

## SECTION 3.6 INTRODUCTION

**3.6 Revise Your Explanation****How Do a Lever and a Pulley Change Force?**◀  $\frac{1}{2}$  class period\***Overview**

Students revise their explanations about levers and pulleys, and machines in general. Students may also include explanations about the wheel and axle. The class discusses their explanations and updates their *Project Board*.

\*A class period is considered to be one 40 to 50 minute class.

Targeted Concepts, Skills, and Nature of Science	Performance Expectations
Scientists often work together and then share their findings. Sharing findings makes new information available and helps scientists refine their ideas and build on others' ideas. When another person's or group's idea is used, credit needs to be given.	Students should share their ideas in small groups and then with the class. As a class, students should come up with explanations about some simple machines.
Scientists must keep clear, accurate, and descriptive records of what they do so they can share their work with others and consider what they did, why they did it, and what they want to do next.	Students should refer back to their old explanations to revise them based on what they now know. Students should keep track of their ideas and explanations on the class's <i>Project Board</i> .
Scientists make claims (conclusions) based on evidence obtained (trends in data) from reliable investigations.	Students should make claims in their explanations.
Explanations are claims supported by evidence, accepted ideas, and facts.	Students should revise and construct explanations based on what they now know about simple machines.
There are six different simple machines all of which provide mechanical advantage: Inclined plane, wedge, screw, wheel and axle, lever, and pulley.	Students should write explanations that contain information about how a lever and a pulley can change a force.

Targeted Concepts, Skills, and Nature of Science	Performance Expectations
<p>There are three different types of levers in which the load, effort, and fulcrum are in different places in relation to each other.</p>	<p>Students should include in their explanations about levers information about the classes of levers.</p>

**Materials**

1 per student	Create Your Explanation page
1 per class	class Project Board

## Homework Options

### Reflection

- Science Content:** List an example for each type of machine: Inclined plane, wedge, screw, lever, pulley, and wheel and axle, and describe the mechanical advantage of it. *(Students should give at least one example of each machine and in the description of the mechanical advantage they should describe if and how the machine changes the applied force and describe the force-distance tradeoff.)*

### Preparation for Back to the Big Question

- Science Process:** Write a brief plan for the challenge—designing a machine to lift the crate up the cliff with one weak rope. *(This prepares students for the next section.)*

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## SECTION 3.6 IMPLEMENTATION

◀  $\frac{1}{2}$  class period**3.6 Revise Your Explanation****How Do a Lever and a Pulley Change Force?****Explain**

Look at the explanations you have created so far as a class. Work with your group to make your explanations better. When you revise an explanation, you should consider any new information you have, especially science information. Other times you will want to add new evidence or even revise the claim. It is important that all the parts of your explanation work together with each other. Make sure when you revise one part that the whole explanation still makes sense.

If you think an additional claim and explanation is needed based on what you have just learned, spend time in your group working on that, too. Use a new *Create Your Explanation* page for each explanation you create.

When you are finished, you'll share your revised explanations with the class and discuss the wording, so make sure it is clear and complete.

**What's the Point?**

From the investigations you did with levers and pulleys, you learned simple machines can do two things. They can either change the direction of the force or multiply the applied force. First-class levers and fixed pulleys both change the direction of the force. Second-class levers and free pulleys do not change the direction of the force. They both multiply the applied force. Third-class levers actually produce a force that is less than the applied force. However, they multiply the distance of the applied force.

One thing you have learned about all simple machines is that there is a tradeoff. A machine can multiply the applied force, but the tradeoff is that you must apply the force over a longer distance. No machine can increase the applied force and decrease the distance at the same time. A machine cannot change the amount of work required to move an object.

You may have seen this in the graphs you made from the data you collected during the investigations. For example, if a machine reduces the amount of force needed to move a weight then the distance must be increased. How much the applied force, or effort, is multiplied is the machine's mechanical advantage.

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**3.6 Implementation****How Do a Lever and a Pulley Change Force?**

20 min.

