Energy: Every Day, Everywhere
Lesson 2: Patterns of Energy in Collisions

Grade: 4	**Length of lesson:** 55 minutes	**Placement of lesson:** 2 of 5 lessons on energy

Anchoring Phenomenon: The distance the rubber band is stretched in a toy car launcher affects the energy of a toy car as evidenced by the speed and distance the car travels.

Unit Learning Goal: The energy of objects and systems can be transferred and/or transformed. Changes in the energy of objects and systems can be observed and compared.

Lesson Main Learning Goal: Motion energy can be transferred from object to object through collisions. The faster an object is moving, the more motion energy it has that can be transferred to another object in a collision.

Science and Engineering Practices

Asking Questions ~~and Defining Problems~~

- Ask questions about what would happen if a variable is changed.
- Ask questions that can be investigated ~~and predict reasonable outcomes~~ based on patterns such as cause and effect relationships.

Crosscutting Concepts

Energy and Matter

- Energy can be transferred in various ways and between objects.

Patterns

- Patterns of change can be used to make predictions.

Unit Central Question: How does the energy of an object or system change?	**Lesson Focus Question:** What happens to motion energy when objects collide?

Science content storyline

The faster an object moves, the more motion energy it has. When a moving object collides with a stationary object, the moving object slows down (its motion energy decreases) and the stationary object begins to move faster (its motion energy increases). Because the speed of the objects changes during a collision, this is evidence that the motion energy of the objects also changes. Energy is transferred from a moving marble to a stationary marble during a collision. The faster an object is moving, the more motion (kinetic) energy it has and the more motion (kinetic) energy can be transferred through collisions.

Ideal student response to the Lesson **Focus Question:** When an object is moving, it has motion energy. When a moving object collides with a second object that isn't moving, the first object slows down or stops and the second object starts moving. The first object has motion energy. It transfers its motion energy to the second object. Because the first object transfers motion energy to the second object, it has less motion energy so it slows down. When the second object gets motion energy from the first object, it starts to move because it has more motion energy.

Preparation

MATERIALS NEEDED	AHEAD OF TIME
Teacher Resources • TE2.1 *Investigating Energy Changes in Collisions—Teacher Key* • TE 2.2 *Investigating Energy Changes: Analogy Map—Teacher Key Lesson 2* **Student Handouts** • HO 2.1 *Investigating Energy Changes in Collisions* (1 per student) • HO 2.2 *Investigating Energy Changes: Analogy Map* (1 per student) **Other Materials** • sticky note arrows • car launcher system • chart paper, markers, and painter's tape *per team of 4 students* • 1 red pencil and 1 blue pencil • 1 red marble and 1 blue marble • 1 12" ruler with center groove	• Review the information about energy transfer in the *Content Background* document. • Prepare all handouts and resources. • Post the CSW poster and Driving Question Board in a visible location. • Prepare a sheet of chart paper with the title "Science Ideas We've Figured Out". • Practice with the ruler-marble system so that you can easily push the red marble to make it roll down the groove in the ruler and collide with the stationary blue marble. When the red marble hits the blue marble, the red marble should stop and the blue marble should start moving.

Lesson 2 General Outline

Time	Phase of lesson	How the science content storyline develops
5 min	**Introduction:** Students summarize what the class figured out in the previous lesson.	
5 min	**Focus Question:** The teacher redirects students to the DQB questions about collisions and introduces the focus question. Students share their initial ideas about the question, *What happens to motion energy when objects collide?*	
10 min	**Setup for Activity:** Students are introduced to the ruler and marble system to explore energy changes in a collision. They think about how to represent the energy in a system and are introduced to energy bars as a way to show the amount of energy an object has.	The faster an object moves, the more motion energy it has. The amount of energy an object has can be represented with energy bars.
15 min	**Activity:** Students explore collisions using the marble-ruler system. Students consider the observable changes in the marbles before and after the collisions. They identify where the energy comes from and where the energy goes in the marble-ruler system and where in the system energy changes are occurring. They consider the amount of energy of each marble before and after the collision and represent the energy changes using energy bars.	When a moving object collides with a stationary object, the moving object slows down (its energy decreases) and the stationary object begins to move faster (its energy increases). Because the speed of the objects changes during a collision, the energy of the objects also changes.
10 min	**Follow-Up to Activity:** Students identify that energy is transferred from one object to another and use an analogy map to link science ideas from the marble-ruler system to the car launcher system.	Energy is transferred from a moving marble to a stationary marble during a collision. The faster an object is moving, the more energy it has and the more energy can be transferred through collisions.

Time	Phase of lesson	How the science content storyline develops
5 min	**Summarize and Synthesize:** Students revise and add to their response to the Lesson Focus Question. The class summarizes the science ideas of the lesson.	
5 min	**Link to Next Lesson:** Teacher links science ideas to the next lesson.	

