Pulleys & Gears

Pre and Post Activity Guide

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This package includes activities for you to do with your class before and after the workshop to reinforce the concepts and terms presented in the lesson. It also contains book titles, vocabulary words and extension activities for a variety of subject areas related to the topic.

Ontario Science & Technology Standards

The activities in this workshop have been specially designed to build skills and develop understanding in critical areas of science for students in Grade 4 as outlined in the 1998 edition of the Ontario Science & Technology Curriculum.

Overall Expectations

By the end of Grade 4, students will:

- Demonstrate an understanding of the characteristics of pulleys and gears;
- Design and make pulley systems and gear systems, and investigate how motion is transferred from one system to another;
- Identify ways in which different systems function and identify appropriate criteria to be considered when designing and making such systems.

Specific Expectations: Understanding Basic Concepts

By the end of Grade 4, students will:

- Describe, using their observations, the functions of pulley systems and gear systems;
- Describe, using their observations, how rotary motion in one system is transferred to rotary motion in another in the same structure;
- Describe, using their observations, how gears operate in one plane and in two planes;
- Demonstrate an awareness of the concept of mechanical advantage by using a variety of pulleys and gears.

Specific Expectations: Developing Skills of Inquiry, Design and Communication

By the end of Grade 4, students will:

- Formulate questions about and identify needs and problems related to structures and mechanisms in their environment and explore possible answers and solutions;
- Plan investigations for some of these answers and solutions, identifying variables that need to be held constant to ensure a fair test and identifying criteria for assessing solutions;
- Use appropriate vocabulary, including correct science and technology terminology to describe their investigations;
- Compile date gathered through investigation in order to record and present results, using tally charts, tables and labeled graphs produced by hand or with a computer;
- Communicate the procedures and results of investigations for specific purposes and to specific audiences, using media works, written notes, and descriptions, drawings, charts and oral presentations;

- Design, make and use a pulley system that performs a specific task;
- Design and make a system of pulleys and/or gears for a structure that moves in a prescribed and controlled way and performs a specific function;
- Manipulate pliable and rigid materials as required by a specific design task.

Specific Expectations: Relating Science and Technology to the World Outside School

By the end of Grade 4, students will:

- Demonstrate awareness that most mechanical systems are fixed and dependent on structures;
- Compare in qualitative terms the performance of various mechanical systems and describe how they are used;
- Identify and make modifications to their own pulley and gear systems to improve the way they move a load;
- Evaluate, in general terms, the performance of a system that they have made and the performance of another system designed to do the same task;
- Explain how various mechanisms on a bicycle function;
- Demonstrate awareness that finishing techniques can adversely affect the performance of a mechanical system;
- Identify the properties of materials that are best suited for use in a structure that contains a mechanical system;
- Describe the consequences of having a limited choice of materials when making a device or a structure;
- Identify common devices and systems that incorporate pulleys and/or gears.

