Always follow the safety procedures outlined by your teacher.

Never put any materials in your mouth. Do not taste any chemical unless your teacher specifically tells you to.

Do not smell any unknown material. If your teacher asks you to smell a material, wave a hand over the material to draw the scent toward your nose.

Avoid touching your face, mouth, ears, or eyes while working with chemicals, plants, or animals.

Do not mix unknown chemicals just to see what might happen.

Always wash your hands immediately after using chemicals.

Clean up spills immediately.

Clean up your work space after each investigation.

Be careful when using sharp or pointed tools. Always make sure that you protect your eyes and those of your neighbors.

Report all accidents, even small ones, to your teacher.

Follow directions and ask questions if you’re unsure of what to do.

Behave responsibly during science investigations.
LEVER EXPERIMENT A

Lever experiment with LOAD positioned 10 cm from fulcrum

<table>
<thead>
<tr>
<th>Position of effort (cm from fulcrum)</th>
<th>Effort (scale + 0.5 N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5 cm</td>
<td></td>
</tr>
<tr>
<td>5.0 cm</td>
<td></td>
</tr>
<tr>
<td>10.0 cm</td>
<td></td>
</tr>
<tr>
<td>15.0 cm</td>
<td></td>
</tr>
<tr>
<td>20.0 cm</td>
<td></td>
</tr>
<tr>
<td>25.0 cm</td>
<td></td>
</tr>
</tbody>
</table>
Randy and Kevin had been working with levers for a couple of days. They were trying new ways to set up levers. They each set up a lever system. Both lever systems had the load hanging at the 40-cm position on one side, and the effort pressing at the 40-cm position on the other side.

Randy said, “Our levers are the same. They will both take the same amount of effort to lift the load.”

Kevin responded, “I don’t think so. One of these systems will require less effort to lift the load.”

Which student do you think was right? Explain why you think so.
LEVER EXPERIMENT B

Lever experiment with EFFORT applied 10 cm from fulcrum.

<table>
<thead>
<tr>
<th>Position of load (cm from fulcrum)</th>
<th>Effort (scale + 0.5 N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5 cm</td>
<td></td>
</tr>
<tr>
<td>5.0 cm</td>
<td></td>
</tr>
<tr>
<td>10.0 cm</td>
<td></td>
</tr>
<tr>
<td>15.0 cm</td>
<td></td>
</tr>
<tr>
<td>20.0 cm</td>
<td></td>
</tr>
<tr>
<td>25.0 cm</td>
<td></td>
</tr>
</tbody>
</table>
You are going to read a story that will give you more information about the levers you have been investigating as well as other devices that are designed to make work more effective. After you read the story, please answer the following questions using complete sentences.

1. How could you lift your teacher in the air?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

2. Could you lift your teacher in the air with one hand?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

3. What are some of the simple machines we use every day?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

4. Why do people use simple machines?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
You are going to read an article to learn more about the class-1 lever. After you read the article, please answer the following questions using complete sentences.

1. What is a mechanical advantage?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

2. What advantage rule can we state about a class-1 lever?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

3. What is the cost of making the work easier?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
You are going to read an article that will provide more information about how wheels and axles work and how they are like class-I levers. After you read the article, please answer the following questions using complete sentences.

1. Why do you think the wheel and axle is described as a "lever in the round?"

2. When you use a wrench to tighten a bolt, are you looking for a gain in effort or distance?

3. When you use a windlass to raise a bucket from a well, what is the gain?

4. How do you think the key to a music box works, in terms of a wheel and axle?

5. When you read the article on page 9 "The Tricycle versus the Bicycle," how do you think the front wheel and the rear wheel of a bicycle are different?
6. Which wheel on the bicycle is the wheel and which one is the axle?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

7. Explain how a bicycle works.

______________________________________________________________________________
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______________________________________________________________________________
Rand and Amy want to make lever arms for their class to do some lever experiments. Read the descriptions of the lever arms they want to make, and figure out what length of board they need to buy and how they should cut it up to make the lever arms.

- They want to make 18 lever arms.
- They are making equal numbers of lever arms of three sizes: short, medium, and long.
- All the lever arms are 2 cm wide.
- The long levers are three times longer than the short levers.
- The medium levers are half as long as the lengths of the long and short levers added together.
- The short lever is six times longer than it is wide.
- The board is 12 cm wide.

What length of board should they buy?

