

# 4-H Machines Series

## Exploring Machines

### Welcome 4-H Leaders!

Welcome to the “Exploring Machines” project. There is lots of information, fun facts, and hands on activities that covers the basic scientific principles on how machines work. This guide provides you with project meeting plans (**Skill Builders**) that include a skills list, background information, activity suggestions, and ways to know if your members have learned the skills identified. In short, all the information and tools necessary to make this project a rewarding one for you and your members.

In this project, members will examine, by **learning to do by doing**, the different kinds of simple machines, how electricity and magnets work, and how to make their own machines. The Leader Guide is written with the expectation that the project leader(s) will have a working knowledge about machines and how they work. If not, you may need to do some pre-work / research on the activities, or recruit assistance for certain sections.

Be sure to try out activities, demonstrations or hands on work ahead of time to ensure you have an understanding of each Skill Builder - this also allows for any adjustments should an activity not work for you or if any equipment or supplies are unavailable.

**The 3D’s of Learning** - Each Skill Builder has three sections of learning called “Dream it!”, “Do it!” and “Dig it!”. Below is a description of each.

**Dream it! Plan for Success** - this gives members a chance to help plan their activities. A skills checklist, background information, important words, and activating questions are included in the Member Manual so they will be able to think about the topic and activity and decide how they will approach it. The Leader Guide contains in-depth background information on the topics, material lists, suggestions, time requirements for activities, and activating, acquiring, and applying questions to engage member’s thinking through each step of the learning process.

**Do it! Hands on learning** - this is where members are engaged in the activity planned / discussed in the *Dream it!* Section. Here members are doing the activities and leaders are observing, recording, and providing feedback on how well they are doing. Allow as much individual practice as required; you are assessing the progress and understanding of individual members.

**Dig it! What did you learn?** - this simply means that members and leaders need to ‘dig into their learning’. For the learning cycle to be completed, both need to reflect on how things went and how well they did. For members, this involves self-assessment, giving feedback, creating meaning from their experiences, and thinking about what they would do differently next time. Once this is done they will be in a good position to apply what they have learned to the next experience.



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- Draft 2009 -

The sequence of project meetings and specific skills building outcomes for members in this project are on the chart on the following page.



# What Skills Will The Member Learn?

Each section, Skill Builder (or Builder) in this project has activities that will help your project group learn to do by doing while learning new skills and having fun!



## To complete this project, members must:

- Complete the activities in each Builder OR a similar activity that focuses on the same skills as you and your members may plan other activities
- Plan and complete the Showcase Challenge
- Complete the Portfolio Page
- Participate in your club's Achievement (See the inside back cover for more information about 4-H Achievements).

	Members will be able to...	Activities	Page
Skill Builder 1	What is a simple machine? <ul style="list-style-type: none"> <li>• Explain what “work” is</li> <li>• Identify the 6 simple machines</li> <li>• Demonstrate how a wedge, inclined plane, &amp; lever work</li> </ul>	<ul style="list-style-type: none"> <li>• Whazzit?</li> <li>• A Common Wedge</li> <li>• Inclined Plane vs. Lifting</li> <li>• The Incredible Lever</li> </ul>	8 9 10 10
Skill Builder 2	More Simple Machines <ul style="list-style-type: none"> <li>• Explain how machines save time</li> <li>• Demonstrate how a screw and a pulley work</li> <li>• Plan and build a simple machine using wheels and axles</li> </ul>	<ul style="list-style-type: none"> <li>• How Screws Work</li> <li>• Pulley Power</li> <li>• Spool-a-rama</li> </ul>	15 16 17
Skill Builder 3	Electricity <ul style="list-style-type: none"> <li>• Explain the science behind electricity</li> <li>• Identify conductors and insulators</li> <li>• Demonstrate how circuits and switches work</li> <li>• Explain how to stay safe around electricity</li> </ul>	<ul style="list-style-type: none"> <li>• Electrifying Breakfast</li> <li>• Staying Safe with Electricity</li> <li>• A Simple Electric Circuit &amp; Switch</li> </ul>	22 23 24
Skill Builder 4	Magnetism <ul style="list-style-type: none"> <li>• Explain what magnetism is</li> <li>• Identify what substances are magnetic</li> <li>• Build an electromagnet</li> </ul>	<ul style="list-style-type: none"> <li>• Marvellous Magnets</li> <li>• Making Electromagnets</li> </ul>	29 30
Skill Builder 5	Compound Machines <ul style="list-style-type: none"> <li>• Plan &amp; build a compound machine</li> <li>• Show how simple machines work together</li> <li>• Demonstrate &amp; explain how your compound machine works</li> </ul>	<ul style="list-style-type: none"> <li>• Create a Contraption</li> </ul>	35
Skill Builder 6	Monster Machines <ul style="list-style-type: none"> <li>• Plan and create your own machine</li> <li>• Demonstrate ability to solve problems</li> </ul>	<ul style="list-style-type: none"> <li>• Mousetrap Car or Junkyard Crane</li> </ul>	40 42
Once your members successfully complete their builders, they will showcase what they have learned.			
Showcase & Portfolio	<ul style="list-style-type: none"> <li>• Explain success in using the skills listed above</li> </ul>	<ul style="list-style-type: none"> <li>• Showcase Challenge</li> <li>• My Portfolio Page</li> </ul>	46 47



## Showcase Challenge and My Portfolio Page

At the end of the members' section are the “**Showcase Challenge**” and “**My Portfolio Page**”. The Showcase Challenge page gets members to think about their accomplishments and explain or demonstrate how they were successful. There are a number of suggestions along with planning information to help them decide how they will best “showcase” their learning to friends, family, community members and/or fellow 4-H members.



Record keeping is an important part of every 4-H project. “**My Portfolio Page**” is a graphic organizer used to keep track of members' 4-H experiences. As each member learns skills, the evidence of learning (through participation and completion of the various activities) is recorded on the page. When the Portfolio Page has been completed and confirmed by the leader, then it becomes a record of the member's completion of the project and participation in other 4-H activities beyond the project.

**4-H leader assessment** of members will happen throughout the project as you assess the progress and understanding of individual members. You need to observe the members doing the skill and record what you see and hear. Your feedback should be positive and descriptive (not just “well done”). Share that feedback with members frequently so they can put your suggestions into action. How you choose to observe and record is up to you. Some methods are to create checklists, videos and notes while encouraging discussions, peer observations and questions. Recognize that members may improve over the course of a builder and that records should be updated to reflect when they demonstrated their best learning. You are discussing how well members are meeting the skills checklists that are at the beginning of each of the project books, in each Builder and on the Portfolio Page.

Projects promote technical, communication, meeting management, and leadership skills, as well as community involvement and real-world experiences. In addition to the specific skills members are to learn in each builder, the following general learning goals for members are important: Following instructions - Working with others - Using supplies safely - Using the key words - Improving with practice - Respecting timelines.

### 4-H Project Series Skill Development Levels

Each project topic series contains three levels of skill development: explore, discover, and master.

**Explore** - each project series has is one project outlining the fundamentals. All members will be expected to complete the Explore level project before moving into the Discover level projects. It introduces the basic skills and terms needed by members for subsequent projects in that series.

**Discover** - each project series has several project options and members are encouraged to take as many as they would like. At this level, members practice topic specific techniques and gain theme related skills through specialized builders.

**Master** - multiple project options encourage members to specialize in a topic. They may branch out and take advantage of community options such as cooking for a canteen or participating in a food drive. The Leader's role is look for opportunities for their members to have more authentic experiences by: working with other mentors, partnering with outside agencies, participating in exchanges, entering competitions, etc. Projects at this level may include the “Partner-a-Project” whereby pre-approved courses will allow members to advance their skills, while applying their learning to the 4-H program.

## 4-H LEADER TIPS FOR SUCCESS!



- ◆ To complete, members **must** complete all the activities referred to on the “Project Completion Requirements” page **OR** alternate idea for an activity that would teach the same skill or an age appropriate variation. If activity substitutions are used, be sure to have the member make note in their manuals.
- ◆ Dependent on time available at each meeting, group size and abilities of group members, you may wish to break the Builders into more than one project meeting.
- ◆ The internet has lots of interesting websites and educational activities. You may choose to use a search engine to explore the options available. We do not endorse any website or the safety or functionality of any products they may sell. Information/products will be used at your own discretion.
- ◆ Safety is a number one priority. Care has been taken to create safe, age appropriate activities throughout this manual. As leaders, it is important for you to emphasize safety rules and manage or adapt activities in a manner that will safely match your members abilities. Ensure members have a good understanding of safe working and handling practices when using tools, that they use the appropriate safety equipment when necessary, and that appropriate supervision is provided. A quality experience needs to be a safe experience.
- ◆ The multiple intelligences theory teaches us that people learn in at least 8 different ways. All individuals will be stronger in some ways of “intelligences” and weaker in others. It follows that the more ways we teach, the more members we will reach. Throughout this project, you will find a mix of writing, reading, hands-on work, artwork, self-evaluation, group discussion and math calculations. Teaching projects using a broad blend will help increase the learning potential of all members.
- ◆ Projects are designed to teach many skills, such as an understanding of the science behind how machines work. However, the 4-H member is always more important than the subject matter. Stress cooperation in the activities where possible to develop teamwork and cooperation skills. These are valuable skills that will assist them in a number of settings. Ensure the work is completed in a manner that members feel good about themselves and their efforts. This can be done by assigning appropriate tasks or roles based on member’s individual abilities. Modelling and expecting supportive behaviour (i.e. no “put-downs”) amongst members, or by other adults, also contributes to a positive experience.
- ◆ There will be opportunity for experimentation and applying skills that members have learned throughout this project. Experimenting can be frustrating, but learning through trial and error is an important life skill. Explain to members that it is alright to either go onto the next builder or do the builder again if they need the practice. Help the members work through their challenges until they are satisfied with the quality of their designs. Creating inventive 4-H members will be very rewarding.
- ◆ Celebrating success is an important but sometimes overlooked part of our lives. We encourage you to use the final section to empower the members by celebrating all they have learned in a fun manner. Anything that you do to add to the spirit of fun and the sense of accomplishment of each member will likely be remembered as the highlight of their 4-H year.



**Have fun and thanks for your belief in young people!**



# Skill Builder 1: What Are Simple Machines?

## Skills Checklist

- ◇ Explain what “work” is
- ◇ Identify the 6 simple machines
- ◇ Demonstrate how a wedge, inclined plane, & lever work



## Dream it!

### Background for Leaders

A machine is a tool used to make work easier. To put it another way, machines help you get a job done with less effort. Simple machines are “simple” because most have only one moving part, and some don’t have any moving parts. Simple machines include the lever, the screw, the wheel and axle, the inclined plane, the pulley, and the wedge.

Ranchers do work when they move cattle. Rougers do work when they pull weeds in certified seed crops. Grain farmers do work when they move grain into a bin. Machines make their work easier. The ranchers use a ramp to move cattle onto a truck. The rougers use a hand shovel to help break through the weeds. The grain farmers use an auger to move the grain to the top of the bin. The ramp, the shovel, and the auger are examples of simple machines.

There are six categories of simple machines: Inclined Plane, Wedge, Lever, Screw, Wheel and Axle, and Pulley. In this Builder (project meeting) the activities will focus on three simple machines: wedge, inclined plane, and lever. The next project meeting will include the remaining three simple machines.

Other simple machine examples for members:

- The Ancient Egyptians used long ramps (inclined planes) to move the giant blocks of stone they used to build the pyramids
- Sailors, swashbucklers, and pirates used pulleys to move their ships’ giant sails
- Bicycles use wheels and axles to make them move.

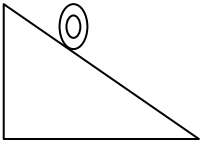
### Important Words



Help members define the following words and listen for them using these words in their discussions. To increase the members’ understanding try providing a synonym members know or provide examples. The more personalized the examples the better.

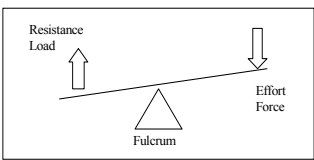
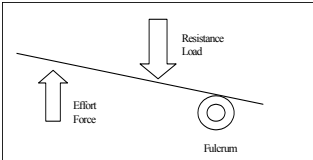
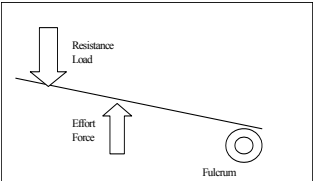
Work	Work is the transfer of energy in order to move an object. Pushing, pulling, and lifting are all common forms of work.
Wedge	A wedge is made up of a pair of inclined planes. Its pointy end is used to spread things apart or lift an object .
Lever	A lever is an arm that pushes against a point (called a fulcrum). Levers are used to lift and pry things.
Inclined Plane	An inclined plane is a flat surface set at an angle (its ends have different heights). It makes it easier to lift heavy objects by using less effort over a longer distance.
Machine	Simple machines have few or no moving parts and use energy to make work easier.
Energy	Energy is the capacity to do work.

