Energy Transfer
Lesson 3b: Mumford and Leroy's Energy Transfer

Grade 4	**Length of lesson:** 35 minutes	**Placement of lesson in unit:** 3b 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 happens to energy when objects collide?
Main learning goal: Energy can move or transfer from object to object.		
Science content storyline: Objects in motion have energy. Motion energy is called *kinetic energy.* When an object moves faster, it has more kinetic energy. Energy is transferred from one object to another during a collision. This results in a change of speed in both objects after the collision. These energy transfers can be tracked using a diagram.		
Ideal student response to the focus question: When two objects collide, energy moves from one object to the other object.		

Preparation

Materials Needed
- Science notebooks
- Chart paper and markers
- Colored pencils (including 1 blue pencil and 1 red pencil)
- *For demonstration, if needed:*
  - Ruler (with groove in the middle)
  - 2 marbles
  - Blocks of wood (or notepads) (to elevate ramp)

Student Handouts
- 3.3 Mumford and Leroy's Collision, Part 1 (1 per student)

Ahead of Time
- Review the Energy and Energy Transfer Content Background Document: sections 1–8.
- **ELL support:** Identify Tier 2 and Tier 3 words in the lesson plan to review in advance with ELL students. Possible terms include *object(s)*, *collide*, *collision*, *transfer*, *transferred*, *motion energy, kinetic energy*.

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Lesson 3b General Outline

Time	Phase of Lesson	How the Science Content Storyline Develops
3 min	**Link to previous lesson:** Students reread the final paragraph of Mumford and Leroy's story (part 2) and review key science ideas from the previous lesson.	• When two objects collide, energy moves or transfers from one object to the other object.
1 min	**Lesson focus question:** The teacher reviews the focus question from the previous lesson: *What happens to energy when objects collide?*	
5 min	**Setup for activity:** The teacher revisits the ramp-and-marble model students used in the previous investigation to represent Mumford and Leroy's collision.	• Models, or content representations, help scientists visualize and make sense of situations they can't examine in real life. The ramp-and-marble model helps us understand how motion energy transfers from one object to another object during a collision.
10 min	**Activity:** Students make diagrams of the ramp-and-marble model to investigate what happens to motion energy before, during, and after a collision between two objects. Then they explain how energy transfer occurred in Mumford and Leroy's collision.	• Energy transfers from one object to another object during a collision. This results in a change of speed in both objects after the collision. The movement of energy from one object to another in a collision is called *energy transfer*. Energy transfer can be illustrated in a diagram.
10 min	**Follow-up to activity:** Students describe what happens to Mumford's and Leroy's motion energy in three stages of the collision—before, immediately before, and after.	• When two objects collide, energy moves or transfers from one object to the other object.
5 min	**Synthesize/summarize today's lesson:** Students learn that motion energy is called *kinetic energy*. Then they answer the focus question by synthesizing what they've learned about motion (kinetic) energy and energy transfer.	• The scientific term for motion energy is *kinetic energy*. When two objects collide, kinetic energy transfers from one object to the other object.
1 min	**Link to next lesson:** The teacher announces that in the next lesson, students will think about where the energy of a moving object comes from.	

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3 min	**Link to Previous Lesson** **Synopsis:** Students reread the final paragraph of Mumford and Leroy's story (part 2) and review key science ideas from the previous lesson. **Main science idea(s):** • When two objects collide, energy moves or transfers from one object to the other object.	Highlight key science ideas and focus question throughout.	**Show slide 1.** In our last lesson, we learned about Mumford and Leroy's big crash. Who can briefly describe what happened? Now let's reread the last two paragraphs from part 2 of the story. **NOTE TO TEACHER:** *Have students locate handout 3.2 (Mumford and Leroy's Big Crash, Part 2), and ask one or two volunteers to read the last two paragraphs of the story aloud.* **Show slide 2.** We discovered three key science ideas from our investigation in the previous lesson. Let's review them. 1. The faster an object moves, the more energy it has. 2. Energy can move or transfer somewhere else when objects collide. 3. When two objects collide, energy moves or transfers from one object to the other object. When Mumford and Leroy collided on their bikes, some of Mumford's motion energy transferred to Leroy, and Leroy began to move. So we know there was a		