*Have students revise their explanations. Then have the class discuss them and update their Project Board.*

**META NOTES**

In the last section students have been introduced to new material about levers and the wheel and axle. There has not been much new information about pulleys so it is not expected that students, explanations about pulleys should change very much. Their explanations about levers should be revised to include the three classes of levers and a new explanation about the wheel and axle might be constructed. You may later want students to create a general explanation about simple machines and mechanical advantage.

**△ Guide**

Begin by letting students know that they will be updating their explanations today since they have new information now on levers and pulleys. Let them know that they may be revising their old explanations and/or writing new ones. They should first construct their explanations on their own and then discuss them with their group. Inform students that they will be sharing their explanations with the class and that the class will come up with some class explanations to put on the *Project Board*.

**META NOTES**

The class will come up with a class explanation after reviewing all the explanations.

**META NOTES**

New explanations should include information about the three classes of levers. Some may have separate explanations for each type of lever.

**◇ Get Going**

Distribute *Create Your Explanation* pages and let students know how much time they have.

**□ Assess**

Monitor groups' progress. Check to see if they have the main parts of an explanation: A claim supported in a logical way by evidence and science knowledge.

**△ Guide**

*Have the class construct explanations and update the class's Project Board.*

Ask groups to give their best explanations and record these for the class to see. Consider making lists for explanations on just pulleys and those for levers, etc.

While the groups are giving their explanations encourage class discussion on the structure and content of the explanation. Ask questions like the following:

- Where is the claim?
- What evidence is listed?
- What is the science knowledge?
- Do the science knowledge and evidence support the claim in a logical way?
- Are there any opinions? Is it O.K. to have opinions? Why?

After recording everyone's explanations, lead the class in discussion on what should be written on the *Project Board*. Let the class know that they should come to a consensus (agreement) about what to write down on their *Project Board* and that it should be based on all the groups' explanations.

As the class is coming up with their explanations, edit the class explanations on the board or an overhead before writing it on the class *Project Board*.

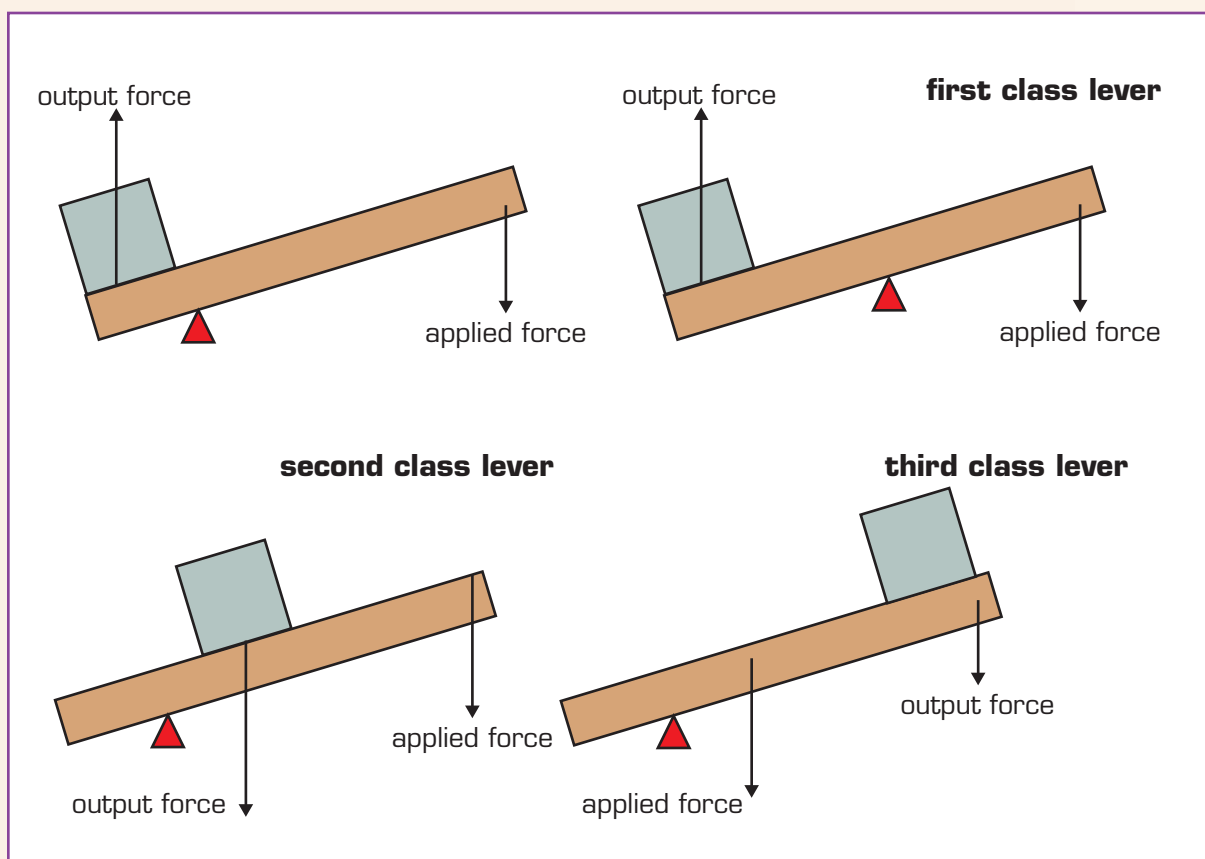
Some examples are provided below. Remember that each class will have a different wording and may combine ideas in different ways:

