Energy Transfer
Lesson 2a: High-Speed Energy

Grade 4	**Length of lesson:** 50 minutes	**Placement of lesson in unit:** 2a of 6 two-part lessons on energy transfer
Unit central question: How does the energy of an object move and change?		**Lesson focus question:** What causes a moving object to have more or less motion energy?
Main learning goal: When an object moves faster, it has more energy.		
Science content storyline: Energy is all around us, and we can detect it with our senses. Objects in motion have energy. A marble rolls faster down a higher ramp than a lower ramp of the same length. When a faster-moving marble rolls down a higher ramp and collides with an object at the bottom, it will push that object farther than it would if it rolled down a lower ramp at a slower speed. Therefore, the faster-moving marble has more energy.		
Ideal student response to the focus question: When an object goes fast, it has more energy than when it's moving more slowly. An object will go faster down a higher ramp than a lower ramp of the same length.		

Preparation

Materials Needed

- Science notebooks
- Chart paper and markers
- *For each group of 4 students:*
  - 1 ruler (with a groove down the middle)
  - 1 marble
  - Blocks of wood (or notepads) approximately 1/2 inch high (to elevate the ramps)
  - Small block of Styrofoam (see Ahead of Time section)
  - 2 sheets of plain white paper
  - Tape

Student Handouts and Teacher Masters

- 2.1 Ramps, Speed, and Energy (1 per student)
- 2.2 High-Speed Energy Procedure (Teacher Master) (1 for display)

Ahead of Time

- Review the Energy and Energy Transfer Content Background Document: sections 1–4.
- Assemble materials for each group of 4 students (see Materials Needed).
- Prepare handout 2.2 (High-Speed Energy Procedure) for display on a document reader or projector during the main activity.
- Run through the investigation a day or two before the lesson to make sure glitches are worked out.
- Carve out a groove in the block of Styrofoam (see photo below) so the marble will nest in the groove when it rolls off the ramp. The marble should push the Styrofoam across the table until both come to a stop. Making the groove in the Styrofoam will produce more consistent results. **Note:** You can use an inexpensive Styrofoam cooler to cut out a block of Styrofoam.

Lesson 2a General Outline

Time	Phase of Lesson	How the Science Content Storyline Develops
3 min	**Link to previous lesson**: Students share how they detected energy in the previous lesson and at home.	• Energy is all around us, and we can detect it with our senses.
5 min	**Lesson focus question:** The teacher introduces the focus question, *What causes a moving object to have more or less motion energy?*	• Energy is all around us, and we can detect it with our senses. Seeing motion is one way to detect energy.
10 min	**Setup for activity:** The teacher introduces the lesson activity and elicits student ideas and predictions about ramp height and marble speed. Students work in small groups to construct two ramps of varying heights that will cause two marbles to move at different speeds.	• A marble moves faster down a higher ramp.
20 min	**Activity:** Students roll a marble down ramps of differing heights to produce variable speeds. Then they record data related to marble speed, the distance a Styrofoam block moved when the marble collided with it, and the height of the ramp.	• A marble will roll down a higher ramp faster than it will roll down a lower ramp of the same length. When the faster-moving marble rolls down the higher ramp and collides with an object at the bottom, it will push that object farther than it would if it rolled down the lower ramp at a slower speed.
5 min	**Follow-up to activity:** Students resume their role as energy detectives from the previous lesson and discuss how they detected energy in today's investigation.	• Energy is all around us, and we can detect it with our senses. Objects in motion have energy.
6 min	**Synthesize/summarize today's lesson:** Students write a preliminary answer to the focus question.	
1 min	**Link to next lesson:** The teacher announces that next time, students will analyze their data to determine which marble had more motion energy.	