# The Six Simple Machines

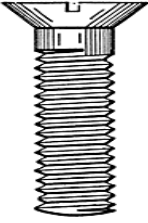


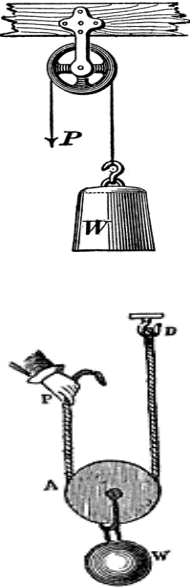
Name	Description	Examples
<b>Inclined Plane</b> 	<p>The word "inclined" means "at an angle". The word "plane" means "a flat surface". For example, a smooth board is a plane.</p> <p>Inclined planes don't move. An inclined plane helps a person to move or raise heavy objects. It enables a load to be lifted with less force, but the distance over which it moves is greater. The steepness of the inclined plane helps determine how much effort (force) is needed to do the work. If a person uses a longer board to make the inclined plane, they will need less force to move the object up the ramp. If a shorter board is used (the angle of the slope is steeper), more force is required but the distance over which it must be applied is less.</p>	Ramps Slides Hoppers Funnels


<b>Wedge</b> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <p>Good Wedge</p>  </div> <div style="text-align: center;"> <p>Poor Wedge</p>  </div> </div>	<p>The wedge is the working twin of the inclined plane, made up of a <i>pair</i> of inclined planes. Instead of just using one smooth side of the unmoveable inclined plane, you can use the pointed edges to do other kinds of work. It does its work by being able to move, while the inclined plane always stays in one place. A wedge uses force to spread things apart or to raise an object. The longer and thinner a wedge is, the less strength (force) you need to do the work. A wedge is able to do three different types of work: connecting (the nail), splitting (the knife, axe), and tightening (the doorstep).</p>	Saws Shovels Woodpecker's beak
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<b>Lever</b> <div style="display: flex; flex-direction: column; align-items: center;"> <div style="text-align: center;"> <p>Class 1</p>  </div> <div style="text-align: center;"> <p>Class 2</p>  </div> <div style="text-align: center;"> <p>Class 3</p>  </div> </div>	<p>Any tool that pries something loose is a lever. A lever is an arm that pushes against a "fulcrum" (or point).</p> <p>A Lever has three (3) parts:</p> <ol style="list-style-type: none"> <li>1. Resistance Force or Load - what you are trying to move or lift</li> <li>2. Effort Force - the work done on the lever</li> <li>3. Fulcrum – a fixed pivot point</li> </ol> <p>The farther the force is from the fulcrum, the easier it is to work the lever.</p>	See saw Wheel barrow Screwdriver Catapult Nutcracker
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<p>Screw</p> 	<p>The screw is a simple machine that uses an inclined plane to do its work. It's an inclined plane that is cut into a spiral shape and wrapped around a cylinder or shaft. It can hold two things together, make a hole in things or help lift items. It is kind of hard to see the similarities with a cattle chute, but the screw is really just another kind of inclined plane.</p>	<p>Airplane propellers</p> <p>Helicopter blades</p> <p>Fan blades</p> <p>Boat propeller</p> <p>Drills</p>
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<p>Pulley</p> 	<p>A pulley is a simple machine made with a rope, belt or chain wrapped around a grooved wheel. As the wheel rotates, the rope, belt or chain moves either up or down. This grooved wheel (pulley) turns freely in a frame called a block.</p> <p>Pulleys are wheels that, when strung together, allow a person to lift an object. A pulley works two ways. It can change the direction of a force or it can change the amount of force needed to lift an object. Given enough pulleys, a very powerful machine can be created, although you might have to pull two meters of rope or cable through the pulleys in order to lift an object one meter.</p> <p>A pulley can be fixed or movable.</p>	<p>Winch</p> <p>Window blinds</p> <p>Flag pole</p> <p>Clothesline pulley</p>
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<p>Wheel &amp; Axle</p> 	<p>A wheel and axle is really two machines but used different ways.</p> <p>The wheel and axle is just another type of lever. The axle (a small wheel) acts as the fulcrum, which is in the center. The outside rim of the wheel is like the handle of a lever; it just wraps all the way around.</p> <p>Once again, there's an energy trade-off: The larger the diameter of the wheel, the less effort you need to turn it, but you have to move the wheel a greater distance to get the same work done.</p>	<p>Doorknob</p> <p>Faucet</p> <p>Bicycle</p> <p>Windmill</p> <p>Record player</p> <p>Computer fan</p>
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## Age Considerations

- 8 and up

## Thinking Ahead

- What will you discuss with members? Gather observations and think of examples that will help support your discussion.

## Preparing for Success

- Linking back to the Skills Checklist, help members identify how they will know they have been successful in learning from this builder. Discuss what success in these activities might look like, sound like, or feel like.

## Activating Strategies

- Activate member's prior knowledge of machines by asking them to think about machines they know, what they do, and how they work.

## Whazzit? What is it?

- What are Simple Machines & what do they do?

**Time Required:** 1 hour

## Equipment/Supplies

- Several examples of simple machines - tape dispenser (pulley), drill bit (screw), utility knife, nail (wedge), toy slide or ramp (inclined plane), pizza cutter (wheel & axle), hammer (lever)

## Resources/Handouts/References

For more information on simple machines, try the following Internet links:

Mikids.com: <http://www.mikids.com/Smachines.htm>

Franklin Institute: <http://sln.fi.edu/qa97/spotlight3/spotlight3.html>

## Safety Considerations

Ensure that members do not play with or grab any sharp object.

## Instructions

1. Display the simple machines you have gathered on a table and have the members look over and hold the examples in the collection.
2. Define what a simple machine is.
3. Ask members if each item could be considered a simple machine and why.
4. Identify the 6 simple machines and explain to members how they make work easier.
5. Discuss with members the kind of simple machines that can be found around a farm (e.g. wheelbarrow, combine, axe, plough, tractor, etc.).





## Do it!

- Members should now have an idea of what the six simple machines are, how they work and examples of each. Now is the time for them to acquire a deeper understanding of how the wedge, inclined plane, and lever work.
- Help members do the skill builder activities below.

*Note: Make sure you ask members the activating and applying questions at the end of each activity to get them thinking about the activity and applying the knowledge they have acquired.*



### Simple Machines Scavenger Hunt

Have members to do a “Simple Machines Scavenger Hunt” at home. Ask them to explore around their homes and/or community for examples of simple machines. Have them make a list or take pictures and bring it next meeting. These could be used to begin the conversation - “why might this be considered a simple machine?”. Individual members could then “present” one of the machines to the group, discussing its characteristics.

#### A Common Wedge

- How do wedges work?

**Time Required:** 15 minutes

#### **Equipment/Supplies**

- Apples or potatoes
- Kitchen knives

#### **Safety Considerations**

- Make sure members know how to use knives safely.

#### **Instructions**

1. Pass out an apple or potato to each member.
  2. Ask them to break it apart with their hands. Then ask if they would like a simple machine to cut it for them.
  3. Pass out knives and ask that they (carefully) use the dull (flat) side to cut the apple.
  4. Following that, have them use the sharp side. Ask members if they noticed a difference between the two sides of the knife.
  5. Explain the difference in the force to make the cut and how a knife is a wedge (it converts motion in one direction into a splitting motion that acts at right angles to the blade). Because you push a little farther, the push force you have to use is less. Wedges work better if they are long and thin.
- How is a knife a wedge?
  - What are other examples of wedges used to cut stuff?



## Inclined Plane vs. Heavy Lifting: Who Will Win?

- How do inclined planes work?

**Time Required:** 30 minutes

### **Equipment/Supplies**

- Large books
- Ruler
- One cup of uncooked rice placed in a small sandwich bag and tied with a twist tie
- Rubber band strip (a rubber band that is cut) tied to the top of the sandwich bag)

### **Instructions**

1. Have members stack books in a pile and lean one book against the others to make a ramp.
  2. Have a member lift the bag by the rubber band and measure the length of the rubber band.
  3. Put the bag at the bottom of the ramp and drag it near to the top. Measure the length of the rubber band.
  4. Experiment with different heights for the inclined plane and predict which height would be the easiest (require the least amount of effort). Members can record the results in their project books.
- What are some real-life examples where inclined planes are used instead of lifting items?

## The Incredible Lever

- How can a kid lift an adult?
- Which of the three types of levers would be best to lift something very heavy? Why?

**Time Required:** 30 minutes

### **Equipment/Supplies**

- Fulcrum (wood block or brick)
- Plank of wood, 1 foot thick and at least 4 feet long

*Note: If these materials are not available, use a playground see-saw or a smaller version*

### **Safety Considerations**

- Only one member at a time should try lifting the adult

### **Instructions**

1. Make a lever by placing the plank over the wood block.
2. To begin, place the fulcrum closer to the opposite side where the adult will stand. Have the adult stand on the long end and a member on the opposite pushing down (members will not be able to move the adult).
3. Next place the fulcrum in the middle of the board. Have the adult stand on one end and a member on the other pushing down (lifting will be a little easier).

4. To take advantage of the properties of the lever, place the fulcrum closer to the end of the lever on which the adult will stand. Have the adult stand on the short end and a member on the opposite end pushing down (If the child cannot lift the adult, adjust the fulcrum so that it is closer to the side on which the adult is standing. Show the members how strong they can be through the use of the lever.
5. Ask members if they see any patterns.
  - What other things could you do with this kind of lever?



## **Dig it!**

Now that members have a deeper understanding of how three of the six simple machines work, it is time for them to reflect on their learning and apply what they now know by answering the following questions.

1. What have you learned? Have members go back to the skills checklist and review what they have learned. Ask them how they know that they can . . .
2. How would you teach others? Show members a new example of a simple machine. From the three types they have learned and ask them to do a two minute role-play. They are explaining what the machine is and how it works to a kindergarten class. They must use at least three of the key words from this builder in their talk. This could be videotaped.

## **What's next?**

In the next builder members will learn more about the other three simple machines: the screw, pulley, and wheel and axle. They will also be building their own type of simple machine. To get members thinking about the next builder have them discuss what they know about the screw, pulley, and wheel and axle, and what more they would like to know about each one.

### **Leader's Notes**



# In the Member Manual

## Skill Builder 1: What is a Simple Machine?

### Gizmo Says....

In science, work is the transfer of energy in order to move an object. Pushing, pulling, and lifting are all common forms of work. For example, a golfer transfers energy from his or her arms to move the club and the energy from the club moves the golf ball. When you use a see-saw you transfer the energy in your legs to push up which makes the other person move down! Golf clubs and see-saws are examples of simple machines!



### SKILLS CHECKLIST

- Explain what "work" is
- Identify the 6 simple machines
- Demonstrate how a wedge, inclined plane, & lever work



### Important words

Watch for these important words throughout this builder:  
**Machine, Wedge, Inclined Plane, Lever, Work, Energy**



## Dream it!

To begin any project and be successful you need to plan. In Dream It! you will learn important background information on simple machines as well as prepare yourself to have a successful learning experience.

Simple machines have few or no moving parts and use energy to make work easier.

There are the six types of simple machines:

**Wedge**   **Inclined plane**   **Lever**   **Screw**   **Pulley**   **Wheel & axle**



In this builder the focus will be on the **wedge, inclined plane, and lever.**

## Three Simple Machines

### Wedge

A wedge is made up of a pair of inclined planes. Its pointy end is used to spread things apart or lift an object. Examples of wedges are nails, axes, & door stops.



### Lever

A lever is an arm that pushes against a point (called a fulcrum). Levers are used to lift and pry things. Examples of levers are shovels, wheel barrows and see saws.



### Inclined plane

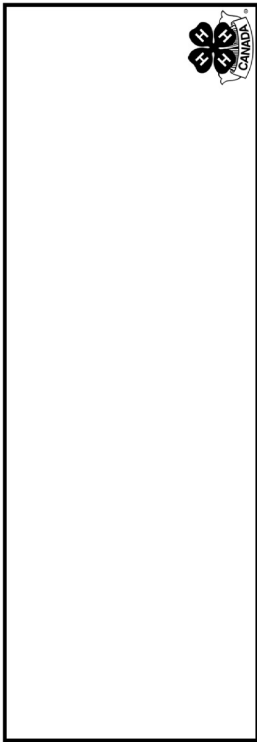
An inclined plane is a flat surface set at an angle (its ends have different heights). It makes it easier to lift heavy objects by using less effort over a longer distance. Examples are ramps, chutes, and slides.



## Whazzit?

Look at the items that your leader has assembled for you. Are these machines? Discuss with other members what the items are, what they do, and how they work.. Choose one item to explore further. **Sketch it below.** What type of machine is this?

## EXPLORE



## Do it!



### Common Wedge

**What you will need:** an apple or potato, kitchen knife

- What is the difference between a good wedge and a poor one? In this activity you will learn how the size and shape of a wedge affects how it works.

### Safety First!

Always be careful when using any sharp object like a knife

1. Try cutting your apple or potato with the flat (dull) side of your knife. Now try to cut with the sharp side.

**Think about it:** What's the difference between the knife's two sides? Did you notice that a knife is like a wedge? How does a knife (wedge) make work easier?

## Inclined Plane vs. Lifting: Who Will Win?

- Let's see if an inclined plane really does make work easier!



**What you will need:** large books, ruler, a cup of uncooked rice in a sandwich bag, rubber band strip

1. Stack some books with one leaning against the others (like a ramp, which is an inclined plane).
2. Put rice in the sandwich bag and tie it with a twist tie. Cut rubber band and attach one end to the bag. Lift the bag in the air and measure the length of the rubber band. HINT: The more the rubber band stretches, the more effort is needed to lift the bag.
3. Now drag the bag up the ramp. When almost at the top measure the length of the rubber band. Try putting the ramp at different heights to see which one requires the least effort.

**Rubber band length:** at start \_\_\_\_\_ lifting \_\_\_\_\_ inclined plane \_\_\_\_\_



**And the winner is!** \_\_\_\_\_

# In the Member Manual

## The Incredible Lever

- Let's see just how levers work! Think of an example of a lever at the playground. In this activity you will use the lever's power to lift your leader!