How should they cut the board?
HOME/SCHOOL CONNECTION

INVESTIGATION 1: LEVERS

The levers we are studying in class are examples of simple machines. Simple machines are used in many tools, appliances, and complex machines. Simple machines provide us with some advantage. Usually they make work easier, but sometimes they provide other advantages. There are six simple machines in all: lever, pulley, wheel and axle, inclined plane, wedge, and screw.

Three of these simple machines are somewhat related, the inclined plane, the wedge, and the screw. An inclined plane is a slope or ramp; a wedge is a modified inclined plane used to insert, open, or pierce; and a screw is an inclined plane spiraled around an axis.

Here’s your challenge. Look around your home and neighborhood to see where you can find examples of these three simple machines. Look in tool drawers, kitchens (particularly at utensils), and cars. See how many examples you can list in the spaces below.

<table>
<thead>
<tr>
<th>Inclined plane</th>
<th>Wedge</th>
<th>Screw</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curb cut</td>
<td>Ax</td>
<td>Nut and bolt</td>
</tr>
<tr>
<td></td>
<td>Nail</td>
<td>Jar lid</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### LEVER DIAGRAMS

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

**Diagram 1**

- L: 20
- E: 25
- F: 0

**Diagram 2**

- [Blank]

**Diagram 3**

- [Blank]

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>8</td>
</tr>
</tbody>
</table>

---

**Investigation 2: More Leverage**

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Can be duplicated for classroom or workshop use.
Millie and Jasmine were looking at a clothespin. They were pretty sure that the clothespin is a class-1 lever. They analyzed it like this.

When Carrie looked at the clothespin, she said, “When you squeeze the clothespin, it is a class-1 lever, but when it is holding clothes on the line, it is a class-3 lever.” Carrie analyzed the clothespin like this.

Do you agree with the girls? Why or why not? Explain your reasoning.
LEVERS AT WORK

**Class-1 lever**

- **L**
- **F**
- **E**

**Class-2 lever**

- **F**
- **L**
- **E**

**Class-3 lever**

- **L**
- **E**
- **F**

<table>
<thead>
<tr>
<th><strong>1</strong></th>
<th><strong>2</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BROOM</strong></td>
<td><strong>NUTCRACKER</strong></td>
</tr>
<tr>
<td>This is an example of a class- ___ lever.</td>
<td>This is an example of a class- ___ lever.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>3</strong></th>
<th><strong>4</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SCISSORS</strong></td>
<td><strong>BOTTLE OPENER</strong></td>
</tr>
<tr>
<td>This is an example of a class- ___ lever.</td>
<td>This is an example of a class- ___ lever.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>5</strong></th>
<th><strong>6</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PLIERS</strong></td>
<td><strong>TWEEZERS</strong></td>
</tr>
<tr>
<td>This is an example of a class- ___ lever.</td>
<td>This is an example of a class- ___ lever.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>7</strong></th>
<th><strong>8</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HAMMER</strong></td>
<td><strong>HUMAN ARM</strong></td>
</tr>
<tr>
<td>This is an example of a class- ___ lever.</td>
<td>This is an example of a class- ___ lever.</td>
</tr>
</tbody>
</table>
LEVER PICTURES A

Class-1 lever

Class-2 lever

Class-3 lever

This is an example of a class- ____ lever.

This is an example of a class- ____ lever.

This is an example of a class- ____ lever.

This is an example of a class- ____ lever.
### LEVER PICTURES B

<table>
<thead>
<tr>
<th>Class-1 lever</th>
<th>Class-2 lever</th>
<th>Class-3 lever</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Fishing Rod" /></td>
<td><img src="image" alt="Paper Cutter" /></td>
<td><img src="image" alt="Tree Pruners" /></td>
</tr>
<tr>
<td><img src="image" alt="Golf Club" /></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This is an example of a class- ____ lever.  
This is an example of a class- ____ lever.  
This is an example of a class- ____ lever.  
This is an example of a class- ____ lever.
You are going to read a story that describes class-2 levers and how they are used. After you read the story, please answer the following questions using complete sentences.

1. What is the mechanical advantage of the class-2 lever?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

2. What advantage rule can we state about a class-2 lever?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

3. What is the load in a bellows?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

4. How is the bellows like the nutcracker and garlic press?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
You are going to read an article about class-3 levers. After you read the story, please answer the following questions using complete sentences.

1. What is the mechanical advantage of a class-3 lever?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

2. What advantage rule can we state about a class-3 lever?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
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______________________________________________________________________________

3. Explain why the catapult on page 13 is a class-2 lever when it is being loaded and a class-3 lever when it is hurling a rock.

