BACK TO THE BIG QUESTION INTRODUCTION

Back to the Big Question

◀ *1 class period**

How Do Machines Help Move Large, Heavy Objects

Overview

Student groups use what they have learned about mechanical advantage and inclined planes to design a plan using an inclined plane that could lift the crate up 20 cm. After discussing their plans with the class and incorporating any new ideas, they build and test their designs, comparing the amount of force necessary to lift the "crate" (1-kg mass and cart) up 20 cm using the inclined plane to the amount of force necessary to lift it straight up to the top. Finally, they share their final designs and their results with the class in *Solution Briefings*, discuss what they have learned and what it means for the *Big Question*, and update the *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 engage with their classmates ideas, actively ask questions during *Solution Briefings*, and use ideas from *Plan Briefings* in their plans.
Criteria and constraints are important in design.	Students' design plan should meet all the criteria and constraints.
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 use the information they have recorded before to help them design their plans and must carefully describe their plan for this iteration.
Scientists use models to simulate processes that happen too fast, too slow, on a scale that cannot be observed directly (either too small or too large), or that are too dangerous.	Students use a model of the crate and cliff to run a simulation to see how the biologists can get the crate up the cliff.

Targeted Concepts, Skills, and Nature of Science	Performance Expectations
Machines provide mechanical advantage to assist in moving objects. Mechanical advantage is the tradeoff between force and distance.	Students apply their knowledge of inclined planes and mechanical advantage as they design a plan for moving the crate up the cliff.
There are six different simple machines all of which provide mechanical advantage: Inclined plane, wedge, screw, wheel and axle, lever, and pulley.	Students use inclined planes to design a plan for moving the crate up the cliff.

Materials

1 per group	1-kg hooked mass
several per group	20 cm length of thread
1 per group	model cliff
1 per group	metric ruler
1 per group	Beach and Cliff Area BLM
1 per class	class *Project Board*

Activity Setup and Preparation

It is possible to move the cart and 1-kg mass up the incline with one thread using the inclined planes that are part of the kit. Students should not know this until the end of the activity. This information may make them less enthusiastic about doing the other sections that pertain to the challenge. Consider revising this section by choosing one of the following:

- Skip the build and test parts of this section and only have students plan their design. For this situation, some students might consider building a winding ramp. Later, when groups build their design, you could allow them to construct such a ramp, or you could emphasize that their model is constrained by the equipment you supply.
- Change the criteria so that students are required to use more than one machine.
- Update the criteria so that the beach in front of the cliff requires the incline to be very steep so that students have to use another machine. This may require you to change the model.

Homework Options

Reflection

- **Science Content:** : How can you compare the amount of work you did when you used an inclined plane to lift the weight up the box to the amount of work you did when you lifted the weight straight up the box? *(The amount of work done when you use a machine to lift something is the same as the amount of work done without the machine. So students did the same amount of work using the inclined plane as they did lifting the weight straight up.)*
- **Science Process:** What variables did you control when you tested your inclined plane against a straight lift? *(Students should have lifted the load to the same height and they should have made sure the load was the same weight.)*

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BACK TO THE BIG QUESTION IMPLEMENTATION

Back to the Big Question

How do machines help move large, heavy objects?

10 min.

Ask students to apply what they've learned to the Big Question.

PBIS

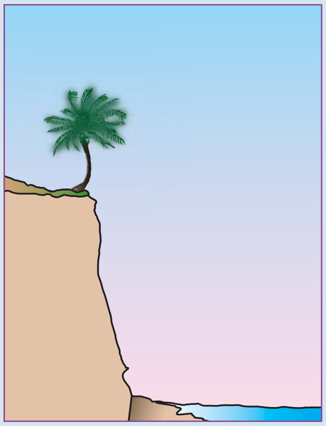
Learning Set 2

Back to the Big Question

How do machines help move large, heavy objects?

You've raised questions about how machines work and learned about different types of machines. You then did investigations to find out how a machine affects force. You created and revised explanations summarizing the effects of a machine on force. However, your challenge for this Unit is to help the biologists, Drs. Enrique, Susan, and Tanika, lift a large crate to the top of a cliff. Remember, you are trying to answer the question *How do machines help move large, heavy objects?*

Plan Your Design



Get a drawing of the beach and cliff area from your teacher. Meet with your group and decide how Drs. Enrique, Susan, and Tanika might be able to use an inclined plane to help solve their problem. You will sketch where and how an inclined plane might be used on the drawing.

