Energy Transfer
Lesson 4b: Potential Energy and Kinetic Energy

Grade 4	**Length of lesson:** 50 minutes	**Placement of lesson in unit:** 4b of 6 two-part lessons on energy transfer
Unit central question: How does the energy of an object move and change?		**Lesson focus question:** Where does the energy of a moving object come from?
Main learning goal: Energy can change, or transform, from potential energy to kinetic energy.		
Science content storyline: Energy moves from place to place and can transfer from object to object during a collision. Some forms of energy, such as potential energy, can't be detected in the same way kinetic energy is detected. Objects above the ground (such as at the top of a hill) have potential energy. Potential energy can change or transform into detectable kinetic energy.		
Ideal student response to the focus question: Energy can transfer from one object to another object in a collision. This is one place energy comes from. The energy of an object can also come from potential energy. If an object is higher up off the ground—like on the top of a hill— but isn't moving, it has potential energy. Gravity is pulling on the object, so it *could* move. Once the object starts moving—like rolling down the hill—its potential energy changes to kinetic energy.		

Preparation

Materials Needed
- Science notebooks
- Chart paper and markers
- Colored pencils (2 different-colored pencils for each student)

Student Handouts
- 4.3 Potential and Kinetic Energy: Energy Changing Costumes (1 per student and 1 for display)

Ahead of Time
- Review the Energy and Energy Transfer Content Background Document: sections 1–8.
- Prepare handout 4.3 (Potential and Kinetic Energy: Energy Changing Costumes) for display on a document reader or an overhead projector.
- Choose two pencil colors to represent potential and kinetic energy that all students will have access to. Students should use the same colors to represent each form of energy (e.g., ***green*** for potential energy and ***red*** for kinetic energy).

Lesson 4b General Outline

Time	Phase of Lesson	How the Science Content Storyline Develops
4 min	**Link to previous lesson:** The teacher reviews the concept of energy changing costumes, and students share their ideas about what it means.	• Potential energy can change, or transform, into kinetic energy when an object begins to move.
1 min	**Lesson focus question:** The teacher reviews the focus question from the previous lesson: *Where does the energy of a moving object come from?*	
5 min	**Setup for activity:** Students examine four diagrams and write a sentence describing the energy in each diagram.	• Objects above the ground, such as at the top of a hill, have potential energy because gravity is pulling on them. When an object begins to move, potential energy can change, or transform, into kinetic energy.
20 min	**Activity:** Students use diagrams to analyze how much potential and kinetic energy an object has as it rolls down a hill.	• An object above the ground, such as on a table or at the top of a hill, has potential energy. Potential energy can transform into kinetic energy as the object moves from a higher position to a lower position (i.e., toward the ground). Energy isn't created; it comes from somewhere. Therefore, the kinetic energy of an object can come from potential energy.
10 min	**Follow-up to activity:** Students describe their completed meters showing how much potential and kinetic energy an object has as it rolls down a hill.	
8 min	**Synthesize/summarize today's lesson:** Students summarize how potential and kinetic energy are involved when Mumford coasts down a hill on his bike.	
2 min	**Link to next lesson:** Previewing the next lesson, the teacher asks students to detect evidence of energy changing costumes in a picture of Mumford and Leroy's crash and challenges students to think about where the energy came from that led to this collision.	

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4 min	**Link to Previous Lesson** **Synopsis:** The teacher reviews the concept of energy changing costumes, and students share their ideas about what it means. **Main science idea(s):** • Potential energy can change, or transform, into kinetic energy when an object begins to move.		**Show slides 1 and 2.** In our last lesson, we explored the idea of energy changing costumes. Let's review what that means. Think about our final reading about Mumford and Leroy's crash last time. What new term did you add to your descriptions and pictures?		
				Potential energy.	
			What do you think it means for energy to change costumes?		
		Link science ideas to other science ideas.		It has something to do with potential energy and an invisibility cloak, like a superhero or something.	Say more about your ideas.
				We talked a lot about how an object at the top of a hill or ramp has potential energy.	Can anyone add to these ideas? Does it matter how high the object is?
				Yes. If an object is higher up off the ground, like at the top of a hill, it has more potential	

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			Good thinking! It sounds like you remember a lot from our last lesson. Today we'll use a different content representation to help us make sense of potential energy changing its costume into kinetic energy.	energy because it can go faster before it hits the ground. Somehow potential energy changes to kinetic energy as an object moves down a hill, but I'm not sure I understand how that happens.	Does potential energy ever change its costume?
1 min	**Lesson Focus Question** **Synopsis:** The teacher reviews the focus question from the previous lesson: *Where does the energy of a moving object come from?*	Set the purpose with a <u>focus question</u> or goal statement.	**Show slide 3.** Today's focus question is the same one we investigated last time: *Where does the energy of a moving object come from?* In this lesson, we'll examine some diagrams that will help us make sense of energy changing costumes. By the end of the lesson, we should be able to answer this question.		
5 min	**Setup for Activity** **Synopsis:** Students examine four diagrams		**NOTE TO TEACHER:** *Distribute handout 4.3 (Potential and Kinetic Energy: Energy Changing Costumes*). *Ask students to set up a new page in their*		

