SECTION 3.1 INTRODUCTION

◀ *1 class period**

3.1 Understand the Question

Thinking about Other Machines That Can Change Force

Overview

Students review what they learned so far about how machines move heavy things and think about how it can be applied to lifting a heavy crate up a 20-m cliff. Each group comes up with two questions that will help guide their investigations into exploring new machines (the lever, the pulley, and the wheel and axle), and how they might combine machines in order to move the crate up the cliff.

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 discuss in small groups what they think they need to learn and then as a class they discuss what they need to investigate as they fill out the class' *Project Board*.
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 participate in a class discussion updating their *Project Board*, which is an organized record of their ideas and what they are learning.
Machines provide mechanical advantage to assist in moving objects. Mechanical advantage is the tradeoff between force and distance.	Students discuss how machines will be used in the challenge.

Materials

1 per class class *Project Board*

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

Activity Setup and Preparation

The second statement provided on page 67 of the student text implies that the inclined plane would not fit on the beach, but it does. Please refer back to how you decided to deal with the *Back to the Big Question* section of *Learning Set 2* and decide if you want to replace the second bullet in the student text. The second statement was not one of the criteria originally stated in the challenge. If you have not already specified the length of the beach, you could do so now and make it shorter than the length needed by the inclined plane. The initial model of the cliff allows for just the incline to be needed to lift the cart and 1-kg mass. You may want to replace the second bullet with the changes you chose in the *Back to the Big Question* section at the end of *Learning Set 2*, or add an additional criterion.

Homework Options

Reflection

- **Science Content:** Can you think of any machines you've seen outside the classroom that might help the biologists lift the crate? How would they help? Keep in mind that they won't be able to use motorized machines. *(Students might suggest something like a winch, lever, or pulley. They should say whether they think the machines would help by increasing force, by redirecting it, or both.)*
- **Science Process:** Which of the questions the class put on the *Project Board* do you think will most help to design a machine to lift the crate to the top of the cliff? Why? *(Consider revisiting students' answers once they have finished with this* Learning Set*.)*

Preparation for 3.2

- **Science Process:** Describe how you obtained evidence for the way an inclined plane helps lift things. How would you obtain evidence for the way some of the other machines you've thought about lift things? *(Students should describe how they tested the machine by lifting the weight with and without the machine, and by varying how they used the machine. They can use a similar approach with other machines.)*

SECTION 3.1 IMPLEMENTATION

◀ *1 class period**

3.1 Understand the Question

Thinking about Other Machines That Can Change Force

The question for this *Learning Set* is *What other machines can change force?*. You know that an inclined plane, a wedge, and a screw reduce the force required to move an object. However, the trade-off is that you must apply this force over a longer distance. Other simple machines, such as the wedge, also change the direction of the force.

How can this information be used to help you design a machine that can lift a heavy crate up 20 m (65 ft) to the top of a cliff? What have you learned so far that can be helpful? Are there other machines such as the lever, pulley, and wheel and axle that may be possibilities?

Get Started

Below are some students' ideas about how to apply what they have learned so far to the problem. Read and think about each student's idea.

Michelle: "We know, for sure, that we must generate an unbalanced force that is strong enough to overcome the force of gravity."

Aiden: "An inclined plane seems like the most practical machine so far, but the distance is too far."

Jack: "I don't think we should try to change the direction of the force. I think we need something to reduce the amount of force needed."

Julie: "None of the machines we have learned about so far seem ideal. There has to be something else. Maybe, there are machines we can combine."

Conference

In your group, discuss whether you agree or disagree with each student? What might you say to each student? What might you investigate to determine if a student's idea is correct? After your conference, you will discuss your answers to these questions with your class.

3.1 Understand the Challenge

Thinking about Other Machines That Can Change Force

Review what students found out about inclined planes and mechanical advantage.

△ Guide

Review the major points of the class explanation of how inclined planes work. Emphasize the tradeoff (mechanical advantage) that students found between force and distance.

TEACHER TALK

"What evidence did you collect about inclined planes and what did you conclude from it?

How can this information be used to design a machine to lift a heavy crate up 20 m? How might the other machines help lift the crate up the cliff?"

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

Get Started

5 min.

Go over the model dialogue and help students understand the major points.

META NOTES

Students will discuss the four statements in small groups after the class pulls out the main ideas. They will then use the main ideas of each of the statements to develop questions to investigate for the class's *Project Board*.

META NOTES

The second statement was not one of the criteria originally stated in the challenge. If you have not already specified the length of the beach, you could do so now and make it shorter than the length needed by the inclined plane. The initial model of the cliff allows for just the incline to be needed to lift the cart and 1-kg mass. At the end of *Learning Set 2* in *Back to the Big Question,* ideas were provided on how you could alter the criteria of the challenge. You may want to replace the second bullet with the changes you chose, or add an additional criterion.

and wheel a… …e that may be possibilities?