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		Link science ideas to other science ideas.	transfer of energy from one object (Mumford) to another object (Leroy). In today's lesson, we'll continue exploring these important science ideas.		
1 min	**Lesson Focus Question** **Synopsis:** The teacher reviews the focus question from the previous lesson: *What happens to energy when objects collide?*	Set the purpose with a focus question or goal statement.	**Show slide 3.** Our focus question for this lesson is the same one we thought about last time: *What happens to energy when objects collide?* We'll continue building on what we've already learned about motion energy from our investigations. Then we'll use these science ideas to help us answer the focus question.		
5 min	**Setup for Activity** **Synopsis:** The teacher revisits the ramp-and-marble model students used in the previous investigation to represent Mumford and Leroy's collision. **Main science idea(s):** • Models, or content representations, help scientists visualize and make sense of situations they can't examine in real life. The ramp-and-marble model helps us	Make explicit links between science ideas and activities **before** the activity.	**Show slide 4.** Last time, we used a model to show what happened to motion energy when Mumford and Leroy collided on their bikes. What did your team's model look like? Why did we use a model to represent Mumford and Leroy's collision?	We used a ramp and two marbles. One marble represented Mumford at the top of the hill, and the other represented Leroy at the bottom of the hill. It wouldn't be very safe	

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	understand how motion energy transfers from one object to another object during a collision.		You are so right! So using a model helped us explore science ideas about speed and motion energy without having an actual bike crash. Scientists also use models, or content representations, to learn about science ideas and explore objects or events that can't be observed directly because they're too small, too far away, or too dangerous to investigate in real life. During today's investigation, we'll make diagrams of our ramp-and-marble model to help us learn more about how energy transfers from one object to another in a collision. Then we'll use these science ideas to answer our focus question, *What happens to energy when objects collide?*	to have two kids run into each other with their bicycles.	
		Highlight key science ideas and focus question throughout.			
10 min	**Activity** **Synopsis:** Students use diagrams of the ramp-and-marble model to investigate what happens to motion energy before, during, and after a	Select content representations and models matched to the learning goal and engage students in	**Show slide 5.** Let's begin our investigation by making three diagrams of our ramp-and-marble model. In our story, Mumford was sitting on his bike at the top of the hill, and Leroy was		

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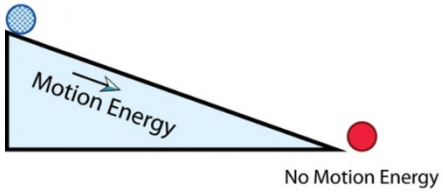
	collision between two objects. Then they explain how energy transfer occurred in Mumford and Leroy's collision. **Main science idea(s):** • Energy transfers from one object to another object during a collision. This results in a change of speed in both objects after the collision. The movement of energy from one object to another in a collision is called *energy transfer*. Energy transfer can be illustrated in a diagram.	their use. Engage students in using and applying new science ideas in a variety of ways and contexts. Make explicit links between science ideas and	sitting on his bike at the bottom of the hill, right? So let's show this with the marbles in our first diagram. Draw one marble sitting at the top of the ramp, and the other sitting at the bottom of the ramp. **NOTE TO TEACHER:** *Sketch the following diagrams on chart paper (or on the board) and have students sketch them in their notebooks. Make sure to label the key components of the diagrams (e.g., Ramp, Marble 1, Marble 2).* **Before the Collision**  What do the marbles and the ramp represent? **NOTE TO TEACHER:** *Have students label the marble at the top of the ramp "Mumford" and the marble at the bottom of the ramp "Leroy."* In the story, Mumford started coasting down the hill, and Leroy was waiting for him at the bottom. So in your diagram,	The marble at the top of the ramp represents Mumford at the top of the hill. The marble at the bottom of the ramp represents Leroy at the bottom of the hill.	

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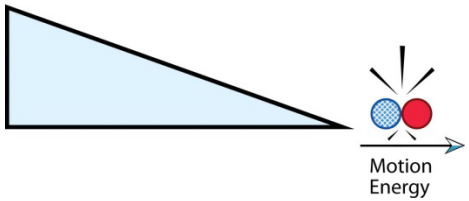
		activities **during** the activity. Engage students in constructing explanations and arguments.	draw an arrow like the one on the slide to show the marble starting to roll down the ramp. Just before the marbles collide, what is the motion energy of each marble? **NOTE TO TEACHER:** *Write the following descriptions below the first diagram:* • *Marble 1 (blue) has a lot of motion energy because it's rolling down the ramp.* • *Marble 2 (red) has no motion energy because it isn't moving at all.* **Show slide 6.** Now let's sketch another diagram showing the collision. **During the Collision**  	The blue marble has more motion energy as it rolls faster and faster down the ramp. The red marble has no motion energy before the collision.	Why does the blue marble have a lot of motion energy? Why does the red marble have no motion energy?