______________________________________________________________________________
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______________________________________________________________________________
You are going to read an article to learn how the inclined plane can be used. After you read the article, please answer the following questions using complete sentences.

1. What is the advantage of an inclined plane?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

2. What is the disadvantage of an inclined plane?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

3. What simple machine is used to make a wheelchair ramp?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

4. What is the advantage of the simple machine that is used to make a wheelchair ramp?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

5. How can a plank be used as an inclined plane?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

6. Are there inclined planes in your school? If so, list some examples.

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
7. Imagine that you see two trails going up a hill. If one of the trails is a winding trail and the other is a straight trail, which trail would be the easiest to hike to get to the top of the hill? Explain why.

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

8. What is the disadvantage if you take the easiest route?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
Buddy was working with a class-1 lever. He had a load that pulled with a force of 20 N. He did these three experiments.

Buddy looked at experiment 1. He looked at the force of the load (20 N) and its distance from the fulcrum (20 cm). Then he looked at the force of the effort (20 N) and its distance from the fulcrum (20 cm). Everything balanced.

Buddy looked at experiment 2. The load was at the same location, but now the effort was only 10 N, and it was way out at 40 cm. And everything still balanced.

Suddenly Buddy saw something that he thought might be important. He said, “I bet if I move the load 30 cm from the fulcrum, and put the effort 10 cm from the fulcrum, I will have to use an effort of 60 N to lift the load!” He set up experiment 3 and discovered that he was right. What did Buddy figure out? Can you predict the effort needed to lift the load on the levers below?
Levers are everywhere. You can find them at work in tools, construction machinery, sports equipment, kitchen utensils, and the bodies of humans and other animals.

Levers come in three classes. The class of lever is determined by the relationship of the fulcrum (pivot point), load (weight to be lifted or resistance to be overcome), and effort.

Look through some magazines, catalogs, or newspapers for examples of levers at work in the real world. Try to find at least one picture of each class of lever. The pictures will be fun to share at school.
**PULLEY DIAGRAMS**

**Part 1. One-Pulley Systems**

<table>
<thead>
<tr>
<th>Pulley system</th>
<th>Load (N)</th>
<th>Direction of pull</th>
<th>Scale reading (N)</th>
<th>Effort (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-fixed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single-movable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What did you learn about pulleys?

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

**Part 2. Pulley-System Diagrams**

<table>
<thead>
<tr>
<th>Pulley system</th>
<th>Load (N)</th>
<th>Direction of pull</th>
<th>Scale reading (N)</th>
<th>Effort (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-fixed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single-movable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single-fixed/ single-movable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single-fixed/ single-movable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Karl told his brother Charles, “I just couldn’t lift that 30-kg bag of cement into Dad’s wheelbarrow until I got a pulley and a rope. Then it was easy.”

Charles was surprised. "You got the cement into the wheelbarrow!? How did you do it? How much easier was it?"

Explain how you think Karl lifted the cement and how much effort he had to apply.
You are going to read a story that will give you examples of how one-pulley systems work. After you read the story, please answer the following questions **using complete sentences**.

1. Give some examples of how fixed pulleys are used.

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

2. What is a compound pulley?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

3. What is a block and tackle?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
“Dear Boss”
Pages 19-20

You are going to read a poem and find out what happens to the bricklayer who uses a pulley system to lift bricks to a higher level. After you read the poem, please answer the following questions using complete sentences.

1. Do you believe that the events in the poem could really have happened?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

2. Does the poem explain how pulleys really work?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

3. What kind of pulley system did the bricklayer use?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

4. The poem uses expressions that suggest the storyteller is from another country. What country might that be? Explain your answer.

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

5. What do you think sod and hod mean?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

6. What makes the poem humorous?

______________________________________________________________________________
You are going to read an article about another simple machine that we did not study in our classroom investigations: the wedge. After you read the story, please answer the following questions using complete sentences.

1. How do they keep the airplane on page 21 from moving?
   
   ____________________________________________
   ____________________________________________
   ____________________________________________

2. How is a wedge related to an inclined plane?
   
   ____________________________________________
   ____________________________________________
   ____________________________________________
   ____________________________________________
   ____________________________________________

3. What are some of the wedges you have seen in use?
   
   ____________________________________________
   ____________________________________________
   ____________________________________________
   ____________________________________________
   ____________________________________________

4. How does the slope of a wedge's planes affect the sharpness of a blade?
   
   ____________________________________________
   ____________________________________________
   ____________________________________________
   ____________________________________________
   ____________________________________________

5. Explain how the following items act as a wedge:
   
   a. nail ____________________________________
b. pin


c. needle


d. chisel


e. ax blade


f. saw blade


g. knife blade


h. scissors blade


i. bow of a ship


j. nose of an airplane


k. woodpecker's bill
...and then they came to the cliff. A rope was hanging from a single pulley, with a platform attached to the end of the rope. There was no other way up. How would Julie, her mom, her uncle, and her grandfather get to the top of the cliff with Sparky the pony?