GRADE FOUR: PULLEYS AND GEARS	Educational Objective Achieved
Overall Expectations	
Demonstrate an understanding of the characteristics of pulleys and gears	✓
Design and make pulley systems and gear systems, and investigate how motion is transferred from one system to another	✓
Identify ways in which different systems function and identify appropriate criteria to be considered when designing and making such systems	✓
Specific Expectations: Understanding Basic Concepts	
Describe, using their observations, the functions of pulley systems and gear systems	✓
Describe, using their observations, how rotary motion in one system is transferred to rotary motion in another in the same structure	✓
Describe, using their observations, how gears operate in one plane and in two planes	
Demonstrate an awareness of the concept of mechanical advantage by using a variety of pulleys and gears	
Specific Expectations: Developing Skills of Inquiry, Design and Communication	
Formulate questions about and identify needs and problems related to structures and mechanisms in their environment and explore possible answers and solutions	✓
Plan investigations for some of these answers and solutions, identifying variables that need to be held constant to ensure a fair test and identifying criteria for assessing solutions	✓
Use appropriate vocabulary, including correct science and technology terminology to describe their investigations	✓
Compile date gathered through investigation in order to record and present results, using tally charts, tables and labeled graphs produced by hand or with a computer	✓
Communicate the procedures and results of investigations for specific purposes and to specific audiences, using media works, written notes, and descriptions, drawings, charts and oral presentations	✓
Design, make and use a pulley system that performs a specific task	✓
Design and make a system of pulleys and/or gears for a structure that moves in a prescribed and controlled way and performs a specific function	✓
Manipulate pliable and rigid materials as required by a specific design task	✓
Specific Expectations: Relating Science and Technology to the World Outside School	
Demonstrate awareness that most mechanical systems are fixed and dependent on structures	
Compare in qualitative terms the performance of various mechanical systems and describe how they are used	
Identify and make modifications to their own pulley and gear systems to improve the way they move a load	
Evaluate, in general terms, the performance of a system that they have made and the performance of another system designed to do the same task	
Explain how various mechanisms on a bicycle function	
Demonstrate awareness that finishing techniques can adversely affect the performance of a mechanical system	
Identify the properties of materials that are best suited for use in a structure that contains a mechanical system	
Describe the consequences of having a limited choice of materials when making a device or a structure	
Identify common devices and systems that incorporate pulleys and/or gears	✓

Before the Workshop

To maximize the workshop's impact and educational value, it is recommended that you introduce your students to the topic of electricity prior to the Mad Science program. Included are fun, easy and educational activities that will prepare your class for the workshop. These experiments will also help your students to become familiar with the concepts of *observation*, *hypothesis*, *experimentation* and the *scientific method*.

POWERFUL PULLEY

This is a great way to show students how simple machines help to make work easier

Materials:

- Jump rope or clothesline
- 2 broom sticks

Note:
Do this experiment as a whole class activity.

Procedure:

1. Explain to your students that you are going to try an activity to learn about simple machines. Ask them if they know what simple machines are.
2. Explain to your students that simple machines help make work easier for us, and that they are found all around us and we use them all the time.
3. Tell the class that there are six types of simple machines. You may want to write them down on the board. The six simple machines are—the lever, inclined plane, wheel and axel, screw, pulley and wedge. Use the chart found at the back of this package to provide examples of each for the students. Explain that gears are also used to help make work easier for us and are often found in bikes, gumball machines, wind up toys and music boxes. Tell the students that you are going to be learning more about pulleys and gears.
4. Have two students come forward to help with the *experiment*. Ask the rest of the class to watch carefully so they can share their *observations* with the rest of the group.
5. Tie the string to one of the broom sticks and then have each student hold a broomstick and stand about a chair width apart from each other.
6. Take the string and weave it under and over each of the broomsticks about four times as indicated in the illustration.
7. Have another student come forward and pull on the string. The challenge is for the students holding the broomsticks to try to pull the broomsticks apart while the student holding the string should pull the string as hard as possible to try to pull the broomsticks together.
8. Have the class share their *observations* with the group about what happens during the experiment.
9. Have two other students come up and hold on to the broomsticks and try to pull them apart.
10. Have the class share their *observations* and what type of simple machine they think it is an example of.

Explanation:
By winding the rope around the broomsticks you created a double pulley system. This means that when the end of the rope was pulled on a small force was exerted but over a long distance, because of the length of rope that was used. The result is that the force created by pulling on the rope was greater than the force exerted by the students pulling on the broomsticks. This type of pulley system is used for loading ships, lifting and lowering boats, pianos and safes.

MARVELOUS MACHINES

Send your students on a hunt for simple machines.

Materials:
- Paper, with a chart of the six simple machine categories printed on it
- Pencils
- Your classroom or school

Note:
Conduct this experiment as a small group activity or in pairs.