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Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
5 min	**Introduction** <u>Synopsis</u>: Students summarize what the class figured out in the previous lesson.	Ask questions to elicit student ideas and predictions. Ask questions to probe student ideas and predictions. Engage students in communicating in scientific ways.	Let's look at our DQB chart to remind ourselves of our Unit Central Question, **How does the energy of an object or system change?** Last time, we explored the car launcher system to begin our learnings about energy. We used the Communicating in Scientific Ways, or CSW, strategies to help us communicate like scientists, which we will continue to use throughout this unit. Please turn in your science notebook to your revised Lesson Focus Question response from last time. Turn to your elbow partner to summarize what we learned from the car launcher system. Use sentence stems from rows 6 and 7 on the CSW chart as you share your ideas. Be prepared to share with the class. **What did we learn in the last lesson about energy?** ***NOTE TO TEACHER:*** *As students share their ideas, listen for the distinction between what we <u>did</u> and what we <u>figured out</u>. Ask elicit and probe questions as needed to support students to focus on what we <u>figured out</u>.* ***NOTE TO TEACHER:*** *Ideas to highlight in the discussion include the following:* • *Releasing the pulled-back rubber band can make the car start moving.* • *We saw a pattern: the more the rubber band is pulled back the farther the car will go when the rubber band is released to launch the car.* • *Energy is present when an object (the car, the launcher) is moving.* *Record these ideas on the sheet of chart paper titled "Science Ideas We've Figured Out" and add to the list in subsequent lessons. Each time you add to the list, use a different colored marker to highlight that we are*	We used the car launcher to see what parts had energy. **What parts of the car launcher system had energy?** The launcher had energy when we released the rubber band and the launcher pushed into the car. **What do others think? How did you know a part had energy?** It was moving. When something is moving, it has energy. **Did any other parts of the launcher have energy?**

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			learning more ideas about energy with each lesson. We've Figured Out chart will help students see that they are adding to their understanding of science ideas and making progress toward answering the Unit Central Question.	The car had energy after the launcher hit it because it started moving. **Did anyone notice any patterns?** We saw that when we pulled the rubber band back farther, the car went faster and farther.
5 min	**Focus Question** <u>Synopsis</u>: The teacher redirects students to the DQB questions about collisions and introduces the focus question. Students share their initial ideas about the question, "What happens to motion energy when objects collide?"	Set the purpose with a focus question. Ask questions to elicit student ideas and predictions.	Great job summarizing our learning from last time! At the end of our last lesson, we thought that our DQB questions about collisions would be a good place to continue our investigations into energy. Our focus question for this lesson is, **What happens to motion energy when objects collide?** As we investigate it today, it will help us begin to answer some of our questions on the Driving Question Board. **Will someone share what "motion (kinetic) energy" means, please?** Yes, that is correct. We know from our last lesson that there are other kinds of energy, but we will focus on motion energy as we study collisions. ***NOTE TO TEACHER:*** *Write this lesson's focus question on the board and have students write it in their notebook and draw a box around it. Refer to the focus question often throughout the lesson. It is imperative to emphasize the use of motion energy. This will help establish the foundational knowledge necessary for students to understand and differentiate between transfer and transformation of energy in general.*	It is the energy that moving objects have.

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			Under your focus question, please record your initial thinking using the sentence starter: *When objects collide, ...* Write this sentence in your notebook and leave plenty of room after it because we will revisit, add to, and revise our ideas as we investigate. ***NOTE TO TEACHER:*** *Allow time for students to write and respond to the focus question. Ask elicit questions to encourage students to share their best idea about the focus question so far.*	
10 min	**Setup for Activity** <u>Synopsis</u>: Students are introduced to the ruler and marble system to explore energy changes in a collision. They think about how to represent the energy in a system and are introduced to energy bars as a way to show the amount of energy an object has. <u>Main Science Ideas</u> The faster an object moves, the more motion energy it has. The amount of energy an object has can be represented with energy bars.	Ask questions to elicit student ideas and predictions. Ask questions to probe student ideas and predictions. Engage students in communicating in scientific ways. Engage students in using content representations and models.	Today we will use a different system to focus on what we observe happen and what that tells us about motion (kinetic) energy in collisions. Our new system will be a ruler and two marbles that will allow us to investigate what happens to motion (kinetic) energy when two objects collide. ***NOTE TO TEACHER:*** *Invite the class to gather around a demonstration ruler-marble system. With the ruler lying flat on a table, place the blue marble in the groove in center of the ruler and the red marble in the groove at one end of the ruler.* This is the marble-and-ruler system you will be using today. **Can you name the parts of our system?**	Well, there is the ruler, a red marble, and a blue marble. **Does anyone notice anything else that might be a part of our system?** Maybe the groove in the ruler? **What do others think? Why might we consider this a separate part from the ruler?**

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
		Highlight key science ideas and focus question throughout. Make explicit links between science ideas and activities.	OK, we have identified our system parts. **Does our system have any motion energy at this point? What observable changes can you provide as your evidence?** Now watch as I make a change to the system. ***NOTE TO TEACHER:*** *Give the red marble a push so that it rolls toward and collides with the blue marble. The blue marble should start moving and the red marble should stop. Repeat the demonstration several times, asking students to describe the changes they observe using CSW sentence stems. The purpose of this step is to identify observable changes in the system and use those observations to describe where energy changes are occurring. Support students to differentiate between observational changes in the system and the energy changes in the system. Remind them that their observations of change give them evidence for any energy changes. Support students to reach class consensus that initially the system has no observable motion, which is evidence that there is no motion (kinetic) energy. The moving finger inputs energy when it hits the red marble, causing it to move. The blue marble has "no motion" and the red marble has "more motion". After the collision, the blue marble has "more motion" and the red marble has "no motion" or "less motion".*	I agree with (___); it might be important because it is like a track for the marbles. I say no because I don't see anything moving. **And what do others think about that statement? D**o you a**gree** or **disagree?**

