Energy: Every Day, Everywhere
Lesson 3: Predicting and Observing Changes in Energy

Grade: 4	**Length of lesson:** 100 minutes	**Placement of lesson:** 3 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: Position energy (potential energy) can be transformed to motion energy (kinetic energy). The more position energy an object has, the more energy can be transformed to motion energy. As position energy is transformed to motion energy, the object will move faster.

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.

Constructing Explanations and Designing Solutions

- Construct an explanation of observed relationships (e.g., the distribution of plants in the backyard).
- Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation ~~or design a solution to a problem~~.
- Identify the evidence that supports particular points in an explanation.

Crosscutting Concepts

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:** How can we change the amount of motion (kinetic) energy of an object?

Science content storyline

The faster an object moves, the more motion (kinetic) energy it has. As an object goes down an incline, it goes faster and faster as position energy (potential energy) is converted to motion energy (kinetic energy). The higher the incline, the faster the object goes when it moves down the incline. Objects that are not moving can have position (potential) energy. Position (potential) energy can be transformed into

energy of motion (kinetic). If the moving object has a collision with another object, energy can be transferred from one object to another and the motion of each object will change. The more motion (kinetic) energy an object has, the more energy will be transferred in the collision.
Ideal student response to the Lesson Focus Question: We can change the motion energy of an object when its stored (potential) energy is transformed to energy of motion and the object begins to move faster. The more stored energy it has, the faster it will move as the energy is transformed from stored to motion. If the moving object has a collision with another object, energy can be transferred from one object to another and the motion of each object will change. The more motion energy an object has, the more energy will be transferred in the collision.

Preparation

MATERIALS NEEDED	AHEAD OF TIME
Teacher Resources • TE 2.2 *Investigating Energy Changes: Analogy Map—Teacher Key Lesson 2* • TE 3.1 *Predicting and Observing Changes in Energy—Teacher Key* • *Teacher Key: Energy Changes Card Sort* **Student Handouts** • HO 2.2 *Investigating Energy Changes: Analogy Map* (from Lesson 2; 1 per student) • HO 3.1 *Predicting and Observing Changes in Energy* (1 per student) **Other Materials** • sticky note arrows • car launcher system *For each team of 3 students* • 1 red pencil and 1 blue pencil • 1 red marble • 2 12” rulers with center groove • 1 Styrofoam piece with a notch cut out • 3 wooden blocks • 1 sheet of plain, white 8.5” × 11” paper • transparent tape	• Review the information about energy transfer and transformation in the *Content Background* document. • Prepare all handouts and resources. Make a few extra copies of HO 2.2 from Lesson 2 in case students do not have theirs from the last lesson. • Post the CSW poster and the Driving Question Board and the Science Ideas We’ve Figured Out chart in visible locations. • If needed, cut a small notch in the Styrofoam so that the marble will land in the notch once it rolls off the ramp (figure 3.1).  **Figure 3.1**: After the marble rolls down the ramp, it collides with the Styrofoam in the notch. Both marble and Styrofoam move together until they both come to rest.

For each pair of students • *Energy Changes Card Sort Set 1* • *Energy Changes Card Sort Set 2*	• Practice with the ruler-marble-Styrofoam ramp system so that when the marble rolls down the groove in the ruler and collides with the Styrofoam piece, then the marble and Styrofoam move together until both come to rest.

Lesson 3 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 introduces the focus question. Students share their initial ideas about the question, *How can we change the amount of motion (kinetic) energy of an object?*	
20 min	**Setup for Activity:** Students predict what will happen to a piece of Styrofoam block when a marble is rolled down a ramp placed at different heights.	The faster an object moves, the more motion (kinetic) energy it has (Lesson 2).
30 min (20 min in the first class period + 10 min in the next class period)	**Activity:** Students use the ruler-marble-Styrofoam system to roll a marble down a ramp placed at different heights into a Styrofoam block. They observe and compare how the energy changes with the height of the ramp. Students use energy bars to compare the amounts of energy to changes in the height of the ramp and speed of the marble. Students identify that, in addition to energy of motion, an object may have stored energy of position (potential energy). They identify that stored energy of position can be transformed into energy of motion. They explain that the more stored energy an object has the more	As an object goes down an incline, it goes faster and faster as energy of position (potential energy) is converted to energy of motion (kinetic energy). The higher the incline, the faster the object goes when it moves down the incline. We observe a pattern that can be used as evidence to support our explanation (CCC 1): An object that is released from a higher position goes faster and farther than an object that is released from a lower position. Objects that are not moving can have stored (potential) energy of position. Stored (potential) energy of position can be transformed into energy of motion (kinetic).

Time	Phase of lesson	How the science content storyline develops
	energy will be transformed into energy of motion, causing the object to move faster.	
30 min	**Follow-up to Activity:** Students link observed changes in the marble-ruler system with science ideas in a card sort to explain the energy changes in the system. They use additional cards to link science ideas from the marble-ruler system to the car launcher system.	Pulling back a rubber band gives it more stored (potential) energy of position. We can construct an explanation of observed relationships (SEP 6): A stretched rubber band has stored (potential) energy of position. When the stretched rubber band is released, stored energy (potential energy) decreases and energy of motion (kinetic energy) increases (CCC 5). The more energy of motion an object has, the more energy it can transfer to another object through a collision (Lesson 2).
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:** The class revisits the Driving Question Board to identify questions they have figured out and questions they still need to figure out. The teacher links science ideas to the next lesson.	