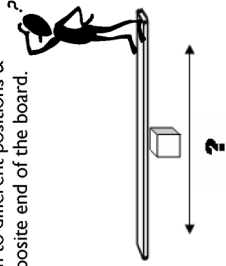
**What you will need:** Wood block or brick, long & sturdy wood plank, your leader

- Make a lever with a long sturdy wood plank & a wood block or brick for the fulcrum
- Where will you put the fulcrum (block of wood)? Move the fulcrum to different positions & try to lift your leader or another adult by pushing down on the opposite end of the board.

Discuss with other members what happened in this activity:

- Where was the best position for the fulcrum?
- What other things could this kind of lever be used for?

EXPLORE



### More Machines!

For more information on simple machines:  
<http://www.explainthatstuff.com/toolsmachines.html>

**Gizmo's Fun Facts!**

The Greek scientist Archimedes (c. 287 BC – c. 212 BC) once claimed that if he had a point of support, he'd be able to move the world! He was referring to the lever's amazing ability to make heavy lifting easier.

## Dig it!



**Think about this builder and the activities you did ...**

Review the Skills Checklist on page 3. What skills have you developed? Do you need more practice?

**Record it . . .**

Discuss what you have learned with your leader so that the information can be recorded on your Portfolio Page.

**Apply it . . .**

How could you explain to others what work is?

**What's next?**

Now that you have an basic understanding of what the simple machines are and are able to show how wedges, inclined planes, and levers work, it is time to learn more about the other simple machines. In the next lesson you will demonstrate how a screw, pulley, and wheel and axle make work easier - by you building your very own simple machine!

EXPLORE

# Skill Builder 2: More Simple Machines



## Skills Checklist

- ◇ Explain how simple machines save time
- ◇ Demonstrate how a Screw and a Pulley work
- ◇ Build a simple machine using wheels and axles

## Dream It!

### Background for Leaders

A scientific definition of "work" is defined as "a force acting on an object to move it across a distance". Pushing, pulling, and lifting are common forms of work. It's important to relay to members that when you use a simple machine, you are doing the same amount of work – it just makes it seem easier. This is because there is an energy trade-off. For example, a simple machine reduces the amount of energy to move something, but you end up moving it a greater distance to accomplish the same amount of work (e.g. a ramp).

Since work is achieved by having a force act over a distance, science has figured out a simple mathematical formula:  $Work = Force \times Distance$ . If you keep the amount of work the same and you decrease the amount of force, the distance must increase. This is exactly what happens with most simple machines. They reduce the effort (force) needed to get the job done, but you're moving things a greater distance. The equation balances. No matter what, the amount of work you do is exactly the same. Remember: any type of "work" only happens when you move an object over a known distance.

### Important Words

Help members define the following words and look for members using this vocabulary in their discussions.

Work	Work is the transfer of energy in order to move an object. Pushing, pulling, and lifting are all common forms of work.
Wheel & Axle	A wheel and axle is a type of lever (the axle acts like a fulcrum). Wheels move objects across distances.
Screw	A screw is an inclined plane that is cut into a spiral shape and wrapped around a shaft. Screws hold things together, makes holes in things, and move things.
Pulley	Pulleys are wheels that when strung together with ropes, belts or chains allow a person to lift heavy objects. It can change the direction of effort or change the amount of effort needed to lift an object.
Energy	Energy is the capacity to do work.

Here are some examples of how to use the "important words" to increase the members understanding:

- Ask members to form a mental image of the new word.
- Get members to use a dictionary and show them the range of information it provides.
- Have members describe (rather than define) the new word in terms of their experiences.

## Age Considerations

- 8 and up

## Thinking Ahead

- What will you discuss with members? Gather observations and think of examples that will help support your discussion.



## Preparing for Success

- Linking back to the Skills Checklist, help members identify how they will know they have been successful in learning from this builder. Discuss what success in these activities might look like, sound like, or feel like.

## Activating Strategies

- Ask members what they had learned in Skill Builder 1 about work and effort, and how simple machines affect us in our everyday lives.

## Hidden Wheels

After explaining how the wheel and axle work, have members think about examples of wheels around them. Give a couple of examples of seen and hidden wheels (E.g. clock, door knob, casters, computer fan, etc.). Members then search their surroundings and write down what they find in their project books.

## **Do it!**

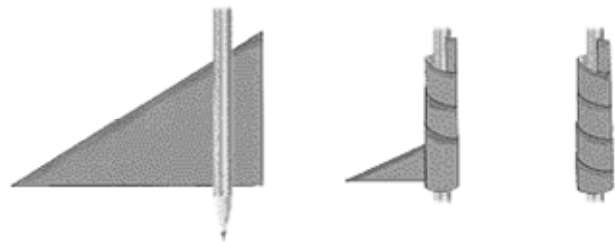
### How Screws Work

- How is a screw an inclined plane?

**Time Required:** 30 minutes

### **Equipment/Supplies**

- Pencil (one per member)
- Paper (one piece per member)
- Coloured felt tip marker
- Scissors
- Same length large screws with different threads
- Magnifying glass (for small screws)
- Screwdrivers
- Piece of wood (e.g. 2x4)



### **Safety Considerations**

- Ensure members use tools properly and safely

## Instructions



1. Explain to members that a screw is really an inclined plane. Show them by cutting out a triangle from a piece of paper, making a line along the edge of the long side with a marker and wrapping it around a pencil like the diagram above. Now have members make their own inclined planes.
  - Cut a right triangle from the paper. The dimensions should be about 5 inches (13 cm), by 9 inches (23 cm), by 10.3 inches (26 cm).
  - Use the felt tip marker to colour the longest edge (10.3 inches) of the triangle.
  - Position the shortest side (5 inches) of the triangle along the side of the pencil, then evenly wrap the paper around the pencil by rolling the pencil.
  - The marker line will show how the screw pattern is developed by wrapping an inclined plane around a cylinder.
2. Assemble the screws in front of the members and have them observe the different spaces between grooves (use magnifying glass for small screws). Ask them if they think this will make any difference to how easy or hard it is to screw them into the wood.
3. Members can now turn their screws into the wood. Ask them which screws were easier to turn and why.

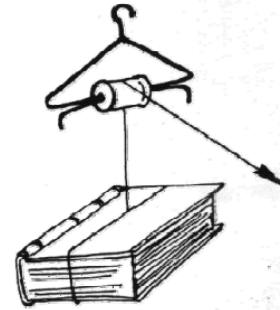
## Pulley Power

- How do pulleys make lifting easier?

**Time Required:** 1 ½ hours

### Equipment/Supplies

- One wire coat hanger or other heavy bendable wire
- One wooden or heavy plastic spool
- String
- One cup hook
- Board (fixed)
- Weight (anything heavy – a work boot with laces works well)



### Safety Considerations

- Ensure members handle and use tools safely

### Instructions

1. Ask members to think of pulley examples (e.g. flag pole, venetian blinds, clothesline wheel, etc.)
  2. Have members think about how a pulley could help them lift a heavy object.
  3. Show members how to cut the bottom of the coat hanger and insert the spool into the open ends of the wire.
  4. Adjust the wire so that the spool turns easily, and then bend the ends down to keep the wires from spreading.
  5. Screw a cup hook into a fixed board.
  6. Hang the coat hanger pulley on the cup hook.
  7. Loop a string once around the spool.
  8. Attach a weight to the end of the string.
  9. Pull the string to lift the weight.
- Why is it easier to pull down than lift up? (gravity helps pull stuff down)



## Spool-a-rama

- How do wheels work in a machine?

**Time Required:** 2 hours

### **Equipment/Supplies**

- Spools of various sizes (wood or plastic)
- Scrap lumber
- Nails
- Hammer
- Handful of different-sized rubber bands



1. Have members define in their own words; wheel and axle.
  2. Brainstorm with members all the various types of wheels you can think of (e.g. bicycle, rolling pin, rotary phone). Explain that the spools in this activity are really wheels turning on posts called axles, forming a simple machine.
  3. Ask members what would happen if the spools were attached to one another by a string or rubber band. If one spool moved, would the other? What would happen if another spool was added?
  3. Place the spools on the board as shown above to start.
  4. Insert a nail into the center of the spool and hammer the nail into the board. The nail should go in far enough to hold the spool in place. Turn the spool until it will turn easily.
  5. Loop a rubber band around two or more spools. Ask members:
    - When you turn one spool, what happens to the others?
    - Does it matter which one you turn?
  4. Try putting a twist in the rubber band. Or use a combination of large and small spools.
    - How does that affect what happens?
  5. Tape an action figure or small toy to the top of one spool. Make sure that the spool is still able to turn.
  6. Connect all the spools together in a system you design. Have member pick the spool they will use to drive the system. Ask members:
    - Can you guess which way the figure will turn?
    - Will it turn faster or slower than the driving spool?
- Can you think of some practical uses of the spool machine you created?
  - If you were to build another spool machine, what would you do differently?

## **Dig it!**

- Members should now understand how the 6 simple machines make work easier. Have them reflect on their learning by asking the following questions:
  - ◇ Why is it important to learn about simple machines?
  - ◇ How do screws, pulleys, and wheels and axles make work easier?
  - ◇ How could the skills you learned today help you in the future?

### **What's next?**

In the next skill builder members will be learning about electricity. To get them thinking about it discuss the importance of electricity in our lives and what kinds of machines use or run on electricity.

# In the Member Manual

## Skill Builder 2: More Simple Machines



### Gizmo Says....

When we use machines we do not do less work. The same amount of energy is used, but the work we do is easier. Simple machines make work easier because they change force (physical energy), distance or the direction of the force.

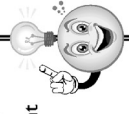


### SKILLS CHECKLIST

- Explain how machines save time
- Demonstrate how a screw and a pulley work
- Plan and build a simple machine using wheels and axles

### Important Words

Look out for these important words in this builder:  
**Work, Energy, Pulley, Wheel & Axle, Screw**



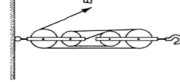
### Dream it!



### The Other Three Simple Machines

#### Screw

A screw is an inclined plane that is cut into a spiral shape and wrapped around a shaft. Screws hold things together, makes holes in things, and moves things. Examples of screws are fan blades, drills, and boat propellers.



#### Pulley

Pulleys are wheels that when strung together with ropes, belts, or chains allow a person to lift heavy objects. It can change the direction of effort or change the amount of effort needed to lift an object. Examples of pulleys are flagpoles, window blinds, and winches.



#### Wheel & Axle

A wheel and axle is a type of lever (the axle acts like a fulcrum). Wheels move objects across distances. Examples of a wheel & axle are doorknobs, faucets, and bicycles.

#### Hidden Wheels

Wheels and axles are everywhere, but some are hidden. Examples of hidden wheels are computer fans, electric pencil sharpeners, and watches. Think of as many examples of wheels and axles as you can, but don't limit them to vehicles. Now think of hidden wheels in machines. Look closely at the machines around you and write down ones with a wheel and axle in them.


### Do it!

#### How Screws Work

Screws fasten and move things. Different screws have different numbers of spirals or grooves. Does it matter how many grooves a screw has? What kind of screw (lots of grooves or only a few) is easiest to turn?

1. Take a piece of paper and draw a triangle with the sides being 13cm (5 inches) by 23cm (9 inches) by 26cm (10 inches).

**What you will need:** pencil, piece of paper, scissors, coloured marker, a few same-length screws with different threads, screwdriver, and a piece of wood

## Leader's Notes



# In the Member Manual

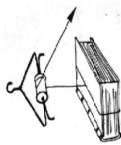
2. Colour the edge of the triangle with the marker and then cut it out.
3. Hold the shortest side (1.3cm) along the pencil and wrap the triangle around it by turning the pencil (What does it look like?).
4. Now take your screws and observe the different number of grooves of the threads. Take the screw with the least number of grooves and screw it into the wood.
5. Then take the screw with the second least number of grooves and screw it into the wood.
6. Do the same with the other screws (going from least to most grooves).

Discuss with other members or your leader. Which screw was the easiest to put into the wood? Why? In the "Inclined Plane vs. Lifting" activity, what kind of inclined plane made work the easiest? If you were to make another triangle with the longest side made a lot longer and the short side a lot smaller and wrapped it around a pencil, what would it look like?



## Pulley Power

- How do pulleys make lifting easier?



Try to think of examples of pulleys at home, at school, on the farm, or other places. How might a pulley help you lift a heavy object?

1. Cut the bottom of the hanger and insert the spool onto the open ends of the wire.
2. Adjust the wire so the spool can turn easily then bend down the ends.
3. Attach the cup hook to the board and hang the top of the coat hanger on it.
4. Attach the string to the heavy object then loop it around the spool.
5. Pull the string to lift the object. Compare the effort to just lifting the object.



Discuss with other members or your leader: Was it easier to lift the object with the fixed pulley? Why is it easier to pull down than lift up?

## Spool-a-rama

- How can you build a machine out of wheels?

How can you build a machine that turns one wheel by turning another (like how a bicycle's pedal turns the rear wheel) using only a board, spools, nails, and rubber bands? Let's find out!

Before you begin you need to make a plan. Your group will design a machine together. After discussing your plan with your leader, sketch the blueprint that your group came up with in the space provided on the next page (a drawing of your machine's design).



