Lessons 8–9
Energy Changes during a Collision

Prepare

In Lessons 6 and 7, students concluded that transferring more energy to an object allows it to move with more speed. In Lesson 8, students build on the investigation from Lesson 7 by investigating how far objects moving at various speeds can move a second object after a collision. Students then graph their data to identify patterns in the transfer of energy between colliding objects in the ball bearing and catch system. In Lesson 9, students make sense of their investigations by developing a model to explain what happens to energy during a collision. Because energy transfer and transformations occur before, during, and after a collision, students model each stage to track the presence of energy phenomena.

Concept 2: Energy Transfer

Focus Question

How does energy transfer from place to place?

Phenomenon Question

What happens to energy when objects collide?

Student Learning

Knowledge Statement

Energy in a system can transfer between objects through collisions, causing changes in their motion.

Objectives

- Lesson 8: Predict the transfer of energy of motion between objects during a collision.
- Lesson 9: Explain the transfer of energy of motion between objects through forces in a collision.

Texas Essential Knowledge and Skills Addressed

- 4.2A **Plan** and implement descriptive **investigations**, including **asking** well defined **questions, making inferences**, and selecting and **using appropriate equipment** or technology **to answer** his/her **questions**. (Addressed)
- 4.2C **Construct** simple tables, **charts, bar graphs,** and maps using tools and current technology **to organize, examine, and evaluate data**. (Addressed)
- 4.2D **Analyze data and interpret patterns to construct reasonable explanations from data that can be observed and measured.** (Addressed)
- 4.2F **Communicate** valid **oral and written results** supported by data. (Addressed)
- 4.3B **Represent the** natural **world using models** such as the water cycle and stream tables and identify their limitations, including accuracy and size. (Addressed)
- 4.4 **Collect, record, and analyze information using tools,** including calculators, microscopes, cameras, computers, hand lenses, **metric rulers,** Celsius thermometers, mirrors, spring scales, balances, graduated cylinders, beakers, hot plates, meter sticks, magnets, collecting nets, and **notebooks**; timing devices; and materials to support observation of habitats of organisms such as terrariums and aquariums. (Addressed)
- 4.6D **Design a descriptive investigation to explore the effect of force on an object** such as a push or pull, gravity, friction, or magnetism. (Introduced)

English Language Proficiency Standards Addressed

- 2C Learn new language structures, expressions, and basic and academic vocabulary heard during classroom instruction and interactions.
- 4A Learn relationships between sounds and letters of the English language and decode (sound out) words using a combination of skills such as recognizing sound-letter relationships and identifying cognates, affixes, roots, and base words.
- 5G Narrate, describe, and explain with increasing specificity and detail to fulfill content area writing needs as more English is acquired.

Materials

		Lesson 8	Lesson 9
Student	Science Logbook (Lesson 8 Activity Guide)	●	
	Collision Investigation (per group): textbook (at least 1″ thick; the same type or size for each group), 2 rulers, 1″ ball bearing, tape, ball bearing catch	●	
	Science Logbook (Lesson 9 Activity Guides A and B)		●
Teacher	Anchor chart, anchor model		●
Preparation	None		

Lesson 9

Objective: Explain the transfer of energy of motion between objects through forces in a collision.

Launch 5 minutes

Ask students to compare the investigations from Lessons 7 and 8.

▶ What differences did you notice between the two investigations and their results?

- *In the second investigation, the ball bearing collided with the catch. In the first, the ball bearing didn't bump into anything.*
- *In the first investigation, the ball bearing kept rolling for a while. In the second investigation, the ball bearing moved with the catch for a second and then stopped.*
- *In the first investigation, the ball bearing just rolled and there was hardly any sound. In the second investigation, the ball bearing hit the container and made a louder sound.*

▶ Why do you think the ball bearing in the catch did not travel as far as the ball bearing by itself?