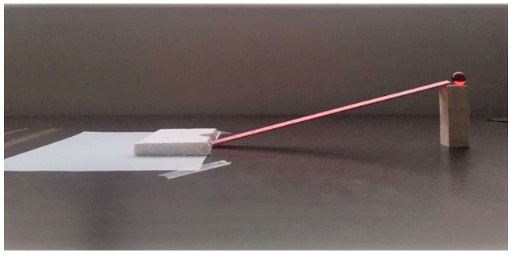
Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
5 min	**Introduction** <u>Synopsis</u>: Students summarize what the class figured out in the previous lesson.	Ask questions to elicit student ideas and predictions. Ask questions to probe student ideas and predictions. Engage students in communicating in scientific ways.	Let's begin today by looking at our Driving Question Board, the DQB. Our Unit Central Question, which is the title of the DQB, is **How does the energy of an object or system change?** As in every day, we will use our CSW chart to communicate like scientists. Please turn in your science notebook to your revised answer to the focus question from the last lesson, reread your response, and quietly think about your learning. Once you've done that, refer to the Science Ideas We've Figured Out chart. **What did we figure out in the last lesson?** ***NOTE TO TEACHER:*** *Provide a few moments for silent think time. Mark rows 6 and 7 on the CSW chart and encourage students to use sentence stems from these rows as they share their ideas with the class.* *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>.* *Ideas to highlight in the discussion include the following:* • *Energy is present when an object is moving; the faster an object is moving, the more energy it has. The energy is in the form of motion (kinetic) energy.* • *We can show the amount of energy an object has by using energy bars.* • *When a moving object collides with a stationary object, the moving object slows down or stops and the stationary object begins to move.*	We figured out that motion energy gets transferred when things collide. **Can you say more about motion (kinetic) energy transfer when things collide?** When the red marble collided with the blue marble, the red marble stopped and the blue marble started moving. **How does the change in motion you described show how energy changed?** Well, the red marble had motion energy when it was moving. The blue marble didn't have any motion energy at first. But when the red marble hit the blue marble, it started moving, so it got motion energy.

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			• *Energy can be transferred from one object to another through a collision.* • *The more energy a moving object has, the more energy it can transfer to another object through a collision.* • *Scientists think and communicate in specific ways. We can think and communicate like scientists when we use the Communicating in Scientific Ways (CSW) sentence stems.*	**Where did the blue marble's motion (kinetic) energy come from?** It came from the red marble. The red marble gave its energy to the blue marble. I want to piggyback on ___'s answer. When the red marble gave its energy to the blue marble it transferred its energy. And, when the red marble transferred all its energy to the blue marble it didn't have any motion energy left, so it stopped moving. **Wow! You figured out a lot of ideas about motion (kinetic) energy in the last class! You also did a great job of communicating like scientists as you shared your ideas with the class.**
5 min	**Focus Question** <u>Synopsis</u>: The teacher introduces the focus question. Students share their initial ideas about the question, *How can we change the amount of motion (kinetic) energy of an object?*	Set the purpose with a focus question. Ask questions to elicit student ideas and predictions. Ask questions to probe student ideas and predictions.	At the end of our last lesson, we wondered if there are other ways to change the amount of motion (kinetic) energy an object has. This group of questions on our Driving Question Board focuses on the amount of energy or changes to the amount. Today we will investigate ways to change the amount of motion (kinetic) energy of an object. Our investigations will help us answer the focus question for this lesson, **How can we change the amount of motion (kinetic) energy of an object?** ***NOTE TO TEACHER:*** *Write this lesson's focus question on the board and have students write it in their*	

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			notebook and draw a box around it. Refer to the focus question often throughout the lesson. Take a few minutes to write your best ideas under the question in your science notebook. As we move through our lesson, you will have a chance to revise your ideas. Be prepared to share your current thinking with the class.	
20 min	**Setup for Activity** <u>Synopsis</u>: Students predict what will happen to a piece of Styrofoam when a marble is rolled down a ramp placed at different heights. <u>Main science ideas</u>: The faster an object moves, the more motion (kinetic) energy it has (Lesson 2).	Ask questions to elicit student ideas and predictions. Ask questions to probe student ideas and predictions. Ask questions to challenge student thinking. Engage students in communicating in scientific ways. Make explicit links between science ideas and activities.	Let's start by revisiting and thinking about motion (kinetic) energy changes in one of the systems we have investigated—the car launcher system. **How did we change the amount of motion (kinetic) energy in the car launcher system?** Who will start our sharing? ***NOTE TO TEACHER:*** *Ask elicit, probe, and challenge questions to help students link evidence from observed changes to their ideas about energy changes in the system. Listen for student ideas such as stretching the rubber band farther caused the launcher to move faster before the collision and the car to move faster after the collision. Faster motion is evidence that the motion energy in the system increased. Add to the Science Ideas We've Figured Out chart, if not already listed, this idea that we can change the motion energy in the car launcher system by changing how far the rubber band is stretched.*	When we pulled the rubber band farther back, we made the launcher move faster. **What do others think?** I agree, and that made the car move faster, and farther, after the collision. **Where did the collision occur?** When the rubber band launcher hit the car. **What evidence was there that the amount of motion (kinetic) energy in the system changed?** The faster something is moving, the more motion energy it has. So, the faster the launcher moves, the faster the car moves, and the more motion energy they have.

