Energy Transfer
Lesson 4a: Energy Changing Costumes

Grade 4	**Length of lesson:** 45 minutes	**Placement of lesson in unit:** 4a 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 • Student notebooks • Chart paper and markers • One ramp-and-marble setup (from lesson 2a) • Colored pencils (for each student) **Student Handouts** • 3.3 Mumford and Leroy's Collision, Part 1 (from lesson 3b) • 4.1 Mumford and Leroy's Collision, Part 2 (1 per student) • 4.2 Mumford and Leroy's Big Crash, Part 3 (1 per student)	**Ahead of Time** • Review sections 1–8 in the Energy and Energy Transfer Content Background Document. • Prepare a copy of handout 4.1 (Mumford and Leroy's Collision, Part 2) for display on a document reader or overhead projector.

Lesson 4a General Outline

Time	Phase of Lesson	How the Science Content Storyline Develops
5 min	**Link to previous lesson:** Students revisit the unit central question and discuss how they would answer this question based on what they've learned so far about energy.	• Energy moves from place to place and can transfer from object to object during a collision.
1 min	**Lesson focus question:** The teacher introduces the focus question, *Where does the energy of a moving object come from?*	
7 min	**Setup for activity:** The teacher engages students in a discussion about Mumford's energy before and during his ride down the hill. Then students share their ideas about where his energy came from.	• Senses alone can't detect all forms of energy. Potential energy is one form that can't be detected the same way kinetic energy is detected (using our senses). Objects above the ground, such as at the top of a hill, have potential energy because gravity is pulling on them, and they have the *potential* to move. When an object begins to move, its potential energy changes to kinetic energy.
15 min	**Activity:** Students read part 3 of Mumford and Leroy's big crash and learn about the science idea of potential energy. Then they describe the potential energy in Mumford and Leroy's collision.	• 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 ground level). 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 revisit the ramp-and-marble investigation from lesson 2 and describe the potential and kinetic energy of a marble as it rolls down ramps of varying heights. Then they relate ideas about energy transformation to Mumford as he rode his bike down the hill.	
6 min	**Synthesize/summarize today's lesson:** The teacher revisits the focus question, and students write a preliminary answer using science ideas about energy and moving objects.	
1 min	**Link to next lesson:** The teacher foreshadows the next lesson in which students will gather more information about potential and kinetic energy to explain how energy changes costumes.	

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5 min	**Link to Previous Lesson** **Synopsis:** Students revisit the unit central question and discuss how they would answer this question based on what they've learned about so far about energy. **Main science idea(s):** • Energy moves from place to place and can transfer from object to object during a collision.	Link science ideas to other science ideas. Ask questions to elicit student ideas and predictions. Ask questions to challenge student thinking.	**Show slides 1 and 2.** Let's revisit our unit central question, *How does the energy of an object move and change?* Based on what we've learned about energy from our investigations, how would you answer this question? **NOTE TO TEACHER:** *Write students' responses on chart paper so you can revisit and revise them as needed. Answers should include accurate statements about how kinetic energy moves or transfers from object to object (energy transfer). Students may not necessarily talk about how the energy of an object changes, since energy transformation will be introduced later in this lesson. But they may have some ideas from previous investigations. Challenge student ideas that are scientifically inaccurate. At this point in the lessons, students should be forming accurate science ideas about kinetic energy and energy transfer.*	Energy can move from place to place and from one object to another. When two objects collide, energy moves or transfers from one object to another object. Faster-moving objects have more kinetic energy than slower-moving objects. The energy of an object changes when the object's speed changes.	Can anyone add to this idea? Can someone use our new vocabulary word *kinetic* in their answer? How do you know that? What's your evidence? How does energy change? What did we do in class that helped

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				We detected energy by seeing motion, hearing sound, feeling heat, and seeing light in different objects. We used a model with ramps and marbles to show that a faster-moving object has more motion energy. We used a model of Mumford and Leroy to show how Mumford's energy transferred to Leroy when they collided on their bikes.	you understand how energy moves and changes?
1 min	**Lesson Focus Question** **Synopsis:** The teacher introduces the focus question, *Where does the energy of a moving object come from?*	Set the purpose with a focus question or goal statement.	**Show slide 3.** Our focus question today is *Where does the energy of a moving object come from?* Write this question in your science notebooks and draw a box around it. To help us answer this question, we'll investigate what happened to Mumford's energy when he rode his bike down the hill.		

