Grade 4 Science, Unit 6

Force and Motion

Overview

Unit abstract

In this unit of study, students are able to use evidence to construct an explanation of the relationship between the speed of an object and the energy of that object, and are expected to develop an understanding that energy can be transferred from object to object through collisions. The crosscutting concept of energy and matter is called out as an organizing concept. In the fourth grade performance expectations, students are expected to demonstrate grade-appropriate proficiency in asking questions and defining problems and constructing explanations and designing solutions. Students are expected to use these practices to demonstrate understanding of the core ideas.

Essential questions

- How is energy transferred?
- What is energy and how is it related to motion?

Bristol–Warren, Central Falls, Cranston, Tiverton, and Woonsocket, with process support from The Charles A. Dana Center at the University of Texas at Austin

Written Curriculum

Next Generation Science Standards

4. Energy

Students who demonstrate understanding can:

4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object. [Assessment Boundary: Assessment does not include quantitative measures of changes in the speed of an object or on any precise or quantitative definition of energy.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. ▪ Use evidence (e.g., measurements, observations, patterns) to construct an explanation. (4-PS3-1)	**PS3.A: Definitions of Energy** ▪ The faster a given object is moving, the more energy it possesses. (4-PS3-1)	**Energy and Matter** ▪ Energy can be transferred in various ways and between objects. (4-PS3-1)

Connections to other DCIs in fourth grade: N/A

Articulation of DCIs across grade-levels: **MS.PS3.A** (4-PS3-1)

Common Core State Standards Connections:

ELA/Literacy –

RI.4.1 Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text. (4-PS3-1)

RI.4.3 Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text. (4-PS3-1)

RI.4.9 Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably. *(4-PS3-1)*

W.4.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly. (4-PS3-1)

W.4.8 Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-PS3-1)

W.4.9 Draw evidence from literary or informational texts to support analysis, reflection, and research. (4-PS3-1)

4. Energy

Students who demonstrate understanding can:

4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide. [Clarification Statement: Emphasis is on the change in the energy due to the change in speed, not on the forces, as objects interact.] [Assessment Boundary: Assessment does not include quantitative measurements of energy.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Asking Questions and Defining Problems

Asking questions and defining problems in grades 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships.

- Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. (4-PS3-3)

Disciplinary Core Ideas

PS3.A: Definitions of Energy

- Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-3)

PS3.B: Conservation of Energy and Energy Transfer

- Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-3)

PS3.C: Relationship Between Energy and Forces

- When objects collide, the contact forces transfer energy so as to change the objects' motions. (4-PS3-3)

Crosscutting Concepts

Energy and Matter

- Energy can be transferred in various ways and between objects. (4-PS3-3)

Connections to other DCIs in fourth grade: N/A

Articulation of DCIs across grade-levels: **K.PS2.B** (4-PS3-3); **3.PS2.A** (4-PS3-3); **MS.PS2.A** (4-PS3-3); **MS.PS3.A** (4-PS3-3); **MS.PS3.B** (4-PS3-3); **MS.PS3.C** (4-PS3-3);

Common Core State Standards Connections:

ELA/Literacy –

W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-PS3-3)

W.4.8 Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-PS3-3)

Clarifying the standards

Prior learning

The following disciplinary core ideas are prior learning for the concepts in this unit of study. By the end of kindergarten, students know that:

- When objects touch or collide, they push on one another and can change motion.

By the end of Grade 3, students know that:

- Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but these forces add up to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative, addition of forces is used at this level.)
- The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: Technical terms, such as magnitude, velocity, momentum, and vector quantity are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.)

Progression of current learning

Driving question 1
What is the relationship between the speed of an object and its energy?

Concepts	Practices
• Energy can be transferred in various ways and between objects. • The faster a given object is moving, the more energy it possesses.	• Describe various ways that energy can be transferred between objects. • Use evidence (e.g., measurements, observations, patterns) to construct an explanation. • Use evidence to construct an explanation relating the speed of an object to the energy of that object. (Assessment does not include quantitative measures of changes in the speed of an object or on any precise or quantitative definition of energy.)

Driving question 2
In what ways does energy change when objects collide?

Concepts	Practices
• Energy can be transferred in various ways and between objects. • Energy can be moved from place to place by moving objects or through sound, light, or electric currents. • Energy is present whenever there are moving objects, sound, light, or heat. • When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. • When objects collide, the contact forces transfer energy so as to change the objects' motions.	• Describe the various ways that energy can be transferred between objects. • Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. • Ask questions and predict outcomes about the changes in energy that occur when objects collide. Emphasis is on the change in the energy due to the change in speed, not on the forces, as objects interact. (Assessment does not include quantitative measurements of energy.)

