SCIENCE NORTH SCIENCE NORD
SUDBURY, ONTARIO, CANADA

Making an Elevator Part 2 | **Grade 4 – Pulleys and Gears**

Lesson Plan

Assessment	AFL, questions
Cross-curricular	

Big Ideas

- Pulleys and gears change the speed, direction, and motion of, and force exerted on, moving objects. Sound is created by vibrations
- Pulleys and gears make it possible for a small input force to generate a large output force

Learning Goals

- To build a working elevator with a pulley
- To discover how changing the pulley changes the force required to raise the elevator
- Assess benefit of elevators and different designs.

Specific Expectations:

2.2 use scientific inquiry/experimentation skills to investigate changes in force, distance, speed, and direction in pulley and gear systems
2.3 use technological problem-solving skills to design, build, and test a pulley or gear system that performs a specific task
2.4 use appropriate science and technology vocabulary, including pulley, gear, force, and speed, in oral and written communication
3.1 describe the purposes of pulley systems and gear systems (e.g., to facilitate changes in direction, speed, or force)
3.8 identify the input components that drive a mechanism and the output components that are driven by it (e.g., the pedals on a bike are the input component; the rear wheel is the output component)

Description:

This is the **second** of five lessons on the topic of elevators. The focus of this lesson is to build an elevator using pulleys. Students will become familiar with pulleys through inquiry-based learning.

Materials/Resources:

Cardboard boxes
Masking or duck tape
Small Containers (optional: tubing)
String
Skewers or wooden dowels

Safety Notes

Introduction

If students have not yet built a tower, use the instructions in lesson 1 to have them build one.

Notice that the elevator can also just be attached to the edge of a desk, so building a tower may be skipped. Building a tower allows the students to create a more complete project though and also lets them explore structures and forces acting upon them a lot more.

Action

The teacher can guide the students by giving them instructions for each step. Circulate to each group to make sure they are getting it and then bringing everyone back together for the next step when the whole class is ready.

Build an Elevator

- Return to your groups that you built your tower with (two students per group is ideal).
- **Step 1: Gather your supplies**
    - You will need:
        - A container to use as an elevator
        - Two skewers
        - Optional: two pieces of corrugated tubing – cut long enough to have at least four grooves in each piece
        - A piece of string about 4 times as long as your tower is tall
- **Step 2: Make your elevator**
    - Attach the bottom pulley to the elevator (See image 2 of 'Reference Images')
        - E.g. for a cardboard box this could be a skewer that is pushed through the top of the walls of the box.
        - Slide one piece of tubing onto the skewer between the two walls of the elevator.
        - Tie one end of the string around the tubing (See image 3).
- **Step 3: Pull something up**
    - Place your (somewhat heavy) material into the elevator.
    - Try lifting it. Remember about how much weight you feel as you do this!
    - How high do you have to lift your hand to lift the elevator a certain distance? (same as the height the elevator is pulled up to)
- **Step 4: One wheel pulley**
    - Now attach a skewer to the top of your tower
        - If it's sticking out from the side of the tower, use tape on both ends of the skewer to hang it from your "arm". The skewer should stay horizontal if you put a bit of weight on it and there has to be enough room that you can put the piece of tubing on it and wind the string around it!
    - Slide a piece of tubing on the skewer (before you attach it to the tower at both ends!)
    - Place the elevator on the floor and loop the string over the top tube (See image 4).
    - This is a one "wheel" pulley. You don't have a wheel but the smooth groove of the tube is almost as good! (see image)

- OK. We are ready to pull up our elevator. Which direction do we have to pull in now? Up or down? Does it feel as hard to pull the elevator up as before?
    - The pulley reverses the direction of motion – so now we pull DOWN. It will still feel as hard to pull the weight as it did before.
  - How far do we have to pull the string? (as far as before, but going down)
- **Step 5: Two and four wheel pulleys**
  - Untie the string from the elevator. Tie that end directly to the top skewer or arm instead.
  - Now loop the string around a groove on the bottom and then the top pulley tube. (See image 5)
    - Is it easier to pull the elevator up now? (Yes) Does it take more string? (Pull elevator all the way in and measure the length of string that took – should be TWICE as much).
  - Add another loop (around the bottom and then top pulley - See image 6).
    - Again compare distance to pull the elevator all the way up. Again it gets easier and move string is pulled in.
    - We could keep going… (Time permitting and if the string is long enough feel free to add another loop – kids might be quite into trying it out)
  - As it gets easier the elevator also starts going very slowly and there is a lot of string to pull in. Would that be convenient for a real elevator?
    - This is great for things like lifting heavy objects up when speed is not super important
  - For elevators in buildings we can do something else that helps. That is, to create a BALANCE of forces with a counterweight. Let's see what we mean:
- **Step 6: Make an elevator with a counterweight**
  - Return the elevator to the one wheel configuration (string tied to elevator and looped through top pulley)
  - Now tie a weight about equal to the weight you are pulling up in the elevator to the string at the top, right after the string has gone through the pulley. (See image 7)
    - For example, tie the loose string around a full yogurt container or small Tupperware container filled with water.
  - Now pull down on the counterweight to lift the elevator. Is it hard? (Discuss – with points below)
    - No. We have now almost created a balance of forces. This works great for an elevator where we know about how heavy it usually is and we won't have to move it. It wouldn't work so great when the weight we lift up often changes often (e.g. for a crane) or if we had to lug that heavy counterweight around (e.g. on a ship where pulleys are used to help hoist sails – we wouldn't want to take along a lot of heavy counterweights for the ride).
  - Compound pulleys and simple pulleys with counterweights each have their place!

Consolidation/Extension

Final discussion:

- What are the advantages of the pulley?
- For the elevator, what is the input component (the applied force)? - Students work – in a real elevator it would be the motor.

- What is the output component (the result)? – the elevator moving a certain distance
- What happens when you add more loops?
- It gets easier BUT it also takes longer/greater distance.
- So the INPUT force becomes smaller though you still get the same output force.
- The force is applied over a greater distance though so the total WORK is still the same.
- Can you use a pulley to change the direction of the motion? Yes – the elevator goes up, but you can set it up so you pull DOWN. This may be beneficial. For example a crane would be very top heavy if it had a huge motor at the top to wind in the cable. Instead the crane has a winch at the bottom that pulls in the cable from the pulleys.
- Optional: Show some images of pulleys in the real world (Making an Elevator Part 2)