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			What did you observe about the system? As we share our thinking, refer to the CSW chart, rows 2, 6, and 7. Let's use observation sentence stems and terms like "no motion," "more motion," and "less motion". These are great observations about motion energy that you actually saw or observed in the system. Now let's consider our collision more closely. **Based on your observations, what can you say about motion (kinetic) energy in our system?** ***NOTE TO TEACHER:*** *Students will associate energy with motion, so most students will say the stationary marble has no energy since it is not moving.* **So, if the red marble did *not* have motion (kinetic) energy, and then it did, where do you think it got its energy?**	Well, I observed that you pushed the red marble and it started to move. **That's a great description of an observational change. Who can add to ___'s observation?** I saw that the blue marble didn't start moving until the red one hit it. Well, before you flicked the red marble it had no energy, but when it moved, it had energy. **What kind of energy are we considering?** Oh, I should have said motion energy! **What about the blue marble?** Well, when the blue marble wasn't moving, it had no motion energy. But then, when I saw it start moving it had motion energy. It started moving and had motion energy after you pushed it. Your finger was moving, so when you hit the marble some of your

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				motion energy went to the marble, so it moved. **Do others agree or disagree and why?**
			Let's consider the same question about the blue marble. **Where did it get its motion (kinetic) energy?**	The red marble hit it, and some of its motion energy went to the blue marble, making it move. **What do others think? Did you observe anything else about parts of our system that helps us describe any other motion (kinetic) energy in our system due to the collision?** I want to add to what ___ said. After the collision, the blue marble started moving, and then it had motion energy, but the red marble stopped moving, which means it then had no motion energy. I agree with ___, and I want to add that the red marble moved a little bit after the collision and then stopped moving. So that means it still had a little motion energy after it hit the blue one.
			You've done a nice job of sharing your observations about changes that you saw in our system. And then, based on those observations you described how motion	

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			(kinetic) energy changed during a collision. Great job of communicating like a scientist! I am going to introduce a new term for us to use when we talk about energy going from one object to another—*transfer.* Let's use that term from now on so we have a way of clearly expressing motion (kinetic) energy going from one object to another. We will continue to use the words *moving* or *motion* as evidence of motion (kinetic) energy being present in an object. Here is a challenge to help you begin to use this term: **How did the motion (kinetic) energy transfer into our system and throughout it during the collision? What was your evidence?** Take a few minutes to think and talk in your groups about it, then record your own thinking in your science notebook by using these sentence starters. *Motion (kinetic) energy transferred into our system to the red marble ...* *My evidence is ...* *Motion (kinetic) energy transferred during the collision from ... to ...* *My evidence is ...* We will keep practicing with these words to learn to communicate our thinking scientifically. ***NOTE TO TEACHER:*** *If the term "force" is used, then use this as another opportunity to help students differentiate between* force *and* energy. *Refer to Lesson 1 for suggested probe questions.* Now, let's consider another way to represent the amount of motion energy objects have before and after a collision. Under the sentences you wrote in your	

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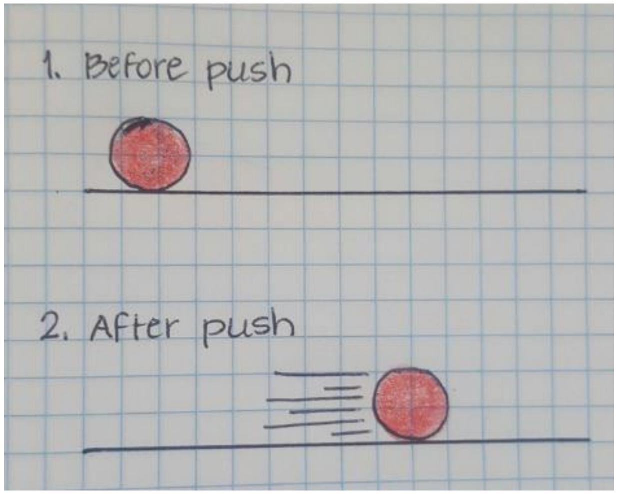
			notebook, draw and label a representation of only the red marble before and after it is pushed. ***NOTE TO TEACHER:*** *Ask a few students to share their representations with the class to show that there are many ways to represent the amount of motion energy an object has (see an example in figure 1).*  *Figure 1: Sample representation of a marble's motion energy* We saw a few different ways to represent an object's motion (kinetic) energy. Now, let's establish a common representation that we will all use so we can communicate clearly about our thinking. We will use energy bar representations for the amount of motion (kinetic) energy an object has. ***NOTE TO TEACHER:*** *Draw a stationary marble, before a push, on the board and add an energy bar below. Then draw the marble after the push and add an energy bar below. Invite students to share how we could represent the amount of motion (kinetic) energy of the marble*	