Integration of content, practices, and crosscutting concepts

Students in Grade 3 learned that all objects, whether in motion or at rest, have forces acting on them. In this unit, students will observe objects in motion in order to understand the relationship between the speed of an object and its energy. They will also investigate the transfer of energy from one object to another, as well as the transfer of energy from one form to another, during collisions. Throughout this process, students will ask questions and gather evidence from observations in order to construct explanations.

In order to understand and explain the relationship between an object's speed and its energy, students need multiple opportunities to observe objects in motion. Students can roll balls down ramps, build and race rubber band cars, or build roller coasters. As they observe the motion of objects, they should collect data about the relative speed of objects in relation to the strength of the force applied to them. For example, when a ball is placed at the top of a ramp, it has stored energy, due to the force of gravity acting on it. When the ball is released, that stored energy is changed (transferred) into motion energy. Increasing the height of a ramp also increases the amount of stored energy in the ball at the top of the ramp. If the ball is released from a higher starting point, it rolls faster and farther. Likewise, winding the rubber band in a rubber band car stores energy in the rubber band, which is then changed, or transferred, into motion energy (kinetic) as the car moves forward. The more times you wind the rubber band, the greater the amount of stored energy in the rubber band, and the farther and faster the car goes. As students investigate these types of force and motion systems, they should conduct multiple trials, increasing and decreasing the amount of energy, then collect qualitative data as they observe the impact differing amounts of energy have on the relative speed of the object in motion. Students should then use their data as evidence to support their explanation of the relationship between the relative speed of an object and its energy.

Once students understand that the faster an object moves, the more energy it possesses, they can begin to explore ways in which energy can be transferred. As they investigated the relationship between speed and energy, students learned that stored energy was changed, or transferred, into motion energy. To broaden their

understanding of energy transfer, students should be provided with opportunities to observe objects colliding and should be encouraged to ask questions that lead to further investigation. For example, if students roll a ball towards a wall, or roll two balls so that they collide, they may observe any or all of the following:

- Change(s) in the direction of motion
- Change(s) in speed
- Change(s) in the type of energy (e.g., motion energy to sound energy, sound energy to heat energy)
- Change(s) in the type of motion (rolling to bouncing).

As students continue to investigate interactions between moving objects, they should notice that when a moving object collides with a stationary object, some of the motion energy of one is transferred to the other. In addition, some of the motion energy is changed, or transferred to the surrounding air, and as a result, the air gets heated and sound is produced. Likewise, when two moving objects collide, they transfer motion energy to one another and to the surrounding environment as sound and heat. It is important that as students observe these types of interactions, they collect observational data, document the types of changes they observe, look for patterns of change in both the motion of objects and in the types of energy transfers that occur, and make predictions about the future motion of objects. Their investigations will help them understand that:

- Energy can be transferred in various ways and between objects.
- Energy is present whenever there are moving objects.
- Energy can be moved, or transferred, from place to place by moving objects.
- When objects collide, some energy may be changed or transferred into other types of energy.

Integration of English language arts

To support the integration of the CCSS for English language arts in this unit, students will need an opportunity to conduct a short research project to build their understanding of the transfer of energy (motion, heat, and sound) in force and motion systems. They will need access to a variety of texts and should use information from their class experiences and from print and digital sources to write informative/explanatory texts. As students gather information, they should take notes and categorize information. In their writing, students should detail what they observed as they investigated simple force and motion systems, describe procedures they followed as they conducted investigations, and use information from their observations and research to explain the patterns of change that occur when objects move and collide. As students participate in discussions and write explanations, they should refer specifically to text, when appropriate.

Future learning

The following disciplinary core ideas are future learning related to the concepts in this unit of study.

In middle school, students will know that:

- For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law).
- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.

- All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.
- Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.
- A system of objects may also contain stored (potential) energy, depending on their relative positions.
- Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.
- When the kinetic energy of an object changes, there is inevitably some other change in energy at the same time.
- The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.
- Energy is spontaneously transferred out of hotter regions or objects and into colder ones.
- When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.
- The term *heat* as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects.
- The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.

Number of Instructional Days

Recommended number of instructional days: 18 (1 day = approximately 45–60 minutes)

Note—The recommended number of days is an estimate based on the information available at this time. Teachers are strongly encouraged to review the entire unit of study carefully and collaboratively to determine whether adjustments to this estimate need to be made.