SCIENCE NORTH SCIENCE NORD
SUDBURY, ONTARIO, CANADA

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

Lesson Plan

Assessment	AFL, trials
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
3.2 describe how rotary motion in one system or its components (e.g., a system of pulleys of different sizes) is transferred to another system or component (e.g., a system of various gears) in the same structure
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

Description:

This is the **fourth** of five lessons on the topic of elevators. In this lesson students will use their gears to make an elevator go up.

Materials/Resources:

Cardboard gears
String
Skewers
Masking tape
Ruler or measuring tape

Safety Notes

Introduction

In this lesson students will play with the gears they created, culminating in creating a setup to pull the elevator up.

- This lesson is designed to reinforce a lot of the concepts discussed in lesson 3
- They will first perform a set of challenges to figure out which gear configuration would work best to use for the elevator. They will have to consider whether the elevator would benefit more from added force or added speed.

Action

Gears Challenges

These challenges can be done with students working in their groups so that each group has a couple of gears of different sizes. They will have to stick their gears into a cardboard box. If possible they can use the tower they built for the elevator for that. They can either lay the tower down to have a horizontal surface, or they can work on a vertical surface as well.

1. Turn the large gear with the small gear (See image 1 from Reference Images)
    a. Make a clear mark on each gear, so you can tell how far it has turned during the exercises
    b. Use skewers to stick the large and small gear into a cardboard surface. These are the axles of each gear.
        i. Make sure to measure the separation from one gears centre to the other one when they interlock. Mark this distance on your cardboard surface and ONLY THEN poke the axle of each gear in.
    c. Make sure the teeth interlock so you can spin one gear with the other one.
    d. Now gently turn the small gear and observe what happens to the large gear.
        i. How far does the large gear turn for one turn of the small gear? (Less than one turn)
        ii. Does the large gear spin fast or slow? (Slow)
        iii. Gears may be a bit "sticky" due to using cardboard that is not totally even. You can gently assist turning the second wheel.
    e. Try pushing a bit on the large gear to create resistance. Is it still possible to turn it using the small gear? (It should not be too hard as this setup creates more torque on the output component, i.e. the large gear)
2. Turn the small gear with the large gear
    a. Leave the setup as is, but now turn the small gear with the larger one. What do you observe? (The small gears spins faster, it's easier to stop the small wheel though by applying friction to it.)
3. Raise the elevator
    a. Which setup would be better to raise the elevator? Small to large gear or vice versa?
        i. Let students choose between speed (large = drive gear, small = load gear) and power (small = drive gear, large = load gear)

ii. Note: They will notice that the elevator goes up VERY slowly with the second setup, while with the first one they will really feel the pull of the elevator on the gears.

b. Create a setup to wind up the string of the elevator. You will need to hang the string on the axle of one of the wheels (see image 2).
   i. It may be easier to do this by hanging the elevator on the inside of the tower so that the axle can be poked through the walls of the tower on each side.
   ii. Attach the string in such a way that it won't slip when you rotate the axle. You can make your axle out of two or more skewers and pinch the string between them and tightly tape them together (see image 3).
   iii. The gears load gear (who's axle the elevator is attached to) needs to be taped to the axle well enough that it won't slip when you turn it with the elevator attached (see image 4)

c. Raise the elevator by turning the drive gear.
   i. Have one student gently push on the gears to make sure they stay aligned while the other one winds up the elevator.

Consolidation/Extension

Compound gears demo (time permitting)
It will probably be too difficult to raise the elevator using compound gears. So, here we just show how compound gears work on their own.

- Preparation ahead of time: Glue a small gear onto a large gear (perfectly centered).
- Stick the compound gear into a surface, and then stick a large gear so it connects with the teeth of the small gear (See image 5).
- Spin the large gear and observe the effect it has on the large compound gear.
- How could this type of setup be used? (To make something spin very fast)

Changing planes demo (time permitting)
- Pull one gear out of the surface and hold it up to a gear that is stuck in the surface at a 90-degree angle.
- Make sure teeth interlock and spin the gear you are holding.
- You can transfer rotation from one plane to another using gears. This is very useful!