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.	OK, now think about the second system we have used—the ruler-marble system. **How did we change the amount of motion (kinetic) energy in the marble-ruler system?** ***NOTE TO TEACHER:*** *Listen for student ideas such as the harder or bigger the push, the more energy the red marble had. Faster motion of the red marble is evidence that it had more motion (kinetic) energy. Make sure to draw a distinction between observed changes in the system (e.g., changes in motion) and changes in motion (kinetic) energy. Observable changes in the system provide evidence for where in the system motion (kinetic) energy changes are occurring.* **Can you think of any other ways we could change the amount of motion (kinetic) energy in the ruler-marble system?**	We changed how hard we pushed the red marble. **What did pushing the red marble harder cause?** The harder we pushed the red marble, the faster it rolled. **Can anyone add to that idea?** I want to add to what ___ said. The faster the red marble rolled on the ruler, the more motion energy it had. **Yes, and so what happened when the red marble collided with the blue one?** Well, because it had more motion energy, it transferred more to the blue marble. **Who can tell us what our evidence was?** We observed that the blue marble rolled faster, too. We could use a rubber band to launch the marble. **That's a great idea. How else could we change the amount of motion (kinetic) energy in the ruler-marble system?**

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			This is a great time to make some links or connections between our two systems and how motion (kinetic) energy can be increased. We've just said that stretching the rubber band farther in the car launcher system increases the motion (kinetic) energy in the system. And, on our Notice and Wonder chart, we wondered if increasing the height of the red marble by making a ramp could increase the motion (kinetic) energy in the system. So, let's investigate our wondering! Please quietly gather around to observe the system we will use today. We will call it the ruler-marble-Styrofoam system. Notice we will use only the red marble in this system. We will replace the blue marble with a Styrofoam piece. This change will help us better observe the evidence of changes we can use in motion (kinetic) energy. ***NOTE TO TEACHER:*** *Demonstrate elevating one end of the ruler to make a ramp. Explain that one wooden block will be used for the low ramp and three wooden blocks for the high ramp. Place the notched side of the Styrofoam piece at the edge of a piece of white paper taped down to the table surface. Point out that the Styrofoam and the paper should be at the end of the ruler, with the ruler centered at the notch. Show how a mark should be made on the paper at one end of the Styrofoam (figure 3.2). Place the marble at the top of the ramp, emphasizing that, in each trial, the marble should start from the same place on the ruler and that it is important to not push the marble but rather to just release it. Demonstrate this from the low ramp so students can observe how the marble will collide with*	We could lift up one end of the ruler to make a ramp.

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			the Styrofoam, causing them to move together until they come to rest. Note that if the marble does <u>*not*</u> *collide with the Styrofoam in the groove or the marble bounces back from the Styrofoam before it stops, then the trial must be repeated. Once the marble and the Styrofoam come to a stop, mark on the paper at the notched side of the Styrofoam. Demonstrate how to use a second ruler to measure the distance the Styrofoam piece moved.*  **Figure 3.2:** Ruler-marble-Styrofoam system setup	
30 min (20 min in the first class period + 10 min in the next class period)	**Activity** <u>Synopsis</u>: Students use the ruler-marble-Styrofoam system to roll a marble down a ramp placed at different heights into a Styrofoam . They observe and compare how the energy changes with the height of the ramp. Students use energy bars to compare the amounts of energy to changes in the height of the ramp and speed of the marble.	Ask questions to elicit student ideas and predictions. Ask questions to probe student ideas and predictions. Ask questions to challenge student thinking.	Now, you will use this system for your own investigation. ***NOTE TO TEACHER:*** *Distribute HO 3.1:* Predicting and Observing Changes in Energy *to each student. Invite students to examine with an elbow partner the organization of the handout and what data they will be collecting.* Notice that first you will compare two ramp setups and make predictions about the changes we might observe and why you think this. Use terms that show a comparison of the two systems, for example, *faster* or *slower*, *more energy* or *less energy*, and *farther* or *less far*.	

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
	Students identify that, in addition to energy of motion, an object may have stored energy of position (potential energy). They identify that stored energy of position can be transformed into energy of motion. They explain that the more stored energy an object has the more energy will be transformed into energy of motion, causing the object to move faster. <u>Main science ideas</u> As an object goes down an incline, it goes faster and faster as energy of position (potential energy) is converted to energy of motion (kinetic energy). The higher the incline, the faster the object goes when it moves down the incline. We observe a pattern that can be used as evidence to support our explanation (CCC 1): An object that is released from a higher position goes faster and farther than an object that	Engage students in communicating in scientific ways. Engage students in analyzing and interpreting data and observations. Engage students in using content representations and models. Make explicit links between science ideas and activities. Link science ideas to other science ideas. Highlight key science ideas and focus question throughout.	Take a few minutes to complete step 1 by making your predictions with your elbow partner. ***NOTE TO TEACHER:*** *The purpose of this step is for students to use their prior and current knowledge to predict observable changes in the system and link those changes to changes in energy. Students will revisit their predictions to see if they are supported or not by their data. Therefore, at this point, do not have students share.* Now it is time to test your predictions. After each trial, record your data in the table in step 2 of the handout. Please complete ramp 1 first, then move to ramp 2. Remember to measure in centimeters! Once you have completed step 2, stop. ***NOTE TO TEACHER:*** *If necessary, make sure that students can read the ruler in centimeters to ensure proper data collection. Distribute a set of materials to each group. As groups work to complete the trials, circulate among groups asking elicit, probe, and challenge questions to make student thinking visible and move their thinking forward.* Good job collecting and recording your data! Please look up here at the Communicating in Scientific Ways chart. I am placing a sticky note arrow to rows 2 and 3: Observe and Organize data and observations and look for patterns. Please work in your group to complete step 3. Identify pattens in your data using the appropriate sentence stems. Also, look back at your predictions to see if your data support your predictions. Now, let's quietly gather around my ruler-marble-Styrofoam system and dig more deeply into the energy changes that occur. We will use ramp 2, the higher ramp.	