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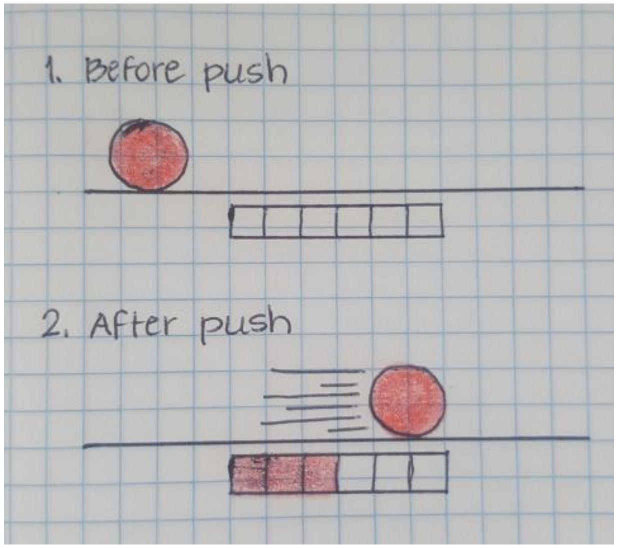
			before and after the push. Color the bars based on student ideas (figure 2).  *Figure 2: Sample representation of a marble's motion energy using energy bars*	
15 min	**Activity** <u>Synopsis</u>: Students explore collisions using the marble-ruler system. Students consider the observable changes in the marbles before and after the collisions. They identify where the energy comes from and where the energy goes in the marble-ruler system and where in the system energy	Ask questions to elicit student ideas and predictions. Ask questions to probe student ideas and predictions. Ask questions to challenge	As we continue to investigate motion (kinetic) energy and how it can be transferred in a collision using the ruler and marble system, we will use energy bar diagrams to clarify our thinking. We will also consider different collisions when the red marble has different amounts of motion (kinetic) energy before the collision. ***NOTE TO TEACHER:*** *Distribute HO 2.1:* Investigating Energy Changes in Collisions *to each student.* Take a moment to read the heading of each trial on your handout.	

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	changes are occurring. They consider the amount of energy of each marble before and after the collision and represent the energy changes using energy bars. <u>Main science ideas</u> When a moving object collides with a stationary object, the moving object slows down (its energy decreases) and the stationary object begins to move faster (its energy increases). Because the speed of the objects changes during a collision, the energy of the objects also changes.	student thinking. Engage students in communicating in scientific ways. Engage students in analyzing and interpreting data and observations. Link science ideas to other science ideas.	**What do you notice?** Yes, so let's establish our procedure. First, the blue marble should be stationary in the center of the ruler, and the red marble should be at one end of the ruler. In each trial you will give the red marble a different size push—small, medium, or large—as indicated on the handout. As your group completes each trial, discuss and come to consensus about the changes in motion (kinetic) energy of each marble and the amount of motion energy you will represent by filling in the energy bars with the appropriate color. Be sure to complete the representations for a trial before your group moves to the next trial. ***NOTE TO TEACHER:*** *Now, distribute a ruler, 2 marbles (1 red, 1 blue), and colored pencils (1 red, 1 blue) to each group. Provide any safety precautions for your classroom setting at this time. For example, you may have students use the system on the floor rather than on desktops or tables and designate a member of each group to stop the marble or have the marble run into a stationary object after it has traveled a certain distance. If desired, assign roles for students in their group. As groups work together to complete the trials and representations, circulate among groups asking elicit, probe, and challenge questions to make student thinking visible and move their thinking forward.* Scientists often share their thinking with other scientists. We will do that now by sharing data with another group. Our particular focus will be on looking for similar patterns in our groups' motion (kinetic)	The trials go from small to medium to large amounts of motion energy.

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			energy data. To do this you will be using sentence stems from Communicating in Scientific Ways chart row 3: "Organize data and observations; look for patterns". Remember, your focus is on finding similar patterns in both sets of data. ***NOTE TO TEACHER:*** *Emphasize that groups do not need to have consensus about the number of energy bars for each trial. However, groups should come to consensus about the pattern of change in motion and motion (kinetic) energy that occurred. Encourage students to use qualitative terms such as "no motion", "some motion", "more motion", and "no motion (kinetic) energy", "some motion (kinetic) energy", "more motion (kinetic) energy" to describe what happens before and after the collision. As groups share, circulate among groups asking elicit, probe, and challenge questions to focus student discussion on observable changes in the system, where in the system motion (kinetic) energy changes are occurring, where that energy comes from, and where the motion (kinetic) energy goes.* Let's now come together as a class to share the patterns you observed. Please use sentence stems from the rows on the CSW chart marked with sticky note arrows . **What patterns in motion (kinetic) energy did you observe from your energy bar data representations?** ***NOTE TO TEACHER:*** *Patterns to highlight in the discussion include the following:* • *In all three trials, before the collision, the red marble had motion (kinetic) energy as it was rolling toward the blue marble. The blue marble didn't have motion (kinetic) energy because it wasn't moving.*	We saw a pattern that the red marble always has less motion energy after the collision. **Did other groups find that same pattern? How was that pattern identifiable from your energy bars?** Yes, not as many red energy bars were colored in after the collision compared to before—so, less.

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			• *Just after the collision, the red marble slowed down or stopped and the blue marble started to move. The motion (kinetic) energy of the red marble decreased while the motion (kinetic) energy of the blue marble increased.* • *The more motion (kinetic) energy the red marble had before the collision, the more motion (kinetic) energy the blue marble had after the collision.*	**What other patterns did you see?** The blue marble had no motion energy before the collision and some motion energy after the collision. I want to add to what ___ said. The blue marble wasn't moving before the collision, but it was moving after the collision. It had more motion energy because it was moving. Our groups agreed. We colored no blue energy bars before, and we have more blue energy bars filled in after the collision. **Fantastic! Did you see any other patterns?** The faster the red marble was moving, the faster the blue marble went after the collision. **That's a great observation. How did you recognize that pattern in your energy bar data?** Well, going from trial 1 to 2 to 3, the red marble had more and more energy bars colored before the collision, and then, so did the blue marble after each collision. **What does that pattern tell us about motion (kinetic) energy? See if you can use the word "transfer" in your answer.**