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
3 min	**Link to Previous Lesson** **Synopsis:** Students share how they detected energy in the previous lesson and at home. **Main science idea(s):** • Energy is all around us, and we can detect it with our senses.	Make explicit links between science ideas and activities.	**Show slide 1.** **ELL support:** Definitions of the word *high* (in high-speed energy) vary based on context. ELL students might benefit from a review of the meaning in this lesson series. In our last lesson, you detected energy in several different objects using your senses. Can someone tell me one way you detected energy? What senses did you use? **ELL support:** ELL students will be better equipped to participate in this review if they first engage in a Think-Pair-Share with same-language partners. **Show slide 2.** I also asked you to be energy detectives at home and use your senses to detect energy in at least three different objects. What three objects did you find at home that have energy? How do you know each object has energy? What's your evidence? **NOTE TO TEACHER:** *Call on student volunteers to share one way they detected energy at home. Ask questions*	I saw something moving. I saw light. I felt heat. I heard sound. My hair dryer has energy because I felt heat when I dried my hair.	Where did you see motion? Where did you see light? Where did you feel heat? Where did you hear sound?

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			to make sure students connect their experiences to their understanding of energy.	Lamps have energy. I know because I saw light when I turned on a lamp in my bedroom. Our TV has energy because I heard sound and saw light when I turned it on. My smartphone has energy because it lights up and makes sounds. It also vibrates when I get text messages, and I can feel it heat up. We have a computer at home, and I know it has energy because it makes sounds and gives off light and heat.	
5 min	**Lesson Focus Question** **Synopsis:** The teacher introduces the focus question, *What causes a moving object to have more or less motion energy?* **Main science idea(s):** • Energy is all around us, and we can detect it with our senses. Seeing motion is one way to detect energy.	Set the purpose with a focus question or goal	**Show slide 3.** One of the ways we can detect energy is by observing an object in motion. That's what we'll focus on today as we explore the idea of *motion energy*. **ELL support:** You may want to write this idea (motion energy) on the board so that ELL students can easily refer to it throughout the lesson. Our focus question is *What causes a moving object to have more or less motion energy?*		

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		statement.	Write this question in your notebooks and draw a box around it. **NOTE TO TEACHER:** *Write the focus question on the board for students to refer to throughout the lesson.* We began thinking about this question at the end of our last lesson when you gave some rubber balls energy. Afterward, I asked which ball had the *most* energy, and you came up with some great ideas. Today we'll investigate the *amount* of energy objects have and gather evidence to answer our focus question.		
10 min	**Setup for Activity** **Synopsis:** The teacher introduces the lesson activity and elicits student ideas and predictions about ramp height and marble speed. Students work in small groups to construct two ramps of varying heights that will cause two marbles to move at different speeds. **Main science idea(s):** • A marble moves faster down a higher ramp.	Make explicit links between science ideas and activity **before** the activity.	**NOTE TO TEACHER:** *Ask student volunteers to help you with the first class demonstration. For this practice demo, use two rulers with grooves for the ramps of differing heights, two marbles, and blocks of wood or notepads to elevate the ramps.* **ELL support:** ELL students will better understand the demonstration if the relationships between steepness, speed, and energy are explained ahead of time. For today's investigation, we'll use a marble as our moving object, a ruler as a ramp, and wood blocks [*or notepads*] to elevate the ramp. **Show slide 4.**		

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		Select content representations and models matched to the learning goal and engage students in their use. Ask questions to probe student ideas and predictions.	In a moment, we'll do a practice run so you can see how it all works. For this demonstration, we'll use two marbles, two rulers as ramps, and blocks of wood [*or notepads*] to elevate the ramps at different heights. But first, I'll divide the class into groups of four. Then you'll talk with your teammates about how you would set up one ramp to make a marble roll slow and one ramp to make a marble roll fast. You'll have 1 minute to come up with a plan for setting up your ramps. **NOTE TO TEACHER:** *Divide the class into groups of four students and allow students 1 minute to discuss how to set up the ramps. Circulate among the groups, asking probe questions to find out what students are thinking. Groups should quickly conclude that a lower ramp will make the marble move slower, higher ramp will make the marble move faster.* **Small-group discussion (1 min).** OK, I need one volunteer to come up and build a ramp that will make the marble roll slow. I'll also need a volunteer to catch the marble when it rolls down the ramp. Everyone should pay close attention to what happens when the marble rolls down the ramp. **NOTE TO TEACHER:** *Choose one*		*Questions to ask as small groups work out their ramp plans:* • What do you already know that can help you predict which kind of ramp will make the marble move faster? • How do you know that a higher ramp will make the marble move faster? • How do you know that a lower ramp will make the marble move slower?

