Playful machines

A Facilitator's Guide to Simple Machines in the Playground
Our Vision
Canadians recognize that Science\(^1\) is intrinsic to their lives and acknowledge the fundamental importance of a quality Science education to prepare young people for our rapidly changing world.

Our Mission
Let's Talk Science is striving to improve Science literacy through innovative educational programs, research and advocacy. We exist to motivate and empower young Canadians through Science education.

\(^1\)Our Science includes life and physical sciences, technology, engineering and mathematics.

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A. Description of Workshop

Overview of Workshop

Power Play 1
Welcome to the science of the school playground! In this workshop, students examine simple machines by incorporating levers, wheels and axles, and inclined planes into a playground environment. Simple machines will be transformed into real objects that are familiar to the children.

Power Play 2
Welcome to the science of the school playground! In this workshop, students examine simple machines by incorporating levers, wheels and axles, and inclined planes into a playground environment. Pulleys and gears will be investigated through hands-on activities. Simple machines will be transformed into real objects that are familiar to the children.

Overall Objectives

- To understand the names and examples of simple machines.
- To learn the difference between simple and complex machines.
- To learn the importance of machines in our everyday lives.

Science Topics

- Simple Machines
- Energy
- Forces

Grade for Workshop/ Appropriate Age

Power Play 1 is designed for use in Grades K-2 classrooms or with children ages 5-8.
Power Play 2 is designed for use in Grades 3-5 classrooms or with children ages 8-11.
## B. How to Run This Workshop

### Physical Requirements

You will need a large classroom with a demonstration area at the front. Arrange desks so that you can put groups of students together to share materials.

### Materials and Set-up

*Note: For more detail, see Kit List*

<table>
<thead>
<tr>
<th>Activity #1 - Roundabout</th>
<th>Activity #2 - Slide</th>
<th>Activity #3 - Teeter-Totter</th>
<th>Activity #4 - Pulleys</th>
<th>Activity #5 - Gears</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Cut-out cardboard circles (1 per child)</em></td>
<td><em>Pipe cleaners (1 per child)</em></td>
<td>Lever parts to put on blackboard</td>
<td>3 single pulleys -same size</td>
<td>Plastic Gears and bases</td>
</tr>
<tr>
<td><em>Brass fasteners (1 per child)</em></td>
<td><em>Short pipe cleaners (2 per child)</em></td>
<td>Sample lever pictures</td>
<td>1 large single pulley</td>
<td>Gear Task Card</td>
</tr>
<tr>
<td><em>Pipe cleaners (1 per child)</em></td>
<td><em>Craft sticks (3 per child)</em></td>
<td><em>Pipe cleaners (2 per child)</em></td>
<td>2 double pulleys</td>
<td></td>
</tr>
<tr>
<td><em>Styrofoam base, cardstock base or paper plate base (1 per child)</em></td>
<td><em>Clear tape (use same as for Activity #1)</em></td>
<td><em>Craft sticks (3 per child)</em></td>
<td>Thick string or rope</td>
<td>Wrap-Up</td>
</tr>
<tr>
<td><em>Clear tape (20-25 rolls)</em></td>
<td>Slide Task Card</td>
<td><em>Straw (1/4 per child)</em></td>
<td>Coloured tape (to attach to ends of string to identify where to pull down)</td>
<td></td>
</tr>
<tr>
<td>Roundabout Task Card</td>
<td><em>Clear tape</em></td>
<td>4 water bottles filled with same amount of water. Lids with hooks and washers to attach pulleys and strings.</td>
<td>Simple machine picture cards</td>
<td></td>
</tr>
<tr>
<td>Teeter-totter Task Card</td>
<td>2 metre sticks with four small hooks to hang pulleys from.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LEVER TESTING</td>
<td>2 hooks to attach pulleys on #3 and #4 to water bottles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beams</td>
<td>Number labels for water bottles (#1, #2, #3, #4).</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fulcrums</td>
<td>Pulley Task Card or poster</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weights</td>
<td></td>
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</tbody>
</table>

*Consumable items*
C. Introduction to Topic

Objectives of Introduction

➢ To provide a basic background of machines - simple and complex.
➢ To provide examples of simple machines that children can relate to.

Suggested Discussion, Q & A

What is a machine?
Car, washing machine, crane, tools...
A machine is a device that enables you to do difficult mechanical work by changing the direction or the size of the force (load) required to do the work.
In some cases, a machine may do work faster than is possible without the machine. Often the force exerted is spread out over a greater distance.