- *The container was heavy and stopped the ball from rolling.*
- *The catch is flat on the bottom and doesn't roll, so it stopped the ball bearing.*

Point out that students explored two situations in which the same amounts of energy were transferred to the ball bearing, but the ball bearing moved different distances. Because energy does not disappear, there must be an explanation for why the ball bearing moved a shorter distance when it collided with the catch. In this lesson, students will develop an explanation as they continue exploring the Phenomenon Question **What happens to energy when objects collide?**

Agenda

Launch (5 minutes)

Learn (30 minutes)

- Model Energy before a Collision (10 minutes)
- Model Energy during a Collision (10 minutes)
- Model Energy after a Collision (10 minutes)

Land (10 minutes)

- Conceptual Checkpoint (5 minutes)

Differentiation

Use investigation materials from the previous lesson as a visual support for students as they share their responses to these questions.

Tell students that modeling the second investigation may help develop an explanation. Explain that students will model each stage of the collision to track the energy efficiently:

- Before the collision (when students place the ball bearing on the ramp)
- During the collision (when the ball bearing collides with the catch)
- After the collision (when the catch slides to a stop)

Remind students that during their investigation, they tested four different release point heights, which produced four different ball bearing speeds. Ask them to discuss which collision would be the most helpful to model. As students share and challenge one another's thinking, prompt discussion with the following questions as necessary: What is the purpose of our models? Which collision would have the most obvious changes in energy for us to model?

When students agree on which speed to model, have them record it in their Science Logbooks (Lesson 9 Activity Guide A).

Learn 30 minutes

Model Energy before a Collision 10 minutes

Ask students to work with a partner to develop a model in their Science Logbooks explaining what happened before the collision. Before students begin, ask them to reiterate the purpose of this model: to find out what happens to energy when objects collide. Explain the importance of showing where energy is present in their models so that they can accurately track energy at each stage.

Allow students up to 5 minutes to work with their partners to develop their initial models and label where energy is present. When students complete their models, reconvene and develop a class model. Record the model on chart paper or a whiteboard. Students should note that the energy comes from placing the ball bearing on the ramp. If necessary, guide students by asking one or more of the following questions: How did the ball bearing get energy? Where did that energy come from? What did the energy allow it to do?

Teacher Note

Although it may be most revealing to model the collision of the bearing with the fastest speed, modeling any of the four test groups will reveal the same principles.

Differentiation

Some students may need access to the materials from the investigation to help them think through their models. To provide this support, separate students into the same groups from the collision investigation in Lesson 8, and provide each group with the investigation materials (textbook, rulers, ball bearing, tape, ball bearing catch). If providing these supports, allocate additional time for the Learn portion of the lesson.

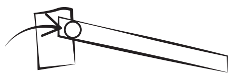
Teacher Note

It may be necessary to explain how to approach these models in the Science Logbook. Space is provided to model energy before, during, and after the collision. Ask students to reflect on which components of the system should be included in each section of the model.

Differentiation

Consider providing unlabeled collision models for students who need additional support. Ask students to label and provide an explanation for each drawing. This will allow these students to focus on developing understanding rather than on drawing (5G).

Sample class model:

Before the Collision  We transferred energy to the ball by placing it high on the ramp.		

Check for Understanding

In Lessons 6 and 7, students focused on the relationship between energy and speed, including how energy entered a system. Use this discussion to ensure that students can apply those concepts.

Evidence

As students discuss their models, listen for the following claims:

- The higher the starting point, the more energy the ball bearing had.
- The energy came from me lifting the ball bearing up to the ramp.
- The energy transferred to the ball bearing caused it to roll with more speed.

Next Steps

If students need to develop these ideas, have them repeat the investigation from Lesson 7 with simple adjustments: double the height of the ramp and then release the ball bearing from only the highest and lowest release points (28 cm and 7 cm). These adjustments will yield more visible differences in speed.

Model Energy during a Collision 10 minutes

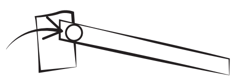
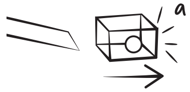
Repeat the process from the previous section by asking students to work with a partner to develop a model in their Science Logbooks explaining what happened during the collision. Before students begin, again ask them to reiterate the purpose of this model: to find out what happens to energy when objects collide. Explain the importance of modeling the moment of the collision between the ball bearing and the catch to find out what happened to energy.