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			volunteer to set up this ramp and another volunteer to be the marble catcher. Then ask the marble catcher to get into position and have the ramp-setup volunteer roll the marble down the ramp. After the demonstration, have both students remain with their ramp. **Setup and demonstration of Ramp 1.** Now I need another volunteer to come up and build a ramp that will make the marble move faster than the first marble. I'll also need a volunteer to catch the marble when it rolls down the ramp. **NOTE TO TEACHER:** *Have the new ramp-setup volunteer use a different ruler to construct a second ramp that will make the second marble go faster. Also choose another volunteer to be the marble catcher. After the new ramp has been built, have the marble catcher get into position and the ramp-setup volunteer roll the marble down the ramp.* **Setup and demonstration of Ramp 2.** **NOTE TO TEACHER:** *After the second ramp demonstration, have both ramp-setup volunteers roll their marbles down their ramps at the same time so students can compare how fast the marbles move down the different ramps. Then engage students in a class discussion.*		

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			Demonstration and comparison of both ramps. **Show slide 5.** **Whole-class discussion:** So what did you observe when the marbles rolled down the different ramps in our practice run? Who can describe the speed of the marbles? Who can describe the ramps these marbles rolled down? How would you compare the two ramps and the speed of the two marbles? When you answer, use the sentence starters on the slide.	The marble moved faster down the ramp that was higher. One ramp was higher than the other. The marble on Ramp 2 was faster because that ramp was steeper. The marble on Ramp 1 was slower because that ramp was less steep.	How do you know that the higher ramp makes the marble move faster? What's your evidence? The marble moved faster than what? How do you know that the lower ramp makes the marble move slower?

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		Make explicit links between science ideas and activities. Summarize key science ideas. Ask questions to elicit student ideas and predictions. Ask questions to probe student ideas and predictions.	**Show slide 6.** Now let's think about energy for a moment. What did you learn in our last lesson about motion and energy from the objects in the bag? Think about what you learned and then complete this sentence in your science notebooks and draw a box around it: *If an object is moving, it has* _____. **Individual work time.** **Whole-class share-out:** So how did you complete this sentence? **Show slide 7.** So we know that a moving object has energy, but about the *amount* of energy in an object? Which marble do you think has the most energy—the faster marble or the slower marble? **Small-group discussion:** Discuss this question in your small groups and predict which marble has the most energy. Make sure to include your reasons. **NOTE TO TEACHER:** *Most students will intuitively think that the faster marble has the most energy. Probe their ideas when they share their predictions*	If an object moves, it has energy.	What's your evidence?

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			and ask how they know that a faster marble has more energy. Students may reply, "I just know!" or "I saw it." They may struggle to supply actual evidence. Although this question will be more difficult for students to answer, it's important that they support their ideas with scientific evidence, not just evidence from using their senses. **Whole-class share-out:** What did you predict about which marble has the most energy? Do you think the faster or the slower marble has more energy? Why? What evidence do you have that one marble has more energy than the other? So your senses helped you determine that the faster marble has more energy. But how might we gather evidence to support this idea the way a scientist would? For example, how could we measure or compare the speed of the marbles so we can know for sure which is faster?	I predicted that the faster marble has the most energy. I saw one marble move faster than the other.	Why do you think so? How do you know the faster marble has more energy? Do you think the speed of an object counts as evidence that it has more energy?

