MIDDLE SCHOOL PHYSICAL SCIENCE: KINETIC ENERGY AND POTENTIAL ENERGY

Standards Bundle

Standards are listed within the bundle. Bundles are created with potential instructional use in mind, based upon potential for related phenomena that can be used throughout a unit.

MS-PS3-1 Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. [Clarification Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a wiffle ball versus a tennis ball.]

MS-PS3-2 Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. [Clarification Statement: Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include: the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate's hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems.] [*Assessment Boundary: Assessment is limited to two objects and electric, magnetic, and gravitational interactions.*]

MS-PS3-5. Engage in argument from evidence to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. [Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.] [*Assessment Boundary: Assessment does not include calculations of energy.*]

Content Overview

This section provides a generic overview of the content or disciplinary core ideas as an entry point to the standards.

When an object is in motion, the energy it contains is called kinetic energy. When an object is at rest, the energy it contains is called potential energy. When an object changes from being at rest to being in motion, its energy transfers from potential to kinetic energy. An example of this energy transfer is a bowling ball striking a set of bowling pins. Energy is neither lost nor destroyed so that when energy in an object appears to leave the system, it actually is transferred to another object within the system at the same time.

Phenomena

Phenomena can be used at varying levels of instruction. One could be used to anchor an entire unit, while another might be more supplemental for anchoring just a unit. Please remember that phenomena should allow students to engage in the SEP and use the CCC/DCI to understand and explain the phenomenon.

- Rubbing your hands together for one minute makes your palms feel warm.
- A rollercoaster does not have an engine, yet completes multiple loops and hills without stopping.

- When an outside ball on Newton's cradle is dropped, the ball on the opposite end is put into motion.
- A skateboarder on a parabolic ramp has more potential energy at the top of the ramp than in the center of the ramp.

Storyline

This section aims to decode not only the DCI connections, but also the SEP and CCC in a detailed account of how they possibly fit together in a progression for student learning, including both rationale and context for the bundle.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data ● Construct and interpret graphical displays of data to identify linear and nonlinear relationships. **Developing and Using Models** ● Develop a model to describe unobservable mechanisms. **Engaging in Argument from Evidence** ● Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon.	**PS3.A: Definitions of Energy** ● 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. **PS3.B: Conservation of Energy and Energy Transfer** ● When the motion energy of an object changes there is inevitably some other change in energy at the same time. **PS3.C: Relationship Between Energy and Forces** ● When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.	**Systems and System Models** ● Models can be used to represent systems and their interactions—such as inputs, processes and outputs and energy and matter flows - within systems. **Scale, Proportion, and Quantity** ● Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. **Energy and Matter** ● Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion).

Kinetic energy is the energy of an object when the object is in motion. The amount of kinetic energy an object has can change and is related to the object's mass and speed. The greater the mass of the moving object, the greater the amount of kinetic energy. Likewise, the greater the speed of the object in motion, the greater the amount of kinetic energy. In these performance expectations, students are expected to create and read graphs about kinetic energy. In order to construct and interpret a graph, students may be given objects of different masses. Students will plan an investigation with these differently massed objects to make observations and collect data which can be analyzed to determine the proportional relationship between kinetic energy, mass, and speed. By developing a plan and then analyzing and interpreting their data, students should come to realize that kinetic energy increases with mass and speed of the object.

Potential energy is the energy an object has due to its position within a system. The larger the mass of an object or the higher the object rests, the more potential energy the object has. For example, a boulder resting on top of a cliff has more potential energy than a pebble resting next to it due to its larger mass. Likewise, the pebble resting on top of a house has more potential energy than it does if it rests on a windowsill, due to its height difference.

As with kinetic energy, potential energy can change. When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the other object. Students should develop models to demonstrate the relationship between distance and the amount of potential energy between two objects. Models are useful in demonstrating/experiencing this and can exhibit cause and effect. (When an elastic band is stretched, the band gains potential energy the further it is stretched. If a rubber ball is squeezed inward, the ball gains potential energy the more it is squeezed. Both of these changes in potential energy are due to elastic potential energy.) Potential energy can increase due to increased or decreased height distances.