- A lever can change the amount of force needed to move an object. For a first-class lever, we observed that as the fulcrum moves closer to the load, the amount of force that needs to be applied to the lever to move an object decreases and the distance it must be applied for increases. For a first-class lever, the output force is opposite to the applied force. There are three types of levers that can all change the force needed to move an object. Some are used mainly to increase the force, some to decrease

it, and others focus on changing the distance of the output force. A first-class lever has its fulcrum located between the load (output force) and the effort (applied force). This type of lever was described above. A second-class lever has the load between the effort and the fulcrum. For these levers the applied force is usually increased and the output force is in the same direction as the applied force. For third-class levers the effort, or applied force, is between the fulcrum and the load. These levers usually decrease the applied force and increase the distance over which the output force acts.

**META NOTES**

There has not been sufficient new information for students' explanations to change very much. Students, however, should still refine explanations if needed.

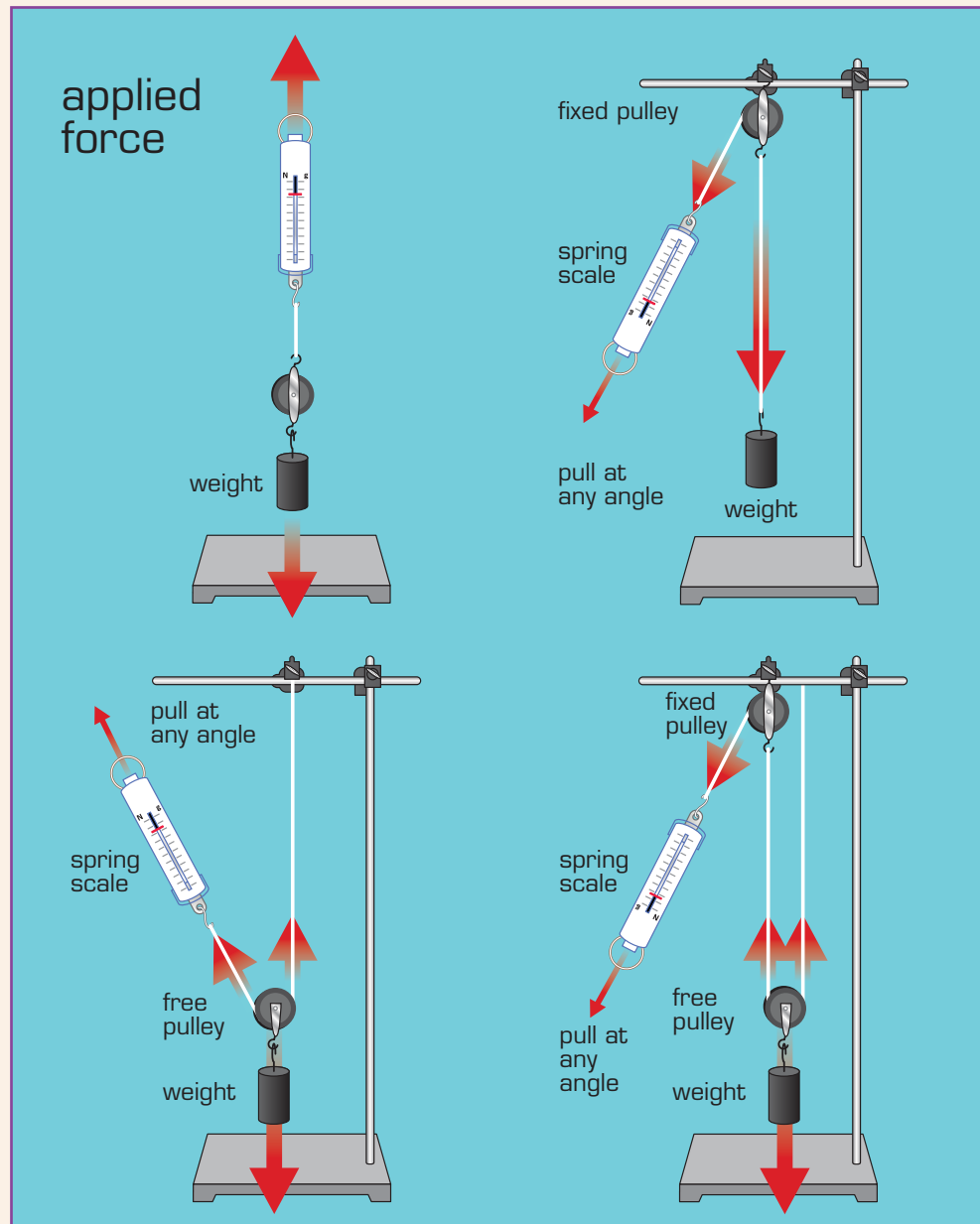


- Pulleys can change the force needed to move an object. A fixed pulley has a mechanical advantage of one. Our measurements show that the fixed pulley requires the same force as that needed to directly lift the 1-kg mass, and you must apply that force through the same distance as that of the direct lift, but it can change the direction of the applied force. A free pulley has a mechanical advantage of two. Our measurements show that the

**META NOTES**

The wheel and axle were introduced but not discussed in depth. Students may or may not provide explanations. If they do, the explanations will not contain much information. You may want to discuss how a wheel and axle is a lever that rotates around a center point or fulcrum. The axle is basically the fulcrum point and the wheel is where you place your effort on the lever.