## EXPLORE



## EXPLORE

- Let's build a machine together!
1. Using the blueprint as a guide, mark on the board where the spools will go, then hammer them into place with nails.
  2. Attach the rubber bands to the spools.
  3. Tape a small toy to the top of a spool. Turn one spool and watch it spin!
- What happens when the driving wheel (the spool you turn) is larger than the second one? If the driving wheel is smaller? What are some practical uses of the spool machine you created?



**What you will need:** Wire coat hanger, spool, string, board, and something heavy

## Spool-a-rama Blueprint



**Gizmo's Fun Facts!**  
A wheel and axle is really just a first class lever, like the one you made in Skill Builder 1! The axle is a fulcrum and the outside of the wheel (rim) is like the handle of a lever, it just wraps all the way around!

## Big It



Think about the builder and the activities you did... Review the Skills Checklist on page 6. What skills have you developed? Do you need more practice?

## How Did it Go? - Answer these questions:

- How did the simple machines in this builder save time?
- What was it like to make a simple machine?
- How closely did you follow the blueprint?
- Go back to the blueprint drawing and sketch in one improvement (use a different colored pen). Show your leader and explain why you made that choice.
- What's next?

You have now learned about simple machines and how they make work easier. Simple machines are important because they are found in almost every machine. In the next lesson you will learn about electricity, another important part of many machines. You will learn about how electricity works, safety with electricity, and how to build your own light switch!

## More Machines!

For fun interactive games about simple machines: <http://www.edheads.org/activities/simple-machines/>

# Skill Builder 3: Electricity

## Skills Checklist

- ◇ Explain the science behind electricity
- ◇ Identify conductors and insulators
- ◇ Demonstrate how circuits and switches work
- ◇ Explain how to stay safe around electricity



## Dream it!

### Background for Leaders

*Where Does the Word "Electricity" Come From?*

Electrons, electricity, electronic and other words that begin with "electr..." all originate from the Greek word "elektor" meaning "beaming sun." In Greek, "elektron" is the word for amber.

Amber is a very pretty yellowish brown "stone" that sparkles orange and yellow in sunlight. Amber is actually fossilized tree sap. Ancient Greeks discovered that amber behaved oddly - like attracting feathers - when rubbed by fur or other objects. They didn't know what it was that caused this phenomenon. But the Greeks had discovered one of the first examples of static electricity. The Latin word, **electricus**, means to "produce from amber by friction." So, we get our English word electricity from Greek and Latin words that were about amber.

*What is Electricity?*

In simple terms, electricity can be described as free electrons (subatomic particles) moving from one atom to another inside a conductor, such as wire or an electrical cable. We know when it is working, but it is hard to know exactly what it is. Before we can understand electricity, we need to learn about atoms.

*What are atoms?*

Everything is made of atoms - every star, every tree, every animal. Even you and I are made of atoms. The air and water are, too. Atoms are the building blocks of the universe. Scientists so far have found only 115 different kinds of atoms. An atom looks like the sun with the planets spinning around it. The center is called the **nucleus**. It is made of tiny **protons** and **neutrons**. **Electrons** move around the nucleus in clouds, or **shells**, far from the nucleus. When an atom is in balance, it has the same number of protons and electrons. It can have a different number of neutrons.

Electrons stay in their shells because a special force holds them there. Protons and electrons are attracted to each other. We say protons have a **positive charge (+)** and the electrons have a **negative charge (-)**. Opposite charges attract each other while the same charges repel each other.

Ask members if they have ever rubbed a balloon on their heads. Did their hair stand straight up? If so, they rubbed electrons off the balloon. The electrons moved into their hair from the balloon. They tried to get far away from each other and they moved to the ends of their hair. They pushed against each other and made your hair move - they **repelled** each other.

Explain to members that a charged object will also attract something that is neutral. Think about how you can make a balloon stick to the wall. If you charge a balloon by rubbing it on your hair, it picks up extra electrons and has a negative charge. Holding it near a neutral object will make the charges in that object move. If it is a conductor, many electrons move easily to the other side, as far from the balloon as possible. If it is an insulator, the electrons in the atoms and molecules can only move very slightly to one side, away from the balloon. In either case, there are more positive

charges closer to the negative balloon. The balloon sticks. (At least until the electrons on the balloon slowly leak off.) It works the same way for neutral and positively charged objects.

The same applies in winter with a toque and our dry hair. When you pull your toque off, it rubs against your hair. Electrons move from your hair to the toque. Each of your hairs now has the same positive charge. Things with the same charge repel each other. So the hairs try to move away from each other. The farthest they can get is to stand up and away from all the other hairs. Moving electrons is called **electricity**. Using the common example of the charged balloon or the flyaway hair will help bring this concept to life for members.



## Circuits & Conductors

In an electric circuit, there must be a path from the source to the appliance - through the appliance - and back to the source. The word "circuit" has the same root as the word circle. If any of the circle or circuit is broken, the electric current is stopped and won't flow through. Therefore, the appliance -like a bulb - will not work - if the wire is not attached in a complete circuit from the appliance terminals to the power source terminals.

Electricity goes through conductors. Two main conductors are metal and water. That is why we use metal in the form of wire to create electrical circuits. Because wet things and things with water in them such as animals and people are good conductors, you should never be in a pool when there is lightning.

Electricity does not go through insulators. Insulators are materials like glass, plastic and most types of rubber. These materials are put around wires to keep electricity away from you.

We already know that a complete circuit must be formed for the appliance to work. However, sometimes we would want to break the circuit in a safe manner to stop the flow of electricity to the appliance and shut it off. This is why we use switches. Switches interrupt and connect current flow to complete and break the circuit. For example, a light switch turns a light on and off by breaking and making contact to complete a circuit.

## Important Words

Help members define the following words and look for members using this vocabulary in their discussions. The word puzzle later in this builder will help you identify which words they know!

Insulator	A substance that resists the flow of electric current.
Positive charge	Having a deficiency of electrons; having a higher electric potential.
Conductor	A material allowing the flow of electric current.
Electron	The electron is a subatomic particle that carries a negative electric charge.
Atom	The atom is a basic unit of matter consisting of a nucleus surrounded by negatively charged electrons.
Negative charge	Having a surplus of electrons; having a lower electric potential.
Switch	In electronics, a switch is an electrical component that can break an electrical circuit, interrupting the current or diverting it from one conductor to another.
Circuit	An electrical circuit is a network that has a closed loop, giving a return path for the current.



## Age Considerations

- 8 and up

## Thinking Ahead

- What will you discuss with members? Gather observations and think of examples that will help support your discussion.

## Preparing for Success

- Linking back to the Skills Checklist, help members identify how they will know they have been successful in learning from this builder. Discuss what success in these activities might look like, sound like, or feel like.

## Activating Strategies

- Ask members, “What do you know about electricity?”, “What does electricity do?” (powers things), “What do nearly all electrical appliances have?” (power cord).

## Electrifying Breakfast

- How can electrons move things?

**Time Required:** 30 minutes

## Equipment/Supplies

- Plastic comb or static charged balloon
- Thread
- Pieces of dry O-shaped cereal

## Resources/Handouts/References

For more information on electricity try the following sites:

<http://cipco.apogee.net/foe/fb.asp> or [http://www.hydro.mb.ca/learning\\_zone/world\\_of\\_energy.shtml](http://www.hydro.mb.ca/learning_zone/world_of_energy.shtml)

## Instructions

1. Have members discuss what happens when they pull off their toque. What happens to positive electrons when in contact with negative electrons, and what happens when two negatively charged electrons come into contact with each other?
  2. Ask them to think about how they could move an object using electrons.
  3. Tie a piece of the cereal to one end of a 30 cm length of thread.
  4. Find a place to attach the other end so that the cereal does not hang close to anything else (Like taping the thread to the edge of a table) .
  5. Wash the comb to remove any oils and dry it well.
  6. Charge the comb by running it through long, dry hair several times, or rubbing the comb on a wool sweater.
  7. Slowly bring the comb near the cereal. It will swing to touch the comb. Hold it still until the cereal jumps away by itself.
  8. Try to touch the comb to the cereal again. It will move away as the comb approaches.
- What created the electrical charge (combing your hair moved electrons from your hair to the comb)?
  - What caused the cereal to move? (the comb had a -'ve charge, the neutral cereal was attracted to it. When they touched, electrons slowly moved from the comb to the cereal. Now both objects had the same -'ve charge, and the cereal was repelled)
  - Based on what you have learned, what is electricity?

## Staying Safe With Electricity

What do you need to know to be safe around electricity?

Ensure members have read the “Electrical Safe Smarts” section of their project books. Review the information again if needed to ensure understanding.



**Children should not be working with electricity.  
Adults working with electricity should use these safety tips:**

- Always turn off the power source before working on an electrical circuit and then double check by testing that the power is off. For example, if it is house wiring, turn off the power at the main electrical service panel before working on electrical circuitry. Check the circuit with a voltage tester to be sure it is powerless. If it is a battery operated device or vehicle, disconnect and/or remove the battery. If it is an electrical appliance or tool, pull the plug out of the wall socket. If it is a piece of machinery, disconnect from the tractor and /or power take off.
- Use a wooden or fibreglass ladder (insulator) not a metal one (conductor).
- Never work with electricity while standing on a damp or wet floor or earth.
- Be sure the electrical circuit is protected by a ground fault circuit interrupter.

**Time Required:** 30 minutes

**Equipment/Supplies:** Pencil

### **Instructions:**

1. Have members think of electrical safety rules and make a list in their workbooks before completing the puzzle in their workbooks.
2. Ask members the following questions:
  - What can happen if you are not careful around electricity?
  - What safety precautions must you follow?

<b>Across Clues &amp; Answers</b>		<b>Down Clues &amp; Answers</b>	
2	Electricity will flow through your <u>BODY</u> if you get between it and the ground	1	Metals, water and humans are <u>CONDUCTORS</u> because electricity flows through them easily.
4	Taking the right precautions can keep you safe around <u>ELECTRICITY</u> .	3	Shock and fire can happen with <u>FRAYED</u> electric cords.
8	Contact with electricity may cause death, <u>SHOCK</u> , or burns.	5	Electricity is lazy - always seeking the <u>EASIEST</u> path to the ground.
9	A <u>CIRCUIT</u> is the path electricity travels.	6	<u>INSULATORS</u> do not let electricity pass – keeping the electricity flowing through wires.
10	GFCI’s stand for Ground <u>FAULT</u> Circuit Interrupters.	7	Birds can sit on a power line because they do not touch the <u>GROUND</u> .
11	Kites should be blown in <u>OPEN</u> areas away from overhead power lines.	12	Never climb transmission <u>TOWERS</u> , hydro poles, or substation fences.
14	Electrical fires may be caused by overloaded <u>OUTLETS</u>	13	Call for <u>HELP</u> in an electrical emergency.
16	Read and obey warning signs like “Danger high <u>VOLTAGE</u> ”.	15	The human body is conductor because it is 70% <u>WATER</u> .

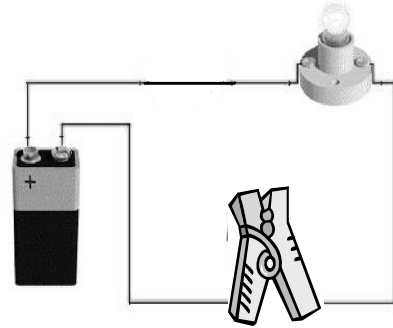


## Do it!

### A Simple Electric Circuit & Switch

- How does a light switch work?

**Time Required:** 1 hour



#### Equipment/Supplies

- 1.5 to 6 volt battery
- Light bulb and socket (size is dependent on battery size)
- Two pieces of insulated wire with 2 -3 cm of insulation stripped off the ends.
- Clothespin

*(Shopping tip: Occasionally bulbs and sockets can be difficult to find – hardware and electronic stores are good sources. Schools can sometimes access through their supply sources. Dependent on bulb and socket sizes available, battery size may need to be larger.)*

#### Resources/Handouts/References

Another good source on electricity: <http://www.eia.doe.gov/kids/energyfacts/sources/electricity.html>

#### Safety Considerations

Go over the proper way to connect and disconnect a battery. Ensure members are aware of the danger of shock should they not follow the proper procedure.

#### Instructions

1. Ask members: what is a circuit?, what is a switch? Can they think of some examples? (e.g. light switch), what do you think happens when the switch is turned off? (Circuit is interrupted)
2. Attach the two pieces of wire to the two battery terminals and the 2 lamp socket terminals.
3. Explain to the members how the circuit is a complete circle and that is why the bulb lights up.
3. Have the members experiment with removing one of each of the four wire ends from the terminal. The bulb will go out as the circuit is broken.

For the Switch:

1. Cut one of the wires in your circuit and bare the ends. (Note: you may have to add additional wire if you did not use enough length to include a switch.) Be sure to unhook them from your power source while working to avoid shock.
2. Wrap the bare end of the wire around a clothespin leg.
3. Do the same with the other wire around the other clothespin leg. Please note that you need to leave enough room at the bottom of the leg so that you can place your fingers there to squeeze the legs together. Both sets of wire must, also, be at the same height - so they touch when squeezed together.
4. Reconnect the ends of the wire to where you detached them. To complete the circuit: Press the clothespin legs together so that the wires touch. The switch is now "on" - completing the circuit and lighting the bulb. When the clothespin legs are apart, the circuit is not complete and the switch is "off."

Idea Adapted from: "Electric Gadgets and Gizmos" by Alan Bartholomew, Kids Can Press, 1998



- What happens when you turn off a light switch?
- If an electrical device is not working, what might be the problem?

## **Dig it!**

- I. Have members reflect on their learning by asking the following questions:
  - What have you learned about electricity?
  - Why is knowing electrical safety important?
  - How will your new skills help you at home?