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
	is released from a lower position. Objects that are not moving can have stored (potential) energy of position. Stored (potential) energy of position can be transformed into energy of motion (kinetic).		***NOTE TO TEACHER:*** *It is important to have this discourse with the class* ***before*** *asking students to complete step 4 as they have not yet been introduced to position energy. Roll the marble down the ramp and catch it at the bottom before it collides with the Styrofoam block. Invite students to consider the red marble when it is in the position at which you caught it—at the bottom of the ramp just before collision. Although your students' responses may not be just like the examples shown, be prepared to ask elicit, probe, and challenge questions to guide the discourse as follows.* **What can we say about the marble's energy at this point?** **Now, what if I place the marble at the top of the ramp and just hold it here? Does it have energy here?**	The marble is moving fast there, so it has lots of energy. **What kind of energy does the marble have?** Motion energy. **What do others think?** I agree with ___ and think it has the most motion energy because it looked like it went faster and faster down the ramp. I want to piggyback on ___'s idea. The marble would have more motion energy at the bottom because it is moving faster than at the top of the ramp. No, the marble isn't moving, so it has no energy. **Can someone add to what (_) said?** Well, it has no motion energy at the top when you are holding it still.

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			Yes, good job pointing out that it is not moving, so it has no motion (kinetic) energy. But here is a challenge: **Where did the motion (kinetic) energy the marble had at the bottom of the ramp come from if it had none at the top?** Here is a hint: Think about the ruler now as compared to the ruler in Lesson 2. Turn to your elbow partner to think about this and share your ideas. Interesting; what do others think? Let's think about and compare ramp 1 and ramp 2 from today. **Does this comparison tell us anything about lifting one end of the ruler?** So, our data indicate that the ramp 2 marble had more motion (kinetic) energy at the bottom than the ramp 1 marble. Our evidence is that the Styrofoam and the marble went farther. **Does that help us think about where that energy might have come from?**	Well, your hint made us remember that the ruler was flat, but now we made it into a ramp, so maybe lifting it up gave it energy? Is that it? The marble looked like it was moving faster at the bottom of ramp 2. And it was higher. **Can anyone give us evidence of that?** Yes, our data show that the Styrofoam and the marble moved farther from ramp 2 than from ramp 1. So, they were moving faster from ramp 2. **Do other groups' data agree with that?** It must come from the height of the ramp because the higher ramp gave the marble more motion energy. **What do others think about that idea?**

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			Yes, in fact, when we make one end of the ruler higher than the other, the marble has stored energy at the top of the raised side. We will call this *position (potential) energy*. Notice that we now have identified two kinds of energy—motion energy (kinetic energy) and position energy (potential energy). But it seems there is more to this idea. Let's consider a few scenarios: **What if I place and hold the marble here about halfway down the ramp? What would you say about its energy?** That is important for us to remember. An object has position (potential) energy if it is in a place that is higher than another place. So, if one end of the ramp is higher than the other, the marble has some position (potential) energy all along the ramp until it gets to the bottom. Based on what we have said so far, please write and complete these sentence stems in your science notebook:	It isn't moving so it has no motion energy. **What about position (potential) energy?** It is not as high as the top, but it still is higher than the bottom of the ruler, so it must have some position energy.

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			Any object that is in a raised or higher position has ... *The higher it is raised ...* *Any object that is moving has ...* *The faster it is moving ...* ***NOTE TO TEACHER:*** *Ask students to share their responses. Use elicit and probe questions to ensure that they can differentiate motion energy and position energy. Position (potential) energy can be hard for young students, especially if the ground is mentioned. Whether you are on the top of a hill or at the bottom, you are still on the ground! Therefore, use a phrase like "the object is at a place higher than this place" or "at position A, the object is higher than at position B" to avoid student confusion.* Considering what we have just discussed, as well as our data from step 2, let's think about this question: **How would you describe the changes in the motion (kinetic) energy and in the position (potential) energy of the marble as it is held at the top and then is released and moves down the ramp? And what about the energy of the Styrofoam block before and after collision?** Turn to an elbow partner and discuss your thinking. Now, let's represent your thinking about these questions by working with your partner to complete step 4 of your handout. As you read the instructions, I will distribute red and blue pencils to you. Notice that you are asked to use a symbol to represent motion (kinetic) energy and to represent position (potential) energy. Since we will be sharing our thinking	How about straight lines for position and wavy ones for motion? I think that is too confusing—they both seem like motion to me.

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			as scientists do, it is important that we decide on and use the same symbols. **Does anyone have a suggestion for a symbol for either form of energy?** OK, you've made some good suggestions, and we could continue this discussion, but let's decide on one and all agree to use it. May I suggest this: • lines for motion (kinetic) energy like this =, and add more lines to represent faster speed and more motion (kinetic) energy • parentheses for position (potential) energy like this ( ), and add more to show more position (potential) energy ***NOTE TO TEACHER:*** *Do not spend much time on symbol discussion. The purpose is to allow some student input. Based on your students' suggestions, you may suggest two different symbols than above. These two symbols are used in the* Teacher Key*.* I see that all groups have completed your representations. Now, I will team you up with another group. Please share and compare your work. If you find differences, discuss your thinking and see if you can come to consensus. If so, make edits to your	**Other suggestions?** This is hard. Maybe a little angle to show the ramp for position? In cartoons, there are lines by something that is moving.

