



Pulleys and Locks

Part of: **Dartmouth Rural STEM Educator Partnership**

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<p>Driving Question How do forces and energy transfer through pulleys?</p>	<p>Overview The students will become familiar with pulleys and the role of pulleys in the interaction of energy with forces. Students will use pulleys to determine and explore mass and kinetic energy of objects.</p>
<p>NGSS Standards PS3.A: Definitions of Energy PS3.B: Conservation of Energy and Energy Transfer PS3.C: Relationship Between Energy and Forces</p>	<p>Objectives Through this lesson, students will (2-3 measurable objectives): 1) The students will better understand what a counteract weight is and how it relates to forces/weights. 2)The students will better understand how counterweight impacts falling velocity.</p>

Materials

washers/weights (of multiple sizes)
string
Scissors
meter sticks
rulers
cups
hole punch
pulleys
boxes/mystery masses
rubber bands
force meters
masking tape
scotch tape
spark timer
timer paper rolls
chairs
table
extension cords

Preparation (ahead of time)

Lesson 1:

Assemble mystery box (~30-80 grams)

Put weights in the mystery box

Wrap a rubber band around the box twice to ensure mobility of weight

Cut up a few strings of ~20 cm each (3-4 per station) and one of ~60-80 cm (per station)

For each group: 1 weight set, 2 paper cups, strings above, 1 mystery box, two force meters, 1 hole puncher, 1 meter stick, 1 pulley, and 2 chairs

Lesson 2:

Cut paper strips that are about half the distance from the table to the ground plus 30 cm (2-3 strips of the same length per group).

Cut 2 strings of ~20 cm each for each station, 2 paper cups, 1 hole puncher, 1 mystery box, 1 role of scotch tape, 1 spark timer, 1 weight set, and 1 table clamp, 1 rubber band, and 1 table pulley

Line up the materials above at the table (students set up the experiments themselves) and be sure that the spark timers can be plugged in either to outlet or extension cords if available

Background information

A force is an interaction between two objects. Any exertion of force on an object leads to the object speeding up, slowing down, changing trajectory, or changing shape. An object's position determines its potential energy and its movement with a field determines its loss of potential energy and its gain of kinetic energy ([see brief summary](#)).

See qualitative and quantitative activity instructions for relevant background information

Lessons

Detailed description of the lesson with sub-headings as needed.

Lesson 1 Overview:

- Set up stations for ~3-4 students prior to class
- Have 2 sets of materials ready in case any station needs extras
- Distribute handouts for lesson 1 at the beginning of class
- Go over activity instructions
- Supervise students during the lesson
- Be prepared to assist and clarify steps if/when needed

Lesson 1 Activity: Exploring the effect of counterweights

Students will use suspended pulleys to make effective counterweights for an object. This could be done qualitatively with just masses or quantitatively with defined masses and force meters. Students use a single pulley to determine the mass of a mystery box by exactly balancing out the pulley system



Lesson 2 Overview:

- Set up stations for ~3-4 students prior to class
- Have 2 sets of materials ready in case any station needs extras
- Distribute handouts for lesson 2 at the beginning of class
- Supervise students during the lesson
- Be prepared to assist and clarify steps if/when needed
- direct quantitative students to the [spark timer pdf](#) to review before activity

Lesson 2 Activity:

Students will use a single pulley at a right angle to explore the idea of how counterweights impact potential and kinetic energy. Students will use different mass counterweights and measure with a spark timer the different speeds that the cup has at the end of the fall given different counterweights used

Evidence of Learning

How will students demonstrate their learning? Exit questions?

Students demonstrate learning by finding the respective values/relations from each activity:

- 1a) Students successfully find weight/mass of mystery mass
- 1b) Students successfully see a reduced force needed with more pulleys
- 2) Students effectively reduce fall velocity with the counterweight

Extensions

Activity 1: could be done with student-sized wagons in the hallways or on a track to use pulleys to make it easier to move themselves or larger wagons with items (see difference in pull between 0, 1, 2 pulleys used)



Specific Activity extension: Students explore a multiple pulley system and then re-balance out the mystery box. Students can compare the masses needed for the one pulley system to the two pulley system.

Activity 2: could be done outside or in the gym, use melons or other objects dropped on the ground or into water/sand, observe how the counterweights work with larger objects/heights (can look at splash to determine speed perhaps or record and analyze video frames)

Glossary of terms

mass, weight, energy, counterweight, forces, potential energy, kinetic energy

Appendices

https://www.forestville.com/cms/lib/NY19000591/Centricity/Domain/38/04_timer_tape_prelab.pdf

<https://www.physicsclassroom.com/class/energy>