BACK TO THE BIG QUESTION IMPLEMENTATION

Learning Set 3

Back to the Big Question

How do machines help move large, heavy objects?

You have learned about levers and pulleys. You did investigations to find out how they affect the force required to move a weight. You created and revised explanations summarizing the effects of these machines 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 a lever or pulleys to help solve their problem. You will sketch where and how these machines might be used on the drawing.

Also, think of ways in which you might use a lever or pulleys in your model of the cliff. Think about how you could attach them and use them with 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 each 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*.

◀ *1 class period*

Back to the Big Question

How do machines help move large, heavy objects?

5 min.

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

△ Guide

Remind students what the challenge of the Unit is, and ask them how they think they can use what they've learned about levers and pulleys 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-meter cliff using a single, fragile rope. What other criteria and constraints did we have? What have we learned about levers and pulleys that make moving things easier that you could apply to the challenge?"

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

Plan Your Design

10 min.

Have groups plan their design.

Tanika, [illegible] crate to the top of a [illegible]ember, you are [illegible] answer the question *How do machines help move large, heavy objects?*

Plan Your Design

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Also, think of ways in which you might use a lever or pulleys in your model of the cliff. Think about how you could attach them and use them with 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 each 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*.

△ Guide

Let students know that they will now construct a drawing to depict their design plan for the challenge using one or more pulleys and/or a lever. The first step will be to sketch the pulley(s) and/or lever on a drawing of the cliff. Emphasize that they need to keep in mind how the pulley(s) and/or lever 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 pulley(s) and/or lever. Then show students the materials.

TEACHER TALK

"You are going to use one of these drawings to sketch where and how one or more pulleys and/or a lever can help solve the problem of moving the crate up the cliff. You'll want to think about how the pulley(s) and/or lever are attached to the cliff, and how the force and distance tradeoff affects your plans. You should record your reasoning on the drawing."

⬡ 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 decrease the force needed by incorporating free pulleys and/or choosing a lever that will help them achieve their goal (probably by reducing the force, but some may try to increase the distance the force is applied through). 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 them present their plans 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 Your Design* segment of the section.

NOTES

Communicate Your Idea: *Plan Briefing*

15 min.

Have students present their ideas using Plan Briefings.

META NOTES

On page 94, the student text incorrectly asks students for information about using an inclined plane. The "inclined plane" should be replaced by "pulley(s) and/or lever."

Communicate Your Ideas

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 more focus. If your teacher calls for a *Plan Briefing*, 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 these machines might be helpful and how they help you answer the big question. 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 before. Your materials will include the weight and the threads. Remember how many threads were needed to pull the weight up the cliff. Build your new machine and see how many threads you need to lift the weight using a lever, pulley, or wheel and axle. When you are finished building, you will share your solution with the class.

△ 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 groups build and test their designs.

△ 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 and cart 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 and cart using the pulley(s) and/or lever 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.