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			representations. If not, that is OK at this point as long as you can justify your answer. ***NOTE TO TEACHER:*** *Circulate among groups as they share and compare. Listen for common conceptions and for concepts students seem to grasp to help guide your class discourse. Have a method to display each element of the diagrams in step 4 so a different student can complete each one as you discuss it. If possible, separate the ramp diagram from the energy bars—this will give eight students (one from each group) an opportunity to share. Ask elicit, probe, and challenge questions of the class as each part is completed to draw out more student thinking. Also use questioning of the class to collaboratively display each representation correctly.* It's time to share our thinking with everyone. Scientists often share their thinking by showing their own diagram or representation. We will do that now—I will ask someone from each group to represent your thinking by coming up and showing us how you completed that part. Everyone be ready because I will also be asking questions to all of you as we go through each part. Also, as we collaborate on completing each part, take a minute to revisit your initial diagrams and make any edits or changes based on our conversation. ***NOTE TO TEACHER:*** *Groups may have colored in different numbers of energy bars than other groups. However, the number of energy bars colored at the top and bottom of the ramp should be the same. Highlight that the number of energy bars for the marble at the top of the ramp is the same as for the marble at the bottom of the ramp. The amount of energy of the marble did not change from the top of the ramp to the bottom. No energy was added to the system; it was*	The energy bars look like motion energy goes up and position energy goes down in all four.

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			transformed from stored (potential) energy to energy of motion (kinetic). OK, awesome collaboration, scientists! Look back over your representations and think about this: **Do you see any pattern when comparing changes in energy in the four positions?** Yes, the change in motion (kinetic) energy is the opposite of the change in position (potential) energy. Let's put the two together to answer this question: **What energy changes are occurring as the marble rolls down the ramp but doesn't hit the Styrofoam?** Talk to your elbow partner, then be ready to share with the whole class. **And, where did the marble get its motion (kinetic) energy?** ***NOTE TO TEACHER:*** *These questions don't specify motion or position energy, but rather just energy—meaning both of them. If students don't notice this, point it out. Make sure they understand that means their response must include all forms being considered. Students may or may not use the term* transform *at this point. If students have not used the term* transform,	**Who can add to that or say it differently?** The motion energy goes from none to some to most, but the position energy goes from most to some to none. They seem opposite. Position energy decreased and motion energy increased. Oh, maybe because the position energy was decreasing? **Interesting. What do others think?** Maybe the energy is changing from position to motion? Yes, and the farther down the ramp the marble gets, the more stored energy is changed into motion energy until it is all motion energy!

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			highlight student ideas that stored energy has <u>changed</u> or <u>turned into</u> energy of motion. The term transform *will be introduced later in the lesson.* I noticed that you used the word *changing* (or *changed*). And that is exactly what is happening. There is a science word for this idea of one energy changing to another. It is *transformed* (or *converted*). You may have heard this word used to describe something that has changed from one form to another, such as the toy transformers. We also use the term *energy transformation*, which means the same thing**.** Now, let's answer the same question using our new term. **What energy changes are occurring as the marble rolls down the ramp but doesn't hit the Styrofoam?** We now have four energy terms to consider: *motion energy* (*kinetic*), *position energy* (*potential*), *energy transfer*, and *energy transformation*. Let's put it all together, starting with this question:	I'll try it! At the top of the ramp the marble has only position energy. When it starts to move down, position energy starts to transform to motion energy. At the bottom, all the position energy has been transformed to motion energy. **Awesome job! Who can add to this by making a statement about the middle of the ramp?** In the middle there is some of both. Some position energy has transformed into motion, but not all of it. I think the marble transfers some of its energy to the Styrofoam block because the marble makes the block start to move. **What do others think?** I agree with ___. I think the marble transfers its energy to the Styrofoam block. At the bottom of the ramp, the marble has all motion energy. So, then both the marble and the block have motion energy. The

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			What energy changes are occurring when the marble hits the Styrofoam block? ***NOTE TO TEACHER:*** *Students may attempt to explain stored or potential energy as a force. If this happens, take time to revisit the questions from Lesson 1 to guide the discourse. The following information is for teacher benefit and is <u>not</u> meant for students: Every form of stored, or potential, energy is associated with a force and has two features in common: (1) it exists because of a force acting between two objects and (2) its magnitude depends on the arrangement of objects relative to each other.* *In the case of the marble and the ramp, the stored gravitational potential energy is associated with the force of gravity. The greater the difference between the top of the ramp and the bottom of the ramp, the more stored potential energy the marble will have when it is at the top of the ramp.* *When the rubber band is pulled back in the car launcher, it has elastic potential energy due to the electromagnetic force between the charged particles in the atoms and molecules that make up the rubber band. The amount of potential energy depends on how stretched the rubber band is; that is the difference between its stretched and unstretched positions.* *In discussing stored (potential) energy with students, acknowledge ideas about forces such as gravity but focus student attention on the observed changes in the system (e.g., ramp height, distance stretched) and the differences that result in changes in magnitude as stored energy is transformed to energy of motion.*	marble gives some of its motion energy to the Styrofoam. **What do others think?** I agree with ___. I think that collisions just transfer motion energy. They don't transform stored energy to motion energy. **Who can make a statement that compares the transfer of energy and the transformation of energy?** I think if it stays the same form of energy, like motion energy, then it is transferring it. But if it changes, like from position to motion, then it is transforming it. **Let's see a thumbs up, down, or sideways of what others think.** Um, I'll try. At the top of the ramp, the marble isn't moving, so it has no motion energy. It does have position energy because of where it is on the ramp. Rolling down, some of the position energy is transformed to motion energy. At the bottom of the ramp, all its position energy has been transformed to motion. Then it hits the block and they move together, which means some of the

