SIMPLE MACHINES : THE PULLEY

CAT NO. WDMS12

Experiment Guide

GENERAL BACK GROUND:

Machines are used to make work easier. Here work is defined as a force applied over a given distance. The force applied and the distance traveled must be in the same direction.

Pulleys are one of six simple machines that include levers, pulleys, inclined planes, wedges, wheel and axles, and screws. Compound machines have two or more simple machines that when used together make work easier. A pulley is a variation of a wheel and axle in which a rope or cord is stretched over a wheel to make it rotate as the rope is pulled. Pulleys are used to raise and lower flags, on oil derriks, to raise, lower, and adjust the sails on a sailboat, and to pull open or close curtains. A single pulley can change the direction that a force is needed to be applied in order to make it easier to do work. By applying a smaller force over a large distance mechanical advantage is gained.

Mechanical advantage is a way of measuring how much easier it is to do work or how much less force is required. Written as a formula:

$$\text{Mechanical Advantage} = \frac{\text{Output force (load)}}{\text{Input force (effort)}}$$

The load is the amount of force or weight that is being lifted. The effort is the amount of force or weight being applied to the rope in order to move the load.

Another parameter used to describe machines is efficiency. All machines have an efficiency of less than one because all machines lose some energy due to friction and other factors. Written as a formula:

$$\text{Efficiency} = \frac{\text{Energy delivered}}{\text{Energy needed}}$$

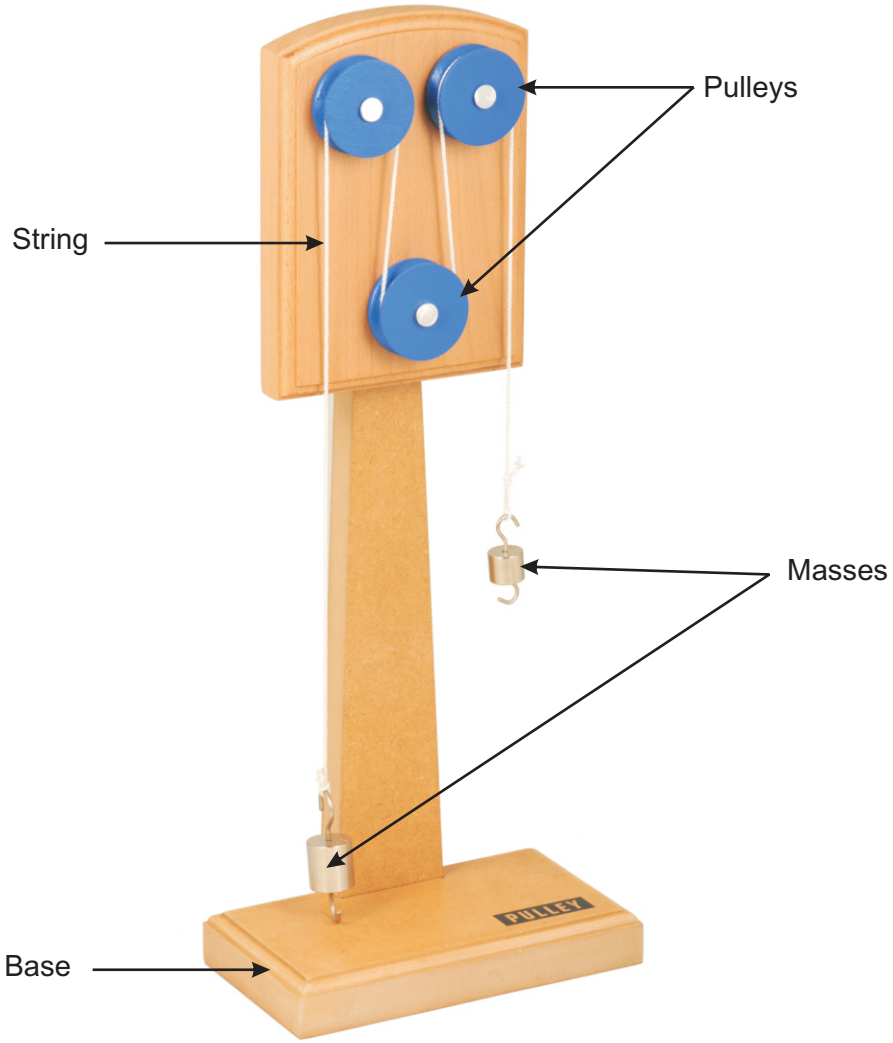
REQUIRED COMPONENTS (INCLUDED)