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			That's what we'll investigate next.		
20 min	**Activity** **Synopsis:** Students roll a marble down ramps of differing heights to produce variable speeds. Then they record data related to marble speed, the distance a Styrofoam block moved when the marble collided with it, and the height of the ramp. **Main science idea(s):** • A marble will roll down a higher ramp faster than it will roll down a lower ramp of the same length. When the faster-moving marble rolls down the higher ramp and collides with an object at the bottom, it will push that object farther than it would if it rolled down the lower ramp at a slower speed.	Make explicit links between science ideas and activities **during** the activity. Ask questions to elicit student ideas and predictions.	**ELL support:** ELL students are more likely to understand the relationship between steepness and distance if you make explicit connections during the activity between a marble's energy and the distance moved. Our next investigation will help us gather evidence that shows which marble has the most energy. **NOTE TO TEACHER:** *Distribute handout 2.1 (Ramps, Speed, and Energy).* **Show slide 8.** Look at the two ramps on your handout and predict the speed of the marble as it rolls down each ramp. Which marble is faster and which is slower? Write your predictions on the first row of your handout for each ramp. **NOTE TO TEACHER:** *Make sure students predict that the marble will move slower on Ramp 1 and faster on Ramp 2. They'll complete the remaining rows on the handout as they work through the investigation.*		

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			So we all agree that the marble will move slower on Ramp 1 and faster on Ramp 2, right? Now let's test our predictions about the marble's speed and gather some evidence about whether an object's speed determines how much energy it has. So far, we've learned that if an object is moving, it has energy. Now we'll find out whether an object moving at different speeds has different amounts of energy. We'll test our predictions by rolling a marble down a higher ramp and a lower ramp and seeing how far the marble can push a piece of Styrofoam it collides with at the bottom of each ramp. Then we'll measure and record the distance the Styrofoam moved each time. **ELL support:** Introduce the phrase *test your predictions* if it's likely to be unfamiliar to ELL students. Consider having students engage in a Think-Pair-Share with a same-language partner to talk about their predictions and what it means to test them. **NOTE TO TEACHER:** *Display handout 2.2 (High-Speed Energy) on a document reader or projector. Review the materials list and the procedure students will use for the investigation.* **Show slide 9.**		
		Select content representations and models matched to the learning goal and engage students in their use.			

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			First, let's review the materials you'll need for this investigation. In our practice run, we used two rulers and two marbles, but this time, each group will use one marble and one ruler for the ramp. To change the height of the ramp, you'll add more wood blocks to make the ramp higher and steeper. The new twist is that we're adding a block of Styrofoam at the bottom of the ramp to catch the marble. **Show slide 10.** Now let's go over the instructions for this investigation. First, you'll set up a ramp like Ramp 1 on your handouts and raise it up using a block of wood [*or notepads*]. Your ramp setup should look something like the picture on this slide. **Show slide 11.** Place the Styrofoam block at the bottom of the ramp with the grooved side facing the ramp so the marble will roll into the groove when it reaches the bottom of the ramp. The photo on this slide shows what this will look like. After you finish setting up your ramp, work together to complete steps 2–9 for Ramp 1. Make sure to carefully follow the procedure displayed on the document reader [*or projector*]. **NOTE TO TEACHER:** *Display the*		

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			photographs on slides 10 and 11 and demonstrate the proper ramp setup.   *Explain that when the marble rolls down the groove in the ruler, it will collide with the block of Styrofoam at the bottom of the ramp, and nest in the groove of the Styrofoam. The motion of the marble should push the Styrofoam across the paper. Tell students that they may have to perform several practice runs to get the marble to land correctly in the Styrofoam groove.* *Then go over the procedure from handout 2.2 to make sure students understand the steps involved. Emphasize that they should carefully follow the directions displayed on the document reader.* *Show students how to mark the paper to show where the Styrofoam stops moving*		