Julie had studied pulleys in science. She thought about the problem for about 10 minutes and came up with a plan. Can you figure out how to get the whole troop up the cliff? What is the fewest number of lifts that can get the job done?

<table>
<thead>
<tr>
<th></th>
<th>Weight</th>
<th>Pulling power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platform</td>
<td>250 N</td>
<td>0 N</td>
</tr>
<tr>
<td>Sparky the pony</td>
<td>2000 N</td>
<td>1800 N</td>
</tr>
<tr>
<td>Uncle Pete</td>
<td>1000 N</td>
<td>600 N</td>
</tr>
<tr>
<td>Gramps</td>
<td>750 N</td>
<td>300 N</td>
</tr>
<tr>
<td>Mom</td>
<td>500 N</td>
<td>250 N</td>
</tr>
<tr>
<td>Julie</td>
<td>300 N</td>
<td>100 N</td>
</tr>
</tbody>
</table>

HINT: Julie knew that, if a person could get to the top of the cliff where the pulley was attached, the pulley system could be changed.
HOME/SCHOOL CONNECTION

INVESTIGATION 3: PULLEYS

Here’s an old parlor stunt that should be fun to try on friends.

Get a length of lightweight rope. Fifteen meters would be a good length, but a shorter length will probably work. Nylon cord is good because it is fairly smooth. You will also need a couple of brooms or mops. Any long, smooth stick will do.

Get two or more people to hold each stick while you lace the two sticks together, as shown in the illustration. Start by tying the rope to one of the sticks. Then wrap the rope around the two sticks.

Challenge the two teams to pull on the sticks to keep them from coming together. When everyone is ready, start pulling on the loose end of your rope. Are the teams able to resist the force pulling them together? How many turns of rope do you need in order to overcome the resistance of your opponents?

This is actually a kind of pulley system. Can you figure out the mechanical advantage?
### Part 1

<table>
<thead>
<tr>
<th>One- and two-pulley systems</th>
<th>Number of pulleys</th>
<th>Direction of effort</th>
<th>Load (N)</th>
<th>Effort (N)</th>
<th>Number of ropes lifting load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single fixed pulley</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single movable pulley</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single fixed / single movable pulley</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single fixed / single movable pulley</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Part 2

<table>
<thead>
<tr>
<th>Distance effort moved</th>
<th>Distance load moved</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What relationships can you see in this chart?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

What are the advantages and disadvantages of using pulleys?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
Belinda and her mother cut and polish rocks to make beautiful bookends. They pack them in crates for shipment. Each crate has a mass of 20 kg. Belinda can lift only one crate of bookends at a time up to the shipping area.

Belinda decided to put together a pulley system to lift the crates up the 2 m to the shipping area. She said,

**With this system I will be able to lift six crates at a time. And there is no disadvantage. Using a pulley system is just like getting something for free.**

Is Belinda right about the number of crates she will be able to lift? Is her statement right that there is no disadvantage? Explain.
“The Work of Pulleys”
Pages 23-25

You are going to read an article that summarizes the mechanical advantage of the pulley systems and how the systems are used. After you read the story, please answer the following questions using complete sentences.

1. Where do you find pulleys in the real world?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

2. How does a chain hoist work?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

3. What modern-day machine has replaced pulleys?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
You are going to read an article about another simple machine that we did not investigate in class: the screw. After you read the article, please answer the following questions using complete sentences.

1. How is a screw a variation of an inclined plane?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

2. What tool is used to turn the screw into the wood?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

3. What kind of simple machine is the screwdriver?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
“Thank You, Mr. Clumpet”
Pages 28-32

You are going to read a story that tells about the use of several simple machines on a sailboat. After you read the story, please answer the following questions using complete sentences.

1. List some of the various machines that were described in the story. Use the illustrations to help you.

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

2. Are there any levers? If so, what types of levers are they?

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3. Are there any pulleys? If so, what types of pulleys are they?

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4. Are there any wheels and axles? If so, list them.