Name of Part	*Quantity*
Pulleys demonstration apparatus	1
Cord (string)	1

REQUIRED COMPONENTS (NOT INCLUDED)

Name of Part	*Quantity*
Spring Scale 5.0 N	1
OR Force Probe	1
Masses (slotted masses or even a small pail filled with pennies will work.)	1

DIAGRAM LABELING ALL PARTS:



ACTIVITY 1: THE ADVANTAGE OF A PULLEY

(TEACHER ANSWERS)

PROCEDURE:

1. Using your spring scale, record the weight in Newtons of your mass in the space provided below.

2. Attach a 5.0 N spring scale to one end of the rope and attach your mass to the other end of the rope.

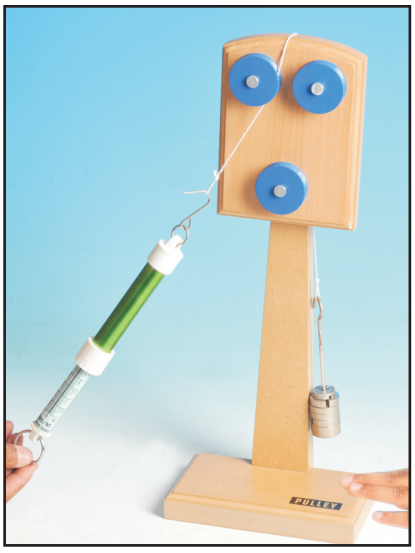


Diagram 1

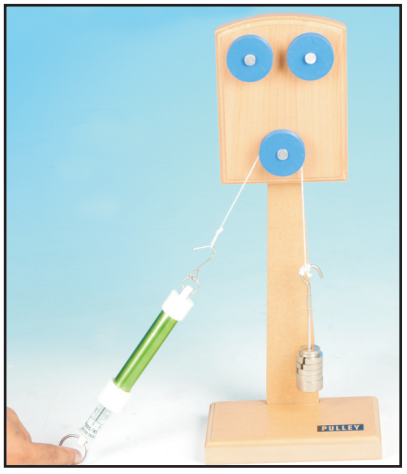


Diagram 2

3. Drape the rope over the back of the pulley demonstration apparatus and pull the mass with the spring scale. Be sure to have one person in your group securely hold the base of the pulley so it doesn't tip over while you are pulling as shown in diagram 1. Record the force used to pull your mass at a constant velocity in the chart below.

4. Now drape the rope over the pulley and again pull the mass with the spring scale as shown in diagram 2. Record the force used to pull the mass at a constant velocity in the chart below.

DATA:

Original Weight of the mass 0.9 N

Force required to pull the mass over the bar 2.3 N

Force required to pull the mass over the pulley 1.0 N

DATA ANALYSIS:

1. Calculate the efficiency of the pulley in diagram 1:

$$\text{Efficiency} = \frac{\text{Energy delivered}}{\text{Energy needed}} = \frac{\text{Force*}\cancel{\text{distance}}}{\text{Force * }\cancel{\text{distance}}} = \frac{0.9\text{ N}}{2.3\text{ N}} = 0.39$$

2. Calculate the efficiency of the pulley in diagram 2:

$$\text{Efficiency} = \frac{\text{Energy delivered}}{\text{Energy needed}} = \frac{\text{Force*}\cancel{\text{distance}}}{\text{Force * }\cancel{\text{distance}}} = \frac{0.9\text{ N}}{1.0\text{ N}} = 0.90$$

3. Calculate the mechanical advantage of pulling with the pulley and without the pulley. Show all work including formula and substitution with units.

$$\text{Mechanical Advantage} = \frac{\text{Output force (load)}}{\text{Input force (effort)}} = \frac{0.9\text{ N}}{2.3\text{ N}} = 0.39$$

$$\text{Mechanical Advantage} = \frac{\text{Output force (load)}}{\text{Input force (effort)}} = \frac{0.9\text{ N}}{1.0\text{ N}} = 0.90$$

For younger students it might be appropriate to ask, which took more work, to pull using the pulley or to pull over the edge of the pulley stand. Students should be able to feel that it was easier to pull up the mass using the pulley than pulling using the back of the pulley demonstration apparatus.

1. Compare the amount of force needed to pull the mass over the back of the pulley demonstration apparatus versus pulling over the pulley.

   (It took less force to pull the mass when using the pulley versus pulling over the back of the apparatus.)

2. Was any less work done on the mass using the pulley? If not, then what is the advantage of using a pulley?

   A pulley is used to change the direction that work is done. Instead of pulling up to lift the mass, using the pulley we can pull down and use the force of gravity on our bodies to help us pull with more force.