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	and write a sentence describing the energy in each diagram. **Main science idea(s):** • Objects above the ground, such as at the top of a hill, have potential energy because gravity is pulling on them. When an object begins to move, potential energy can change, or transform, into kinetic energy.	Select content representations and models matched to the learning goal and engage students in their use. Highlight key science ideas and focus question throughout.	*science notebooks, with the heading "Diagrams of Potential and Kinetic Energy" at the top of the page.* When you look at the diagrams on your handout, what do you notice? What does this remind you of? Good observation! These diagrams are similar to other models and content representations we've used in this unit. But they give us another way of looking at how energy changes costumes. They'll also help us answer our focus question, *Where does the energy of a moving object come from?* **Show slide 4.** Before we begin today's activity, look at the diagrams on your handouts and write one sentence in your science notebooks that describes what is happening to the marble in each diagram. Include in your description the position	A marble is rolling down a hill. First, it's at the top of the hill, and it ends up at the bottom. It looks just like our ramp-and-marble investigations. The marble could be Mumford on his bike too.	

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			of the marble in each diagram and anything else you notice that seems important. Again, write only one sentence for each of the four diagrams. Just ignore the boxes under the heading that says "Marble's Energy." We'll look at those later.		
20 min	**Activity** **Synopsis:** Students use diagrams to analyze how much potential and kinetic energy marble has as it rolls down a ramp. **Main science idea(s):** • An object above the ground, such as on a table or at the top of a hill, has potential energy. Potential energy can transform into kinetic energy as the object moves from a higher position to a lower position (i.e., toward the ground). Energy isn't created; it comes from somewhere. Therefore, the kinetic energy of an object can come from potential energy.	Engage students in using and applying new science ideas in a variety of ways and contexts.	**NOTE TO TEACHER:** *In this activity, students will use colored pencils to complete the diagrams on their handouts. Choose two colors everyone has access to and use those colors to represent potential and kinetic energy. In the example later in this lesson plan,* ***green*** *is used for potential energy (PE), and* ***red*** *is used for kinetic energy (KE).* **ELL support:** Consider having ELL students work on the first diagram in shared-language groups or engage in a Think-Pair-Share to make sure they understand what to do with the other three diagrams. Next, you'll add descriptions and labels to the diagrams on the handout. For each diagram, think about the marble's motion, speed, and position above the ground, as well as its energy. But don't do anything with the boxes marked "Marble's Energy." **Show slide 5.**		

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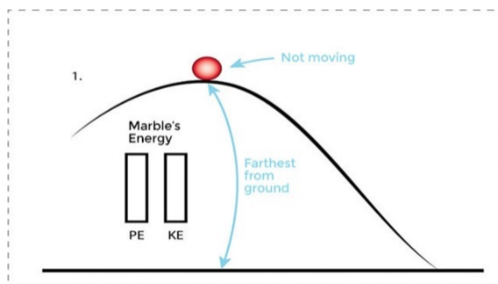
			We'll work on the first diagram together, and then you'll complete the other three diagrams on your own. **NOTE TO TEACHER:** *Display the handout on a document reader or overhead projector and point to the first diagram. Ask students to describe the speed, motion, and energy of the marble and its distance from the ground (ground level). Encourage students to use arrows on their handouts to point to what they're describing. Remind them to ignore the meter boxes on the diagrams for now. As students share their observations, record them on the projected diagram. Make sure the descriptions are scientifically accurate.* *Following is a marked-up sample for diagram 1.*  *Inform students that they can use words like these to describe the position and motion of the marble:*		

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			• *Moving/not moving* • *Faster/fastest* • *Farthest from the ground/closest to the ground.* *Let students know that the thick black line on the diagram represents the ground. Remind them that the ground is the flat surface where an object moving from a higher place to a lower place eventually stops. When we say that an object is above or off the ground, we means that it's higher than ground level (the flat surface). The object could be in contact with the ground (like a bike at the top of a hill) or in the air (like an apple in a tree).* **Whole-class share-out:** So what do you observe about the marble in this first diagram? What do you notice about its position in relation to ground level? What about the marble's motion and speed? What do you notice about the marble's energy? ***NOTE TO TEACHER:*** *After walking*	The marble isn't moving, so it has no speed. The marble is at the top of the hill, so it's farthest from the bottom of the	