Procedure:
1. Review with the group the six different types of simple machines—the lever, inclined plane, wheel and axle, screw, pulley and wedge. Provide examples of each category from the chart at the back of this package.
2. Explain to your students that they are going to have to use their *observation* skills to try and find examples of the different simple machines in the classroom or school.
3. Provide each pair or group with a sheet with a chart outlining the different simple machines and a pencil.
4. Give the students a specific time limit to find different examples of simple machines and to record them in the chart.
5. Have the students share their findings with the rest of the group. Encourage them to share the following information:
   - What object did you find?
   - What type of simple machine is it?
   - Does it include more than one type of a simple machine?
   - How can you tell what type of simple machine you identified?
   - How does this simple machine help to make work easier?

Extension:
You may also want the students to look for examples of gears in your classroom or school.

Explanation:
Simple machines are found all around us and help to make work easier. They are so effective that we often take them for granted and do not notice when they are used. This activity will help to employ students' observation skills to discover the simple machines that they use all the time.

After the Workshop

Here are some activities you may wish to do with your class after the workshop to reinforce and expand the concepts introduced by Mad Science.

BUILD A PULLEY

Try to build a pulley to move objects.

Materials:
- 2 Large Thread Spools
- 2 wire clothes hangers
- 2 chairs
- Broomstick
- Scissors
- 3 meters (10 feet) of strong string
- A small bucket or a pail with a handle (an empty plastic ice cream container would world well)

Note:
You might want to perform this experiment as a demonstration and then let the students try it for themselves. Before the class you should perform the first step and unwind the wire clothes hangers and thread it through the spool. Move the spool to the middle of the flat length of the wire clothes hanger. If you are going to perform the extension part of the activity do the same thing with another wire clothes hanger and a spool.

Procedure:
1. Unwind the wire clothes hangers and thread it through the spool. Move the spool to the middle of the flat length of the wire clothes hanger. If you are going to perform the extension part of the activity do the same thing with another wire clothes hanger and a spool.
2. Take the two chairs and place them back to back, with some space between them.
3. Take the broomstick and lay it across the backs of the chairs as is indicated in the diagram.
4. Take some string and tie it in a loop around the broomstick, this is what the pulley is going to hang on.
5. Cut a piece of string about 1.2 meters (4 feet) in length and tie it around the handle of the bucket or pail.
6. Pull on the end of the string and ask the students to share their observations with the group.
7. Have the students put some objects in the bucket or pail and try to lift them off the ground.

Extension:
8. Take the second wire clothes hanger with the spool attached that you made at the beginning of the experiment and attach the hook to the handle of the bucket or pail. Make sure that you leave the original string attached to the handle of the bucket or pail.
9. Take the end of the string that is wrapped around the original spool and loop it under the second spool.
10. Pull the string and lift up the bucket or pail. Try to add different objects to the bucket or pail.

Explanation:
A pulley is a cable that moves over a wheel that may be grooved or otherwise shaped to hold the cable. A single fixed pulley stays in one place and does not decrease the force needed to move a load. Pulleys are used to lift heavy objects like pianos and even elephants! A pulley can help raise a flag to the top of a flagpole or raise a bucket to a roof. By adding a second pulley you will use less force to lift the load in the bucket or pail than you did with one pulley. Using two pulleys gives you a mechanical advantage, which just means that it is easier to lift a load.

GREAT GEARS

Challenge your students to see if they can make their own moving gears.

Materials:
- Thick cardboard
- Scissors
- Sharpened pencil
- Brass fasteners

Note:
Arrange the students into groups to conduct this activity. You may also want to cut out the circles with teeth prior to the activity rather than having the students do it for themselves.

Procedure:
1. Explain to the students that they are going to work together to create their own gears.
2. Provide each group with some thick cardboard, scissors, a sharpened pencil and some brass fasteners.
3. Instruct the students to take a large piece of thick cardboard and set it aside as this is the sheet that they will be attaching the gears to.
4. Have the students take the other piece of thick cardboard and draw four circles, each exactly the same size, and have them draw teeth all around the outside of the circles.
5. The next step is to cut out each of the circles and to punch a hole with the sharpened pencil in the middle of each.
6. Ask the students to cut out four small square pieces of cardboard.
7. Have the take a circle and attach it to the large piece of cardboard that they set aside at the beginning of the activity with a brass fastener. If necessary they may want to add one of the small pieces of cardboard to the backside of the piece of cardboard before attaching the brass fastener to make a better fit.
8. Have the students attach the other wheels, ensuring that the teeth of the second wheel match up with those in the first wheel.
9. When all of the wheels are attached have the students rotate the upper wheel and share their *observations* about what happens with the rest of the group.