Also, think of ways in which you might use an inclined plane in your model of the cliff. Think about how you could attach and use the inclined plane to the box that represents the cliff.

Describe how the force and distance trade-off would apply to this problem. Try to estimate (make an educated guess) how much their applied force could be reduced by using this machine. For example, would the applied force be reduced by one-half or one-quarter? Be sure to explain your estimate using the information you learned during this *Learning Set*.

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Project-Based Inquiry Science

△ Guide

Remind students what the challenge of the Unit is, and ask them how they think they can use what they've learned to meet the challenge. Review the criteria and constraints. Let students know what you decided upon for this activity: adding criteria; only planning and not testing and building (see the *Activity Setup and Preparation* segment for details.)

TEACHER TALK

"Remember the challenge is to find a way to use machines to make it possible for the biologists to lift a crate to the top of the 20 m cliff using a single, fragile rope. What other criteria and constraints did we have? What have we learned about how machines make moving things easier that you can apply to the challenge?"

Record students' responses on the board and allow the class to briefly discuss them.

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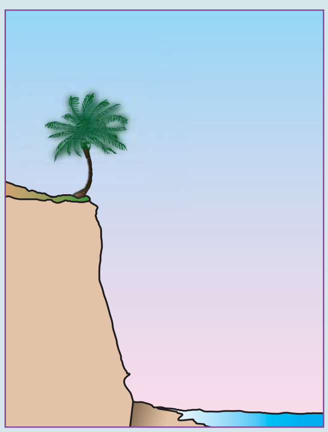
Plan Your Design



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Plan Your Design

10 min.

Have groups plan their design.

△ Guide

Let students know that they will now design a model for the challenge using an inclined plane that will help lift the crate up the cliff. The first step will be to sketch the inclined plane on a drawing of the cliff. Emphasize that they need to keep in mind how the inclined plane will be attached to the cliff, and they will need to think about how the force and distance tradeoff will affect their plans. Students should try to estimate how much their applied force could be reduced by using the inclined plane. Show students the materials.

TEACHER TALK

"You are going to use one of these drawings to sketch where and how the inclined plane can help solve the problem of moving the crate up the cliff. You'll want to think about how the inclined plane is attached to the cliff, and how the force and distance tradeoff affects your plans. You should record on the drawing your reasoning."

META NOTES

If you are having students build and design their plan, you may have them present their plan during this *Plan Your Design* segment of the section.

⬡ Get Going

Distribute the drawings of the cliff to groups and give them a time frame to draw their plans.

△ Guide and Assess

As groups work on their plans, walk around the class and ask groups what ideas they've discussed and how their data and explanations have helped them to make a choice. They should be looking for ways to make the least-steep incline they can within the space available. Make sure they remember to think about how to attach it to the cliff.

If different groups are developing very different ideas or if any groups are stuck, consider having groups present their plans using *Plan Briefings*.

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Communicate Your Idea

Plan Briefing

While you are coming up with a solution for the biologists, your teacher might have you present your idea-in-progress to the class in a short *Plan Briefing*. At this stage in the process, it is important for the briefing to move quickly and have focus. Be prepared to present your idea and rationale for using an inclined plane. Show your sketch to the rest of the class. Explain to the class how this machine might be helpful and how it helps you answer the *Big Question*.

Communicate Your Idea: *Plan Briefing*

15 min.

Have students present their ideas using Plan Briefings.

META NOTES

If you are having students build and design their plan, you may have them present their plan during this *Plan Briefing* segment of the section.

△ Guide

Have groups quickly present their sketches and explain how their machine would work and how it helps answer the *Big Question*.

Then, encourage students to consider some of the ideas they saw presented. Can they use any of the ideas, or did any of the ideas that were presented give them other ideas?

Build Your Design

10 min.

Have students present their ideas using Plan Briefings.

META NOTES

Skip this segment if students are only planning the design.

Your group's experience may provide valuable lessons for others. If you are having trouble thinking of ideas and a solution, a *Plan Briefing* will give you a chance to get help.