### What's next?

In the next builder members will learn about magnetism and how it is related to electricity. They will be building their own electro magnet. To get members thinking about the next lesson discuss with them what they know about magnets. Remind them about the Electrifying Breakfast activity and how the comb repelled the cereal. Compare this to when the same sides of a magnet are brought close together.

### **Leader's Notes**



## Skill Builder 3: Electricity

### Gizmo Says....

What is electricity? Electricity can be described as free electrons (subatomic particles) moving from one atom to another inside a conductor, such as a wire or electrical cable. Electricity is the flow of electrical power or charge, and without it our lives would be very different!

### SKILLS CHECKLIST

- Explain the science behind electricity
- Identify conductors and insulators
- Demonstrate how circuits and switches work
- Explain how to stay safe around electricity



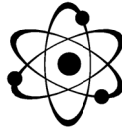
### Important Words

Watch out for these important words in this builder: **Atoms, Electron, Positive charge, Negative charge, Circuit, Switch, Conductor, Insulator**



### Dream it!

- Have you ever wondered what everyday life would be like without televisions, stoves, refrigerators, toasters, stereos, or even light bulbs? These all run on electricity. To better understand electricity, we need to learn about atoms.

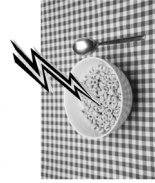


### The Atoms Family

Everything in the universe is made of atoms. Even the human body is made of atoms! Air and water, too. Atoms are the building blocks of the universe and are so small that millions of them would fit on the head of a pin! Inside atoms are even tinier particles called electrons and protons. The protons and electrons of an atom are attracted to each other. They both carry an **electrical charge**. This is a force within the particle. Protons have a positive charge (+) and electrons have a negative charge (-). The positive charge of the protons is equal to the negative charge of the electrons. Opposite charges attract each other. Electrons are also attracted to stuff that is neutral (same number of protons and neutrons).

### Electrifying Breakfast

Let's see how this works by transferring electricity to cereal!



**What you will need:** Plastic comb or balloon, Thread, Pieces of dry O-shaped cereal.

1. Charge up your comb in your hair and hold it close to the piece of cereal on a string.
2. What happened? What caused the piece of cereal to move? Explain below how this is electricity.

### Circuits

- In an electric circuit there must be a path (of wires) from the source of power to the appliance (e.g. light bulb). If the circuit (or path) is broken, no electricity will flow through and the light bulb won't work.

### Conductors

- A conductor is something that allows electricity to go through it easily. Two main conductors are metal and water. Because people are made up mostly of water they are good conductors. That's why it's important for people to be careful around electricity.

### Gizmo Says....

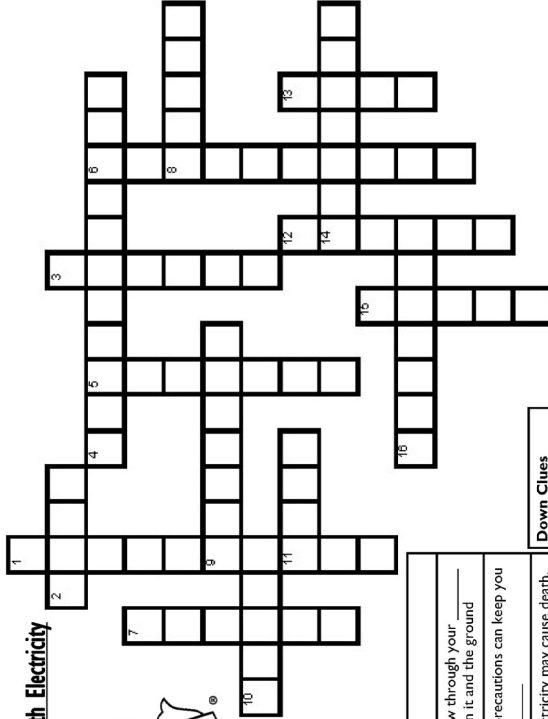
Electricity can shock, burn, or kill you. Electricity flows through water almost as easily as if it flows through the wire that brings electricity to your house. Your body is 70% water, so touching electricity will cause it to flow through you and hurt you.



What do you know about electrical safety? Make a list of all the safety messages you know or can find about being safe around electricity, then you can use them to help solve the puzzle below.

•
•
•

### Staying Safe With Electricity



### Across Clues

- 2 Electricity will flow through your \_\_\_\_\_ if you get between it and the ground
- 4 Taking the right precautions can keep you safe around \_\_\_\_\_
- 8 Contact with electricity may cause death, \_\_\_\_\_ or burns
- 9 A \_\_\_\_\_ is the path electricity travels
- 10 GFCI stands for Ground \_\_\_\_\_ Circuit Interrupters
- 11 Kites should be blown in \_\_\_\_\_ areas away from overhead power lines
- 14 Electrical fires may be caused by over-loaded \_\_\_\_\_
- 16 Read and obey warning signs like "Danger high \_\_\_\_\_"

### Down Clues

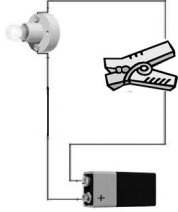
- 1 Metals, water, and humans are because electricity flows through them easily
- 3 Shock and fire can happen with \_\_\_\_\_ electric cords
- 5 Electricity is lazy—always seeking the \_\_\_\_\_ path to the ground
- 6 \_\_\_\_\_ do not let electricity pass—keeping the electricity flowing through wires
- 7 Birds can sit on a power line because they do not touch the \_\_\_\_\_
- 12 Never climb transmission \_\_\_\_\_, hydro poles, or substation fences
- 13 Call for \_\_\_\_\_ in an electrical emergency
- 15 The human body is a conductor because it is 70% \_\_\_\_\_

# In the Member Manual

## Do it!

### A Simple Electric Circuit & Switch

- How do you turn electricity on and off?
- What do you think happens when you turn off a light switch? What happens to the electricity?



Let's make a circuit with a switch and find out!  
With help from your leader, do the following steps:

**What you will need:** 1.5 to 6 volt battery, light bulb and socket, clothespin, 2 pieces of insulated wire

1. Attach the 2 pieces of wire to the two battery terminals (+, -) and the other ends to the light socket.
2. What happened? Did the light bulb light up? How?
3. Disconnect the wires to the battery to avoid a shock and then cut one of the wires somewhere between the battery and the socket.
4. Expose the ends of the wires and wrap the bare end of one wire around a clothespin leg. Do the same with the other wire (make sure there is room for your fingers to squeeze it).
5. Attach the wires to the battery. When you squeeze the clothespin the circuit will be complete!

## Dig it!



### Think about this builder and the activities you did...

- Review the skills checklist on page 9. What skills have you developed? Do you need more practice?

#### Record it....

- Discuss what you have learned with your leader so that the information can be recorded on your portfolio page.

#### Apply it...

- What is needed for electricity to flow? How would you explain to others how people can act as conductors?



#### More Machines!

Check out this fun and informative site from Manitoba Hydro on all things electric:  
<http://manitoba.electriverse.com/>

#### What's next?

With an understanding of electricity you will be ready for the next lesson on magnetism. Electricity and magnetism are related: wherever there is an electricity you will find a magnetic field! You will learn about this and more, and build your own electro magnet!

EXPLORE

EXPLORE

# Skill Builder 4: Magnetism



## Skills Checklist

- ◇ Explain what magnetism.
- ◇ Identify what substances are magnetic.
- ◇ Build an electro magnet.

## Dream it!

### Background for Leaders

All matter is made up of atoms. Atoms combine in different forms to create different substances. Bricks and feathers are both made of atoms, albeit very different atoms! We learned about atoms in Skill Builder 3. A build up of electrons leads to static electricity. When electrons flow from one point to another, then this becomes current electricity. Objects that can be picked up by magnets are called magnetic (nails, paperclips, staples) - called conductors of charge. Objects that can't be picked up are called non-magnetic (paper, rubber, wool) - called insulators – they will not carry an electric charge.

Magnets have two poles called north and south poles (just like the earth has north and south poles). Two north poles or two south poles will repel each other, but a north and south pole will attract each other. Electrical charges are either positive or negative. Remember the experiment with the comb and the cereal in Builder 3. The reason for this is that any electric charge or electrical current generates a magnetic field.

**Electro Magnets** - Electro magnets are really neat! By using a battery, some wire and a nail, anyone can make a powerful magnet that can turn on and off. Batteries hold a lot of electrons. When a wire connects the poles of the battery, the electrons are able to move along the wire path. As electrons move in a wire (current electricity) they produce a magnetic field. If the wire is wrapped in a coil around an iron rod (nail, pencil lead) then the magnetic field intensifies, and the core becomes magnetic. As soon as one of the wires is removed from the one of the poles, the magnetic field stops. This is because the flow of electrons has stopped. Whatever the electromagnet was holding, now drops.

It would be helpful for you to construct a working example of an electro magnet. It will come in handy when explaining the theory behind electro magnets, as well as their function. A strong electro magnet will improve the performance of your junkyard crane. Most electro magnets consist of a wire wound around an iron core. The tighter and more uniform that the wire is coiled around the conductor, the stronger the magnet. Different wire thickness will also vary the magnet strength. Contact must be made with the conductor so the wire loops must be bare for the coils. Caution the members that some wires may heat up when charged by the battery. Remind them that there is an electric current running through the conductor. A nail is the common conductor used. However, many nails today are of a composite material and those nails do not work as well. The conductor must be of iron, cobalt, nickel or a similar alloy. The incorrect combination of materials or construction may result in draining batteries. A good idea is to coordinate the group to work together to perfect one electro magnet through experimentation. When satisfied with the results, members could then recreate the design individually.

## Important Words

Help members define the following words and look for members using this vocabulary in their discussions. One strategy to help members learn new vocabulary is to have them paraphrase the definitions. Having members to use their own words increases connection making.



Magnet	A magnet is a material or object that produces a magnetic field.
Poles	One of the two ends of a magnet.
Conductor	A material allowing the flow of electric current.
Atom	The atom is a basic unit of matter consisting of a nucleus surrounded by negatively charged electrons.
Electron	The electron is a subatomic particle that carries a negative electric charge.
Insulator	A substance that resists the flow of electric current.

### Age Considerations

- 8 and up

### Thinking Ahead

- What will you discuss with members? Gather observations and think of examples that will help support your discussion.

### Preparing for Success

- Linking back to the Skills Checklist, help members identify how they will know they have been successful in their learning in this builder. Discuss what success in these activities might look like, sound like, or feel like.

### Activating Strategies

- Ask members;
  - ◇ What happens to objects with the same electrical charge? (+ +, - -) They repel each other)
  - ◇ How about objects with different charges (+ -) that attract each other?
  - ◇ How might this knowledge apply to magnets?

### Marvellous Magnets

- What's magnetic and what's not?

**Time required:** 30 minutes

### Equipment/Supplies

- Magnets for each member
- Large nails for each member

### Resources/Handouts/References

For more information on magnets:

[http://www.sciencetech.technomuses.ca/english/schoolzone/Information\\_magnetic.cfm](http://www.sciencetech.technomuses.ca/english/schoolzone/Information_magnetic.cfm)



## Instructions

1. Explain to the members that magnets are pieces of iron or steel that can attract or repel other pieces of iron or steel. They can do this because all of their molecules are facing the same way.
  2. Members then can predict what things around them are magnetic.
  3. Give each member a magnet, and allow them to explore their surroundings to make a list of items that are magnetic. Have the members present their findings.
  4. Now explain to the members that they will magnetize a nail. Explain that if they stroke a nail repeatedly in the same direction with a magnet, it will rearrange the molecules so that they will face the same direction. This will cause the nail to become, "magnetized."
5. Have the members re-explore their environment to discover if their new iron magnets are as powerful as their original magnets.
- Ask members the following questions:
    - ◊ What is a magnet made of and how does it work?
    - ◊ What was it that made your nail magnetic?

## Do it!

### Electro Magnets

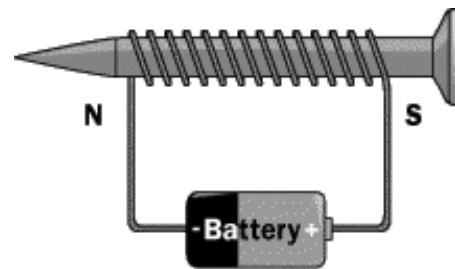
- How can electricity increase a magnet's power?

**Time Required:** 1 ½ hours

### **Equipment/Supplies**

- Six or Nine volt battery (one per member)
- #22 insulated copper wire (or bell wire) (1.5 metres per member)
- Conductor (16d or 20d nails, steel wire, etc.)
- Paperclips
- Wire strippers

Note: It is important that there is about 30 to 45 cm of wire leading to and from the battery to the nail.



### **Resources/Handouts/References**

For more information on electro magnets: <http://www.howstuffworks.com/electromagnet.htm>

### **Procedure**

1. Ask members how electrons affect magnetism. How might electricity help increase magnetism?
2. Show the members your electro magnet. Using the information contained in the science background, explain how the electro magnet works. Demonstrate its ability to pick up a great amount of paper clips, and then drop them when a wire is removed.
3. Next, provide the members with their materials, and have them construct their own electro magnets. Encourage the members to experiment with the coils.
4. Pose these questions:
  - Will close windings of the wire result in a more powerful magnet?
  - Will making several layers of windings make the magnet more powerful?
  - Will using a pencil crayon, or paint brush handle make a good core for your electro magnet? Why?