There are special machines we call simple machines.
Simple machines are not big machines like cranes and cars (refer to examples students may have given you already).
Simple machines help us to do work; however they do not have any power of their own (no engines, etc). They are just what their name says...Simple!

**What are the different types of simple machines?**
There are three main simple machines, including the lever, wheel and axle, and inclined plane. Other simple machines, including the pulley, gear, screw and wedge are modifications of the three basic simple machines (Pulleys and gears are modifications of wheels and axles, screws and wedges are modifications of inclined planes).

**CHOICE:** If this is the first time the class is learning about simple machines, skip the next part and move on to the difference between simple and complex machines.

**What is a commonly used example of a lever?**
See-saw (teeter-totter), arm, balance (scales)
A lever helps us do work by pivoting an object about an axis.

**What is a commonly used example of a wheel and axle?**
Roundabout, toy cars, bicycles, doorknob
A wheel and axle help us do work by moving or lifting loads.

**What is a commonly used example of an inclined plane?**
Slides, ramps outside of buildings, slopes
An inclined plane helps us do work by moving objects up and down.

**What is a commonly used example of a pulley?**
Crane, flagpole, mini-blinds, curtain rods
A pulley helps us do work by moving things up, down and across

**What is a commonly used example of gears?**
Clocks, bicycle, water wheel
A gear helps us to do work by moving things in a circular motion.

**What is a commonly used example of a screw?**
Car jack, screw, jar lids
A screw helps us do work by holding things together and/or lifts things.
What is a commonly used example of a wedge?
The head of an axe, snow plow, nail, pin, knife
A wedge helps us do work by spreading or cutting an object apart.

What is the difference between a simple machine and a complex machine?
A simple machine is a single function device that can do work. A simple machine does not have any source of power other than your body.
A complex machine is a combination of simple machines that perform together to do work. Complex machines may contain a source of power other than your body, such as a battery or a motor.

D. Activities

**CHOICE:** Only use Activity #4 and #5 if you are doing Power Play 2. Activities can be done in any order. Lever testing is optional.

**ACTIVITY #1: ROUNDABOUT (10-15 min.)**
Use Roundabout Task Card

**Objective of Activity**

- To relate the wheel and axle to a roundabout (merry-go-round) at the playground.

**Suggested Instructions, Q & A**

The wheel & axle is an important simple machine. It is found in many things that move. A wheel is a circular, round object. An axle is a post that fits in the middle of the wheel. The wheel turns on the axle, causing movement. Working together, a wheel and axle move objects across a distance.

What are some things that move and have a wheel and axle?
Bicycle, roller blades, ...
Have you ever played on a roundabout (merry-go-round) at the playground?
Yes
That is a wheel and axle!

The first part of our playground is going to be a roundabout.

DELIVERY HINT: Go over the Task Card with the students before they start to build their roundabout and show them an example of what they are going to make. Point out that the wheel should not be placed too close to the edge of the tray or it will hit the edge.

Activity Wrap-Up

Now that you’ve made your roundabout, can you identify the wheel?
Cardboard circle
What about the axle?
Brass fastener
How does a roundabout work as a simple machine?
It makes your work easier.
You can move many of your friends at the same time!

ACTIVITY #2: SLIDE (10-15 min.)
Use Slide Task Card

Objective of Activity

➢ To relate an inclined plane to a slide on the playground.

Suggested Instructions, Q & A

An inclined plane is a kind of simple machine.
An inclined plane looks like a board on an angle, with one end up in the air and the other end touching the ground.
What is an example of an inclined plane?
A ramp

Where might we find an inclined plane on a playground?
A slide

**Activity Wrap-Up**

What kind of simple machine is a slide?
An inclined plane.

How does a slide make your work easier on a playground?
It uses gravity to get you from one place to another (don’t have to exert as much energy)

Can you think of another example of an inclined plane making work easier?
One example is can be found on a moving truck.

Would you want to lift a piano up onto a truck or push it on a ramp?
Ramp

**Objective of Activity**

➢ To relate a lever to a teeter-totter on a playground.

**Suggested Instructions, Q & A**

**BRIGHT IDEA**: Cut out lever parts and laminate. Stick magnets on the back. While discussing the parts of a lever, place the appropriate part on the blackboard.
A lever is another kind of simple machine. There are 4 different parts to a lever:
1. beam (bar)
2. fulcrum (pivot point)
3. load (the thing that you want to lift)
4. effort (the force that you have to apply to lift the load)

(Facilitator designs lever on blackboard with parts.)

**First Class Lever**

This is what’s called a first class lever - the fulcrum is in the middle between the effort and the load. When you push down on one side, the other side goes up.

