



# Teacher Guide: Kinetic and Potential Energy: Skate Park Engineers

Gizmos Investigation

## Overview



**Grade Level:** 6-8

**Subjects:** Physical Science

**Time:** 120 min

**Topic:** Energy

In the *Kinetic and Potential Energy: Skate Park Engineers* Investigation Series, students take on the role of skatepark designers tasked with creating a ramp that's both fun and safe. Using the Gizmo simulation, they investigate how mass, speed, and height affect potential and kinetic energy. Through guided data collection and interactive graphs, students identify key patterns and relationships, such as how increasing height increases potential energy and how that energy transfers into kinetic energy at the bottom of the ramp. Students apply their learning by designing a ramp that meets safety constraints—limiting total energy, speed, and height—and justifying their choices with data. The lesson concludes with a written explanation and CER task, allowing students to demonstrate mastery of energy concepts and the application of skills such as modeling and data interpretation.

## Student Learning Objectives

By the end of this lesson, students will be able to:

- Understand how **mass and speed** affect **kinetic energy**.
- Understand how **height and mass** affect **potential energy**.  
Recognize that **potential energy is converted into kinetic energy** as an object moves downhill.
- Apply these relationships to **optimize a ramp design** that is safe for skaters.





# Summary

## Lesson 1

| Driving Question                                                                      | Practices                                                                                                        | Learning Outcomes                                                                                                                   |
|---------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| How does changing the mass and speed of a skateboard rider affect the kinetic energy? | Constructing and interpreting graphical data displays; analyzing the impact of mass and speed on kinetic energy. | Students understand how kinetic energy is related to mass and speed, and they begin designing a skate ramp based on their findings. |

*Connection to next lesson:* In Lesson 2, the initial ramp design is revisited and refined as students learn about potential energy.

## Lesson 2

| Driving Question                                                                          | Practices                                                                                                                                 | Learning Outcomes                                                                                                                        |
|-------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| How does changing the height of a ramp affect the potential energy of a skateboard rider? | Developing models to describe potential energy, interpreting graphical data on mass and height, and comparing that data with predictions. | Students gain an understanding of potential energy and refine their skate ramp designs to incorporate both kinetic and potential energy. |

*Connection to next lesson:* In Lesson 3, students use their updated ramp designs and their understanding of energy to meet safety constraints.

## Lesson 3

| Driving Question                                                                                              | Practices                                                                                                                                                         | Learning Outcomes                                                                                                                                                    |
|---------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| How is energy transferred during a collision, and how can this knowledge be used to design a safe skate ramp? | Constructing arguments supported by evidence; finalizing ramp designs considering energy constraints and safety; engaging in a claim-evidence-reasoning activity. | Students complete a final skate ramp design, applying their understanding of kinetic and potential energy, and argue for its safety and effectiveness based on data. |

**NOTE:** Need additional support implementing this Gizmos Investigation in your classroom? Check out our other resources under the “Supplemental Resources” section of this Investigation on our website!



# Standards Alignment

Gizmos Investigations are designed to align with the Next Generation Science Standards. This is done in terms of the three dimensions of disciplinary core ideas (DCIs), science/engineering practices (SEPs), and cross-cutting concepts (CCCs). These correlations should also apply to other states' standards that similarly reference DCIs, SEPs, and CCCs or their equivalents (although individual states' numbering schemes will likely differ).

Please note that our alignment is specifically to the **middle grades (grades 6-8)** level learning goals for the below-listed DCIs, SEPs, and CCCs.