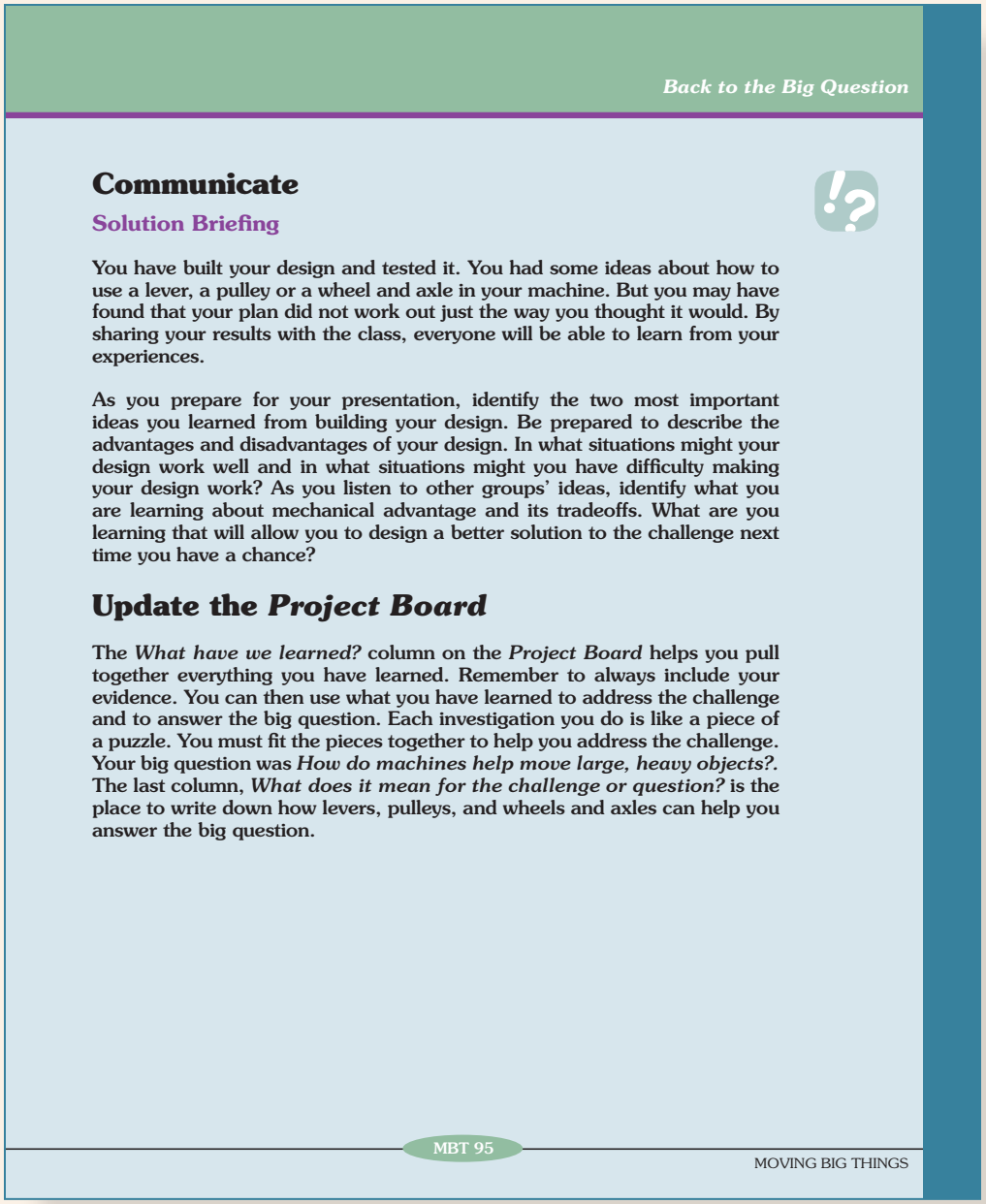
△ Guide

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.

Communicate: *Solution Briefing*

15 min.

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



Back to the Big Question

Communicate

Solution Briefing

You have built your design and tested it. You had some ideas about how to use a lever, a pulley or a wheel and axle 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 have we learned?* 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 address the challenge and to answer the big question. 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 levers, pulleys, and wheels and axles can help you answer the big question.

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MOVING BIG THINGS

△ 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

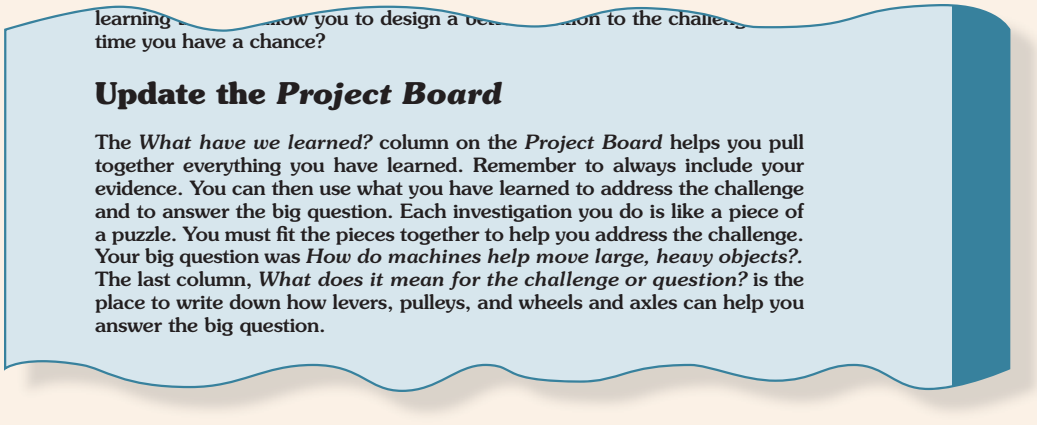
"When you present your solution, make sure your group discusses the two most important things you learned from building your design. Discuss the changes you made to your initial ideas, describe them, and describe why you made those changes. You'll also want to discuss the advantages and disadvantages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

column 5. However, there should also be some questions or ideas raised about combining machines.

◇ Evaluate

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

Teacher Reflection Questions

- What concepts from *Learning Sets 1, 2 and 3*, 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 *Solution Briefings?* What can you do to get students actively thinking about what *Solution 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?*

NOTES