



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 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**.