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7 min	**Setup for Activity** **Synopsis:** The teacher engages students in a discussion about Mumford's energy before and during his ride down the hill. Then students share their ideas about where his energy came from. **Main science idea(s):** • Senses alone can't detect all forms of energy. Potential energy is one form that can't be detected the same way kinetic energy is detected (using our senses). Objects above the ground, such as at the top of a hill, have potential energy because gravity is pulling on them, and they have the *potential* to move. When an object begins to move, its potential energy changes to kinetic energy.	Make explicit links between science ideas and activities **before** the activity. Ask questions to elicit student ideas and predictions. Ask questions to probe student ideas and predictions. Ask questions to challenge student thinking.	**Show slide 4.** **NOTE TO TEACHER:** *Draw a hill on the board or on chart paper. Then draw a circle representing Mumford at the top of the hill. Use the diagram on the slide as a model. Then ask students the following questions about Mumford's kinetic energy in the story.* How much kinetic or motion energy do you think Mumford had at the top of the hill before he started moving? When did he first have kinetic energy? When did Mumford have the *most* kinetic energy? Where do you think Mumford's kinetic energy came from? How did he get the energy to move down the hill?	None. When he started riding down the hill. When he was moving the fastest—at the bottom of the hill. Maybe he got energy from the hill. I think he got energy from gravity.	How do you know this? What's your evidence? How do you know he had the most motion energy at the bottom of the hill? Why do you think that? Are you saying that the hill made the energy? Say more about

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					gravity and energy.
15 min	**Activity** **Synopsis:** Students read part 3 of Mumford and Leroy's big crash and learn about the science idea of potential energy. Then they describe the potential energy in Mumford and Leroy's collision. **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.	Make explicit links between science ideas and activities **during** the activity.	**Show slide 5.** So we know that Mumford had kinetic energy when he coasted down the hill, but we're not sure where that energy came from. Several of you had some great ideas, but let's see if we can gather more information to figure this out. From our story about Mumford and Leroy, we know that energy can move or transfer from one object (or bike rider) to another. Where did you see examples of energy transfer in the story?	When Mumford crashed into Leroy, Mumford slowed down and came to a stop, and Leroy and his bike started moving. Motion energy, or kinetic energy, was transferred from Mumford to Leroy when they collided. Mumford	Can you use the words *motion energy* or *kinetic energy* in your description?

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		Summarize key science ideas.	OK, we saw evidence of energy transfer when Mumford collided with Leroy. The speed and energy of both boys changed after the collision. Mumford's speed and kinetic energy decreased, and Leroy's increased. Did you see something similar when the marbles collided in our earlier investigation? **Show slide 6.** Now let's read more about Mumford and Leroy's big crash. **NOTE TO TEACHER:** *Distribute handout 4.2 (Mumford and Leroy's Big Crash, Part 3) and have students read it aloud as a class.* **Show slide 7.** What new energy words did you see in this reading? What did you learn about potential	lost kinetic energy, and Leroy gained kinetic energy. Yes, the first marble slowed down and stopped, and the second marble started rolling. But it rolled farther than Leroy would have moved. Potential energy.	

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			energy?	Potential energy is energy you can't see, hear, or feel. Mumford had potential energy because he was sitting on his bike at the top of a hill.	From our reading, how is potential energy different from kinetic energy?
		Link science ideas to other science ideas.	What do you think it means for energy to "change costumes"?	Potential energy means that an object could start moving anytime, and kinetic energy means that an object is already moving. An object has to be above or off the ground to have potential energy so it can move from a higher place to a lower place. An object that's off the ground can have kinetic energy too. I guess it means that one kind of energy becomes another kind of energy. So the potential energy Mumford had when he was sitting at the top of the hill became kinetic energy when he coasted down the hill on his bike.	

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			Great discussion! **Show slide 8.** Our new vocabulary term is **potential energy**. Write this term in your science notebooks; then draw a table like the one on the slide and write the same words on top of the table to help you remember two important science ideas: 1. To have potential energy, an object has to be off the ground (above ground level). The ground is the flat surface where an object moving from a higher place to a lower place eventually stops. 2. The higher an object is off the ground (or above ground level), the more potential energy it has. **Show slide 9.** Do you remember the three pictures of Mumford and Leroy's collision from our last lesson? On that handout, you described the kinetic or motion energy of Mumford and Leroy next to each picture. Find handout 3.3 in your notebooks [*Mumford and Leroy's Collision, Part 1*] and read over the descriptions you wrote last time.		

