SCIENTIST IN RESIDENCE PROGRAM™

Science Unit: **Water Around Us**

Lesson 2: ***Lifting Marbles with Pulleys***

School Year:	2015/2016
Developed for:	Aboriginal Focus Elementary School (MacDonald Elementary School in the process of renaming), Vancouver School District
Developed by:	Ingrid Sulston (scientist); Fiona LaPorte and Brenda Koch (teachers)
Grade level:	Presented to grades K and 2-5; appropriate for K-5 with age appropriate modifications
Duration of lesson:	30-45 minutes

Objectives

1. Learn that a pulley changes the direction of a force.
2. Experience how the weight of water can be used to move a mass.
3. Use a single fixed pulley to experiment with how a load can be lifted at different speeds and with different masses.

Background Information

A pulley is a simple machine that changes the direction of a force. A simple, familiar version of a pulley is a rope over a branch used to lift a load up into a treehouse. Adding a wheel eliminates much friction. Pulleys can also be combined to give mechanical advantage, so that a person can use relatively little force to lift a heavy load.

However, there is a trade off: although a small applied force produces a greater resulting force, the smaller force must be exerted over a greater distance than the distance that the load will move i.e. a lot of rope must be pulled through the system to move the load by a smaller distance.

A single, fixed pulley is an appealing experimental system for students to explore direction of forces and balance. This lesson omits the wheel, and uses a low-friction rod, to keep the system very simple.

Vocabulary

Pulley	A simple machine. A wheel with a groove that can hold a line, to change the direction of a force. A combination of pulleys can increase the force applied.

Materials

- stiff, smooth rod, long enough to span two tables (one per small student group)
- string (several metres)
- optional: small S-hooks (two per group)
- plastic pots e.g. Dollar store shot glasses (four per group)
- masking tape
- marbles (several per group)
- water supply and small containers
- towels

In the Classroom

Introductory Discussion

Introduce students to the concept of a pulley: a simple machine that can change the direction of a force.

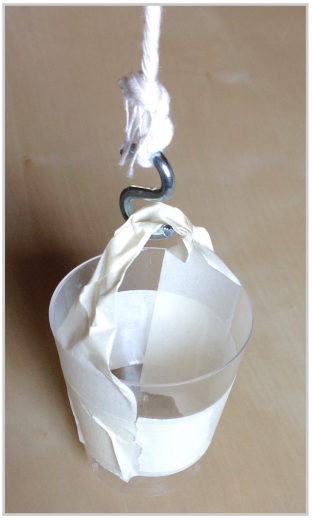
Processes of science that the students will focus on: exploration, curiosity, mechanical manipulation, close observation, designing experiments, classifying and comparing data, inferring, concluding, predicting.

Science Activity

Activity Title: Pulleys for lifting marbles and water

Purpose of Activity: To understand how a simple fixed pulley works

Methods and Instructions:
Set-up prior to experiment: For younger students set up the pulley stations for them, as described in the first step of the instructions below.
Students will work in small groups.



1. Demonstrate how to set up the pulley, and ask (older) students to make their own: Bridge a rod between two tables, then tape down to hold in place. Hang the string over the rod. Cut the string so that one end just reaches the floor and the other end just hangs over the rod. Show students how to make a handle for the plastic pot using masking tape (see photo): tape up one side of the pot, twist the tape to make a (non-sticky) handle, then tape down the other side of the pot; reinforce with a strip of tape around the pot. Either tie each end of the string directly to the pot handles, or attach S-hooks to the string for hanging the pots.
2. Give each student group a handful of marbles, a container for water and more pots to pour water from. Lay a towel under their pulley.
3. Give students their challenge: raise a marble in one pot, only by adding water to the other pot. Although this task is relatively easy, students will become familiar with their pulley system by achieving it. Discuss how the pulley changes the direction of the force: when the weight of the water moves one side down, an equal and opposite force pulls the marble on the other side up.
4. Allow students to experiment with number of marbles and amount of water. Given the chance they will naturally experiment with these and other variables to explore the characteristics and uses of a pulley.
5. If students need focused challenges to guide their experimentation try asking these questions:
   - How much water will raise more marbles?
   - How can you balance the pots half way up from the floor?
   - What can you change to make the marble move upwards slower or faster?

Closure Discussion

Gather as a group to discuss what students found. Use their discoveries to guide concluding remarks about the forces, balanced and unbalanced, in a pulley system.