Extension:
You can have the students create different sizes of wheels to see if there is a difference in the way that the gears work.

Explanation:
Gears, much like simple machines, are used to make work easier. They are toothed wheels that are placed together to transmit motion and force. In any pair of gears the larger one will rotate more slowly than the smaller one, but will rotate with greater force. Typically gears are used to reverse the direction of rotation, to increase or decrease the speed of rotation, to move rotational motion to a different access or to keep the rotation of two axes synchronized.

More To Do

MATH

- Integrate simple machine vocabulary into word problems. For example, pulleys can be used to lift rocks. First Jamie loaded three rocks into the bucket being lifted by the pulley and then put in another four. How many rocks did the pulley lift all together?
- Try the "Build a Pulley" activity and have the students predict and then test how many marbles the single pulley can lift and then try the same experiment with the double pulley.
- Have the students try

LANGUAGE ARTS

- Challenge your students to write public service announcements about the way in which they use simple machines in their daily lives and all the benefits of using simple machines.
- Ask your students to image they could create their very own simple machine and write a short story about what type of work would it do and how would it make their life easier?
- Have your students write poems about simple machines and ask them to print them in the shape of the simple machine they wrote about.
- Ask your students to find examples of gears they use everyday and write a story about how useful gears are and how they are used all the time. Some examples that students may like to write about are gumball machines, bikes, wind up toys and music boxes.

ART

- Provide your students with an assortment of materials and ask them to build their own simple machines.
- Do the "Great Gears" experiment and ask the students to decorate the gears in any way that they would like.
- Provide your students with gear shaped sponges and other textured materials and have them dip them in paint and roll them across paper to make interesting art pieces.

SOCIAL STUDIES

- Have your students conduct research reports on the history of simple machines.
- Challenge your students to investigate the different ways that gears have been used in history.
- Have your students research where pulleys and gears have been used in the past and in what types of construction.

Books

Here are some suggested resources on pulleys and gears that will help to reinforce the concept to your students.

Title: Pulleys and Gears
Author: David Glover
Publisher: Heineman Library
ISBN#: 1575720841
Description: This book includes information and diagrams to introduce children to pulleys and gears and the way that they help to make work easier.

Title: What is a Pulley?
Author: Lloyd G. Douglas
Publisher: Children's Press
ISBN#: 0516240242
Description: Children are introduced to pulleys in this book, which outlines how they work and are designed.

Title: Science Magic with Machines
Author: Chris Oxlade
Publisher: Barrons Juveniles
ISBN#: 0812093682
Description: This book includes ten magic tricks, and a mystery box that appears to make objects disappear. All involve the use of simple machines. It is intended for students in Grades 3 to 6.

Title: Science Book of Machines
Author: Neil Ardley
Publisher: Harcourt Brace
ISBN#: 0152006133
Description: This book presents simple experiments to illustrate the basic concepts of simple machines. It is appropriate for students in Grades 3 to 6.

Title: Axel Annie
Author: Robin Pulver
Publisher: Dial Books for Young Readers
ISBN#: 0803720963
D**escription:** Axel Annie is the best school bus driver in town, especially when it comes to driving her bus up the toughest snow covered hill in town. But, as a result the superintendent never has to declare a snow day, which is exactly why the grouchy bus driver Shifty Rhodes hatches a plan to stop Axel Annie in her tracks.

Vocabulary

Hypothesis: Technically, a hypothesis is a tentative explanation that accounts for a set of facts and can be tested by further investigation; a theory. Put simply, it is a scientist's "educated guess" and a student's best guess. The scientists would then perform experiments to determine if the guess was correct.