| Disciplinary Core Ideas (DCI)                                                                                                                                                                                                                                                                                                                          | Science and Engineering Practices (SEP)                                                                                                                                                                                                                                                                                                   | Crosscutting Concepts (CCC)                                                                                                                                                                                                 |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>PS3.A: Definitions of Energy</b> <ul style="list-style-type: none"> <li>• 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.</li> <li>• A system of objects may also contain stored (potential) energy, depending on their relative positions.</li> </ul> | <b>Analyzing and Interpreting Data</b> <ul style="list-style-type: none"> <li>• Construct and interpret graphical displays of data to identify linear and nonlinear relationships.</li> </ul> <b>Developing and Using Models</b> <ul style="list-style-type: none"> <li>• Develop a model to describe unobservable mechanisms.</li> </ul> | <b>Systems and System Models</b> <ul style="list-style-type: none"> <li>• Models can represent systems and their interactions—such as inputs, processes, and outputs—and energy and matter flows within systems.</li> </ul> |

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The *Kinetic and Potential Energy* Investigations Series builds toward the following NGSS Performance Expectations (PEs):

- **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.dimension.]*



- **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.]*

## Prior Knowledge

Include what students should know leaving the previous grade they were in. (Can be found in [the framework](#))

- Energy is present in all forms of motion and activity, including moving objects, sound, light, and heat.
- When objects collide, energy transfers between them, changing their motion and often producing heat and sound.
- Measure and graph data to identify patterns. (Students should be proficient in collecting data, creating graphs, and interpreting patterns to draw conclusions.)
- Apply mathematical concepts to analyze data. (This includes using basic math skills to calculate and interpret scientific data, such as understanding relationships between variables.)



# Kinetic and Potential Energy—Scientific Background

This lesson explores the **relationship between potential energy (*PE*), kinetic energy (*KE*), and motion**, with a focus on how mass, speed, and height influence energy transfer in real-world systems – specifically a skateboard ramp scenario. Teachers should be familiar with the following concepts to support student learning:

## 1. Kinetic Energy (*KE*)

- **Definition:** The energy of motion. An object has more kinetic energy when it is moving faster or has more mass.
- **Mathematical Relationship:**  $KE = \frac{1}{2} \times \text{mass} \times \text{speed}^2$   
This quadratic relationship means that small increases in speed result in larger increases in *KE* than changes in mass. (Students are not assessed on the mathematical formula for *KE* in middle school.)
- **Real-World Implication:** Higher *KE* results in more impact or "damage" during a collision. In Lesson 1, this is visualized using snowmen knocked over as a proxy for *KE*.

## 2. Potential Energy (*PE*)

- **Definition:** Stored energy based on position. For objects near Earth, it's typically gravitational potential energy, which depends on the object's mass and its height above the ground.
- **Mathematical Relationship:**  $PE = \text{mass} \times \text{gravitational acceleration} \times \text{height}$   
In this lesson, gravitational acceleration is assumed constant at  $9.8 \text{ m/s}^2$ , but students don't need to calculate it directly. (Students are not assessed on the mathematical formula for *PE* in middle school.)
- **Key Idea:** Increasing an object's height or mass increases its potential energy.

## 3. Conservation of Energy and Energy Transfer

- **Core Principle:** Energy is not lost; it transforms. In the ramp context, *PE* at the top transforms into *KE* at the bottom.
- **Application:** Students use this idea to design a ramp that keeps skaters within a safe energy limit, balancing *PE* and *KE* by adjusting ramp height and skater mass.



## 4. Speed and Height Connection

- While students are not expected to calculate acceleration or velocity, they observe in the Gizmo that:
  - **Higher ramps** → **faster speeds**
  - This introduces the idea that **height indirectly controls speed** through energy transfer.

## 5. Science and Engineering Practices (SEPs)

- Students engage in modeling, data analysis, and design evaluation.
- They use simulations to:
  - Collect and graph data
  - Identify patterns in how energy changes
  - Apply constraints to propose design solutions
  - Communicate their reasoning through models and written explanations

## 6. Common Student Misconceptions

- **“More mass means more speed”** – Actually, in free fall or down a ramp with no friction, mass does not affect speed (though it affects *KE* and *PE*).
- **“Energy disappears”** – Students may think energy is used up when it changes forms. Reinforce the idea of **energy transfer** and **conservation**.
- **“Energy is stored in speed”** – Help students understand ***KE* is not stored**, but ***PE* is**; *KE* is **present during motion**, *PE* is **based on position**.