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				The more motion energy the red marble has before the collision, the more motion energy is transferred to the blue marble after the collision, so it moves faster. **Great use of our new term "transfer"!** **Will someone else take a shot at telling us what another pattern means by including our new term?** I'll try ... the red marble wasn't moving at first, so it had no motion energy. But then when we pushed it, motion energy was transferred from us to the marble, making it move. **Yes, another good example! We will keep coming back to this.**
10 min	**Follow-up to Activity** <u>Synopsis</u>: Students identify that energy is transferred from one object to another and use an analogy map to link science ideas from the marble-ruler system to the car launcher system. <u>Main science ideas</u> Energy is transferred from a moving marble to a stationary marble during a collision. The faster an	Ask questions to elicit student ideas and predictions. Ask questions to probe student ideas and predictions. Engage students in communicating in scientific ways.	***NOTE TO TEACHER:*** *Share that we have figured out an important science idea: energy can be transferred from one object to another in a collision. Record this idea on the Science Ideas We've Figured Out chart in a different color marker. Ask students if there are other important science ideas we should add to the chart at this time.* *Using a different color of marker each time you add to the Science Ideas chart will help students see that they are adding to their understanding of science ideas and making progress toward answering the Unit Central Question.* Let's revisit our car launcher system to think more about the idea of transfer of motion (kinetic) energy in a collision. We will start by considering how the ruler	

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
	object is moving, the more energy it has and the more energy can be transferred through collisions.	Engage students in using and applying new science ideas in a variety of ways and contexts. Make explicit links between science ideas and activities.	and marble system and the car launcher system are similar. ***NOTE TO TEACHER:*** *Distribute HO 2.2:* Investigating Energy Changes: Analogy Map *to each student. Share that we can use an analogy map to help us compare how the two systems are similar. Highlight that the first column of the analogy map lists parts of the ruler-marble system, the third column lists parts of the car launcher system, and the fourth column explains how the parts of the two systems are similar.* *Model the process of completing the analogy map by completing the first row as a class. Then have pairs complete the next two rows.* Now, share your ideas with another pair. Focus on using the marked sentence stems on the CSW chart—rows 6 and 7. ***NOTE TO TEACHER:*** *As groups work, circulate through the room, asking elicit and probe questions as needed. Invite several groups to share their thinking about rows 2 and 3 of the analogy map to make sure there is class consensus.* Now that you have shared your thinking, please use your analogy map to individually consider collisions that occurred in the car launcher system. **How was motion (kinetic) energy transferred from one object to another in the system? What is your evidence?** ***NOTE TO TEACHER:*** *Invite students to share their ideas with their group. Then invite several groups to share their thinking with the class, using sentence stems from the CSW chart.* *Ideas to highlight in the discussion include the following:*	

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			• *In the car launcher system, there was a collision between the launcher and the car.* • *Before the collision, the launcher had energy of motion (kinetic) after the rubber band was released. The car did not have energy of motion (kinetic).* • *After the collision, the launcher stopped moving; it no longer had energy of motion (kinetic). The car started moving; it had energy of motion (kinetic).* • *The launcher transferred its motion (kinetic) energy to the car through the collision.* *Ask students to share how the analogy map helped them think about how the two systems were similar and how motion (kinetic) energy was transferred from one object to another in the collision in the car launcher system.*	
5 min	**Summarize and Synthesize** <u>Synopsis</u>: Students revise and add to their response to the Lesson Focus Question. The class summarizes the science ideas of the lesson.	Ask questions to elicit student ideas and predictions. Ask questions to probe student ideas and predictions. Engage students in communicating in scientific ways.	Please return to the Lesson Focus Question in your science notebook: **What happens to motion energy when objects collide?** Review your initial response and add to or revise it in a different color. Draw a single line through any ideas you want to change so you can see how your ideas have changed and grown during today's lesson. **I'd love to hear your answers to the focus question and how your ideas changed from the start of the lesson to now. Who would like to share their thinking?** Notice I have marked row 11 of the CSW chart with a sticky note arrow, so please use those sentence stems.	I said that in a collision, motion energy transfers from the thing that is moving to the thing that isn't moving. I added "transfer" to my first answer.

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		Engage students in making connections by synthesizing and summarizing key science ideas.	Thank you for sharing how your ideas changed. I noticed that you both said that motion (kinetic) energy is transferred from one object to another when they collide.	I changed my idea. At the start of class I said that the collision makes energy because the car starts to move. Now I changed it to say I think the motion energy came from the launcher, which had motion energy.
		Summarize key science ideas.	**What do others think about that?**	Yes, I agree! The thing that is moving has motion energy, and it gives it—it transfers it—to the thing that isn't moving. That's why the red marble stopped. Because it gave its motion energy to the blue marble.
		Highlight key science ideas and focus question throughout.	Underneath your revised focus question response, draw and label an energy bar diagram for two of the trials from our marble-and-ruler system: • A red marble is pushed with a small amount of energy and collides with a nonmoving blue marble. • A red marble is pushed with a large amount of energy and collides with a nonmoving blue marble. Share and discuss your representations with your elbow partner. Ask each other questions if you are not in agreement about something. OK, I am going to go around to each group and ask one question. Listen to the questions, as they will be in order of what happens in each collision. After each group responds to their question, please indicate your agreement or not using thumbs up or thumbs down. If you think their response was a little incomplete or	