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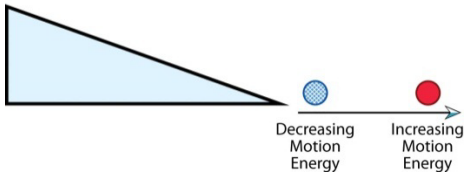
			Can someone describe what happened during the collision?	The blue marble crashed into the red marble.	What do you think happened to the motion energy?
				The blue marble's energy moved to the red marble.	
			Show slide 7.		
			Now let's sketch what happened *after* the collision.		
			After the collision  		
			What happened to the motion energy of the two marbles after they collided?	The blue marble slowed down after the collision, so it had less motion energy, and the red marble started to move, so it got some motion energy.	
			NOTE TO TEACHER: *Write the following descriptions below the diagram:* • *Marble 1 (blue) has less motion energy or decreasing motion energy because it slowed down.* • *Marble 2 (red) has some motion energy or increasing motion energy because it started moving.*		

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			Show slide 8. Now think about the motion energy of the marbles. Where did the motion energy of Marble 2 come from? What happened to the motion energy of Marble 1? This movement of energy from one object to another is called *energy*	It came from the first marble. It went away. To the second marble. No, I think the first marble gave only some of its energy to the second marble. Because the first marble was still moving after the collision. So it still had some motion energy.	What do you mean by "it went away"? Where did the energy go? Do you think all of the energy went to the second marble? How do you know?

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			transfer. After the collision, energy moved or transferred from Marble 1 to Marble 2. **Show slide 9.** Write this new term in your science notebooks; then copy the definition on the slide into your notebooks: ***Energy transfer*** *occurs when energy moves from one object to another.* We know that energy transferred from Marble 1 to Marble 2 in our model. Do you think the same thing happened in Mumford and Leroy's big crash? Describe the energy transfer that happened in their collision. How did energy move from one object to another during and after the collision? Make sure to include evidence from the story and the ramp-and-marble model.	Yes. When Mumford crashed into Leroy, Mumford's energy transferred to Leroy. Leroy was still before the collision, but he started moving after the collision.	How do you know that Mumford's energy transferred to Leroy? What's your evidence?
		Engage students in analyzing and interpreting data and observations.			

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			So where did Leroy's energy come from? Where did Mumford's energy go? **CONTENT NOTE TO TEACHER:** *Students might observe that the ramp-and-marble model doesn't show what would actually happen if two boys ran into each other on their bikes. Marble 2 (representing Leroy) continued to roll after the collision, but in the story, Leroy flew off his bike and then slid, scraped, and skidded across the sidewalk. He certainly wouldn't have moved as far as the marble did.* *The collision of the two marbles is an **elastic** collision in which most of the kinetic energy of the first marble transfers to the second marble. Mumford and Leroy's collision, however, is an **inelastic** collision because the kinetic energy isn't conserved as kinetic energy*	Only some of Mumford's energy transferred to Leroy because Mumford was still moving after the crash. Leroy's energy came from Mumford. Mumford's energy transferred to Leroy.	Did all of Mumford's energy transfer to Leroy? How do you know? Can you say more about motion energy? What else happens to the motion energy of an object?

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			alone. Instead, a significant amount of kinetic energy is lost as heat as Mumford's bike skids to a stop, and Leroy and his bike skid and scrape across the sidewalk. *You don't need to explain elastic and inelastic collisions to students, but honor their ideas if they mention that this model doesn't accurately represent the energy transfer that would occur in an actual bike collision. Students will learn more about the energy transformations involved in inelastic collisions in the next two lessons.*		
10 min	**Follow-Up to Activity** **Synopsis:** Students describe what happens to Mumford's and Leroy's speed and motion energy in three stages of the collision—before, immediately before, and after. **Main science idea(s):** • When two objects collide, energy moves or transfers from one object to the other object.	Engage students in using and applying new science ideas in a variety of ways and contexts. Make explicit links between	**Show slide 10.** **NOTE TO TEACHER:** *Distribute handout 3.3 (Mumford and Leroy's Collision, Part 1).* Who would like to read the directions on the handout aloud? Now I'd like you to work independently on your descriptions of Mumford's and Leroy's motion energy before, immediately before, and after their collision. Think about the diagrams you sketched earlier showing the motion energy of the two marbles before, during, and after their collision. Look at the first picture on the handout. This picture shows Mumford on his bike		