## Kinetic and Potential Energy—Key Vocabulary

To support your students, you can print this graphic organizer and have them draw pictures to support their learning of key vocabulary words from the Gizmos Investigation.

| Glossary Term                                      | Definition                                                                                      | Picture |
|----------------------------------------------------|-------------------------------------------------------------------------------------------------|---------|
| <i>Kinetic Energy</i><br>(“kih-NEH-tik en-er-jee”) | <b>Kinetic Energy</b> is the energy an object has because it is moving.                         |         |
| <i>Motion</i><br>(“MOH-shun”)                      | <b>Motion</b> means an object is changing its position — it’s moving from one place to another. |         |
| <i>Speed</i><br>(“speed”)                          | <b>Speed</b> is how fast something is moving in a certain amount of time.                       |         |
| <i>Mass</i><br>(“mass”)                            | <b>Mass</b> is the amount of matter in an object. More mass means the object is heavier.        |         |
| <i>Height</i><br>(“hite”)                          | <b>Height</b> is how far something is above the ground.                                         |         |





|                                                       |                                                                                                                 |  |
|-------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|--|
| <i>Model</i><br>(“MAH-dul”)                           | A <b>model</b> is a drawing, diagram, or tool that helps explain how something works.                           |  |
| <i>System</i><br>(“SIS-tum”)                          | A <b>system</b> is a group of parts that interact and work together.                                            |  |
| <i>Potential Energy</i><br>(“puh-TEN-shul en-er-jee”) | <b>Potential energy</b> is stored energy an object has because of its position, like being high off the ground. |  |
| <i>Stored Energy</i><br>(“stord en-er-jee”)           | <b>Stored energy</b> is energy that’s not being used right now, but can be used later.                          |  |
| <i>Joules</i><br>(“jools”)                            | <b>Joules</b> are the units scientists use to measure energy.                                                   |  |
| <i>Energy Transfer</i><br>(“EN-er-jee TRANS-fur”)     | <b>Energy transfer</b> happens when energy moves from one object or form to another.                            |  |



# Kinetic and Potential Energy—Usage Guide

This guide provides recommendations for using the *Kinetic and Potential Energy: Skate Park Engineers* Investigation Series in your classroom and covers some general information about Gizmos Investigations for those who might be new to using this product.

In the *Kinetic and Potential Energy* Investigation Series, students investigate how mass, speed, and height impact kinetic and potential energy, and how these concepts apply to skate ramp design and safety constraints.

## Classroom Pacing Schedule (series)

This Investigation series should take approximately three class periods (about 120 minutes). Each lesson has an “End of Lesson” screen that can serve as a pause point for students.

- **Day 1:** Ask students to start the Investigation and **stop** when they reach the “End of Lesson” screen. This signifies the end of Lesson 1, which covers potential energy.
  - Students will have completed up to question 12 in the heatmap.
  - *Note:* Questions are not numbered within the Investigation, and the Heatmap view is only visible to teachers. **Students should stop** when they reach this page:



- **Day 2:** Instruct students to open the Investigation, which will start them where they left off. Students should work through Lesson 2 about kinetic energy and stop when they reach the “End of Lesson” screen.
  - Students will have completed 22 questions in the heatmap.
- **Day 3:** Instruct students to open the Investigation, which will start them where they left off. Students should work through Lesson 3 about energy transfer and stop when they reach the “End of Lesson” screen.
  - Students will have completed all 31 questions in the heatmap

## Series vs. Standalone Lessons

Our lesson platform offers both **series** and **standalone** lessons to support flexible use in a variety of classroom contexts. Teachers can choose to implement an entire sequence of lessons or use a single lesson independently, depending on instructional goals, student readiness, and available time.