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			students through the first diagram, direct them to complete the remaining three diagrams by writing comments within and around each diagram and using arrows to point out what they're describing. Remind students to think about the marble's speed, motion, and position in each diagram, as well as its energy. Students may share their observations with a partner, but they should mark up their own diagrams and make any necessary additions or revisions. Now work on the other three diagrams, writing your comments and observations on the handout and using arrows to point to what you're describing. Make sure to observe what's happening with the marble's energy, as well as its position, motion, and speed. You can talk about your observations with a partner, but make sure you mark up your own handouts and make any necessary changes. **Show slide 6.** **Whole-class discussion:** Let's talk about your descriptions for the other three diagrams. **NOTE TO TEACHER:** *Make sure the handout is displayed throughout the*	hill.	

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		Ask questions to probe student ideas and predictions. Ask questions to challenge student thinking.	*following discussion. As students share their observations and ideas, mark up the projected diagrams and revise as them needed. Make sure the descriptions on each diagram are scientifically accurate. Probe and challenge student thinking to help students achieve a clearer understanding of potential energy transforming into kinetic energy as the marble rolls down the hill.* What did you observe about the marble in diagram 2? How would you describe its position, speed, and motion? What can you say about the marble's *kinetic* energy in diagram 2? Does the marble in diagram 2 have more or less kinetic energy than it did in diagram 1? How do you know? **ELL support:** Students may also answer the questions on slide 6 using a demonstration, an analogy, or an illustration of their ideas. What can you say about the marble's *potential* energy in diagram 2?	The marble in this diagram is starting to move and is a little closer to bottom of the hill. The marble has a little kinetic energy. The marble has more kinetic energy in this diagram than it did in diagram 1 because it wasn't moving at all in diagram 1, and now it is.	

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			Does the marble have more or less potential energy than it did in diagram 1? How do you know? **NOTE TO TEACHER:** *Ask the same questions for diagrams 3 and 4 regarding the marble's potential and kinetic energy. Probe and challenge student thinking and record scientifically accurate descriptions on the projected diagrams.* **Show slide 7.** Now that we've finished our descriptions, let's examine the marble's energy more closely. Notice that there are two bars underneath the hill in each diagram. What do you think PE stands for? What about KE? That's right. Next you're going to shade in these bars or meters to show how much potential and kinetic energy the marble has in each diagram. We'll do the first one together, and then you'll complete the rest. **NOTE TO TEACHER:** *Continue projecting handout 4.3 and ask questions as you guide students through shading the meters for the first diagram.*	The marble still has potential energy in diagram 2 because it's not at the bottom of the hill yet. The marble doesn't have as much potential energy as it did in diagram 1 because it's closer to the bottom of the hill than the marble in diagram 1. Is PE potential energy and KE kinetic energy?	

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			Look at the marble in all four diagrams. In which diagram does the marble have the most *potential* energy? Why do you think so? So for diagram 1, we'll use a ***green***-colored pencil and shade the PE meter all the way to the top. Now how much *kinetic* energy does the marble have in diagram 1? How do you know? So we won't shade in the KE meter at all for diagram 1. We'll leave it blank to show that the marble doesn't have any kinetic energy. Does that make sense to everyone? The marble in diagram 1 has *only* potential energy and *no* kinetic energy. Is that what the meters show for the marble's energy in diagram 1 on the document reader [*or projector*]? Now work with your partner on the meters for the other three diagrams. **NOTE TO TEACHER:** *As you walk around the room, listen to students' discussions about shading in the meters. Are they making sense of potential*	The marble in diagram 1 has the most potential energy because it's farthest off the ground. It doesn't have any kinetic energy because it isn't moving.	

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		Ask questions to probe student ideas and predictions. Ask questions to challenge student thinking.	*energy transforming into kinetic energy? Ask questions to probe and challenge their thinking as needed.* *For example, if students think that a marble has potential energy only when it's at the top of the hill, challenge them by pointing to the marble's position in diagram 2 or 3 and asking, "What if the hill were only this high? Would the marble have potential energy here?" Or ask them to describe the position of the marble in relation to the ground (ground level). "If I let the marble go partway down the ramp, would it start rolling down the ramp? Where does it get the energy to do this?"*		
10 min	**Follow-Up to Activity** **Synopsis:** Students describe their completed meters showing how much potential and kinetic energy an object has as it rolls down a hill. **Main science idea(s):** • An object above the ground, such as on a table or at the top of a hill, has potential energy. Potential energy can transform into kinetic energy as the object moves from a		**Show slide 8.** **NOTE TO TEACHER:** *After students have finished shading the other meters, invite them to share their work with the class. Consider projecting their diagrams as they describe their shading decisions.* **Whole-class share-out:** So how did you show on your meters how much potential and kinetic energy the marble had in each diagram? Let's compare our results! I'll ask you to share your diagrams one at a time. If you're the one sharing, answer these questions on the slide:		