Get Started

Below are some students' ideas about how to apply what they have learned so far to the problem. Read and think about each student's idea.

Michelle: "We know, for sure, that we must generate an unbalanced force that is strong enough to overcome the force of gravity."

Aiden: "An inclined plane seems like the most practical machine so far, but the distance is too far."

Jack: "I don't think we should try to change the direction of the force. I think we need something to reduce the amount of force needed."

Julie: "None of the machines we have learned about so far seem ideal. There has to be something else. Maybe, there are machines we can combine."

…fore…

△ Guide

Read the model dialogue given in the student text and discuss the pulled ideas within the dialogue with the class.

TEACHER TALK

"There are four different views given below. Let's read them one by one and pick out the main idea of each."

Below are the ideas students should obtain from this dialogue:

- We need an unbalanced force to lift it.
- The inclined plane would help, but perhaps the beach does not extend far enough to support it. (*See meta note.*)
- The machine should increase force, not redirect it.
- Maybe we can combine machines.

Jack: "I… …e should try to change t… …n of the force. I think we need something to reduce the amount of force needed."

Julie: "None of the machines we have learned about so far seem ideal. There has to be something else. Maybe, there are machines we can combine."

Conference

In your group, discuss whether you agree or disagree with each student? What might you say to each student? What might you investigate to determine if a student's idea is correct? After your conference, you will discuss your answers to these questions with your class.

△ Guide

Have students briefly discuss these ideas with their groups and then, individually, come up with two questions that will help them learn about how machines move things. Remind them to use the bulleted points on page 68 as guides as they think about their questions. The groups should choose the two most interesting questions that group members came up with and hand the rest in to you.

TEACHER TALK

"Now that we've discussed briefly the main ideas in each of the four statements, it is time that you discuss them in more depth with your group members. Then each group member should develop two questions to investigate using the guidelines on page 68. Finally, your group should pick out the two most interesting questions that the group agrees upon."

Conference

5 min.

Have students meet with their groups and come up with questions to investigate.

META NOTES

By collecting all the questions you can obtain a better understanding of what each student is thinking and what they wish to investigate. Let students know that you will be collecting these questions. As you go through the *Learning Set*, you might point out if any of the questions were answered.