NAME:_____ DATE:_____

ACTIVITY 1 : THE ADVANTAGE OF A PULLEY

PROCEDURE:

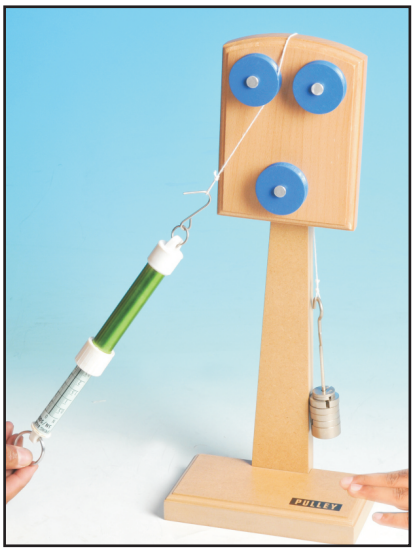


Diagram 1

1. Using your spring scale, record the weight in Newtons of your mass in the space provided below.

2. Attach a 5.0 N spring scale to one end of the rope and attach your mass to the other end of the rope.

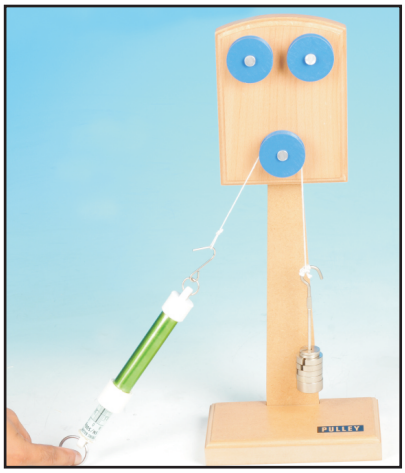


Diagram 2

3. Drape the rope over the back of the pulley demonstration apparatus and pull the mass with the spring scale. Be sure to have one person in your group securely hold the base of the pulley so it doesn't tip over while you are pulling as shown in diagram 1. Record the force used to pull your mass at a constant velocity in the chart below.

4. Now drape the rope over the pulley and again pull the mass with the spring scale as shown in diagram 2. Record the force used to pull the mass at a constant velocity in the chart below.

DATA:

Original Weight of the mass _____ N

Force required to pull the mass over the bar _____ N

Force required to pull the mass over the pulley _____ N

DATA ANALYSIS:

1. Calculate the efficiency of the pulley in diagram 1. Show all work including formulas and substitutions with units.

2. Calculate the efficiency of the pulley in diagram 2. Show all work including formulas and substitutions with units.

3. Calculate the mechanical advantage of pulling with the pulley and without the pulley. Show all work including formula and substitution with units.

ANALYSIS:

1. Compare the amount of force needed to pull the mass over the back of the pulley demonstration apparatus versus pulling over the pulley.

_____

_____

_____

2. Was any less work done on the mass using the pulley? If not, then what is the advantage of using a pulley?

_____

_____

_____

ACTIVITY 2: USING MORE THAN ONE PULLEY

By using more than one pulley, the mechanical advantage of the pulley can be increased. However, in order for this to work one of the pulleys must be moveable not fixed. Since all of these pulleys are in a fixed position, no mechanical advantage can be achieved. But it is fun to try. Have the students arrange their string over the different pulleys in several different ways and see if they can have the input force applied be less than the force of the load. Here are a few examples of fun ways to connect the pulleys with some string.

This activity is great to try before introducing "Block and Tackle" WDMS21

Diagram 3

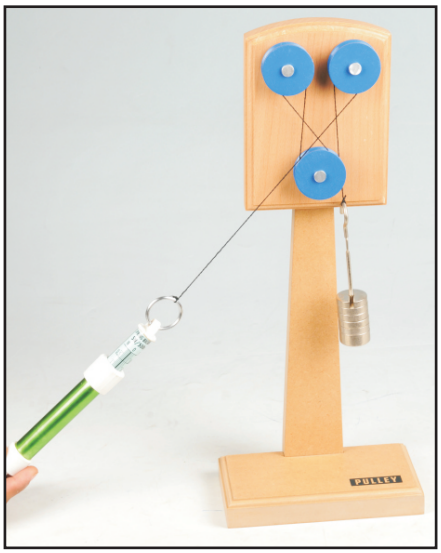


Diagram 4

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EISCO
www.eiscolabs.com

U.S. Distributor :
Eisco Scientific
850 St Paul St, Suite 15, Rochester, NY 14605
Email : www.eiscosci.com