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			needed more detail or you just aren't sure, use a wavy hand like this. Our goal is to work together to develop the best explanation that we can about what happens to motion (kinetic) energy during a collision. This is our best collective thinking, not a competition. OK, let's start. ***NOTE TO TEACHER:*** *As you move through the following questions, encourage other groups and model the use of questions to probe and challenge responses. Aim for something like the responses in the next column. Make sure that students include proper terminology that has been learned thus far.* First, I have a few important general questions which I would like all groups to discuss, then we will need a member of each group to share their group's thinking. **What system did we use today, and what were its parts?** **How did thinking about the system help us describe motion (kinetic) energy and any changes?** Good job! OK, let's now construct our best explanation about what happens to motion (kinetic) energy during a collision. Be sure to remember that our observations provide us evidence of changes.	The ruler and marble system, which had a red marble, a blue marble, and a ruler with a groove. Well, first we looked at, or observed, each part to see if it was moving or not. If it wasn't, that was our evidence that it had no motion energy. When we saw a part moving, we knew it had motion energy. The system had no motion energy. We know that because we observed

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			Group 1: In both trials, before the red marble was pushed, what statement can you make about the motion (kinetic) energy of the system, and what is your evidence? Group 2: In both trials, what caused the red marble to begin moving? Group 3: Compare the motion (kinetic) energy bar data of the red marble in both trials before it collided with the blue marble and explain why they were different. Group 4: How do the motion (kinetic) energy bar data of the blue marble in both trials compare before it was hit by the red marble? Group 5: Make a statement about the transfer of motion (kinetic) energy into and within the marble-and-	that nothing in the system was moving. That is our evidence. It moved because motion energy was transferred to the marble from the hand. We saw the hand move and push the marble, which made the marble move, so it had motion energy. The motion energy bar before collision in the small-amount-of-energy trial had only a few bars colored in, but the energy bar for the large-amount-of-energy trial had many more bars colored in. This is because the red marble had just a little motion energy in trial 1, but lots of motion energy in trial 3. The blue marble motion energy bar before collision in both trials is the same—zero, because it wasn't moving. The moving hand transferred some of its motion energy to the red

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Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			ruler system in the small-amount-of-energy trial collision.	marble, which moved and collided with the blue marble. This collision transferred motion energy from the red to the blue marble.
			Group 6: Make a statement about the transfer of motion (kinetic) energy into and within the marble-and-ruler system in the large-amount-of-energy trial collision.	It is basically the same as the last question, but there is more motion energy transferred. The moving hand transferred some of its motion energy to the red marble, which moved and collided with the blue marble. This collision transferred motion energy from the red to the blue marble.
			Group 7: Summarize what you have learned about what happens to motion (kinetic) energy during a collision.	A moving object has motion energy. When it collides with an object that isn't moving, it transfers some of its motion energy to that object. This causes the first object to move slower and have less motion energy and the second object to start moving and have more motion energy.
5 min	**Link to Next Lesson** Synopsis: The teacher links science ideas to the next lesson.	Link science ideas to other science ideas (next lesson).	That was great collaborative thinking we did! We have used two different systems so far. **In each one, how was the amount of motion (kinetic energy an object had changed?** Yes, our two systems have involved collisions to transfer motion (kinetic) energy. I wonder if there are other ways to change the amount of motion (kinetic) energy	 One object collided into another.

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Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			an object has. Let's look at our Driving Question Board at this group of questions that focuses on amount of energy or changes to the amount on energy. In our next lesson, we will investigate ways to change the amount of energy of an object.	

BSCS Science Learning
Transforming Science Education Through Research-Driven Innovation

Energy: Every Day, Everywhere Lesson 2
Patterns of Energy in Collisions

1

Unit Central Question

How does the energy of an object or system change?

2

Science Ideas We've Figured Out

Science Ideas We've Figure Out
-
-
-
-
-

3

Lesson 2: Focus Question

What happens to motion energy when objects collide?

4

Marble-Ruler System

- Identify the parts of the marble-ruler system.
- What observable changes are happening in the system?

5

Representing Energy in the System

Draw a representation of the red marble before and after the push.

1. Before the push

2. After the push

6

Energy bars can represent energy.

No energy

Some energy

A lot of energy

7

Investigating Energy Changes in Collisions

Investigating Energy Changes in Collisions

Trial 1: A Small Amount of Energy

Energy bars
red energy bars for the red marble
blue energy bars for the blue marble

1. The red marble is rolling toward the blue marble

Red marble Blue marble

2. The red marble has just hit the blue marble

Red marble Blue marble

8

Science Ideas We've Figured Out

Science Ideas We've Figure Out

-
-
-
-
-

9

Analogy Map—Comparing Systems

Investigating Energy Changes
Analogy Map

Part of Ruler/Marble System	Represents...	Part of Car Launcher System	They are alike because:
Red marble			
Blue marble			
		Track	

10

Lesson 2: Focus Question

What happens to motion energy when objects collide?

11

Next Steps

Are there other ways to change the amount of motion energy of an object?

12

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HO 2.1

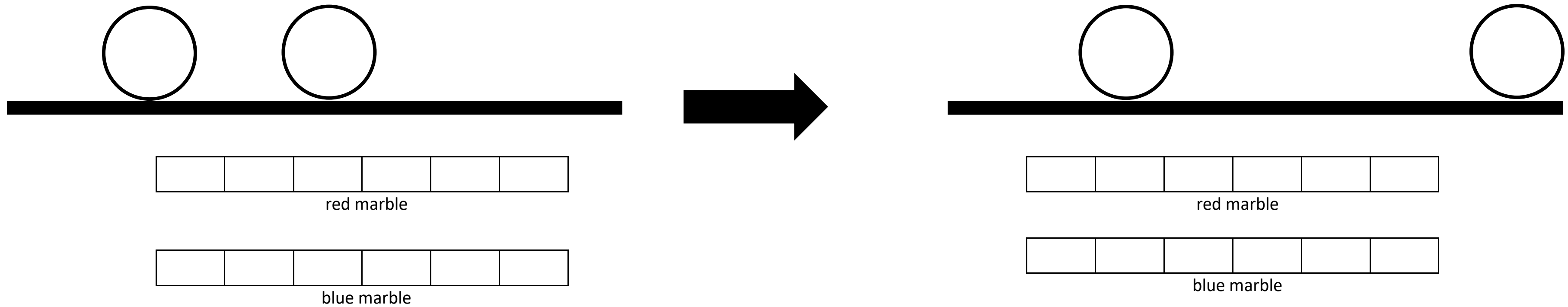
Investigating Energy Changes in Collisions