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			Let's now think about, **What energy changes occur from the marble not moving at the top of the ramp to when it hits the Styrofoam block?** ***NOTE TO TEACHER:*** *If you are unable to finish the activity in a single class period, consider stopping here and resuming the activity in the next class period.*	motion energy of the marble was transferred to the block. **Let's see a thumbs up, down, or sideways of what others think.**
30 min	**Follow-up to Activity** <u>Synopsis</u>: Students link observed changes in the marble-ruler system with science ideas in a card sort to explain the energy changes in the system. They revisit the analogy map and use additional cards to link science ideas from the marble-ruler system to the car launcher system. <u>Main science ideas</u> Pulling back a rubber band gives it more stored (potential) energy of position. We can construct an explanation of observed relationships (SEP 6): A stretched rubber band has stored (potential) energy of position. When the stretched rubber band is	Ask questions to elicit student ideas and predictions. Ask questions to probe student ideas and predictions. Ask questions to challenge student thinking. Engage students in communicating in scientific ways. Engage students in constructing explanations and arguments.	Please draw your attention to the Science Ideas We've Figured Out chart. ***NOTE TO TEACHER:*** *Invite students to contribute ideas from the activity that can be added to the chart. As students share ideas, use a different color marker to add ideas that the class agrees upon.* *Ideas to highlight include the following:* • *In addition to energy of motion (kinetic), objects can have stored (potential) energy.* • *Stored (potential) energy can be transformed into energy of motion (kinetic).* • *The more stored (potential) energy an object has, the more energy can be transformed into energy of motion (kinetic).* • *As an object's position (potential) energy decreases, its motion (kinetic) energy increases. The transforming of energy causes them to be opposite.* Note that we have added a lot of science ideas about energy to our chart so far. We can use these ideas along with our observations of changes to develop a scientific explanation of how the energy changes in the marble-ruler system. **Scientific explanations** can be used to explain how or why a phenomenon occurs. A scientific explanation	

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
	released, stored energy (potential energy) decreases and energy of motion (kinetic energy) increases (CCC 5). The more energy of motion an object has, the more energy it can transfer to another object through a collision (Lesson 2).	Make explicit links between science ideas and activities.	consists of a claim supported by evidence and science ideas. Today we will use cards to help us link the changes we observed in the marble-ruler system—our evidence—to science ideas about energy changes. ***NOTE TO TEACHER:*** *Distribute* Energy Changes Card Sort Set 1 *to each pair. Point out to students that science ideas about energy are listed on the gray-shaded cards and changes we observed in the marble-ruler system (our evidence) are listed on white cards. The cards have letters or numbers on them so we can easily share our pairings. Invite pairs to match each observed change in the system to a science idea about energy. As they match observed changes with science ideas, pairs should discuss how the observed change is evidence for the change in energy on the matched card. As pairs work, circulate among groups asking elicit, probe, and challenge questions to make student thinking visible and move their thinking forward.* Let's come together, class, to share our thinking. Notice I am adding a sticky note arrow to three rows on our CSW chart. They are row 4: Think of an idea that explains your data and observations; row 7: Agree or disagree with others' ideas; add onto someone else's ideas; and row 9: Consider if new ideas make sense. Please use the CSW sentence stems as you share one of your card pairings and how the science idea helps to explain how and why the observed change happened. **Who will begin by sharing one card pairing you made and explain why you paired them?** ***NOTE TO TEACHER:*** *Continue class sharing and discourse until all pairings have been shared and explained. Ask elicit, probe, and challenge questions to draw student thinking out and to involve as many students as possible in the discourse.*	We paired observation card 1 with energy idea card A because card 1 is about the red marble crashing into the blue marble, which is a collision.

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
				How does the energy card A help explain those observations? Well, when the red marble hit the blue marble, it stopped and the blue marble started moving. **Will someone add to this? How does energy idea card A help explain why the red marble stopped moving and the blue marble started moving?** The red marble gave its motion energy to the blue marble, so the blue marble started moving because it got energy from the red marble. And when one thing gives its energy to another thing, the energy is transferred.
			I wonder if the science ideas about energy could also be used to explain the changes in the car launcher system. Let's try it! ***NOTE TO TEACHER:*** *Distribute* Energy Changes Card Sort Set 2 *to each pair. Have pairs link the observed changes in the car launcher system to the science ideas in set 1. As they match observed changes with science ideas, pairs should discuss how the observed change is evidence for the change in energy on the matched card.* **Who will share one of the card pairings they made for observations of the car launcher system and ideas about energy?**	
			Please refer to our marked CSW sentence stems as you share.	We put card 8, "The more the rubber band is stretched back, the faster the launcher bar will move"