Incline Plane: Ground or board that forms a slope or an upward or downward slant.

Lever: This is a simple machine that is used for lifting weights, prying something open or turning an object. All levers consist of a strong stiff bar that turns about a pivot, like a see-saw or a crowbar. You push or pull at one end of the lever and the weight is lifted at the other end. Some levers are used in pairs—scissors, pliers, shears and nutcrackers are all pairs of levers with a single pivot. Most levers put out more force than you put in, and so they make work easier.

Observation: The act of noting and recording something.

Pulley: Is a simple machine that consists of a grooved wheel, around which a rope or chain is pulled to raise a weight. If more than one pulley wheel is used on the same rope, a heavy weight can be lifted with a small amount of force.

Screw: A device with a spirally grooved cylinder used as a machine.

Simple Machine: A device that allows us to reduce the amount of effort we exert to do work. It, therefore, does not do all the work for us, as a complex machine would. A simple machine allows us to exert only a fraction of the effort we would exert without the aid of the machine.

Wedge: A solid triangle piece of wood or metal that tapers to a thin edge and is used to split logs or rocks to raise heavy weights.

Wheel and axle: Together they work as a machine. An axle is a spindle on which a wheel rotates. A wheel is a disk or circular frame capable of turning on a central frame.

Assessment Quiz

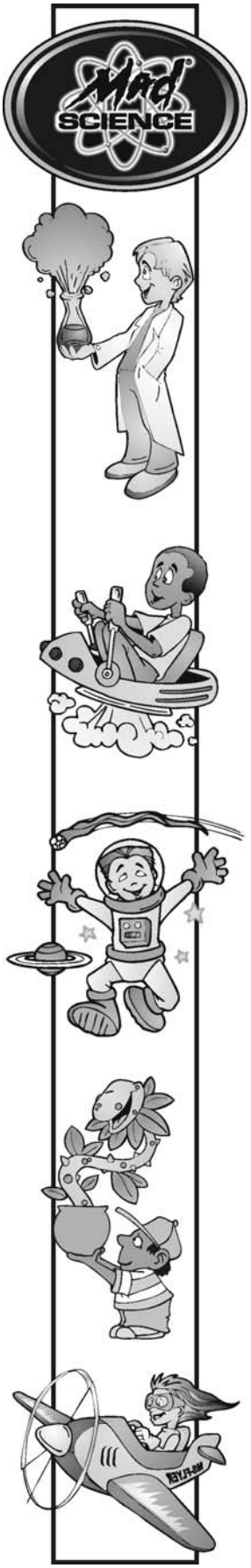
The next page in this package contains a series of questions that are designed to help you assess your students' understanding of the concepts presented in the Mad Science workshop. It has been created in a "pop quiz" format that can be photocopied and given to children to complete after the workshop.

Answer Key to the "Pulleys and Gears" Quiz:

1. C
2. B
3. A
4. B
5. B
6. A

Pulleys & Gears Quiz

Circle the Correct Answer for Each Question



1. Simple machines:

A. are nice to look at.
B. cause problems.
C. make work easier.

2. Examples of pulleys are:

A. pencils and books.
B. flagpoles and clothes lines.
C. lights and radios.

3. Gears are used in:

A. bikes and gumball machines.
B. seesaws and swings.
C. stop signs and balloons.

4. Increasing and decreasing the speed of rotation is done by using:

A. pulleys.
B. gears.
C. bikes.

5. Pulleys help to:

A. split things in half.
B. lift things up.
C. push things to the side.

6. Gears are wheels with:

A. teeth
B. a flat surface
C. nice colours

NAME:

_____

Crash Course

Pulleys, levers, wedges, screws, inclined planes, wheels and axels are all types of simple machines. A simple machine is any device that helps to reduce the amount of effort needed to do work. It does not do all of the work, like an electronic device would, but reduces the amount of work or effort that a human being needs to do. Simple machines help to make work easier by doing tasks like making holes, chopping wood, lifting heavy weights, and plowing fields. Machines are often thought of as large, complex contraptions like drilling machines and tractors but even these impressive machines include simple machines. They are typically made up of combinations of the six types of simple machines (pulleys, levers, wedges, screws, inclined planes, wheels and axels).