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5. Are there any inclined planes? If so, what types of variations of inclined planes are they?
Ted and Jan were working on a search-and-rescue team that needed to lower an injured climber down a 20-m cliff. Ted was at the top of the cliff; Jan was at the bottom of the cliff. The injured climber weighed 720 N. They have two pulleys and three ropes in their rescue kit. The ropes are 50 m, 65 m, and 80 m.

**Scenario A.** Ted is going to attach the injured climber to the pulley system and lower him to Jan.

- How should they set up their pulleys so Ted can lower the climber using as little effort as possible? ________________
- How much effort will Ted have to use? ________________
- Which is the shortest of their ropes they can use for the job? ________________
- What is the mechanical advantage? ________________

**Scenario B.** Ted is going to attach the injured climber to the pulley system, and Jan is going to lower the climber from her position at the bottom of the cliff.

- How should they set up their pulleys so Jan can lower the climber using as little effort as possible? ________________
- How much effort will Jan have to use? ________________
- Which is the shortest of their ropes they can use for the job? ________________
- What is the mechanical advantage? ________________

**NOTE:** Mechanical advantage = \( \frac{\text{Load}}{\text{Effort}} \)
• Put the scale at the end of a class-2 lever (50 cm from the fulcrum). Find out how much effort is required to lift the load as it moves from the fulcrum to the effort in 5-cm intervals. Graph the results.
• Put the scale 10 cm from the fulcrum of a class-3 lever. Find out how much effort is required to lift the load as it moves from the position of the effort out to the end of the lever in 5-cm intervals. Graph the results.
• Create a diagram of a make-believe lever system (it can be one or more levers). Write an imaginative description of its use, name it, and draw it. Make a model of your lever system.
• Use the half-meter sticks and other materials to build a multiple-lever system where one lever acts on another to provide a double advantage. Compare the effort and load in such a system.
• Assemble pulley systems that use a single and a double pulley (two wheels), two single pulleys, and two double pulleys. (You will need an extra long rope.) Record how many different systems you discover and how much effort is required.
• Get some heavy-duty pulleys and strong rope from a hardware store. Find a place outdoors (tree limb, swing set, etc.) to secure a fixed pulley. Rig up some different pulley systems and lift a heavy load like a bucket of sand or another student. Use work gloves when you haul on the rope.
• Research the other four simple machines (wheel and axle, inclined plane, wedge, and screw) and give a short report to the class.
• A steam shovel is a compound machine made of simple machines—levers and pulleys. Research steam shovels and other machinery, analyze them in terms of simple machines, and write a report. Here are a few examples of compound machines.
  • backhoe  • crane
  • drilling rig  • elevator
  • hoist  • drawbridge
  • exercise equipment
• Use centimeter graph paper to graph the results of your investigations.
  • The number of supporting ropes (x-axis) versus the effort required to lift the load.
  • The number of supporting ropes (x-axis) versus the distance the rope is pulled.
• Assemble a pulley system using two single pulleys that will give a 4:1 advantage in effort reduction. Usually 3:1 is the greatest advantage obtained from two single pulleys. The solution, called a Spanish Barton system, involves two ropes.
• Set up a lever-and-pulley system in which a pulley applies effort to one end of a lever that in turn lifts a load. Compare effort and distance.
• Research the other four simple machines (wheel and axle, inclined plane, wedge, and screw) and give a short report to the class.
• A steam shovel is a compound machine made of simple machines—levers and pulleys. Research steam shovels and other machinery, analyze them in terms of simple machines, and write a report. Here are a few examples of compound machines.
  • backhoe  • crane
  • drilling rig  • elevator
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• Use centimeter graph paper to graph the results of your investigations.
  • The number of supporting ropes (x-axis) versus the effort required to lift the load.
  • The number of supporting ropes (x-axis) versus the distance the rope is pulled.
PROJECT PROPOSAL

1. What is the question or the project that you are proposing?

2. What materials or references will you need to complete the project?

3. What steps will you follow to complete the project?
**PRESENTATION GUIDELINES**

You will have exactly 3 minutes to present your project to the class. In those 3 minutes you should answer these questions.

- What were you trying to find out (your question)?
- What materials or references did you need to do your project?
- What procedure did you follow to complete your project?
- What did you learn from doing your project?

When you begin speaking, you will see the *green card* held up for 2 1/2 minutes. When you see the *yellow card*, you have 30 seconds left. When you see the *red card*, it means you can finish your sentence, but you must stop within the next few seconds.

Practice your presentation so you will be sure it is at least 2 1/2 minutes long, but not more than 3 minutes long. Be sure you have included all of the information asked for above.