**Examples of a first class lever:** teeter-totter, balance, crowbar, pliers, scissors
(show sample lever pictures)

**CHOICE:** If the class is advanced enough, you can discuss second and third class levers at this point. If not, skip down to making the teeter-totter.

There is also a second class lever. It has all of the same parts as a first class lever but they are arranged differently.
(Facilitator designs lever on blackboard with parts.)
The effort is in the same direction as the load moves. The effort and the load are on the same side of the fulcrum with the load between the effort and the fulcrum.

**Examples of a second class lever:** wheelbarrow, nutcracker, bottle opener, door
(show sample lever pictures)

Finally, there is a third class lever. It also has the same parts as a first class lever but they are arranged differently.

(Facilitator designs lever on blackboard with parts.)

The effort is in the same direction as the load moves. The effort and the load are on the same side of the fulcrum with the effort between the load and the fulcrum.

**Examples of a third class lever:** fishing pole, hammer, tweezers
(show sample lever pictures)

We're going to build a first class lever that you might have seen in your playground. A teeter-totter!
Lever Testing (Optional)

Provide each pair of students with a beam, a fulcrum and some weights.

CHOICE: Either read the instructions on the Task Card orally to the students as a group or hand out Task Cards to each pair.

DELIVERY HINT: When testing levers, tape the fulcrums to the desk so they won’t slip.

Lever Tasks:

1) Will your beam balance without any weights?
   Yes, as long as the fulcrum is in the middle of the beam.

2) Try balancing the beam with two weights that are the same mass! Where do the weights have to be so that the beam balances?
   There must be one weight on either side of the fulcrum and they must be equal distances from the fulcrum.

3) If a big person was on one side of a teeter-totter could a small person sit on the other side and lift the big person up?
   Yes.

4) If you have a heavy weight on one side of the fulcrum and a lighter weight on the other side, can you balance the beam?
   Yes, the heavy weight must be close to the fulcrum and the lighter weight must be farther from the fulcrum (close to the end of the beam).

5) If you move the fulcrum, can you still balance the beam without weights?
   No.
6) Move the fulcrum to one end of the beam. Can you balance the beam using weights?
Yes, the heavier weight must be close to the fulcrum and lighter weight must be close to the end of the beam.

Activity Wrap-Up

What kind of simple machine is a teeter-totter?
A lever (first class lever)

Where is the beam on your lever (teeter-totter)?
The fulcrum? The load? The effort?

CHOICE: Move on to the workshop wrap-up for Power Play 1. Keep going for the rest of the Power Play 2 workshop.

Activity #4: PULLEYS (20 minutes)
Use Task Card or Poster

Objective of Activity

➢ To introduce pulleys and pulley systems.
➢ To test a fixed pulley when lifting a water bottle.

DELIVERY HINT: Set up the pulley station at the beginning of the workshop. Have students that have completed their playgrounds early come up in small groups to try lifting the water bottles. Debrief activity as a group.

Set-up Instructions:

Duct tape the ends of your metre stick and hooks to two sturdy surfaces (desks, table, chairs...).

Water bottle #1 should be connected to a small single pulley.
Water bottle #2 should be connected to a larger single pulley.
Water bottle #3 should be connected to a 2 pulley system.
Water bottle #4 should be connected to a 4 pulley system.

**Suggested Instructions, Q & A**

*Has anyone ever used a pulley before? What do pulleys help us do?*
A pulley is a wheel fixed to a support with a rope running over it. Pulleys help us to move objects either up and down or side to side. The purpose of a pulley is to change the direction of the force - For example, if you are pulling down, it lifts the object up, if you are pulling to the right, it moves the object to the left...

*Can you name some examples of where you could find pulleys?*
Elevator, clothesline, flag pole, crane, well, vacuum cleaner.....
There are three different types of pulleys.
- **A fixed** pulley is a pulley that remains stationary as the load moves up and down. A good example of a fixed pulley is a flag pole.
- **A movable** pulley is a pulley that moves up and down with the load. A good example of a movable pulley is a bucket in a water-well. The bucket moves up or down the rope when you pull on it.
- **A block and tackle** has both a fixed pulley and a movable pulley. The load feels much lighter with this system. A good example of a block and tackle pulley system is a crane.
There is also something called a **Belt Drive** system. This is when two wheels or pulleys are connected by a belt - a circular strip of flexible material. A good example of this type of pulley system is a clothesline.

*Did everyone have a chance to try lifting the 4 water bottles with pulleys?*

*Did you feel a difference in how hard it was to lift the 4 water bottles?*

*Which water bottle was easiest (required the least effort) to lift?*
Water Bottle #4 should be the easiest to lift. It is set up with a double pulley system.