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			in each of the trials for both ramps (step 4) and then measure the middle distance of the three (steps 6 and 7). Students should only record measurements from trials where the marble nested correctly in the Styrofoam groove and pushed the Styrofoam across the paper. **Show slide 12.** Make sure to record your measurements for questions 2 and 4 on handout 2.1 (the Ramps, Speed, Energy handout) under the **Ramp 1** column. Leave question 3 blank, since we'll complete it during the next lesson. **NOTE TO TEACHER:** *The sections students should complete on handout 2.1 are highlighted on the slide with red arrows, and the section students should skip (question 3) is shown in gray scale. Make sure students are clear about which sections to complete on their handouts.* **Emphasize:** Do *not* start setting up Ramp 2 until you've completed all the steps for Ramp 1 and recorded your measurements on the handout. When you set up Ramp 2, you'll use the same ruler and marble but add another block of wood [*or more notepads*] to increase the height of the ramp. Then you'll repeat steps 2–9 for Ramp 2 displayed on the document reader *[or*		

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			projector]. Make sure to record your measurements for questions 2 and 4 on your handouts under the Ramp 2 column before wrapping up the investigation. Any questions before we begin? **NOTE TO TEACHER:** *Circulate from group to group as students work through the investigation and answer any questions that arise.*		
5 min	**Follow-Up to Activity** **Synopsis:** Students resume their role as energy detectives from the previous lesson and discuss how they detected energy in today's investigation. **Main science idea(s):** • Energy is all around us, and we can detect it with our senses. Objects in motion have energy.	Make explicit links between science ideas and activities **after** the activity.	**NOTE TO TEACHER:** *After students have completed the investigation and put away all materials, convene the class for a brief discussion.* **Show slide 13.** Now let's return to our role as energy detectives and talk about what we discovered in today's investigation. Where did your group detect energy in the ramp-and-marble setups? How did you detect motion energy in the marbles?	We detected energy in the marbles. As the marbles rolled down the ramp, they had motion energy. We saw the marbles move. We heard them	Tell me more about the energy of the marbles.

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				make a little bit of noise, too.	
			Did you detect energy in any other objects?	The Styrofoam piece moved after the marble hit it.	Do you think the Styrofoam had motion energy too?
				It didn't move very much, so I don't know if it really had energy.	Can anyone add on?
				We said earlier that anything that moves has motion energy, so the Styrofoam had a little bit of motion energy, but not as much as the marble did.	
			So using our senses, we've determined that moving objects like the marble and the Styrofoam have motion energy. But we need more than just our senses to determine whether the faster or slower marble has more motion energy. We need data and evidence to support our ideas!		
			What data did we collect today that might help us figure out which marble has more energy?	The speed of the marble.	
				The height of the ramp.	
				The distance the piece of Styrofoam moved.	

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6 min	**Synthesize/Summarize Today's Lesson** **Synopsis:** Students write a preliminary answer to the focus question.	Highlight key science ideas and focus question throughout. Engage students in making connections by synthesizing and summarizing key science ideas.	**Show slide 14.** As we wrap up today's investigation, let's review our focus question, *What causes a moving object to have more or less motion energy?* Think about what you've learned so far about energy. As good energy detectives, what did you discover about energy from our investigations today and in the previous lesson? Then answer this question in your science notebooks using the sentence starter on the slide: *I think a moving object has [more motion energy/less motion energy] when _____. My evidence is _____.* We'll share our answers and ideas next time.		
1 min	**Link to Next Lesson** **Synopsis:** The teacher announces that next time, students will analyze their data to determine which marble had more motion energy.	Summarize key science ideas. Link science ideas to other science ideas.	**Show slide 15.** So in today's investigation, we observed that a marble rolls faster down a higher ramp. And as good energy detectives, we concluded that the faster marble has more energy. But how do we *know* that our ideas about motion and energy are correct? Next time, we'll examine the data we collected on the marbles, ramps, and Styrofoam to see if we can find evidence to support our ideas.		