### Series Lessons

- Designed to be taught in a specific order, with each lesson building on the ideas, models, and evidence from previous lessons.
- Students revisit and revise models, refine explanations, and apply their learning to new scenarios over time.
- Encourages deeper understanding of disciplinary core ideas, crosscutting concepts, and science and engineering practices through a coherent storyline.
- Ideal for comprehensive instruction, sustained engagement, and performance-based assessments.

### Standalone Lessons

- Fully self-contained and can be used independently from other lessons in the series.
- Include necessary background or recap content to ensure all students can engage meaningfully, even without completing prior lessons.
- Useful for targeted instruction, intervention, enrichment, or aligning to specific standards or pacing needs.
- Designed to deliver meaningful learning outcomes in a single class or unit without requiring prior knowledge from other lessons.

### Recommendation

Use **series lessons** when you want students to explore a phenomenon over time, develop and revise models, and connect concepts across multiple lessons. Use a **standalone lesson** when you're focusing on a specific concept, skill, or standard—or when time constraints require a more flexible instructional approach.

### Teacher Preview Version

We highly recommend that teachers complete a preview version of an Investigation before assigning it to their class. In the teacher version, each page functions as it would for your students, so you can preview feedback, scaffolding, and other support tools. You can use this

version to familiarize yourself with the activities that students will complete. You can also use it to review concepts with your class by presenting them via a projector or smartboard.

## Heatmap

The heatmap is a tool available for all Investigations that allows teachers to observe their students' current thinking and monitor student progress in real time. It can also be used to determine what additional support a student might need in the content and practices involved, individually or as a class.

Some questions are automatically graded and instantly populate the heatmap with a score and color, while others are categorized as “teacher graded.” These questions require a teacher to grade a student’s response for points to be awarded. All teacher-graded questions are provided with rubrics to support grading.

## Prior Knowledge

Throughout the Investigation, students are encouraged to share their current thinking and preconceptions to help relate new information they explore with their prior knowledge and experiences. These questions are shown on the heatmap with a purple lightbulb and labeled as “Conversational Questions”.

## Formative Assessment

Students are assessed on their learning by answering questions and receiving feedback as they progress through the Investigation. Students can check their understanding and receive targeted feedback when answering questions to discover if they have a misunderstanding. Students receive three tries on a formative question, listed to the left of the submit button.

Formative questions are color-coded within the heatmap to help teachers best support students. Detailed “scoring criteria” within the question view explains how colors were assigned for the heatmap question. The heatmap color codes are based on colors distributed across three percentage categories:

| Mastered | Developing | Below Expectations |
|----------|------------|--------------------|
| 75%-100% | 50-75%     | 0-50%              |

## Summative Assessment

Additionally, some questions within the Investigation are labeled as summative. These questions reflect moments where students have had ample opportunity to practice their understanding of a concept or skill and are thus assigned points after a single attempt to judge their current knowledge. These questions are color-coded in the heatmap using the same percentages

described above. The only difference here is that students are only given one attempt to answer a summative question. Summative question point values are the only points included in the total on the heatmap. Teachers can use these question types to assess student's knowledge or skills to better support learning in their classroom.

While the final score they receive on the Investigation can be used for a classroom grade book, we recommend assigning points to students' responses based on their ability and expectations.

## Student Support and Accessibility

Investigations include the following supports to help students further in their learning.

### Vocabulary Support

- The Key Vocabulary handout provides definitions and phonetic pronunciation for all key vocabulary terms used in the Investigation. The handout also includes space for students to draw pictures to help them learn these terms.
- Teachers can preview vocabulary using the handout to help support students before starting the Investigation.

### Writing Support

- Where applicable, sentence stems are provided for open-response questions to help students structure their writing.
- For some open-response questions, key vocabulary terms are automatically highlighted in green when included in student responses. This helps reinforce student vocabulary usage.
- Validation feedback is triggered for open-response questions when students submit vague answers or skip important vocabulary. This feedback guides students towards complete and meaningful responses. There is a checkbox at the bottom of this type of feedback so that students can move forward if they choose without getting stuck.