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			NOTE TO TEACHER: *Continue class sharing and discourse until all pairings have been shared and explained. Ask elicit, probe, and challenge questions to draw student thinking out and to involve as many students as possible in the discourse.* *Students may wonder if the launcher bar also has stored (potential) energy that is transformed to motion (kinetic) energy when the rubber band is released. Because the rubber band is attached to the launcher bar, we can consider them as a single object.*	with card B, "Stored energy can be transformed into energy of motion." **Can you share your thinking about how those cards go together?** Our idea was that when the rubber band is pulled back, it has stored energy. When you release the rubber band, the stored energy is transformed into motion energy. **What do others think? Give me a thumbs up if you think the science idea explains the observation, a thumbs down if it doesn't, and a sideways thumb if you're not sure.** **___, you have a sideways thumb. Can you share your thinking with the class?** The science idea makes sense to me because the stored energy is transformed to motion energy when you release the rubber band. But we paired card 8 with D because it's talking about having more stored energy when you pull the rubber band back farther. I want to piggyback on what ___ said. We matched card 8 with D, too, because we think the more the rubber band is pulled back, the more stored energy it will have. **What do others think?**

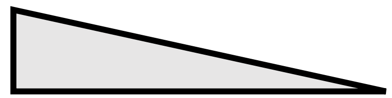
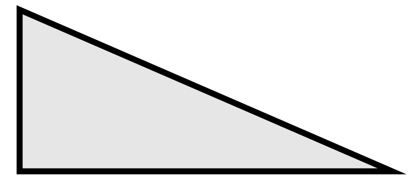
Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			NOTE TO TEACHER: *Once pairings have been complete guide students to a comparison of the two sets of observed changes and their matched science ideas.* *Ideas to highlight include the following:* • *Like the marble at the top of the ramp, the rubber band has stored (potential) energy when it is pulled back or stretched.* • *Stored (potential) energy in the rubber band can be transformed into energy of motion (kinetic) when the rubber band is released.* • *Stretching the rubber band farther increases the difference between its stretched and unstretched positions, giving it more stored (potential) energy. The more stored (potential) energy the rubber band has, the more energy can be transformed into energy of motion (kinetic).* By matching our card sets, we practiced linking science ideas with evidence, which is our data and observations. This is an important part of constructing a scientific explanation. We will have more opportunities in later lessons to practice and deepen our understanding of how to construct scientific explanations.	I agree with both ___ and ___. Energy is transformed from stored to motion. The more stored energy you have, the more energy gets transformed to motion. So maybe they are both right, but card D is more right because it explains why the launcher bar moves faster when the rubber band is pulled back farther.

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
5 min	**Summarize and Synthesize** Synopsis: 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. Engage students in making connections by synthesizing and summarizing key science ideas. Summarize key science ideas. Highlight key science ideas and focus question throughout.	We have investigated and figured out some important science ideas in this lesson. Return to your initial response to the Lesson Focus Question in your science notebook: **How can we change the motion (kinetic) energy of an object?** ***NOTE TO TEACHER:*** *Encourage students to add to or revise their response to the focus question in a different color. Students should draw a single line through any ideas they want to change so they can see how their ideas have changed and grown during the lesson.* *Highlight row 11 of the CSW chart with a sticky note arrow. Invite several students to share their revisions to the Lesson Focus Question using sentence stems from this row.* *As students share, ask elicit and probe questions to make student thinking visible and link changes in their thinking to the activities and science ideas experienced during the lesson. As students share, highlight the science ideas figured out during the lesson.* **How did you revise your answers to our Lesson Focus Question?**	I had some ideas about energy transfer, but I added some new ideas about how energy transforms. **Can you say more about the ideas about transformation you added?** I said that stored energy can be transformed to motion energy. I want to add to what ___ said. I added that and I also added that you can have stored energy when you stretch a rubber band or make a ramp.

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
				How did others revise their ideas about the focus question? I also added what we just talked about—the more stored energy you have, the more energy you can transform to motion energy.
5 min	**Link to Next Lesson** Synopsis: The class revisits the Driving Question Board to identify questions they have figured out and questions they still need to figure out. The teacher links science ideas to the next lesson.	Link science ideas to other science ideas (next lesson).	We have learned a lot so far about energy and how it can change. Let's look at the Driving Question Board to identify what questions we have answered in the last two lessons. **Will someone please share a sticky note question you think we have answered?** Let's use a thumbs up, down, or sideways to show if you agree, disagree, or aren't sure if we answered it. ***NOTE TO TEACHER:*** *For questions the class feels they have answered, add to the sticky note a check mark with a dark marker. After students have identified the questions, they have answered so far, invite them to consider the questions they still need to figure out in order to answer the Unit Central Question.* It seems we still have questions about other kinds of energy such as light, sound, and heat. Next time, we will look for evidence of other kinds of energy.	

Predicting and Observing Changes in Energy—Teacher Key

1. Compare the two ramp systems.
   Predict the observable changes and changes in energy in the ruler-marble-Styrofoam ramp system.

<table>
<tr><td></td><td>
ramp 1</td><td>
ramp 2</td></tr>
<tr><td colspan="3">**Before the collision:** Compare the speed of the marbles as they reaches the end of each ramp.