Trial 1: A Small Amount of Energy

Energy bars
red energy bars for the red marble
blue energy bars for the blue marble

1. The red marble is rolling toward the blue marble.

2. The red marble has just hit the blue marble.

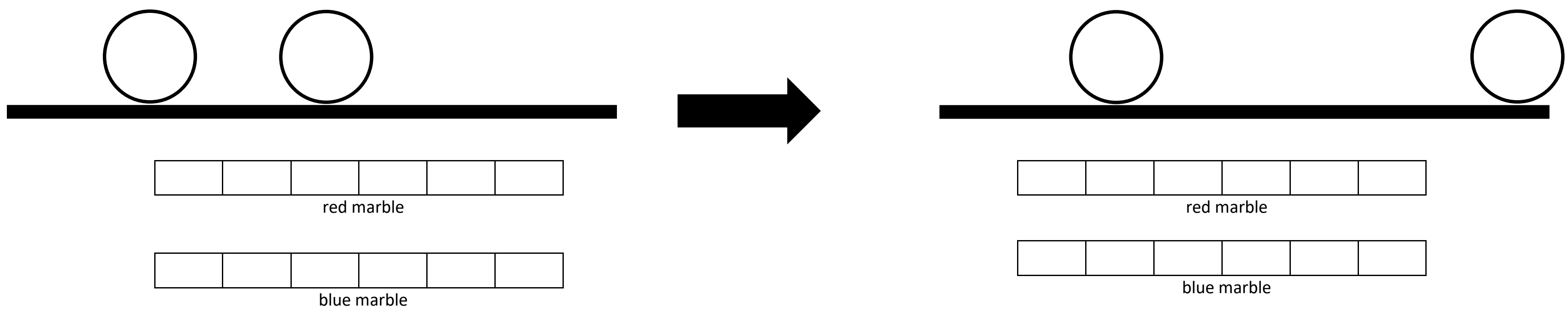


Trial 2: A Medium Amount of Energy

Energy bars
red energy bars for the red marble
blue energy bars for the blue marble

