety guidelines. Wear cloth gloves when holding the handles to avoid rope abrasions. Clear out the demonstration area to remove objects that could be tripped over. Do not jerk on the rope. Pull the rope gently with an even force.

Procedure

1. Select three student volunteers.
2. Assign two volunteers as broom-handle holders and the other as the rope puller.
3. Have the two broom-handle holders wear gloves and stand about 5 to 6 feet apart and extend their arms to hold the broom handles parallel to the floor at waist level.
4. Securely tie one end of the rope to the middle of one of the broom handles.
5. Wrap the rope around the middle of the other broom handle (see Figure 1) and give the free end to the rope puller. The rope puller should stand behind, and slightly to the side of one of the holders, so that the rope will be pulled perpendicular to the length of the broom handles. The free end of the rope should go under the arms of the broom-handle holder so that the rope is pulled parallel to the ground as well. See Figure 2.
6. Have the two broom handle holders try as hard as they can to prevent the broom handles from coming together as the rope puller pulls on the rope. Can the single rope puller draw the two broom handle holders together? What is the mechanical advantage of this pulley system?
7. Repeat steps 5 and 6 several times. For each new trial wrap the rope around the broom handles a different number of times (see Figure 1). How much more difficult is it for the holders with each new trial? How much easier is it for the puller? What is the mechanical advantage of the puller as a new loop is added to the pulley system? How close are the broom handle holders drawn together compared to the amount of rope pulled by the rope puller during each new trial?

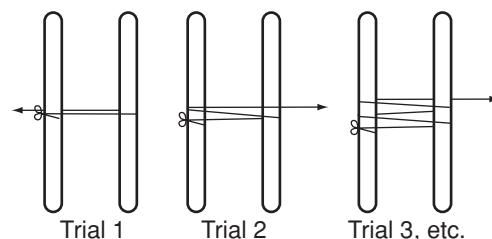


Figure 1.

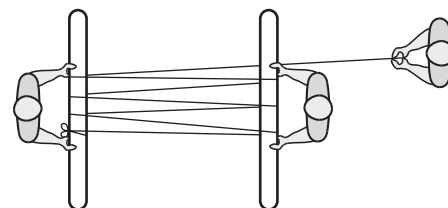


Figure 2.

Tips

- The purpose of this activity is to show how to increase the mechanical advantage of a pulley, not a contest of strength. Pulling too vigorously on the rope or jerking back on the handles may result in injury. The rope puller should take care to pull the rope evenly and straight, and avoid rubbing the rope against the hands of the other two volunteers. As a safety precaution, the volunteer handle holders may wear cloth gloves, available from Flinn Scientific (Catalog No. SE1030), to avoid abrasions from the rope.
- To enhance the effect of mechanical advantage use two “strong” volunteers to hold the broom handles and a “weak” volunteer to pull the rope.

Discussion

Pulleys are used extensively when heavy objects need to be lifted, especially in cranes in shipping and construction areas. Pulleys are one of six types of *simple machines* used to easily change the direction and/or the magnitude of an applied force. (The lever and fulcrum, inclined plane, wheel and axle, wedge, and screw are the five other types of simple machines.) How does a pulley decrease the amount of force necessary to lift an object? The advantage of a pulley is its ability to change the number of “ropes” lifting an object. This gives a lifter a greater mechanical advantage. *Mechanical advantage* is a ratio of the output force compared to the input force. The greater the mechanical advantage is for a system, the greater the output force is compared to the input force. The greater the mechanical advantage, the easier it is to do the work. For a block and tackle pulley system, the mechanical advantage is determined by the number of support ropes that are lifting the object (see Figure 3). Therefore, the more times the rope is wrapped around the broom handles, the greater the mechanical advantage is for the puller.

However, a pulley does not give something for nothing. A block and tackle pulley system gives a high mechanical advantage, but the sacrifice is that the applied force must be carried over a longer distance compared to the distance the lifted object actually moves. Ideally, due to the conservation of energy, the work in must be equal to the work out. *Work* is defined as a force times a distance. Therefore, even though a pulley (or any simple machine) makes it easier to lift a heavy object, the total amount of work necessary to lift the object will be equal. A smaller force will be used over a larger distance in order to lift a heavy object a short distance.

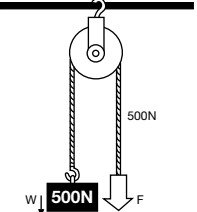
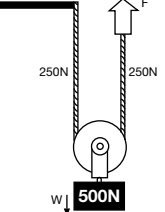
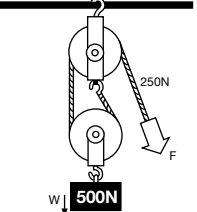
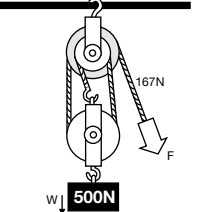
Mechanical Advantage	1	2	2	3
Pulley Setup				

Figure 3.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12

- Systems, order, and organization
- Evidence, models, and explanation
- Constancy, change, and measurement

Content Standards: Grades 5–8

- Content Standard B: Physical Science, understanding of motions and forces, transfer of energy

Content Standards: Grades 9–12

- Content Standard B: Physical Science, motions and forces, conservation of energy and increase in disorder

Reference

Bilash, B. *A Demo A Day: A Year of Physical Science Demonstrations*; Flinn Scientific: Batavia, IL, 1997; p 262.

***Simple Block and Tackle Pulley Demonstration* is available as a Physical Science Demonstration Kit from Flinn Scientific, Inc.**

Catalog No.	Description
AP6890	Human Block and Tackle Demonstration
SE1030	Terrycloth Gloves

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.