Allow students up to 5 minutes to work with their partners to develop their model. When students complete their models, reconvene and develop a class model. Students should note that during the collision, there was a sound, and the force applied to the catch by the ball bearing caused the catch to move. To guide students to this idea, ask questions such as these:

- ▶ What caused the catch to move?
  - *When the ball bearing hit the catch, a force was applied and it pushed the catch.*
  - *The force applied by the ball bearing transferred some energy to the catch, which made it move.*
- ▶ How did the catch get energy to move?
  - *The motion energy of the ball bearing transferred to the catch when they collided. That's why the catch moved.*

Ensure that students understand that during a collision, the contact forces (i.e., the forces that result when two objects physically touch) cause the transfer of energy to change each object's motion. Students should also note in their initial models that there was a sound as the ball bearing was rolling down the ruler and during the collision. Note this on the class model as a reference for when students model what happened after the collision.

Sample class model:

Before the Collision	During the Collision	
 We transferred energy to the ball by placing it high on the ramp.	We noticed a sound.  The force from the collision pushed the catch, transferring energy from the ball bearing to the catch.	

Teacher Note

To help students identify the presence of other energy indicators during the collision, it may be necessary to revisit the anchor chart from Lesson 5. To guide students to identify the presence of sound, ask them to consider whether any of the other energy indicators on the anchor chart were present during the collision.

Model Energy after a Collision 10 minutes

To finish modeling the collision, repeat the process from the previous sections by asking students to work with a partner to develop a model in their Science Logbooks explaining what happened after the collision. Explain the importance of modeling where they notice energy after the collision.

Allow students up to 5 minutes to work with their partners to develop their model. When students complete their models, reconvene and develop a class model. Students should note that after the collision, the catch slid across the surface while making a noise and then came to a stop.

Ask students to share their thinking with the following prompts. Allow students to challenge one another's thinking based on the evidence they saw after the collision. Guide students to notice that indicators of energy other than motion are present after the collision.

▶ What happens to the energy from the ball bearing? Why does it stop moving? Where does the energy go?

- *The energy from the ball bearing gets used up moving the catch across the floor.*
- *There was a lot of sound during and after the collision. Sound is an indicator of energy, so maybe some of the energy made sound.*

Ask students to rub their hands together to mimic the catch sliding on the ground. Have students share what they notice: There is a sound, and their hands get warmer, which both indicate the presence of energy.

▶ Why do you think the ball bearing and catch didn't travel as far as the ball bearing by itself, even though you put in the same amount of energy? What differences did you observe between the investigations?

- *The ball bearing had to transfer some energy to move the catch.*
- *Things that are flat on the bottom (like the catch) don't roll because they slide across the ground. Some of the energy might change to sound or cause a temperature change, like when we rub our hands.*
- *There was a sound during the collision and then some more noise when the catch slid on the floor. The ball bearing by itself didn't make that much noise. Maybe some of the energy changed to sound.*

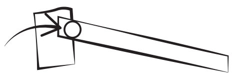
Connect this apparent change in energy to students' questions on the driving question board, and agree to revisit this mystery later in the lesson.

Teacher Note

Students may express misconceptions about energy being used up rather than transferred. Students will further develop their understanding about transfer of energy throughout this module.

Sample class model:

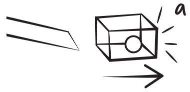
Before the Collision



We transferred energy to the ball by placing it high on the ramp.

During the Collision

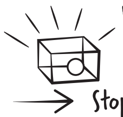
We noticed a sound.



The force from the collision pushed the catch, transferring energy from the ball bearing to the catch.

After the Collision

We noticed sound when the catch was sliding.



The catch slid, then stopped. We noticed there was motion, then a sound and less motion.