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			Now let's think about the potential energy in Mumford and Leroy's big crash. **NOTE TO TEACHER:** *Distribute handout 4.1 (Mumford and Leroy's Collision, Part 2.)* On this handout, I'd like you to show where you think *potential energy* is located in each picture and then write a description in the space provided. **Individual work time.** **Show slide 10.** **Whole-class share-out:** Let's share our descriptions and ideas about potential energy. Make sure to point out where you labeled potential energy on each picture and tell us why you chose those locations. **NOTE TO TEACHER:** *Display a copy of handout 4.1 (Mumford and Leroy's Collision, Part 2) on a document reader or overhead projector during this discussion so that you and/or students can point out locations on each picture as students share their ideas about potential energy.* Look at the first picture on your handouts. Where did you label potential	I labeled Mumford with potential energy because he's sitting on his bike at the top of the hill, and he	

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			energy and why? Who has potential energy?	isn't moving yet.	
			Does Leroy have potential energy in this picture?	I don't think so. He's just sitting at the bottom of the hill on his bike.	Does anyone disagree or have anything to add?
				I think Leroy has a little potential energy at the bottom of the hill because he's still on his bike.	
			Where did you label potential energy in picture 2 and why? Would Mumford have potential energy here?	I don't know, because Mumford has kinetic energy riding down the hill. Can he have both at the same time?	
			What about picture 3? Where did you label potential energy and why? Do Mumford and Leroy have potential energy in this picture? **NOTE TO TEACHER:** *In picture 1, students should respond that they'd place a potential-energy label on Mumford because he's sitting on his bike at the top of the hill. In picture 2,*	I don't think either Mumford or Leroy has potential energy because they're both at the bottom of the hill, and Leroy is lying on the ground!	How does lying on the ground relate to potential energy?

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		Ask questions to probe student ideas and predictions.	*Mumford has kinetic energy because he's moving down the hill, but he also has potential energy because he hasn't reached the bottom of the hill yet. The idea that an object can have potential energy and kinetic energy at the same time is sometimes difficult for students to understand. In picture 3, Leroy has no potential energy because he's lying on the ground. Mumford may have a small amount of potential energy because he's still on his bike, which is higher than the ground.* *Mumford has the most potential energy at the top of the hill, and his potential energy decreases as he moves down the hill. Students will continue to explore these ideas in the next lesson, so don't be concerned if they don't fully understand energy transformation at this time.* So what do you know about potential energy now? How would you describe it? **NOTE TO TEACHER:** *Probe student ideas as they share what they know about potential energy. You may want to focus on the word* potential *and what it means, since some students may have heard the phrase "You have a lot of potential" and be thinking of potential in this sense. Also use the costume analogy to help students think of potential energy*	Anything that is above or off the ground has potential energy, like my pencil on the table. The higher up something is, the more potential energy it has. As it gets lower and moves toward the ground, it has less potential energy.	What do others think about this? Does everyone agree? Can anyone add to these ideas? Can someone describe something else in the room that has potential energy?

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			as energy wearing a costume that makes it invisible. Emphasize that potential energy is still energy even though we can't see it until it changes costumes again into something we can detect, such as kinetic energy.	It changed costumes and turned into kinetic energy!	If Mumford doesn't have as much potential energy halfway down the hill, where do you think his potential energy went?
10 min	**Follow-Up to Activity** **Synopsis:** Students revisit the ramp-and-marble investigation from lesson 2 and describe the potential and kinetic energy of a marble as it rolls down ramps of varying heights. Then they relate ideas about energy transformation to Mumford as he rode his bike down the 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 higher position to a lower position (i.e., toward the ground).	Engage students in analyzing and interpreting data and observations.	**Show slide 11.** **NOTE TO TEACHER:** *For this discussion, set up a ramp-and-marble model for students to refer to as they describe the potential and kinetic energy of the marbles. Alternatively, you could project the images of Ramps 1 and 2 from handout 2.1 (Ramps, Speed, and Energy) so that students can compare them.* Think back to our ramp-and-marble investigation earlier in this unit. In this investigation, we used different ramp heights and rolled a marble down each ramp to see whether the marble had more energy on the higher ramp or the lower ramp. On the steeper ramp, the marble was higher off the ground. What did you discover about the marble's speed as it moved down each ramp? How fast did it move down each ramp?	The marble moved faster	