- After posing the previous questions, and allowing sufficient time for discovery, regroup the members and debrief them for their understanding of the concepts in this activity.
- Remind the members not to lose their electro magnets, as they may be used in an upcoming activity.



## **Dig it!**

To get members to “dig” into their learning, ask them the following questions:

- What happened to the nail when attached to a battery?
- So what causes a magnetic field?
- Based on what you have learned, how could you make an even more powerful battery?

## **What’s next?**

In the next skill builder members will have the opportunity to showcase everything they know so far by building a compound machine using simple machines, magnets, and various other items. Discuss with members how they could use the 6 simple machines and magnets to construct a sort of “super machine” that could perform a task such as place a marble in a cup.

### **Leader’s Notes**



## In the Member Manual

### Skill Builder 4: Magnetism

#### Gizmo Says....

Magnetism is the force of attraction or repulsion of a magnetic material due to the arrangement of its atoms, particularly its electrons. All magnetic occurrences result from forces between electric charges in motion. The ends of a magnet are where the magnetic effect is the strongest. These are called "poles." Each magnet has 2 poles – 1 north, 1 south (just like the earth!). Like repels like... Opposites attract!

EXPLORE

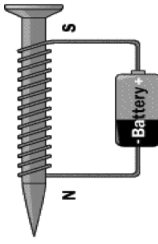
EXPLORE

- Now make your own magnet. If you stroke a nail repeatedly in the same direction with a magnet, it will rearrange the molecules so that they will face the same direction. This will cause the nail to become "magnetized."
- Magnetize your nail. Stroke it with one pole (side) of the magnet, lifting the magnet clear at the end of each stroke. After a few strokes try and lift a paperclip. Stroke the nail some more. Is the nail's magnetism stronger?
- Go back to the things you found to be magnetic and this time use the magnetized nail. See if your nail is stronger than the magnet

#### Do it!

#### Electro Magnets

- How can electricity increase a magnet's power?



You made a nail into a magnet, now let's build a way more powerful magnet that can be turned on & off:

**What you will need:** 6 or 9 volt battery, copper wire, nail, paperclips

- Expose the ends of the wire using wire strippers (this is so they can be attached to the battery)
  - Wrap the wire around the nail (in one direction like the diagram above)
  - Connect the wires to the battery (it doesn't matter which wire goes to which terminal)
  - Try picking up the paperclips and other metal objects.
- How strong is your magnet? What could you do to make it even stronger?

★ Don't lose your electro magnet! You may need it in an upcoming lesson. ★

#### More Machines!

To learn more about the train that "floats" and runs on magnetism, check out this site: <http://www.howstuffworks.com/maglev-train.htm>

If you want to know more about magnetism, try this link: [http://www.physics4kids.com/files/elec\\_magneticfield.html](http://www.physics4kids.com/files/elec_magneticfield.html)

#### From Farming History...

In the 1800's Bull Threshers were machines that separated wheat from the straw. Threshing is the process of separating cereal grains, such as wheat, from the chaff (parts we can't eat). Nowadays we use combines that harvest, thresh, and clean grain crops. Threshers use many simple machines together to work properly.

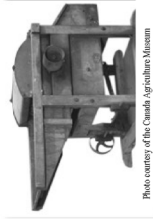


Photo courtesy of the Canada Agriculture Museum  
**Bull Thresher**

#### Important Words

Watch out for these important words in this builder:

**Magnet, Poles, Conductor, Atom, Insulator, Electron**

#### SKILLS CHECKLIST

- Explain what magnetism is
- Identify substances that are magnetic
- Make an electro-magnet

#### Dream it!

Magnets are used in many machines such as hairdryers, telephones, vacuum cleaners, and electric mowers. Computer's use magnets to save information, and there are even trains that use magnetic forces to suspend (float) and propel them! Magnets are pieces of iron or steel that can attract or repel other pieces of iron or steel. They can do this because all of their molecules are facing the same way.

#### Marvellous Magnets

- Can you predict what things around you are magnetic?
- How can you magnetize a nail?

**What you will need:** Magnet, nail, paperclips

- With your magnet explore around you for things that are magnetic. Write your findings below.

Things I found magnetic: \_\_\_\_\_

Things not magnetic: \_\_\_\_\_



12

13



# In the Member Manual

## Dig it!



Think about this builder and the activities you did...

- Review the skills checklist on page 12. What skills have you developed? Do you need more practice?

### Showcase Challenge?

Is there something you've made in this project you are proud of? Maybe you would like to use it in the showcase challenge at the end of this project.



Picture this... (Paste a photo of yourself doing an activity in this builder)

In this picture I am \_\_\_\_\_



## Share your experiences with friends and family

In this picture I want you to notice: \_\_\_\_\_

I want to tell you about how this meeting went: \_\_\_\_\_

I want to explain to you how electricity increases magnetism: \_\_\_\_\_

## What's next?

In the next skill builder you will use the skills you have learned so far and build a compound machine (a machine made up of a number of simple machines and other materials) that performs a specific task - lift a metal washer or marble into a paper cup!



# Skill Builder 5: Compound Machines



## Skills Checklist

- ◇ Plan and build a compound machine (contraption)
- ◇ Show how simple machines work together
- ◇ Demonstrate and explain how your compound machine works

## Dream it!

### Background for Leaders

Machines can be very complex or very simple. Everyone has probably used all of the six machines listed below at one time or another, maybe without realizing it. Simple machines form the basis of more complex constructions. For example, the complex machine we call a "car" is really composed of many different groupings of these six simple machines: Lever, Inclined Plane, Pulley, Screw, Wheel and Axle, Wedge.

This builder may take a few meetings. Divide the project material into the appropriate meeting settings – dependent on the ability and behaviour of your members and the time available per meeting. This is an opportunity for members to “play” with simple machines and see their “real life” applications. Refer to various examples of student-made compound machines to get an idea of what can be built (see recommended website on the next page).

### Important Words

Help members define the following words and look for members using this vocabulary in their discussions. Ask for sentences that "show you know." When members construct novel sentences they confirm their understanding of a new word. Have members use as many terms per sentence to show that connections can be useful. Members can also create impromptu speeches using these terms.

Compound machine	A compound machine consists of two or more simple machines put together.
Blueprint	A blueprint is a type of paper-based reproduction usually of a technical drawing, documenting an architecture or an engineering design. More generally, the term "blueprint" has come to be used to refer to any detailed plan.
Planning	Planning is the process of thinking about the activities required to complete a desired goal.

### Age Considerations

- 8 and up

### Thinking Ahead

- What will you discuss with members? Gather observations and think of examples that will help support your discussion.

## Preparing for Success

- Linking back to the Skills Checklist, help members identify how they will know they have been successful in their learning in this builder. Discuss what success in these activities might look like, sound like, or feel like.

## Activating Strategies

- Ask members to think of machines that include 2 or more simple machines (e.g. wheel barrow, can opener, pencil sharpener, bicycle, etc.)



## Do it!

### Contraption Challenge

In this challenge, you will use simple machines to build a contraption (compound machine) that can lift a steel or iron washer or a marble from a table top into the air far enough for it to then drop the washer into a paper cup placed next to the washer.

### Resources/Handouts/References

See this web site for examples of student made contraptions:  
<http://mousetrapcontraptions.com/cool-machines-3.html>

**Time Required:** 2-3 hours

### Equipment/Supplies

- Any combination of the six simple machines (the more, the better): lever; inclined plane; pulley; screw; wheel and axle; wedge
- Supplies: string or fishing line, iron washers, paper cup, magnet(s), marbles, steel spheres, empty plastic soda bottles, mousetraps, drinking straws, coat hangers, water, etc.

### Instructions

1. Assemble as many types of simple machines and other supplies as you can for the compound machine. Instruct members to think carefully about how they can use the supplies they are given with the various simple machines.
2. Help members come up with a blueprint or plan for their very own machine using the following guidelines:
  - a. No batteries may be used.
  - b. Any combination of simple machines may be used.
  - c. The washer and paper cup must be placed next to each other on the table top, separated by no more than 10 centimetres.
  - d. Once the motion starts, you may touch only one spot on the contraption. The washer/marble must be lifted from the table top and dropped into the cup with only one human touch. e.g. start a marble rolling, pull a string, turn a crank, etc – only one. No combinations allowed.
  - Ensure members' plans are realistic and within the scope of their abilities.
  - Depending on time, resources, and skill level, members can make their contraptions as elaborate as they like.



3. Once they have a plan in place they can start building.
4. Do not let them be afraid to experiment with different configurations. Sometimes trial and error is the best way to learn and achieve success.
5. When completed members can evaluate their contraption in their manual's.

## **Dig it!**

Have members reflect on their learning by asking them the following questions:

- What was the hardest part of building your contraption? Why?
- What advice would you give someone who wanted to build a compound machine?
- If you were to build another contraption, what would you do differently?

Once members have a solid foundation of basic skills and achievements, they should be ready to start working on communication skills and developing leadership roles in the community. Once members have completed their compound machine, have them explain to you the design and building process and their final results.

Further suggestions: Have members plan and give a presentation on their compound machine to members of the community (friends, family members, other school children, senior citizens, etc.). The presentation should include both written (planning, speech) and oral (speaking to group) components.

### **What's next?**

Next up is the last builder in this project. There is a choice of activities - build a mousetrap car or a junkyard crane. These activities should prove to be a fun and challenging conclusion to Exploring Machines!

Get members thinking about what machine they would like to build next. Give an overview of the mousetrap car and junkyard crane activities to give members a better sense of what is involved and what the final product will be. This will hopefully help them make a decision.

### **Leader's Notes**

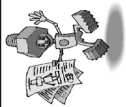


# In the Member Manual

## Skill Builder 5: Compound Machines

### Gizmo Says....

A contraption is a device made out of whatever materials you may have and serves a particular purpose. You will use simple machines, magnets, and whatever else you can think of to make your machine!



EXPLORE

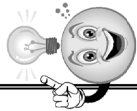


### SKILLS CHECKLIST

- Plan and build a compound machine
- Show how simple machines work together
- Demonstrate how your compound machine works

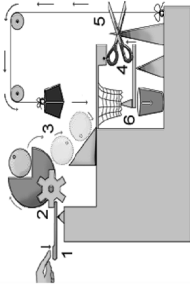
### Important Words

Watch out for these important words in this builder: **Compound machine, Blueprint, Planning**



## Dream it!

A compound machine is a machine that is composed of 2 or more simple machines. In the diagram at right is a compound machine that makes orange juice. If you follow the numbers (from 1 to 6) you will see how the process works.



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In the “Contraption Challenge” activity you will build your own compound machine that will do a specific task: put a metal washer or marble into a cup.

Your compound machine can be as simple or elaborate as you want. As long as your machine performs its task in at least 5 steps and uses a variety of simple machines and other items, it will be a success!

- Come up with a blueprint or plan for your very own machine using the guidelines your leader will provide.
- Check out the More Machines website link on the next page for ideas and suggestions.
- Think carefully about how you can use the supplies you are given with the various simple machines.
- Think about what each simple machine will do.



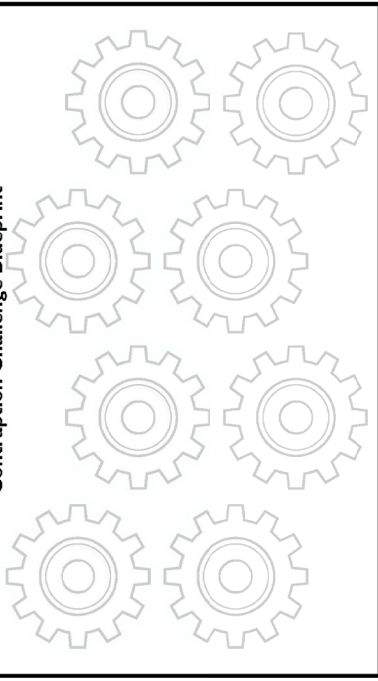
### Gizmo's



Rube Goldberg was an inventor, sculptor, author, engineer and cartoonist. He was famous for his cartoons of complex machines that performed simple tasks (today called “Rube Goldberg Machines”). His inventions were interesting as he did the complete opposite of what most machines do – instead of making difficult things easy, he made easy things difficult!

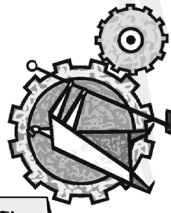
### Fun Facts!

## Contraption Challenge Blueprint



### More Machines!

Check this site out for information, videos, and cartoons relating to Rube Goldberg Machines and ideas for your own compound machine!  
<http://mousetrapcontraptions.com/cool-machines-3.html>



## Do it!

### Contraption Challenge

**What you will need:** Simple machines, paper cup, marble/washer, & whatever you can think of! (e.g. magnets, soda bottles, coat hangers, drinking straws, mousetraps, etc.)

- Once you have your plan in place and your materials gathered you can start building!
- ★ Do not be afraid to experiment with different configurations. Sometimes trial and error is the best way to learn and achieve success!
- How did it go? Evaluate your contraption using the chart below.

### I think that my Contraption deserves a score of:

Score
Number of simple machines used (2 points each)
Everyday materials used to build simple machines from scratch: 5 points each
Washer/marble was lifted in air : 20 points
Washer/marble was placed in cup: 20 points
Operation was done by touching only one spot: 10 points
Creative theme : 5 – 10 points
Total

# In the Member Manual

## More Machines!

If you like inventing things, check out this fun online game where you are the inventor!

[http://inventionatplay.org/playhouse\\_tinker.html](http://inventionatplay.org/playhouse_tinker.html)

## Dig it!



Think about your Learning...