In this performance expectation, students are expected to construct, use, and present arguments from evidence to prove that within a system, energy is transferred from one object to another. These arguments may be constructed by investigating various forms of energy (e.g. energy in fields, thermal energy, or energy of motion).

Students can plan and conduct investigations to collect data about kinetic and potential energy of objects in a system. Students can analyze this data to uncover patterns regarding the relationship between potential and kinetic energy. An object that has potential energy can transfer that energy into kinetic energy when the object begins to move, due to its mass or position. For example, a person jumping on a trampoline has potential energy when they reach the peak of a jump, and their force changes direction from upward to downward. When the person begins falling back down, their potential energy is converted into kinetic energy.

Students can begin to use evidence from their investigations to construct arguments and use scientific reasoning that when the motion energy of an object changes there is inevitably some other change in energy that results in the system. Students can ask further questions about objects and their interactions within a system in order to plan and conduct further investigations about energy transfer within a system. These types of inquiry investigations allow students to develop a deeper understanding that when one object is in motion and comes in contact with another object, the energy from the first object does not simply disappear or leave the system, it must be transferred someplace else within the system. The energy might be transferred to the second object by various means. For example, the first object may transfer kinetic energy to the second object and cause it to move. There might also be a transfer of thermal energy through friction to the second object or the surface upon which the object is rolled. This transfer would decrease the thermal energy of the first object, and transfer the energy to another object or surface. Depending on the object's composition, the first object's energy could even be transferred into sound or light energy.

Formative Assessment

Formative assessment is crucial because all learners benefit from timely and focused feedback from others. It promotes self-reflection, self-explanation, and social learning. It can also make learning more relevant. Each of the questions below might be used throughout the formative assessment process. Specific prompts may focus on individual practices, core ideas, or crosscutting concepts, but, together, the components need to support inferences about students' three-dimensional science learning as described in a given bundle, standard or lesson-level performance expectation.

Resources to inform your formative assessment.

http://stemteachingtools.org/brief/30

http://stemteachingtools.org/brief/41
http://stemteachingtools.org/pd/sessionb

SEP Developing and Using Models

- Present students with two situations of a ball on top of a plane at different heights. Have the students compare the differences in potential energy in the two models.

SEP Engaging in Argument from Evidence

- Allow the students time to play with toy pull-back cars. Have them take turns with a partner student making claims (statements) about the energy in the system. Each student must identify evidence that supports each claim.

SEP Analyzing and Interpreting Data

- Present students with recorded data of kinetic energy, speed, and mass. Ask students to describe a relationship they can infer from the data.
- Describe an investigation, the phenomenon under investigation, and recorded observations from the investigation that are directly relevant to explaining the phenomenon, then ask students to organize the data and describe the patterns they see in the organized data.

CCC Systems and System Models

- Draw a diagram that shows how energy is flowing into, within, and out of the system.

CCC Scale, Proportion, and Quantity

- Present students with recorded data of kinetic energy, speed, and mass. What is the ratio of mass and kinetic energy in the data presented? What is the ratio of speed and kinetic energy in the data presented?

CCC Energy and Matter

- A ball is thrown straight up into the air and then falls back down to the ground. How does energy flow within the system?
- A student rides his or her bike to school. What forms of energy are involved in this system? What energy is undergoing transformation?

Performance Outcomes

These are statements of how students use knowledge and are similar to the standards in how they blend DCI, SEP, and CCC, but at a smaller grain-size. These are potential outcomes for instruction as it plays out in lessons and activities in the classroom. It is important to also think of these as smaller outcomes that build toward the larger goal of mastering the standards.

- Students can use **evidence to explain** the difference between *kinetic (motion) energy and potential (stored) energy.*
- Students can **analyze and interpret data** to prove kinetic energy is *proportional* to the mass of a moving object.
- Students can **use models** to demonstrate that the amount of potential energy an object has is dependent on their relative positions.
- Students can **analyze and interpret data** to verify that the proportionality of kinetic energy increases with the square of its speed.
- Students can **develop models** to demonstrate that an object exerts a force on another object when they interact and energy can be transferred from one object to the other.