Land

10 minutes

As a class, discuss how the ball bearing collision investigation helps answer the Concept 2 Focus Question: **How does energy transfer from place to place?** Add key conceptual understandings to the anchor chart.

Sample anchor chart:

Energy
Energy is why things happen.
Energy is present when we observe something happening (moving objects, light, temperature change, sound) or when something helps make something happen (electricity, batteries).
Energy can transfer between objects through collisions, causing changes in their motion. • Transferring more energy to an object can make it move faster. • Faster-moving objects have more energy to transfer to other objects.

Teacher Note

These diagrams help students understand energy relationships without the use of equations, setting the foundation for deeper understanding in high school.

Before the Collision represents potential energy:

$\text{potential energy} = \text{mass} \cdot \text{gravity} \cdot \text{height}$

During the Collision represents kinetic energy:

$\text{kinetic energy} = \frac{1}{2}(\text{mass})(\text{velocity})^2$

After the Collision represents work:

$\text{work} = \text{force} \cdot \text{distance}.$

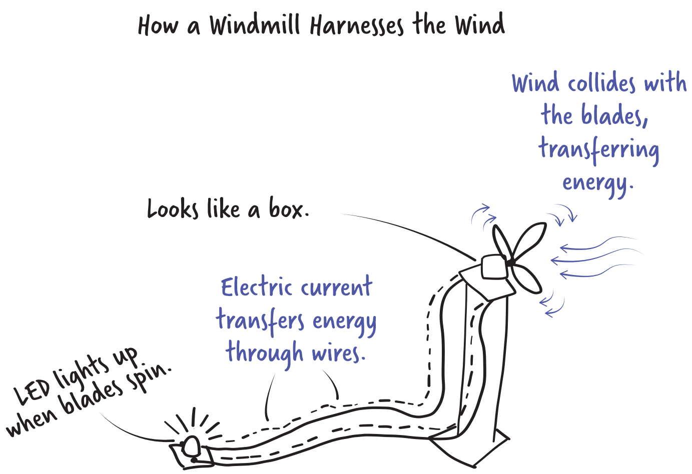
Revisit the anchor model to apply this new knowledge about transfer of energy to the windmill phenomenon. Ask students to identify where energy transfer takes place in the anchor model.

Sample student responses:

- *The wind is pushing the blades of the windmill. This is like when the ball bearing pushes the catch.*
- *The wires connect the blades to the light. So maybe the energy moves through the wires?*

Discuss that energy must move from the windmill to the light through the wires, and electric currents transfer this energy through the wires. Explain that the term *electrical energy* is used to describe this type of energy. Update the anchor chart to include that energy can also transfer from place to place through electric currents in wires.

Sample anchor model:



In the windmill system, wind collides with the blades, which transfers energy to something that looks like a box. An electric current transfers energy through the wires and turns on the light. When the wind blows harder, more energy is transferred to the blades.

Teacher Note

If students begin to discuss why the blades stop turning by sharing ideas about energy transformations, you may add these to the model as well. However, because additional factors cause the blades to stop turning, this depth of understanding goes beyond grade-level expectations.

English Language Development

Allow students to write or draw their ideas about energy transfer in the windmill model on a whiteboard. This can be used as a check for understanding as well as an opportunity for students to gain ideas and clarify misconceptions based on other students' ideas before revising their model (5G).

For more information on using whiteboards as a response technique, refer to the Instructional Routines section of the Implementation Guide.

Teacher Note

Students may use the terms *electricity* and *electrical energy* interchangeably. The term *electricity* in everyday language is often used to describe what makes a light turn on; however, in science, the more precise term is *electrical energy.* Although each form of energy is not explicitly named in this module, teachers may encourage students to use more precise language to discuss energy.

Sample anchor chart addition:

Energy can transfer between objects through collisions, causing changes in their motion.

- Transferring more energy to an object can make it move faster.
- Faster-moving objects have more energy to transfer to other objects.