Review the Skills Checklist on page 15. What skills have you developed? Do you need more practice?

### How Did it Go? Answer these questions:

How well did your contraption work?

How closely did you follow your blueprint?

Go back to the blueprint drawing and sketch in one improvement (use a different colored pen). Show your leader and explain why you made that choice.

### From Farming History...



Photo Courtesy of the Canada Agriculture Museum

#### Horse Drawn Seeder

Seeders (or seed drills) evenly distribute and plant seeds in the ground. Before the invention of the seed drill, seeds were scattered on the ground by hand, which was not very precise as many seeds did not take root. Modern seeders, which are pulled behind tractors, use basically the same technology as the old horse-drawn ones. This is a good example of a compound machine.

### What's next?

Now that you have accomplished building a compound machine, are you ready for the next challenge? The next lesson is the Achievement Builder, where you will have the choice of building two exciting machines: A junkyard magnet or a mousetrap car!

Take a peek at the two activities and think about which one you would like to do the most.

# Skill Builder 6: Mega Machines

## Skills Checklist

- ◇ Plan and create a machine
- ◇ Demonstrate ability to solve problems



## Dream it!

Now that members have developed certain basic skills in this project, it is time to build on that knowledge and apply it to everyday life. In this lesson, there will be more of a focus on real-world experiences. By planning and creating their own machine, members will start to learn important job-readiness skills such as innovation, creativity, and problem solving.

### Suggestions for real world experiences:

- Arrange a tour of a shop or place of business that deals with machines and engines.
- Have someone give a talk to members on their trade and how the machines work.

After the visit or guest speaker, have members reflect on their experience. This could be presented orally, visually, or written.

### Background for Leaders

Members are challenged to create either a "mousetrap car" or a "junkyard crane".

**Mousetrap Car** - The spring of a mousetrap can store a large amount of energy when it is pulled back and let go. This makes the mousetrap the perfect "motor" for a homemade car. As the trap closes, the metal bar pulls a string that has been wrapped around the axle of the mousetrap car. This causes the axle and attached wheels to spin moving the car forward. Using this basic method of movement, the members can build a variety of cars of different designs.

**Junkyard Crane** - Electro magnets are very useful in heavy industry. They have the capability to hold onto very heavy loads of iron and steel. The use of a winch and crane allow workers to move the loads very easily. When the current is turned off, the iron loses almost all of its magnetism, and the load is dropped.

In this lesson, the members will construct a tower with a motorized winch. They will attach the electro magnet that they constructed in the last activity to the winch. Members should be able to use their electro magnets to hold onto several paperclips. They should then be able to use their winches to lift the paperclips up into the air. Then the tower can be moved to a different location, where the winch should be lowered, and the paperclips released by releasing the wire on an electro magnet.

It would be very helpful to your members if you were to construct an example of a junkyard magnet prior to this lesson. This will also help you to anticipate any unforeseen difficulties that may arise in this and the following activities. This is an opportunity for members to "learn to do by doing" and showcase their learning and creativity. There are some basic diagrams to assist but the crane design is limited only by the members creativity and operational demands.

## Important Words

Help members define the following words and look for members using this vocabulary in their discussions. A few strategies you can use include;

- Teach synonyms by providing a synonym members know.
- Also, teach antonyms. Not all words have antonyms, but thinking about opposites requires the members to evaluate the critical attributes of the words in question.
- Provide non-examples. Similar to using antonyms, providing non-examples requires students to evaluate a word's attributes. Invite members to explain why it is not an example.



Motor	A machine that converts electricity into a mechanical motion.
Magnet	A magnet is a material or object that produces a magnetic field.
Crane	An industrial machine for lifting.
Wheel & Axle	A wheel and axle is a type of lever (the axle acts like a fulcrum). Wheels move objects across distances.
Spring	A spring is an elastic object used to store mechanical energy.
Car	A wheeled vehicle used for transporting goods or passengers.

**Age Considerations:** 8 and up

### Thinking Ahead

- What will you discuss with members? Gather observations and think of examples that will help support your discussion.

### Preparing for Success

- Linking back to the Skills Checklist, help members identify how they will know they have been successful in learning from this builder. Discuss what success in these activities might look like, sound like, or feel like.

### Activating Strategies

- Before members begin to build their machine, they must do some planning. They need to have a good idea what their machine will look like (design), what materials & supplies are needed, and a plan for how it will be constructed.
- Help members make realistic and practical choices given the materials, their skill level, and time they have.

## Do it!

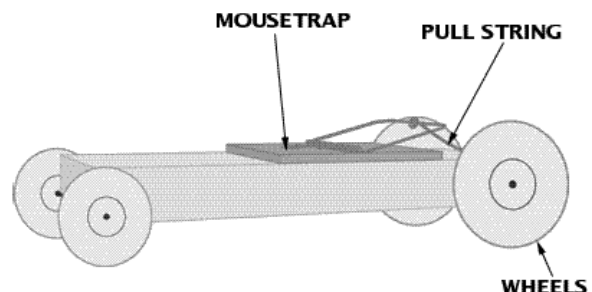
### Mousetrap Car

**Time Required:** Approx. 3 hours

### Resources/Handouts/References

For hints, tips, and other methods of building a mousetrap car check out these links:

- <http://www.hmk.bpsd.mb.ca/Young/mousecars.html>
- <http://users.bigpond.net.au/mechtoys/mouse.html>





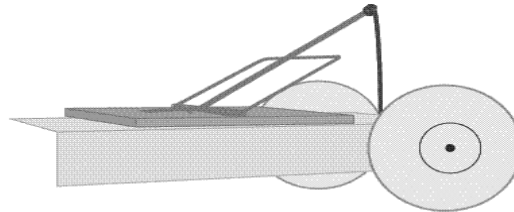
## Equipment/Supplies

To build the car:

- Mousetrap (about 2.5 cm by 10 cm)
- Sturdy box to form car body (similar strength and size to a match box)
- Tools for constructing car
- Decorative materials
- Wheels and axles (encourage members to be creative in their wheel selections)
- String

For the car race:

- Measuring tape (for measuring race track)
- Stopwatch (to time the cars)



EXTENSION OF MOUSETRAP BAR

## Safety Considerations

- Members should wear **protective goggles** when building and racing the mousetrap cars.
- They should be careful when opening, setting, and releasing the tension bar of the mouse traps. Do not use rat traps. Rat traps can easily break a finger when snapped shut.
- Leaders and/or parents should monitor the building of the car to ensure safe building techniques are being used.

## Suggested Variations/Age Appropriate Variations

- There are many ways to make a mousetrap car using variety of materials. Members can also be as creative they like and customize their cars.

## Instructions

### 1. Building Blueprint - Questions for members to consider:

- a. How many wheels will the car have, what size will they be, and where will they be placed?
- b. Where should the mousetrap be placed on the car box chassis?
- c. How can the car be designed to travel the farthest?

### 2. Car Body Design

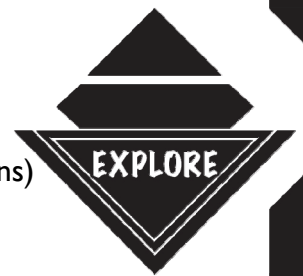
- a. Use a flat, rectangular box. It must be a heavy cardboard box so members have a sturdy platform to attach the trap to and assemble the vehicle.
- b. Determine the placement, number and type of wheels to use.
- c. Test drive the car by pushing it along the ground.
- d. Have members make any design improvements that they think are necessary.

### 3. The Power Plant

- a. Determine the placement of the mousetrap on the car box chassis
- b. Remember, one end of the pull-string is tied to the spring bar of the trap. The free end is wrapped around the power axle. As the mousetrap spring shuts, the movement of the controlled release is transferred to the spin of the axle.
- c. Wear safety goggles to test the design.
- d. Does the car travel enough distance? How can it move quicker Can you gain an advantage with a longer "pull bar"? The member may redesign the car if they think of ways to improve its performance.

### 4. The Race

- a. With safety goggles on, race each of the cars individually.
- b. Record the time and distance data for each of the cars.
- c. Have members discuss what features helped the cars perform better and what features slowed down or stopped the cars.



## Junkyard Crane

**Time required:** approx. 3 hours

### **Equipment/Supplies**

- Electro magnet (as made in previous activity)
- 9 volt electric motor and battery (as found in electronics departments or stores) (Purchasing one with a switch adds possibilities.)
- Building materials (popsicle sticks, common steel or plastic brick building toys, wood, etc.)
- Tape, glue, screws, etc.
- String
- Thread spools (3 per student)

### **Safety Considerations**

- Leaders and/or parents should monitor the building of the crane to ensure safe building and tool handling techniques are being used.

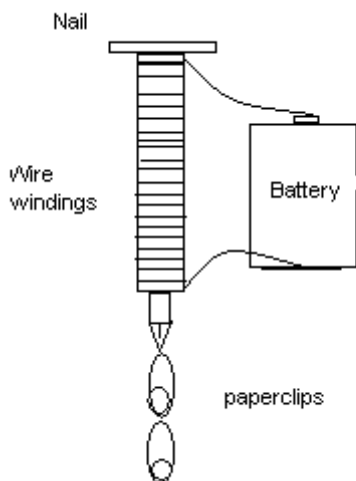
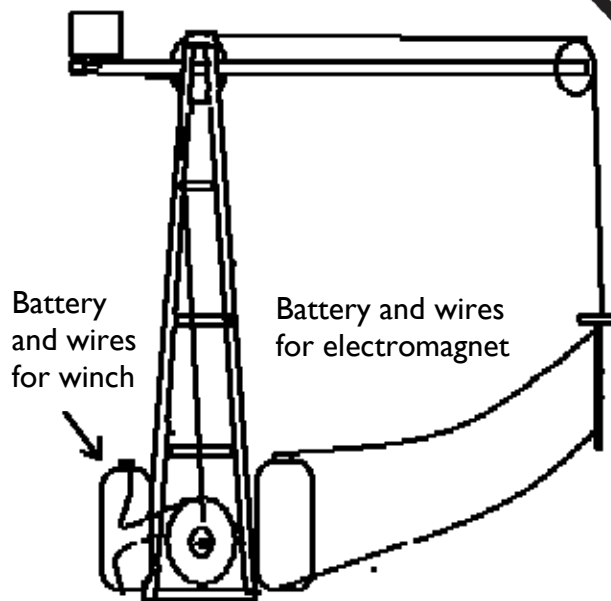
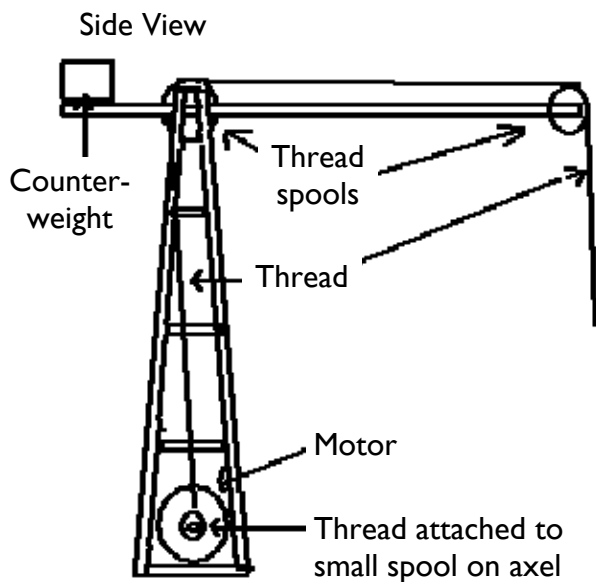
### **Instructions**

#### Crane Construction

1. Show the diagram of the crane. Focus the member's attention on the structure. It is wide at the bottom, and narrows to the top. It has an arm that extends well out past its base. It also has a counter balance weight to help the crane from toppling over.
2. Allow the members to use the materials provided to build a crane. They may wish to use the design template provided. Ensure that the base of the crane is wide enough to allow for the motor and thread spool placement. They should also make sure that the crane is stable. This should be an exercise where members use their creativity and understanding of machines to create their own operational crane.
3. Now explain to members that they will attach an electric winch to their cranes. This will be the motor that will pull up the load, and lower it as well.
  - The winch should be located in the base of the crane. The spool will act as the pulley that holds the string as the motor rotates. The battery that powers the winch motor should also be located in the base of the crane. The wires can be attached to drive the motor when the winch is required. Notice that the spool can be reversed if the wires going to the motor are switched.
4. Attach the Electro Magnet and presto...Junkyard Magnet.
  - The members will tie their electro magnets to the end of the string. They should tie them so that the point of the nail is pointing down. They should also take care to have enough wire as slack so that as the winch lowers the electro magnet, the wires won't impede the process. The battery for the electro magnet should be located in the base of the crane, along with the other battery, motor and spool for the winch. This will allow the crane to be truly mobile.



## EXPLORE



### Optional Activity: Switch it off!

Members may wish to have a switch on their crane. Some inexpensive small motors may come with switches and wiring attached. To build a simple switch, members may use a clothespin as in the activity "Simple Electric Circuit and Switch" in Skill Builder 3. The member can hold the switch on or build a wedge to keep the clothespin open.

## Dig it!

1. Ask members the following questions:
  - What skills did you demonstrate to make this project a success?
  - So what is the secret to building a fast mousetrap car or an effective junkyard crane?
  - If you were to build this machine again, what would you do different?