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		science ideas and activities **after** the activity.	right before he starts to ride down the hill. Leroy is waiting for Mumford at the bottom of the hill. In the boxes next to the picture, describe the motion energy of Mumford and Leroy. **Students work on descriptions for the first image (2 min).** Now look at the second picture. Mumford is racing down the hill toward Leroy, and Leroy is still waiting for him at the bottom of the hill. Describe the motion energy of each boy in the boxes next to this picture. **Students work on descriptions for the second image (2 min).** Finally, look at the third picture on the handout. This picture shows Mumford crashing into Leroy. Describe the motion energy of Mumford and Leroy right after the collision. **NOTE TO TEACHER:** *Point out that the skid marks and lines on the third picture indicate that Mumford was slowing down after the crash, and Leroy started moving.* **Students work on descriptions for the third image (2 min).** **CONTENT NOTE TO TEACHER:**		

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			The third image denotes more than Mumford's motion energy transferring to Leroy, as mentioned earlier. In this inelastic collision, more is happening in terms of energy transformation, but the idea of motion energy becoming heat energy will be addressed in another lesson. In this lesson, students should focus only on motion (kinetic) energy. **Turn and Talk:** Now turn to your elbow partner and share your descriptions of Mumford's and Leroy's motion energy before, during, and after their collision. Start with the first picture on the handout and take turns sharing. **NOTE TO TEACHER:** *Following the Turn and Talk, give students 1 minute to make revisions to their ramp-and-marble diagrams using a different-colored pencil.*		
5 min	**Synthesize/Summarize Today's Lesson** **Synopsis:** Students learn that motion energy is called *kinetic energy*. Then they answer the focus question by synthesizing what they've learned about motion (kinetic) energy and energy transfer. **Main science idea(s):**	Highlight key science ideas and focus question throughout.	**Show slide 11.** ***Embedded Assessment Task*** **NOTE TO TEACHER:** *This is an opportunity for you to assess how well students understand science ideas about motion energy and energy transfer.* Our focus question is *What happens to energy when objects collide?*		

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	• The scientific term for motion energy is *kinetic energy*. When two objects collide, kinetic energy transfers from one object to the other object.	Engage students in making connections by synthesizing and summarizing key science ideas. Engage students in communicating in scientific ways. Highlight key science ideas and focus question throughout.	Think for a moment about Mumford and Leroy's big crash, our ramp-and-marble model, and the diagrams of the model that you drew earlier. Then write an answer to the focus question in your science notebooks. Use complete sentences and make sure to include evidence from the story, the model, and the diagrams. **Student work time.** **Whole-class share-out:** So how did you answer the focus question? As your classmates share their answers, be ready to agree, disagree, add on, or ask questions. **Show slide 12.** So we've talked a lot about motion energy in this unit. The scientific name for motion energy is *kinetic energy*. Write this new term in your science notebooks. Then write down the key science idea on the slide: ***Kinetic energy** is motion energy.* Below this, draw a picture of kinetic	Some energy moves to another object. Energy is transferred to another object.	Can you use the word *transfer* in your description? Does anyone agree or disagree with this answer? Do you have anything to add?

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			energy in your notebooks to help you remember what it is. Here's a hint: Show some kind of motion in your drawing. **NOTE TO TEACHER:** *Students could draw race-car wheels or legs running on top of the word* kinetic. **ELL support:** Consider writing the term *kinetic energy* on the board as well as on a sticky note and posting it on either the ramp-and-marble diagram or the picture of Mumford and Leroy's collision (or both) to help ELL students understand what the term means and what it's referring to.		
1 min	**Link to Next Lesson** **Synopsis:** The teacher announces that in the next lesson, students will think about where the energy of a moving object comes from.	Link science ideas to other science ideas.	**Show slide 13.** Mumford had a lot of motion energy, or kinetic energy, when he raced down that hill. We know that Leroy got some of Mumford's energy when they collided, but where did Mumford's energy come from? We'll explore that question next time.		