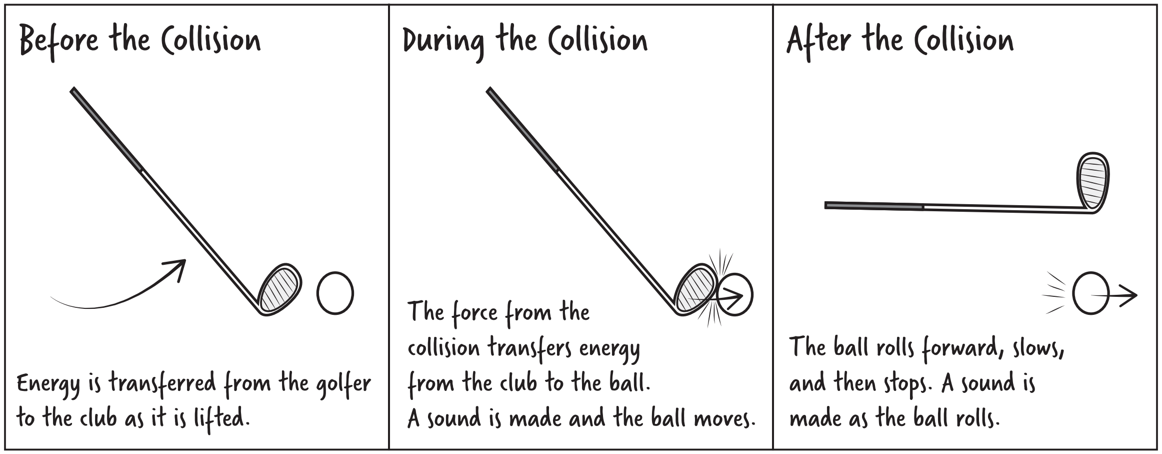
Energy can also transfer from place to place through electric currents.

Conceptual Checkpoint 5 minutes

Tell students they will have an opportunity to demonstrate their learning about energy transfers as they complete the Conceptual Checkpoint in their Science Logbooks (Lesson 9 Activity Guide B). Ask students to imagine they are playing miniature golf and have just hit the ball.

▶ Draw a model and explain each stage of the collision between the golf club and ball by using what you have learned about energy transfers.

Sample student response:



Teacher Note

In the next set of lessons, students learn that there are other ways that energy can be transferred as well—by light, sound, and heat. Leave room on the anchor chart to add these concepts.

Conceptual Checkpoint

This Conceptual Checkpoint assesses the Concept 2 Focus Question **How does energy transfer from place to place?** Students should demonstrate understanding of collisions and energy transfer.

Evidence

Look for evidence that students understand collisions and energy transfer. Student models and responses should reflect the following understanding:

- Energy is transferred from the student to the golf club.
- The force from the collision pushes the object, transferring motion energy.

Next Steps

Work with students in need of support to improve their models and responses. Use the class models that students developed during Lesson 9 to coach students to make improvements.
If necessary, work with students to repeat this Conceptual Checkpoint by using an example from Lesson 6.

Direct students to the list of related phenomena at the bottom of the driving question board. Allow them to Think–Pair–Share about how their new learning can explain these student-generated phenomena. Guide students to make connections between what they know about energy transfers and the phenomena.

Ask students to look back at the driving question board. Add any new questions and ask students to determine the next steps.

▶ Now that we have determined how energy transfers from place to place, what is our next big question?

- *Now we need to find out how motion can become sound.*
- *Now we want to figure out how the windmill changes the energy in wind to the energy in light.*

Use this discussion to connect back to students' observations of sound when modeling what happened to energy during and after the collision. Remind students that in the collision investigation, the energy indicators they observed seemed to transform or change from motion to sound. Tell students that **energy transformation** is what causes the changes in energy indicators. Use this to develop the next lesson's Phenomenon Question **What do we observe when energy transforms?**

English Language Development

Using the process outlined in the English Language Development section of the Implementation Guide, introduce the word *transform* explicitly. Discuss the term in different contexts, such as how new ideas can transform your thinking. The Spanish cognate *transformar* may also be helpful (4A).