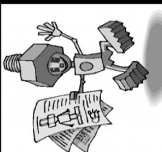
*Credit: This project section was inspired by and adapted from the "Teacher's Source Section" of the "Scientific American Frontiers" website. [www.pbs.org](http://www.pbs.org) – "Games Machines Play" series. Review of this website area may provide you with additional ideas or tips.*

# In the Member Manual

## Skill Builder 6: Mega Machines

### Gizmo Says....

Congratulations! You have made it to the final Exploring Machines builder! Just think of all the skills you have learned so far! In this builder you will continue to apply those skills by building one of two exciting machines: a mousetrap car or a junkyard crane! Which one will you choose?



### SKILLS CHECKLIST

- Planning and creating your own machine
- Demonstrate ability to solve problems



### Important Words

Look out for these important words in this builder:

**Motor, Spring, Wheel & Axle, Car, Crane, Magnet**

### Dream it!

#### Mousetrap car

A mousetrap car is what its name suggests: a car that is powered by a mousetrap. The car gets its energy from the wound-up arm (the part that snaps shut) of a mousetrap. A common design is where a string is attached to the mousetrap arm and then wrapped around the rear axle of the car. When the arm snaps shut it pulls on the axle which makes the wheels move! Mousetrap cars come in all kinds of designs and configurations and are made out of a variety of materials. A common competition among mousetrap car makers is to see which car can go the fastest or furthest.

#### More Machines!

Check out this webpage with pictures of student-made mousetrap cars and useful links: [http://gets.gc.k12.va.us/schools/page/west/mouse\\_trap\\_car\\_projects.htm](http://gets.gc.k12.va.us/schools/page/west/mouse_trap_car_projects.htm)

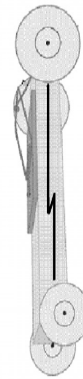
#### Junkyard crane

You have learned about magnets and how electricity increases magnetism. In junkyards and other industrial places electromagnets are used to move and separate heavy material. You can use the electro magnet you built in project meeting 4 and attach it to a crane to make your own smaller-scale version!

### Do it!

#### Mousetrap Car

- How will you build your car?



**What you will need:** mousetrap, sturdy cardboard (matchbox size), wheels & axles, string, safety goggles

## What's next?

At this point members have completed all the builders for this project. This final section is a chance for leaders to evaluate the learning of the members, and a chance for the members to present their findings to their peers, and parents.

## Leader's Notes



EXPLORE

EXPLORE

# In the Member Manual

**Building Blueprint:** Think about how you will design your car by answering the following questions

- How many wheels will the car have? What size will they be? Where will they be placed?
- Where should the mousetrap (the car's power) be placed on the car box chassis?
- How can the car be designed to travel the farthest? The fastest?

## Part 1 - Car Body Design

- Use a small rectangular box made of heavy cardboard to support the mouse trap.
- How many wheels will you use? Attach the axles to the body and then the wheels.
- Test drive the car. How does it move?
- Decorate your car.

## Part 2 - The Power Plant

- Where will you place the engine (mousetrap) on the car?
- Wearing your safety goggles attach the string to the spring bar on the trap. Wrap the other end of the string around the axle.
- Test drive the car. How does it work? Make adjustments if needed to make it run better.

## Part 3 - The Race

- Let's race! - Record you and your fellow members' best times and distances in the chart below.

### Mousetrap Car Race Results

Car	Time to Race 5 meters	Longest Distance Raced

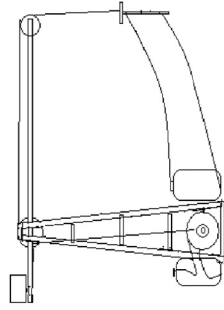
- What features helped your car perform better? What features slowed down or stopped the car?

## Junkyard Crane

- How will you construct your crane?

**Building Blueprint:** Think about your crane's design (use the diagram as a guide)

**What you will need:** Electro magnet, electric motor & battery (for winch), building materials (popsicle sticks, steel or plastic building toys, wood, etc.), tape, glue, screws, string, thread spools (3)



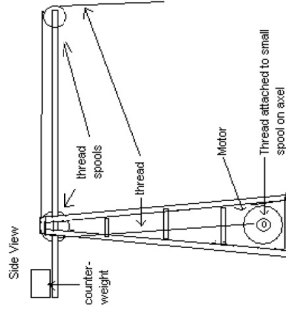
- How will you build your crane's body? What materials will you use? How will you attach the winch and electro magnet?

## Part 1: Crane construction

- Build your crane with the materials you have and using the diagram on the right as a guide

## Part 2: Attach the winch

- Attach the electric motor (winch) and battery to the base of your crane.



## Part 3: Attach the electro magnet

- Attach the magnet to the end of the string (nail pointing down) and the magnet's battery to the base of the crane.

## Part 4: Move that Junk!

- Connect the wires to the winch and the magnet will move. Reverse the wires on the winch for the magnet to go in the opposite direction. Try lifting some metal things!

## Big it!



**Thinking about this builder and the activities you did...**

- Review the skills checklist on page 18. What skills have you developed? Do you need more practice? What skills did you use to make this project a success?

## Record it...

Discuss what you have learned with your leader so that the information can be recorded on your portfolio page.

## Apply it...

How would you explain to others the steps you need to take to have a successful project?



## What's next?

Now that you have finished all the builders in this project it is time to think about and plan for the Showcase Challenge on page 21, which will help prepare for your 4-H Achievement. On page 23 is your portfolio page where you can make sure all your Exploring Machines Project Skills Chart is complete. There will also be space for you to write down some thoughts and reflections on the project (what you liked, didn't like, etc.).

# Showcase Challenge

Have members use their Member Manual to help them in organizing what they have learned. The form of the showcase can vary according to the wishes of the leaders and member's ability. Information could be presented in many forms, some of which are: posters, pamphlets, written reports, speeches, computer presentations, displays, etc. Suggestions are listed on the Showcase Challenge page at the back of the Member Manual. The best results are almost always obtained when members are allowed to present their information in the style of their choice.

## In the Member Manual

### Showcase Challenge Bringing it all together!

Now that you have finished this project, it is time to think about how you will share your experiences and knowledge with others. You may put your new skills to work by helping at a community event or at your club Achievement or teaching others about your topic. The goal of the Showcase Challenge is to help highlight your new skills and help you understand how you can use them. It can be an opportunity to receive feedback from others on your project. So go back through your manual and find some highlights of your learning (what you are proud of) and think about how you will "showcase" it.

### Dream It!

#### Here are some Showcase Challenge Suggestions:

- Demonstrate something you made or learned about
- Make a poster or display
- Make a pamphlet
- Make a computer presentation (e.g. PowerPoint)
- Give a speech
- Write a report
- Use your new skills to help with the Club Achievement plans
- Or come up with your own idea. It is up to you and your leader!



### My Showcase Challenge Plan

My showcase idea: \_\_\_\_\_

What materials and resources do I need? \_\_\_\_\_

Who do I need to help me? \_\_\_\_\_

When do I need to have things done by? \_\_\_\_\_

EXPLORE

EXPLORE

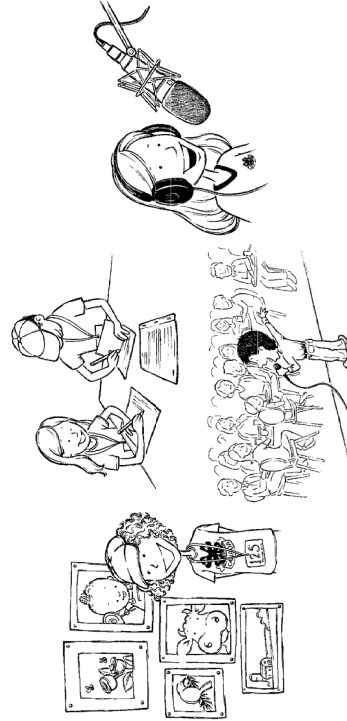
### Do It!

Insert or attach your finished product or a photo of you sharing your skills in your Showcase Challenge.



### Dig It!

- Now that you have showcased your project skills;
- How did your Showcase Challenge go?
  - What would you do differently next time?
  - How will you use your new skills in the future? (in different situations?)



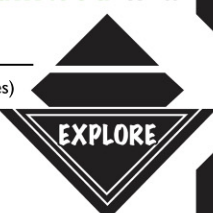
# Portfolio Page

Once members have completed all the builders they will have a lot of information recorded in their manuals. These are products of their learning. As a final project activity, members and leaders will pull together all this learning in completing the Portfolio Page in the Member Manual. There is a skills chart that lists the skills members are expected to complete by the end of the project. Leaders and members must indicate how they know the member was successful at a particular skill. Leaders will find evidence if they think about what they have observed members doing, what discussions they have had with members, and what members have produced. If leaders think that members need to go back and improve on any skill, this chart helps them clarify what needs to be done.



## My 4-H Portfolio Page Manitoba

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Year in 4-H: \_\_\_\_\_  
 Club: \_\_\_\_\_ Hours Spent on 4-H: \_\_\_\_\_ (Project and Other 4-H Activities)



In the Member Manual


<b>Exploring Machines Project Skills Chart</b> To be completed by the leader and the member based on observations and conversations throughout the project.		
Skill Builder	Members will be able to... Each Skill Builder had a Skills Checklist which identified the skill you will learn.	We know this because... Identify activities completed and record observations and information from discussions about activities.
1	<ul style="list-style-type: none"> <li>Know how machines save time</li> <li>Identify the 6 simple machines</li> <li>Know how a wedge, inclined plane, &amp; lever work</li> </ul>	
2	<ul style="list-style-type: none"> <li>Define "work"</li> <li>Know how a screw, pulley, and wheel &amp; axle work</li> <li>Plan and build a simple machine</li> </ul>	
3	<ul style="list-style-type: none"> <li>Know the concept of electricity</li> <li>Identify different conductors and insulators</li> <li>Make an electric circuit with a switch</li> </ul>	
4	<ul style="list-style-type: none"> <li>Know what magnetism is</li> <li>Discover what substances are magnetic</li> <li>Build an electro magnet</li> </ul>	
5	<ul style="list-style-type: none"> <li>Plan &amp; build a compound machine</li> <li>Know how simple machines work together</li> <li>Demonstrate and/or explain their project</li> </ul>	
6	<ul style="list-style-type: none"> <li>Plan and build a mousetrap car or junkyard crane</li> <li>Be creative and solve problems</li> </ul>	
Additional Comments/Activities:		

**Leader Point of Praise!**

I am most impressed by...

I acknowledge that the member has completed the 4-H project requirements.

Leader's Signature: \_\_\_\_\_



## In the Member Manual

### Above and Beyond!

In addition to project skills, 4-H also increases skills in meeting management, communications, leadership, community involvement through participation in club, area, or provincial 4-H events or activities. List below any activities you participated in this year in 4-H.

(Some examples include Executive Positions Held, Workshops, Communication, Community Service, Rally, Bonspiels, Conferences, Judging, Camps, Trips, Awards, Representation to Area or Provincial Councils, etc)

_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

\*\*Feel Free to add additional pages that include awards, certificates, new clippings, photos or other items that describe your 4-H involvement.

### Member Point of Pride!

What I learned...

What I need to improve on...

What I want others to notice...

Member's Signature: \_\_\_\_\_



### Point of Praise! Another's perspective on your achievements in 4-H.

(community professionals, MAFRI staff, 4-H club head leaders, 4-H Ambassadors, friends of 4-H)

I am most impressed by...

I believe that you have learned...

In the future I encourage you to...

Signature: \_\_\_\_\_







## 4-H Achievement

4-H Achievement is... a 4-H club celebration when members have completed their projects. Achievements are planned by the club to give recognition to members and leaders for their accomplishments in their 4-H projects and club activities.



A 4-H Achievement can take many different formats: from choosing a theme, to member project displays, to members using their new skills for the event (entertainment, food, decorating, photographer, etc.), to members presenting their project to the whole group, the options are endless and open to the creativity of the members and leaders in each club!

Clubs may also plan their Achievement to promote 4-H to the community or to recognize sponsors and others who have helped the club.

Members and leaders - be sure to check your project books for the project completion requirements, so you will be ready for your club's Achievement celebration!

**If you have any questions, comments or suggestions for this or other 4-H projects contact:**

**Manitoba 4-H Projects  
Manitoba Agriculture Food and Rural Initiatives  
1129 Queens Avenue  
Brandon, MB R7A 1L9**

**Email: 4h@gov.mb.ca**

**Phone: 204-726-6613**

**Fax: 204-726-6260**

**For more information about 4-H and the many 4-H opportunities available please visit**

**<http://www.gov.mb.ca/agriculture/4-h/>**





## What is 4-H?

4-H is an international youth organization involving more than 7 million members in 80 countries around the world.

In Canada, 4-H began in 1913 in Roland, Manitoba as a community-based organization dedicated to growth and development of rural youth. Today's 4-H program reaches both farm and non-farm youth across Canada. The motto of "Learn to Do by Doing" is embodied in the program, as 4-H focuses on skill development as well as personal development of life skills such as communications, leadership and citizenship.



## 4-H Motto

"Learn To Do by Doing"

## 4-H Pledge

I pledge,  
My HEAD to clearer thinking,  
My HEART to greater loyalty,  
My HANDS to greater service,  
My HEALTH to better living,  
For my club, my community, and my country.

## 4-H Quality Equation Principles

### Quality People

- Promote responsibility, respect, trust, honesty, fairness, sportsmanship, citizenship, teamwork and caring.

### Quality Experiences

- Provide members with personal development and skill development experiences.

### Quality Projects

- Promote and value quality effort.
- Promote high quality, safe food production within industry standards.



Manitoba 4-H project material is developed by  
Manitoba Agriculture, Food and Rural Initiatives (MAFRI)

