GENERATIONGENIUS
ALWAYS QUESTION. ALWAYS WONDER.

TEACHER GUIDE

POTENTIAL VS KINETIC ENERGY

GRADES 6-8

COMMON MISCONCEPTIONS

- **Energy is associated only with moving objects.**
  Nonmoving objects have potential energy. The composition of an object or its position determines what kind of energy it has (e.g., chemical, potential, thermal). A moving object has kinetic energy.

- **Energy is a fluid that flows or transfers between places and systems.**
  Energy is an abstract quantity, not a substance, that can never be seen nor measured directly. It can only be calculated based on the measurement of observable characteristics such as speed, mass, and temperature.

- **Students use "force" and "energy" synonymously**
  A force is simply a push or a pull. Forces can transfer energy. When two object interact, through collisions or at a distance, each object exerts a force on the other that can cause energy to be transferred to or from the object.

ENERGY

"Although energy is ubiquitous in our lives and we all seem to have an intuitive sense of energy as an everyday idea, it is very difficult to define in a rigorous and self-consistent way. Commonly, textbooks will define energy as 'the capacity to do work' or 'the ability to cause a change,' but each of these definitions is flawed. In the first, saying that energy is a capacity to do work is circular, since work is a process of energy transfer between systems. Thus, this definition essentially says 'energy is the ability to transfer energy.' This is hardly helpful for defining what energy is. The second definition is not circular, but it is so broad that it fails to give students specific direction regarding energy as a distinct scientific idea.

It is far more important to be able to describe how energy behaves in physical systems than it is to define what energy is. Though a definition of energy eludes us, we can say very precisely how energy is calculated. For example, kinetic energy is associated with motion and can be calculated by the formula $\frac{1}{2} mv^2$ (when objects are moving much slower than the speed of light), where m is the mass of an object and v is its speed. Potential energy due to gravity is associated with height and can be calculated as mgh (for objects close to the surface of the Earth), where m is the mass of the object, g is the acceleration of gravity, and h is the height of an object above some reference height.

Rather than performing simple calculations of energy or merely learning to name various energy 'forms' (e.g., kinetic energy, gravitational potential energy), middle school students should connect qualitative descriptions of observations of phenomena (e.g., faster/slower, higher/lower, hotter/colder) to each other using the idea of energy transfer between objects and systems." From: *Disciplinary Core Ideas: Reshaping Teaching and Learning*, 2017, NSTA Press, pages 59–60.

ENERGY TRANSFERS

"At the middle school level, students should begin to qualitatively track energy transfers in familiar phenomena and define appropriate system boundaries. By connecting changes in energy related variables across systems (e.g., the speed of an object, the amount of stretch or compression in a spring), students should be able to identify increases and decreases in the energy of systems and objects as phenomena occur and to recognize that when the energy of one object or system decreases, the energy of at least one other must increase. Further, students should begin to identify appropriate system boundaries (e.g., what set of objects should be included in a system) to understand when energy is transferred into or out of the system of interest. By qualitatively tracking energy transfers between familiar systems, students begin to build a sense of conservation that will be further developed in high school." From: *Disciplinary Core Ideas: Reshaping Teaching and Learning*, 2017, NSTA Press, page 64.

ENERGY AND FORCES

"Forces are responsible for changing the speed of an object, and anytime this happens, energy is transferred. When forces act between objects, they are mediated by a 'field.' Energy is transferred between objects and systems because of fields. Mechanical transfer processes, conduction/convection, and sound all transfer energy via forces between particles or objects, and these forces are mediated by fields between the interacting objects. Electromagnetic radiation and electrical processes are mediated by electromagnetic fields that propagate through space and through materials to move energy from one place to another.

When a brick is lifted above the ground and dropped, the kinetic energy with which it will strike the ground will increase as the height of the drop is increased. That is, the gravitational potential energy of the brick–Earth system will increase as the separation of the brick and Earth increases. The gravitational potential energy of this system depends on the arrangement of the objects in it.

The closer the brick and the Earth are to each other, the less potential energy is in the system. Further, the gravitational potential energy is due to the force acting between the brick and the Earth, so we can think of this gravitational potential energy as being 'stored' in the gravitational field between the Earth and the brick." From: *Disciplinary Core Ideas: Reshaping Teaching and Learning,* 2017, NSTA Press, page 65.

TEACHER TIPS

Type here a few sentences (small paragraph) of suggestions for teaching this topic well, like an experienced teacher giving suggestions to a new teacher. (Best practices)

To increase engagement, you may want to have students work in pairs instead of small groups, if you can gather enough canisters. Ask students and colleagues to save oatmeal canisters, coffee cans, paint cans, or large nut canisters (if no students are allergic to nuts) for you.

If possible, construct a comeback can and demonstrate it instead of watching the video. Direct experience and observation are preferable.

A quick internet search can provide you with different ways to construct a comeback can and videos to show students. However, make sure you preview videos; most have explanations along with directions.

Students may already be familiar with kinetic and potential energy and may toss those terms around in their explanation, or they may find an explanation online. Make sure they use evidence to support their thinking, not just the terms or someone else's explanation.

ABOUT THIS LESSON

This lesson was created by the National Science Teaching Association (NSTA) to pair with the Generation Genius video and support *NGSS*.

They have requested we provide the following background with this lesson:

The Next Generation Science Standards (NGSS) are the national standards on how students learn science, and they are based on contemporary research presented in *A Framework for K–12 Science Education (the Framework).* The shift in science teaching and learning required by the Framework is summarized in this infographic: A New Vision for Science Education.

At the start of each Generation Genius lesson, students are presented with a phenomenon, then they try to explain it. Students will notice they have gaps in their knowledge and ask questions, which motivates them to build ownership of science ideas they need in order to explain how or why the phenomenon occurred. The way students build ownership of science and engineering ideas is through active engagement in the science and engineering practices (SEPs). This process of sensemaking, or doing science to figure out how the world works, is one of the major shifts the *Framework* encourages.

To engage in the SEPs, students should be part of a learning community that allows them to share their ideas, evaluate competing ideas, give and receive critiques, and reach consensus. Students can start by sharing ideas with a partner, then with a small group, and finally, with the whole class. This strategy creates opportunities for all students to be heard, build confidence, and have something to contribute to whole-class discussions. Each Generation Genius lesson provides conversational supports to facilitate such productive student discussions to contribute to sensemaking.

Excited to continue your shift toward the new vision for science education? Check out the Generation Genius Teacher Guide page on the NSTA website for resources and strategies to engage every student in your classroom in **doing** science.