free pulley requires half the force as that needed to directly lift the 1-kg mass, but you must apply that force through twice the distance of the direct lift. It can also change the direction of the applied force. For a combination of a free and fixed pulley, the mechanical advantage is two. Our measurements show that the combination of a free and fixed pulley requires half the force as that needed to directly lift the 1-kg mass, but you must apply that force through twice the distance of the direct lift. It can also change the direction of the applied force.



- A wheel and axle is another type of machine that can change the force needed to move an object. The mechanical advantage of this machine can be greater than one. When the applied force is increased, the distance over which it must be applied for is greater than the distance over which the load is moved. This is the case, for example, in a car steering wheel, or a spigot (e.g., a faucet handle).



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You may have seen this in the graphs you made from the data you collected during the investigations. For example, if a machine reduces the amount of force needed to move a weight then the distance must be increased. How much the applied force, or effort, is multiplied is the machine's mechanical advantage.

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### What's the Point?

5 min.

*If needed, summarize the idea of mechanical advantage and remind students that they have considered how six different machines can change the force needed to move an object.*

## Teacher Reflection Questions

- What difficulties did students have understanding the three classes of levers? What evidence do you have that students understand the mechanical advantage of machines?
- What evidence do you have that students are comfortable constructing explanations? What ideas do you have for assisting students that have difficulty in constructing explanations?
- If you had students read this section, how did you approach the various reading levels in the class?