Grade 4/5 Science Unit for Pulleys and Gears & Forces Acting on Structures and Mechanisms

Based on the Ontario Curriculum

This cross-curricular science unit allows teachers to meet the Ontario Science expectations when teaching a Grade 4/5 split.

Created by Teaching Rocks!
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Breakdown of Unit

• Timeline: 12 days (6 weeks with two classes per week; however, this is very flexible and can be changed to adapt to your needs)
• Lessons include the following:
  o Learning centres: students work in small groups or individually to rotate between three centres over the course of the activity (four types of centre activities: technology, reading/writing activity, creative response, and a fun or hands-on activity);
  o Whole class lesson/discussion followed by either small group activities or whole class activity
  o Cross-curricular integration with other subject areas
• Co-curricular integration with the following subjects:
  o Language Arts (Reading, Writing, Oral Communication, Media Literacy)
  o Math
  o 21st Century Learning
  o Art
• Assessment:
  o Assessment For and As Learning: Student self-assessments and group assessments, KWL, reflections, key term worksheets, project planning sheets
  o Formal Assessments: Journal writing, investigations, worksheets, cumulative project, centres booklet
• Differentiated Instruction is achieved through:
  o Learning Centres
  o Creative culminating task
  o Co-Curricular integration to meet various learning styles (kinesthetic, visual, or auditory learners)
  o A variety of hands-on activities/labs
  o Technological activities
Topic: Introducing Structures and Mechanisms

Lesson 1: What is a Structure? What is a Mechanism? A General Class Introduction

Overview: Students will work in groups to develop and describe various structures and mechanisms and how we use them in our everyday lives.

Objectives:
Students will:
- Work in groups to use their observation skills to describe various structures and mechanisms
- Discuss the need for structures and mechanisms
- Use effective communication skills to share their ideas and listen to the ideas of other group members
- Make connections between the various suggestions posed by group members
- Discuss how we use structures and mechanisms everyday

Learning Goal:
Grade 4: We are learning to describe and explain how people use different mechanisms every day.
Grade 5: We are learning to describe and explain how people use different structures every day.

Materials:
- “What is a Structure?” chart for grade 5s, “What is a Mechanism?” chart for grade 4s
- Structure and Mechanism images
- Key Term Worksheet (1/student)

Activities:
1. Have a class discussion with students by posing the question, “What are some things you use every day? Where are some places that you have visited?” Try to have grade 4 students focus on mechanisms that are used on a regular basis (e.g. elevator, car, bike); whereas, the grade 5 students should focus on structures that they have visited (e.g. house, school, museum, airplane).
2. Show that students the images of the skyscraper and the crane. As a class, have students use their observation skills to describe everything that they see in each image (focus on location, materials, surroundings, size) and how/why each item is used. While students are describing the two images, you can record their observations on
chart paper or on the board (this way they understand what type of observations to make).

3. Hand out the worksheet to each person and divide grade 4s into three small groups and do the same with the grade 5s. Provide each grade 4 group with an image of a mechanism (scissors, clock gears, door knob) and each grade 5 group with an image of a structure (Pyramid, igloo, Eiffel Tower).

4. As a group, students are to discuss their observations and record them on their worksheet. Give students about five minutes and then rotate the images so that each group works with each image.

5. Reconvene as a whole class and discuss their findings.

6. Students then work on defining “structure” (grade 5) and “mechanism” (grade 4) through a class discussion. Focus on discussing and answering the questions listed on the Key Term Worksheet (definition, materials used, examples, non-examples, why are they important, where have they seen this before, how is it used).

**Assessment:**
At home, students are to complete the Key Term Worksheet to better understand the two key terms they will explore throughout this unit.
Simple Machines: Student Recording Sheet

**LEVER**

Definition:

Labeled Drawing:

Examples of this simple machine:

How is this machine used in our everyday lives?