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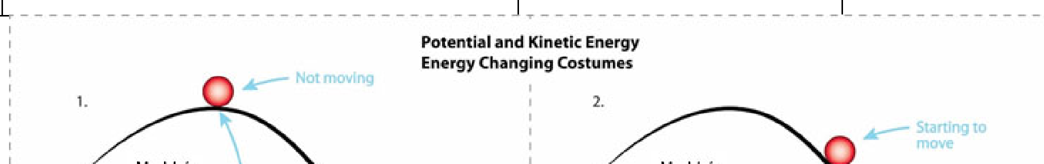
	higher position to a lower position (i.e., toward the ground). Energy isn't created; it comes from somewhere. Therefore, the kinetic energy of an object can come from potential energy.	Engage students in constructing explanations and arguments. Engage students in communicating in scientific ways. Ask questions to probe student ideas and predictions. Ask questions to challenge student thinking.	• How much *kinetic energy* does your meter show for each diagram? Why? • How much *potential energy* does your meter show for each diagram? Why? Make sure to explain your reasoning and include evidence from the diagrams. As your classmates share their ideas and reasons, listen carefully and be prepared to agree, disagree, ask questions, or add on. **NOTE TO TEACHER:** *During the discussion, probe student ideas and challenge their thinking. Students should be connecting the science ideas about potential energy decreasing and kinetic energy increasing as the marble rolls down the ramp. This understanding should be evident in the way they shaded their meters. (A key appears on the following page.)* **Show slide 9.** Now let's compare our meters with the meters on the slide. Did you come up with the same or different results?		



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8 min	**Synthesize/Summarize Today's Lesson** **Synopsis:** Students summarize how potential and kinetic energy are involved when Mumford coasts down a hill on his bike. **Main science idea(s):** • An object above the	Engage students in making connections by synthesizing and summarizing key science ideas.	**Show slide 10.** Next, I'd like you to write three or four complete sentences on the back of your handouts to summarize what happened to Mumford's energy when he rode his bike down the hill. In today's activity, you used *diagrams* and meters to describe how energy changed costumes when a marble rolled down a ramp. Now you'll use *words* to		

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	ground, such as on a table or at the top of a hill, has potential energy. Potential energy can transform into kinetic energy as the object moves from a higher position to a lower position (i.e., toward the ground). Energy isn’t created; it comes from somewhere. Therefore, the kinetic energy of an object can come from potential energy.		describe how potential energy and kinetic energy worked together to help Mumford ride down the hill. As you work on your summaries, think about all of the models we’ve used in our energy investigations: • Our ramp-and-marble models and diagrams • Pictures of Mumford and Leroy before, during, and after their collision • Our diagrams of potential and kinetic energy **ELL support:** Consider having ELL students engage in a Think-Pair-Share to collect their thoughts before they begin the writing assignment. Or in lieu of writing sentences, have students create annotated drawings that express their understandings of energy transformation. **ELL support:** *If some students are struggling with the language, consider allowing them to make an audio recording of their summaries instead.* ***Embedded Assessment Task*** **NOTE TO TEACHER:** *When students have finished their summaries, invite them to read them to the class, if time allows, and comment on one another’s*		

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		Highlight key science ideas and focus question throughout. Summarize key science ideas.	*science ideas. This is an excellent opportunity to assess their understanding of potential and kinetic energy.* **Show slide 11.** Let's revisit our focus question, *Where does the energy of a moving object come from?* How do our ideas about Mumford's energy help us answer this question? **Show slide 12.** We've explored some important science ideas in this lesson. Let's review them. • An object above ground level (off the ground) has potential energy. • Potential energy can transform into kinetic energy as an object moves from a higher place toward a lower place. • Potential energy transforms into kinetic energy. • Energy doesn't disappear. It changes costumes!		
2 min	**Link to Next Lesson** **Synopsis:** Previewing the next lesson, the teacher asks students to detect evidence of energy	Link science ideas to other science ideas.	**Show slide 13.** As we wrap up today's lesson, let's take another look at Mumford and Leroy's crash.		

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	changing costumes in a picture of Mumford and Leroy's crash and challenges students to think about where the energy came from that led to this collision.		We began this lesson thinking about energy changing costumes, and we learned from our marble diagrams that potential energy can change or transform into kinetic energy. The picture on this slide shows Mumford crashing into Leroy. What evidence do you see of energy changing costumes? Where did this energy come from? Think about these questions before the next lesson and be prepared to share your ideas with the class.		