Almost all simple machines and the mechanical principles they utilize are very old. Leonardo da Vinci, an Italian scientist from the fifteenth century documented his ideas on the use of machines in notebooks with diagrams of levers, screws and pulleys. Other scientists like Archimedes developed many of the fundamental mechanical ideas that are the basis of many modern machines.

The world is full of examples of simple machines, you just have to know what to look for. A machine, like everything that moves, works because a force pushes or pulls it. The force can come from a powerful engine or a motor or in the case of most simple machines—human muscle.

Gears are also used to make work easier for us. They are toothed or pegged wheels mashed together to transmit motion and force. In any pair of gears the larger one will rotate more slowly than the smaller one, but will rotate with greater force. Typically gears are used in one of four ways. To reverse the direction of rotation, to increase or decrease the speed of rotation, to move rotational motion to a different access or to keep the rotation of two axes synchronized. Examples of gears can be found in car engines, watches and bicycles.

Simple Machine	**What It Is**	**How It Helps Us Work**	**Examples**
The Lever	A stiff bar that rests on a support called a fulcrum.	Lifts or moves loads	Shovel, nutcracker, seesaw, crowbar, elbow, tweezers, bottle opener
Inclined Plane	A slanting surface connecting a lower level to a higher level.	Things move up or down it	Slide, stairs, ramp, escalator, slope
Wheel and Axle	A wheel with a rod, called an axel, through its center: both parts move together.	Lifts or moves loads	Car, wagon, doorknob, pencil sharpener, bike
Screw	An inclined plane wrapped around a pole.	Holds things together or lifts	Screw, jar lid, vise, bolt, drill, corkscrew
Pulley	A grooved wheel with a rope or cable around it.	Moves things up, down or across	Curtain rod, tow truck, mini blind, flagpole, crane
Wedge	An object with at least one slanting side ending in a sharp edge.	Cuts or spreads an object apart	Knife, pin, nail, chisel, axe, snowplow, front of a boat

More Mad Science Resources

In the School:

In-Class Workshops – Curriculum based, hour long hands-on explorations of one specific topic in science for one classroom. Complete with Teacher Resource Packages.

JK & SK:	Wiggly Worms, Bubbles, Lights On, Space, Human Body, Listen Closely
Grade 1:	Spectacular Structures, Mad Materials, Harnessing Heat, Sonic Sounds
Grade 2:	Moving Machines, Mad About Matter, Dry Ice, Acids & Bases, Harnessing Heat
Grade 3:	Structures & Levers, Make it Move, Watt's Up, Rocket Demo
Grade 4:	Light, Pulleys & Gears, Mineral Mania
Grade 5:	Wacky Weather, Changes, Be Tobacco Free, Dry Ice, Slime, Dem Bones
Grade 6:	Aerodynamics, Electrifying Science, Watt's Up, Rockets
Grade 7:	Be Tobacco Free, Dem Bones
Grade 8:	Be Tobacco Free, Dem Bones

Scratch & Learn – We know that no matter how good our programs are, it doesn't change the budget. Our Scratch & Learn Program provides a means that individual classes can raise money to bring Mad Science to their classroom.

Science Clubs – Once a week extra-curricular science enrichment at lunch hour or after-school. Science Clubs get kids excited about science outside of class time, and are a great way to increase science literacy within the school community without impacting upon the school budget. More than half the schools in Niagara host a Mad Science Club each year.

Spectacular Science Shows – Get everybody excited about science at a school assembly or Fun Fair.

In the Community:

- **Birthday Parties**
- **Spectacular Science Shows**
- **Fairs & Festivals**
- **Scouting & Guiding**
- **Summer Camp**
- **Corporate Parties & Events**

For more detailed information visit our website or give us a call

www.madscience.org/Niagara

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