**INCLINED PLANE**

Definition:

Labeled Drawing:

Examples of this simple machine:

How is this machine used in our everyday lives?
Wheels in Motion
An Introductory Investigative Activity

In this activity, students will work in small groups to investigate both simple machines and linear movement. The activity begins as a whole class activity where simple machines are discussed, to a small group investigation. First, students will examine the car and layout of the experiment to investigate several simple machines. Next, in order to observe linear movement, the cart will be allowed to travel down a ramp. Finally, students will demonstrate how changes to the mass of the cart will then affect its linear movement.

Each group will need the following materials:

- a car (a small Hot Wheels type car)
- weights (if you don’t have small weights, pennies work well)
- masking tape (to tape the weights to the roof of the car)
- a tape measure (to measure the distance the car travels)
- a book (to be used with the ruler to create a ramp)
- a ruler (see above!)
A pulley is a simple machine with a cord or a rope moving around it. A pulley is used to lift or pull. How do people move pianos and heavy furniture into tall buildings? It’s easy if these items fit inside an elevator or they can be carried up the stairs. But what happens when they do not fit inside the elevator or it cannot be carried up the stairs? The answer is to use a **SIMPLE MACHINE**! Follow the directions to create your own pulley! Record your observations on your sheet.

**STEP 1:** Run a piece of string about 1 foot (30 cm) long through the hole in the spool and tie the ends of the string together.

**STEP 2:** Slide the spool and the string onto the broom handle. Rest the handle across the two chairs with the spool hanging between.

**STEP 3:** Put one pail on the floor and tie the end of the piece of ribbon to its handle.

**STEP 4:** Slide the other end of the ribbon over the spool and tie it to the handle of the other pail, which should dangle in the air.

**STEP 5:** Add a few pennies to the hanging pail. What happens to the pail on the ground?

**STEP 6:** Return the pail to the ground and add a handful of pennies or marbles. Pull the handle of the hanging pail toward the ground.
Get Into Science

Observations: Explain what happens when you fill the pail with weights.

As you added pennies to the hanging pail, it started to lift up the pail on the ground. Pulleys let you pull in one direction to move another object in another direction.

Why is this type of system important? Be detailed in your explanation and provide 2 examples of where this type of motion is useful.
When structures are built they are designed to resist forces acting on them. A force is anything that can cause a change in an object. Engineers and designers have divided forces into two categories. One of these categories is Internal Forces. Internal Forces are caused by external forces which create a change on the inside of the object. There are four basic types. They are as follows:

1) **Compression**: A pushing force that compacts or squeezes an object together

2) **Tension**: A pulling force that pulls material apart

3) **Shear**: A force that bends or tears material by pushing parts of the object in opposite directions

4) **Torsion**: A force that acts on an object by twisting its ends in opposite directions
You will be conducting an activity with marshmallows. Ensure that you each have 4 marshmallows to start this activity. When we think of structures we think of buildings but a marshmallow is also a structure, an unusual one but still a structure. When complete, you can definitely eat your structure!

There are four different internal forces you need to action on the marshmallow. Predict what the marshmallow will look like (draw a picture) after applying the force and name the force on the provided sheet.

Action 1: Grab one marshmallow and with your hand press down on it. Don’t forget to predict before you do this action. Draw what the marshmallow looked like before you applied the force and after you applied the force. As a group decide which internal force this represents.

Action 2: Grab another marshmallow and hold each end and then gently pull. Draw what it looked like before and after. As a group decide which internal force this represents.

Action 3: With a new marshmallow hold one end and turn the other end one full time around. Again, predict, draw what it looks like before and after and as a group decide which force is acting on the marshmallow.

Action 4: Grab your last marshmallow, use the scissors to cut the marshmallow into 2 pieces. Make sure you fill in your information on your sheet.
## Get Into Science

<table>
<thead>
<tr>
<th></th>
<th>Prediction: Draw</th>
<th>Prediction: Name the Force</th>
<th>Before applying force (draw)</th>
<th>After applying force (draw)</th>
<th>Name the force</th>
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<td><strong>Action 1</strong></td>
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<td><strong>Action 2</strong></td>
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The world around us is constantly using input and output forces and we use machines to make the work easier. Machines do not reduce the amount of work we need to do, they just change the way work is done. We apply an input force on machines to make them work. The machine then does work by using a force to move an object over some distance. This force is the output force. In the image, the force the man is using to pull the piano is the input force. The output force is the lifting of the piano.