*Which water bottle was hardest (required the most effort) to lift?*
Water Bottle #1 should be the hardest to lift. It is set up with a small single pulley system that really has no mechanical advantage.
Objective of Activity

- To introduce gears.
- To investigate how gears work.

Suggested Instructions, Q & A

Has anyone ever used a gear before? What do gears help us do?
Gears are used to transmit force to another gear with matching teeth.

Can you name some examples of where you could find gears?
Watch/clock, toys, bicycle, can opener, pencil sharpener......

We are going to investigate how gears work a little bit more by doing an activity.

**Choice:** Either read the instructions on the Task Card orally to the students as a group or hand out Task Cards to each pair. Feel free to add your own inquiries/instructions depending on the level of the students' understanding and the gears you have in your kit.

Start turning one of your gears.

Which way does the other gear turn?
In the opposite direction.

Turn the largest gear. Keep turning. Which gear moves faster?
The small gear moves faster than the large gear.

Can you count the number of teeth on the smallest gear?
Can you count the number of teeth on the largest gear?

What is the relationship between the number of teeth and how fast the gear moves?
Students should discover that the larger the gear, the more teeth, the slower it rotates.
Ask the students if they can think of any other questions they can answer using the gears OR add your own questions.

**E. Wrap-Up**

**CHOICE:** If there is time left in the workshop, you can play a wrap-up game (classification of simple machines, small group activity, concentration/memory) with the simple machines picture cards.

**Suggested Q & A**

*What is a machine?*
Something that helps us do work.

*What are the 3 simple machines we built on our playground?*
Wheel and axle, lever and inclined plane

*What is the difference between a simple machine and a complex machine?*
A complex machine is made up of many simple machines.
A simple machine does not have a power source of its own (only the energy you put on it) while a complex machine may have its own energy source, like an engine.

*What is the important benefit of a simple machine?*

- What was your favourite activity today?
- Do you think Science is fun?
- Do you like Science?
- Do you have any questions for me?

**F. Glossary**

**Efficiency**
Efficiency is the comparison of the useful work or energy provided by a machine or system with the actual work or energy supplied to the machine or system.
Effort
The effort is the force supplied to a machine in order to produce an action.

Energy
Energy is the capacity of a system to do work.

Force
A pushing or pulling action.

Gear
A simple machine in which toothed wheels engage to transmit motion between rotating shafts.

Gear Train
A group of 2 or more gears.

Inclined Plane
A slanting surface connecting a lower level to a higher level.

Lever
A simple machine consisting of a rigid bar supported or pivoted at a point along its length called the fulcrum.

Load
The object or force the machine must overcome (the weight it wants to move or the resistance it must overcome).

Mass
Mass is the amount of matter in an object.

Mechanical Advantage
The ratio of the force produced by a machine or system (load) to the force applied to the machine or system (effort).

Pulley
A simple machine for raising loads, consisting of one or more wheels with a grooved rim to take a belt, rope or chain.

Screw
An inclined plane wrapped around a pole. A screw holds things together or lifts.
Wedge
An object with at least one slanting side ending in a sharp edge. A wedge cuts or spreads things apart.

Weight
Weight is the pull of gravity on an object. The weight of an object can change with location.

Wheel and Axle
A wheel with a rod (axle) through its centre, both parts move together. Lifts or moves loads.

Work
The energy transfer that occurs when a force causes an object to move a certain distance in the direction of the force.

G. Background Information

Simple Machines
Machines are devices that do work. The scientific definition of work is applying a force over a distance (W=Fx*d). Many machines help us by making the work easier - they won’t reduce the amount of work we have to do (in fact, they may sometimes increase the amount of work) but they do make that work easier. Machines can make work easier by changing the amount or direction of either the force we have to apply or the distance over which we apply the force.

Simple machines typically form the base for all other, more complex machines. The three basic types of simple machines are levers, inclined planes (ramps), and wheels and axles. Pulleys and gears are modifications of wheels and axles, screws and wedges are modifications of the inclined plane.
H. Suggested Resources

Websites

How Stuff Works
http://www.howstuffworks.com/

Simple Machine Page for Kids
http://www.san-marino.k12.ca.us/~summer1/machines/simplemachines.html

Welcome to the wonderful world of Simple Machines
http://www.kent.wednet.edu/staff/trobinso/physicspages/PhysicsOf/Wade/physics.html

Marvellous Machines
http://www.galaxy.net/~k12/machines/index.shtml

Books


Posters

Simple Machines – Trend Enterprises
From Scholar's Choice