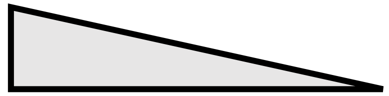
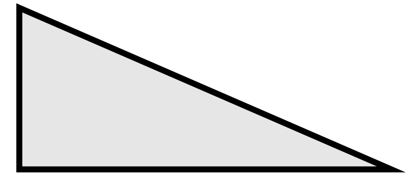
I predict the marble on ramp 2 will roll ____faster______ than the marble on ramp 1.

I think this because ___ramp 2 is higher than ramp 1. The higher ramp causes the marble to roll faster. The faster the marble rolls, the more energy it will have.______________________</td></tr>
<tr><td colspan="3">**The red marble has just hit the Styrofoam block:** Compare the distance the marble and Styrofoam block will move after the collision.

I predict the marble and Styrofoam block at the bottom of ramp 2 will move ___farther___ than the marble and Styrofoam block on ramp 1.

I think this because __ramp 2 is higher than ramp 1. The higher ramp will cause the marble to roll faster. The faster the marble rolls, the more energy it will have. When the marble collides with the Styrofoam, it will transfer some of its energy to the Styrofoam.____</td></tr>
</table>

2. Test your predictions and add your data to the table below.

		 **ramp 1**	 **ramp 2**
Height of ramp (cm)		varies, but less than ramp 2	varies, but more than ramp 1
Distance the Styrofoam moved (cm)	**Trial 1**	varies, but less than ramp 2	varies, but more than ramp 1
	Trial 2	varies, but less than ramp 2	varies, but more than ramp 1
	Trial 3	varies, but less than ramp 2	varies, but more than ramp 1

3. After you complete the trials, compare your data to your predictions. Then answer the following questions:
   What patterns do you observe in your data?
   The Styrofoam always moves farther when the marble rolls down ramp 2.

   Do the patterns you observe support your predictions? Yes, the marble rolled faster and the Styrofoam moved farther on ramp 2.

   Explain your thinking: Because the marble was rolling faster down ramp 2, it had more energy. Because it had more energy, it could transfer more energy to the Styrofoam, making it move farther.

4. Consider Ramp 2.
   - Using symbols, draw a representation of the energy of the marble before it is released, halfway down the ramp, and when it collides with the Styrofoam block.
   - Color in the energy bars to represent the amount of energy.
   - Label the form of energy: P = position energy   M = motion energy

Ramp 2

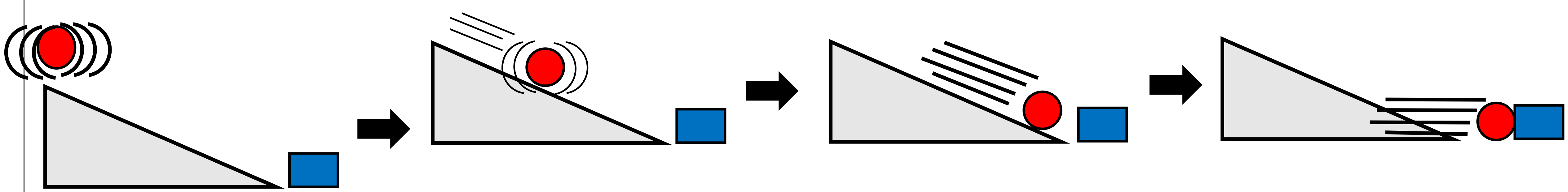
Energy bars
red energy bars for the red marble
blue energy bars for the Styrofoam block

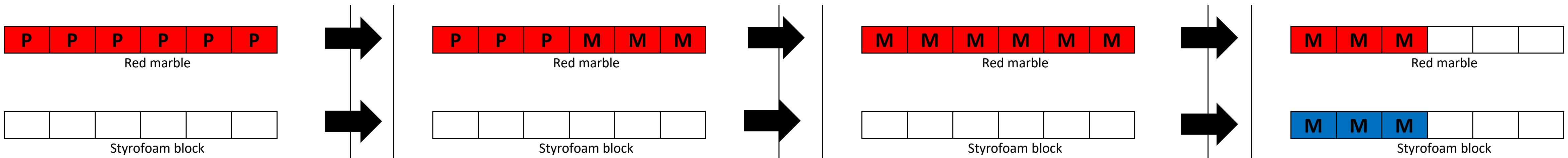
1. The red marble is at the top of the ramp

2. The red marble is hallway down the ramp

3. The red marble is at the bottom of the ramp

4. The red marble has just hit the Styrofoam block





Teacher Key
Energy Changes Card Sort Set 1
Make one card set for each pair of students

1 (A) When the red marble crashed into the blue marble, the red marble stopped, and the blue marble started moving.	**A** **Energy can be transferred from one object to another through collisions.**
2 (C) The faster the red marble was moving, the faster and farther the blue marble moved after the collision	**B** **Stored energy can be transformed into energy of motion.**
3 (B) When the red marble was released at the top of the ramp, it started moving faster and faster as it rolled down the ramp.	**C** **The more energy of motion an object has, the more energy it can transfer through a collision.**
4 (D) The higher the ramp, the faster the red marble was moving at the bottom of the ramp.	**D** **The more stored energy an object has, the more energy can be transformed into energy of motion.**

Energy Changes Card Sort Set 2

Make one card set for each pair of students.

5 (A) When the launcher bar crashed into the car, the launcher bar stopped, and the car started moving.
6 (C) The faster the launcher bar was moving, the faster and farther the car moved after the collision.
7 (B) When the rubber band was released, it moved back to its original size, causing the launcher arm to move forward.
8 (D) The more the rubber band is stretched back, the faster the launcher bar will move.