Build Your Design

You have planned your design and seen the plans of others. Now it is time for you to construct the solution you have planned to test your current ideas. You will be using the same model as in *Learning Set 1*. Your materials will include the weight and the threads. Remember how many threads were needed to pull the weight up the cliff. Build your machine and see how many threads you need to lift the weights. When you are finished with your building, you will share your solution with the class.

△ Guide

Let students know they will now build and test their plans. They will then compare the number of strings required to lift the weight with their design to the number of strings required for a straight lift. They should also use a spring scale or force probe to measure the amount of force required to lift the weight on the inclined plane and compare this with the force required for the straight lift. They should record their observations to use in their *Solution Briefings.*

⬡ Get Going

Distribute the materials students will be using, give groups a time frame, and have them get started.

△ Guide

As groups are working on building their designs, walk around the room and ask groups what issues have come up. You might also ask how they are controlling variables, how they have used the information from their previous investigations, and if they are comparing the result to the result of the straight lift with the cart attached.

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Communicate: Solution Briefing

15 min.

Have groups present their designs using Solution Briefings *and guide a class discussion of the designs.*

META NOTES

Skip this segment if students are only planning the design.

Back to the Big Challenge

Communicate

Solution Briefing

You have built your design and tested it. You had some ideas about how to use an inclined plane in your machine. But you may have found that your plan did not work out just the way you thought it would. By sharing your results with the class, everyone will be able to learn from your experiences.

As you prepare for your presentation, identify the two most important ideas you learned from building your design. Be prepared to describe the advantages and disadvantages of your design. In what situations might your design work well and in what situations might you have difficulty making your design work?

As you listen to other groups' ideas, identify what you are learning about mechanical advantage and its tradeoffs. What are you learning that will allow you to design a better solution to the challenge next time you have a chance?

Update the *Project Board*

The *What are we learning?* column on the *Project Board* helps you pull together everything you have learned. Remember to always include your evidence. You can then use what you have learned to answer the *Big Question* or address the challenge. Each investigation you do is like a piece of a puzzle. You must fit the pieces together to help you address the challenge.

Your *Big Question* was *How do machines help move large, heavy objects?* The last column, *What does it mean for the challenge or question?* is the place to write down how mechanical advantage, force-distance tradeoff, and the benefits of an inclined plane can help you answer the *Big Question*.

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△ Guide

Once groups have finished building their designs, have them prepare *Solution Briefings* to present their designs and results to the class. To start, they should identify the two most important things they learned from building their designs. Remind students that *Solution Briefings* should describe how they arrived at their designs. They should be ready to discuss the advantages and disadvantages of their designs.

TEACHER TALK

"When you present your solution, make sure your group discusses the two most important things you learned from building your design. Discuss the changes you made to your initial ideas, describe them, and describe why you made those changes. You'll also want to discuss the advantages and disadvantages of your final design."

After groups have finished preparing their presentations, begin the class presentations. Remind the class that as each group is presenting their solution, the audience should ask questions to clarify what the group did and why. Also, remind students to think about what they are learning from the presentations about mechanical advantage and its tradeoffs.

TEACHER TALK

"Do you have a clear picture of what changes they made to their original plan, and why they made those changes? What isn't clear? Do we know how their final design worked?"

Then, ask students to summarize the class presentations and ask them what is common about their findings.

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Update the Project Board

5 min.

Lead a discussion of what the class has learned and what it means for the challenge and update the Project Board.

△ Guide

Transition from the last segment by reminding students that their solutions are the beginning answers to the *Big Question: How do machines help move large, heavy objects?* Then ask them if there is anything they wish to update on their class *Project Board* in the *What are we learning?*, *What is our evidence?*, and What does it mean for the challenge or question? columns of the *Project Board.*

◇ Evaluate

Be sure that students have listed information about how mechanical advantage, force-distance tradeoff, and the benefits of an inclined plane can help you answer the *Big Question*.

Teacher Reflection Questions

- What concepts from *Learning Set 1* did students use when they explained their designs in the *Solution Briefings?* What evidence do you have that they are synthesizing all of the information they have been learning?
- What kinds of questions were students asking during *Solutions Briefings?* What can you do to get students actively thinking about what *Solutions Briefings* should be telling them?
- What issues came up in the discussion of the *Solution Briefings?* How can you keep students engaged in answering the *Big Question?*

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