So, input force is everything WE do to make the machine work. Meanwhile, output force is what the MACHINE does for us.
Fill in the following chart. Under example, think of a real world example of a machine with an input and output force. (For example: pedaling a bike).

<table>
<thead>
<tr>
<th>Example</th>
<th>Input Force: Who or what is exerting the force?</th>
<th>Output Force: Who or what is the force acting upon?</th>
<th>Explain: Describe evidence that a force is acting and the effects</th>
</tr>
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Although simple machines make work easier, there is a trade off. Not everything is perfect. There is a mechanical disadvantage when using simple machines. Let’s take a look at what this means.

A Lever is used to reduce the force needed to do a particular task. A lever reduces the force needed to move a very large load but for you to do so you must move a greater distance. The inclined plane works the same way. You can move a load higher than it is using a smaller force, but you need to move it over a much longer distance. The Wedge is forced into an object to break it apart. It makes work easier by increasing the force applied to the object. The down side of this is that it moves a greater distance into the object than it splits apart. The Screw is also a simple machine that increases the force you use. It’s function can be used to convert rotational motion into linear motion (turning to straight line motion) but it moves very slowly! For pulleys, the more supports the load is attached to the easier it is to lift the load but because you have a lot more rope to the system you will have to lift for a longer period to reach the same height you would without a the machine. Lastly, the wheel and axle has a similar disadvantage. You apply a force and movement to the axle which is converted to a greater movement, but less force is at the circumference of the wheel.
1) In your own words give a definition of Mechanical Advantage.

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

2) After reading the text what is your opinion of using simple machines?

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

3) Create a t-chart for each simple machine mentioned in the text. The columns should be labeled Advantage and Disadvantage. Record the information in the t-charts, use the back of this page as well. See the example below:

<table>
<thead>
<tr>
<th></th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wedge</td>
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Topic: Designing, Building, Testing, and Presenting Final Projects

Lessons 11-14: Culminating Task Design Challenge

Overview: Students will design, build, test, and present a final culminating project based on guidelines presented.

Objectives:
Students will:
- Work individually or with a partner to design either a moving elevator (grade 4) or an egg saving device (grade 5)
- Brainstorm and design their devices
- Use a variety of found materials to build their devices
- Build and test their devices and reflect on how well they work
- Address any problems or challenges and fix their devices
- Present their final project and show that class how well their device works
- Create a poster advertising their device using a slogan, catch phrases, bright colours, key features, and an interesting design layout
- Discuss how pulleys were gears are used to build the elevator (grade 4) and the internal and external forces acting on the device (grade 5)

Learning Goal:

Grade 4: We are learning to brainstorm, design, build, and test an elevator that uses pulleys and gears for movement.
Grade 5: We are learning to brainstorm, design, build, and test a device that protects an egg when it is dropped from a height.

Materials:
- Student design worksheets (1/student)
- Students are to bring their own materials for device construction
- Various advertisements from a magazine or newspaper

Activities:
1. As a class, review the concepts of simple machines, compound machines, and forces.
You have been hired by XYZ Construction to design and build a mechanism using pulleys and/or gears to build an elevator made from recycled materials. Your elevator must lift an object and move it up and down.

You are only to use recycled items that are found around your home for this project! The more creative you are with your supplies, the happier XYZ Construction will be. They are a leading environmental company and pride themselves on eco-friendly choices.

Your elevators will be designed, built, and tested during class time. You may work alone or with one partner. All materials needed for this project must be at school. A poster advertising your device will also be created. Good luck!
An egg is a delicate structure. It has a thin shell that is very fragile. Imagine you dropped that egg from the top of a staircase. What do you think would happen? A giant mess! But that’s exactly what we are going to do! There’s a catch, though...you will be building a mechanism to protect the egg during its drop.

You are only to use recycled items that are found around your home for this project! The more creative you are with your supplies, the better your mark.

Your mechanism will be designed, built, and tested during class time. You may work alone or with one partner. All materials needed for this project must be at school. A poster advertising your device will also be created. Good luck!
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