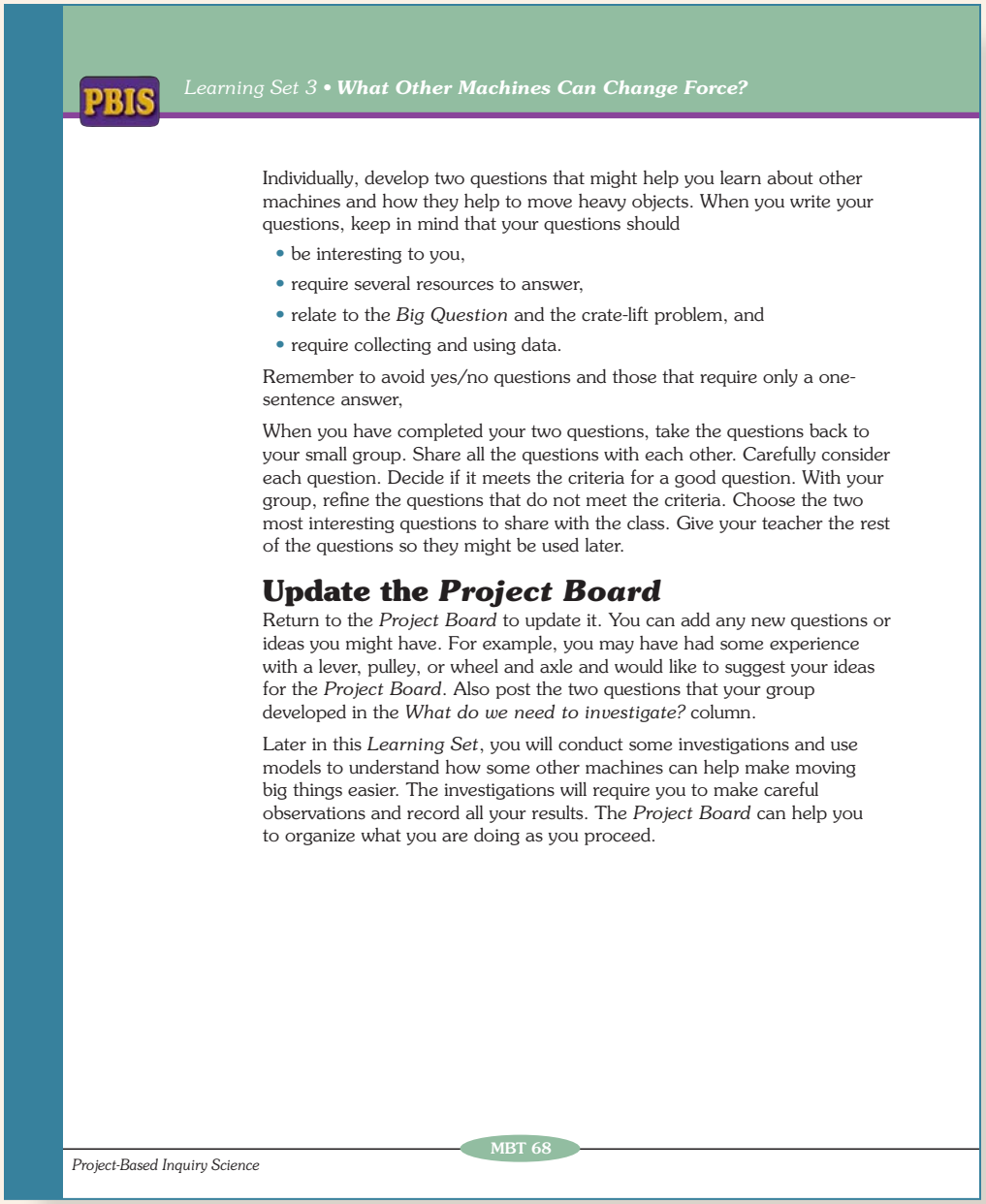
Update the *Project Board*

10 min.

Discuss groups' questions with the class and update the Project Board.

META NOTES

Faced with the challenge of designing a machine to lift a block with a single strand of cotton thread, students need to understand how machines work. They need to understand how machines provide an advantage so that they can apply this knowledge in their own machine design. Their questions should focus on learning about the machines they have not yet investigated—in particular the lever, the pulley, and the wheel and axle. Students will investigate and read more about these machines in the upcoming sections of this *Learning Set*. *Learning Set* 4 focuses on combining simple machines.



PBIS *Learning Set 3 • **What Other Machines Can Change Force?***

Individually, develop two questions that might help you learn about other machines and how they help to move heavy objects. When you write your questions, keep in mind that your questions should

- be interesting to you,
- require several resources to answer,
- relate to the *Big Question* and the crate-lift problem, and
- require collecting and using data.

Remember to avoid yes/no questions and those that require only a one-sentence answer,

When you have completed your two questions, take the questions back to your small group. Share all the questions with each other. Carefully consider each question. Decide if it meets the criteria for a good question. With your group, refine the questions that do not meet the criteria. Choose the two most interesting questions to share with the class. Give your teacher the rest of the questions so they might be used later.

Update the *Project Board*

Return to the *Project Board* to update it. You can add any new questions or ideas you might have. For example, you may have had some experience with a lever, pulley, or wheel and axle and would like to suggest your ideas for the *Project Board*. Also post the two questions that your group developed in the *What do we need to investigate?* column.

Later in this *Learning Set*, you will conduct some investigations and use models to understand how some other machines can help make moving big things easier. The investigations will require you to make careful observations and record all your results. The *Project Board* can help you to organize what you are doing as you proceed.

MBT 68

Project-Based Inquiry Science

△ Guide

When groups have chosen their two questions, lead a class discussion of what the class has learned and what they need to find out. Update the *Project Board* as students suggest new ideas and questions.

Next, ask groups what their two questions are, and post these questions in the *What do we need to investigate?* column.

◇ Evaluate

Make sure that each group's two questions are on the board and that all questions pertain to the simple machines not yet investigated (the pulley, the lever, the wheel and axle) or combining simple machines.

META NOTES

These questions are not expected to be very in depth. It is expected that students will have in depth questions about combining machines after the investigations.

Assessment Options

Targeted Concepts, Skills, and Nature of Science	How do I know if students got it?
Machines provide mechanical advantage to assist in moving objects. Mechanical advantage is the tradeoff between force and distance.	**ASK:** What is mechanical advantage and how can it help with solving the challenge? **LISTEN:** Students should describe mechanical advantage as a tradeoff between force and distance. They should specify that machines can help reduce the force needed to move an object but it would require moving it over a greater distance. They should connect this to the constraint that the biologists need to move the crate up the cliff with one weak strand of rope that will break if they try to lift it up directly.

Teacher Reflection Questions

- What issues did groups' questions address? How difficult do you think it will be for students to answer their questions?
- How did you help students identify things they need to learn more about? How can you help students learn to actively identify things they need to investigate?
- How did you keep students engaged in discussing the ideas in this section and coming up with questions?