1. The red marble is rolling toward the blue marble.

2. The red marble has just hit the blue marble.



HO 2.1

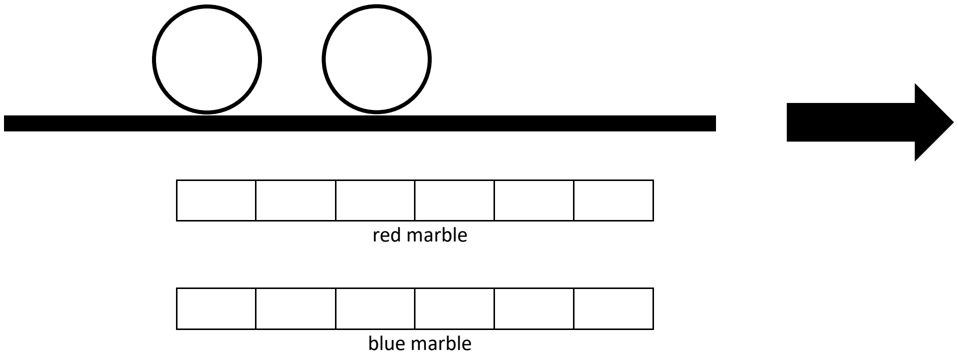
Trial 3: A Large Amount of Energy

Energy bars

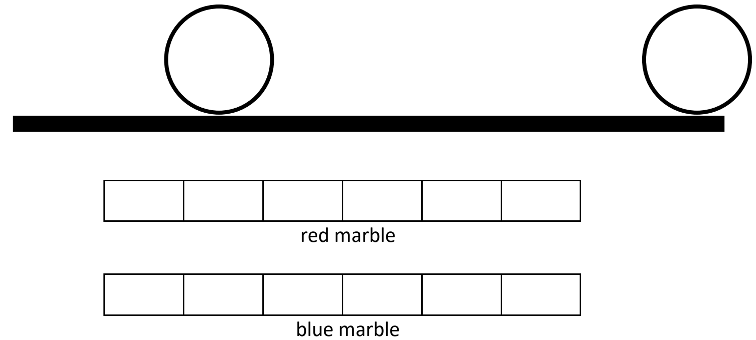
red energy bars for the red marble

blue energy bars for the blue marble

1. The red marble is rolling toward the blue marble.



2. The red marble has just hit the blue marble.



Investigating Energy Changes in Collisions—Teacher Key

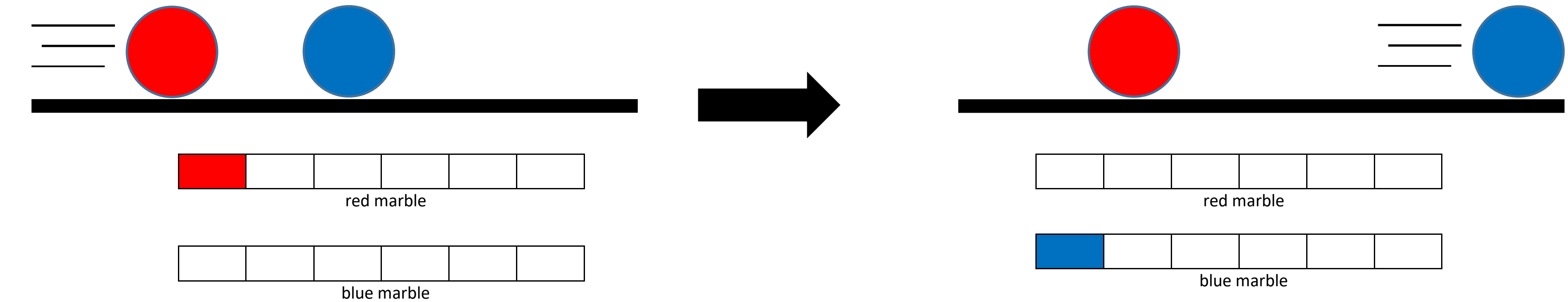
Trial 1: A Small Amount of Energy

Energy bars

red energy bars for the red marble
blue energy bars for the blue marble

1. The red marble is rolling toward the blue marble

2. The red marble has just hit the blue marble



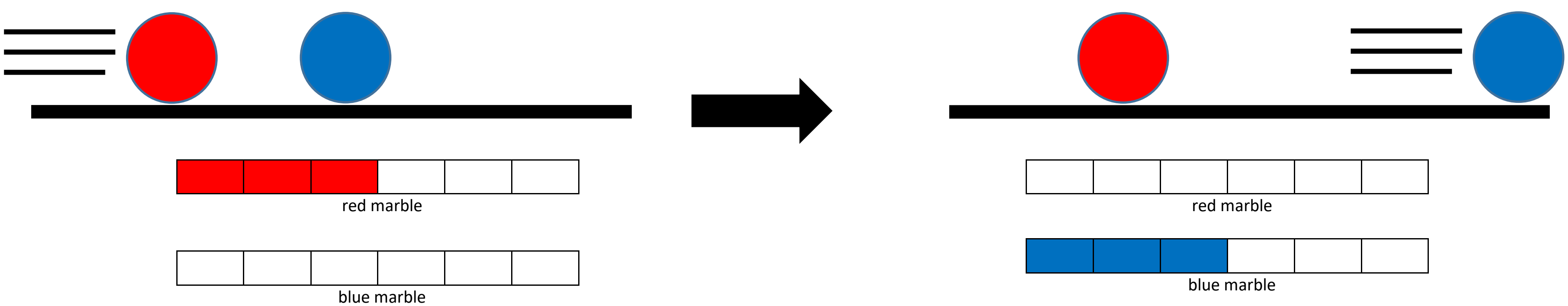
Trial 2: A Medium Amount of Energy

Energy bars

red energy bars for the red marble
blue energy bars for the blue marble

1. The red marble is rolling toward the blue marble

2. The red marble has just hit the blue marble



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Trial 3: A Large Amount of Energy

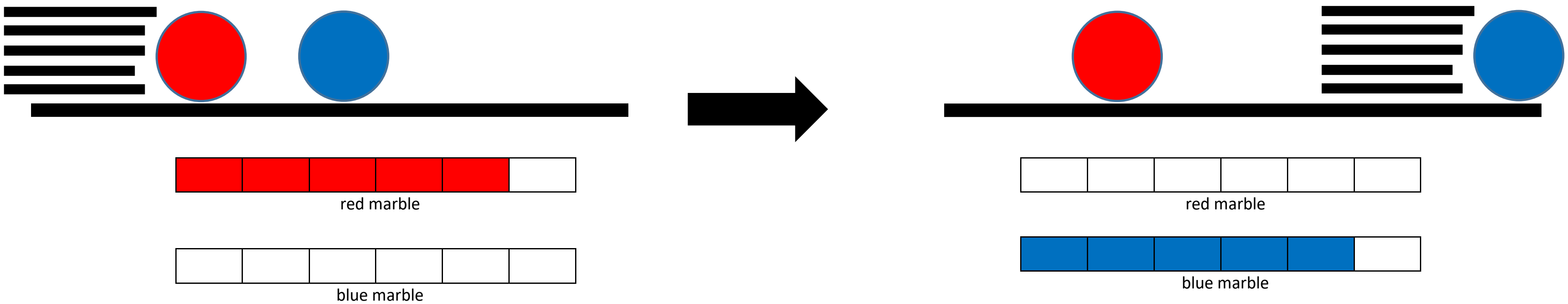
Energy bars

red energy bars for the red marble

blue energy bars for the blue marble

1. The red marble is rolling toward the blue marble

2. The red marble has just hit the blue marble



Investigating Energy Changes
Analogy Map

Part of ruler-marble system	Represents ...	Part of car launcher system	They are alike because ...
Red marble			
Blue marble			
		Track	

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Investigating Energy Changes
Analogy Map—Teacher Key Lesson 2

Part of ruler-marble system	Represents ...	Part of car Launcher system	They are alike because ...
Red marble		Launcher bar	They crash into the stationary object.
Blue marble		Car	They are not moving at the beginning. Something crashes into them.
Groove in the ruler		Track	They keep the objects moving in a straight line.