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	Energy isn't created; it comes from somewhere. Therefore, the kinetic energy of an object can come from potential energy.		How would you describe the marble's motion energy or *kinetic energy* on each ramp?	down the steeper ramp and slower down the other ramp. The faster marble had more kinetic energy on the steeper ramp, and the slower marble on the lower ramp had less kinetic energy.	
			What about the marble's *potential energy* at the top of each ramp? Can you relate the height of the ramp to the potential energy of the marble? Make sure to explain your reasoning.	The marble at the top of the steeper ramp had more potential energy because it was higher off the ground. The marble at the top of the lower ramp had less potential energy because it wasn't as high off the ground.	
			Show slide 12.		
		Engage students in analyzing and interpreting data and observations. Engage student in using and applying new science ideas in a	Now let's use these ideas from our ramp-and-marble investigation to think about the potential and kinetic energy of Mumford as he rode his bike down the hill in our story. **NOTE TO TEACHER:** *Have students refer to handout 3.3 (Mumford and Leroy's Collision, Part 1) and handout*		

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		variety of ways and contexts.	*4.1 (Mumford and Leroy's Collision, Part 2) during this discussion.* Can someone describe Mumford's *potential energy* as he rode his bike down the hill? **CONTENT NOTE TO TEACHER:** *The potential energy of an object (Mumford) decreases as it moves down a hill because it's getting closer to ground level, where it would have no more potential energy.* Can someone describe Mumford's *kinetic energy* as he rode down the hill? **CONTENT NOTE TO TEACHER:** *The kinetic energy of an object (Mumford) increases as it moves down a hill because it picks up speed (moves faster).* Now can someone describe Mumford's *potential energy and kinetic energy* as he rode down the hill?	Mumford's potential energy decreased as rode down the hill. Because he was getting closer to the ground, and we know that the higher an object is off the ground, the more potential energy it has. Mumford's kinetic energy increased as he rode down the hill. Because our ramp investigations showed that the faster an object moves, the more kinetic energy it has. *Example of a complete answer:* Mumford had potential energy at the top of the	How do you know? What's your evidence? How do you know? What's your evidence?

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				hill. When he rode down the hill, his potential energy decreased as he got closer to the ground. His kinetic energy increased as he rode down the hill because he was moving faster and faster. As Mumford got closer to the bottom of the hill, he was moving faster, so his kinetic energy increased. He was also getting closer to the ground, so his potential energy decreased. The potential energy Mumford had at the top of the hill changed to kinetic energy as he rode down the hill. We don't know how steep the hill was, but if it was really steep, Mumford would have had more potential energy at the top of the hill. And with more potential energy at the	Can you relate Mumford's kinetic energy to the potential energy he had at the top of the hill?

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			The idea that energy changes costumes is a challenging one, so we'll continue exploring this idea in the next lesson and see if we can gather more information about potential and kinetic energy.	top, he would have had more kinetic energy moving down the hill. So he would have been moving faster.	
6 min	**Synthesize/Summarize Today's Lesson** **Synopsis:** The teacher revisits the focus question, and students write a preliminary answer using science ideas about energy and moving objects. **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 ground level). Energy isn't created; it comes from somewhere.	Highlight key science ideas and focus question throughout. Engage students in making connections by synthesizing and summarizing key science ideas.	**Show slide 13.** Today, we explored the focus question, *Where does the energy of a moving object come from?* Use everything you know about energy and moving objects to answer this question in your science notebooks. Use the sentence starter on the slide: *I think the energy of a moving object comes from* _____. Think about our ramp-and-marble investigations and our story about Mumford and Leroy's big crash and use the evidence we found. Make sure to include science ideas about potential and kinetic energy, energy transfer when objects collide, and the position of objects in relation to the ground.		

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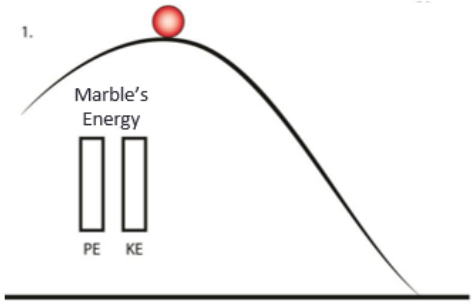
	Therefore, the kinetic energy of an object can come from potential energy.				
1 min	**Link to Next Lesson** **Synopsis:** The teacher foreshadows the next lesson in which students will gather more information about potential and kinetic energy to explain how energy changes costumes.	Link science ideas to other science ideas.	**Show slide 14.** In our next lesson, we'll continue exploring science ideas about potential and kinetic energy using diagrams like the one on this slide.  Let's see if we can figure out how energy changes costumes!		