Stackable Instructionally-embedded Portable Science (SIPS) Assessments Project

Grade 8 Science

Unit 1 Instructionally-embedded Assessment Task Specification Tool:

“Kinetic Energy vs. Mass/Speed Investigation”

Forces and Energy

May 2023

The SIPS Grade 8 Science Unit 1 Instructionally-embedded Assessment Task Specification Tool: “Kinetic Energy vs. Mass/Speed Investigation” was developed with funding from the U.S. Department of Education under the Competitive Grants for State Assessments Program, CFDA 84.368A. The contents of this paper do not represent the policy of the U.S. Department of Education, and no assumption of endorsement by the Federal government should be made.

SIPS Grade 8 Unit 1 Instructionally-embedded Assessment Task Specification Tool

Grade 8	Unit 1	Instructional Segment 3	Task Title: Kinetic Energy vs. Mass/Speed Investigation

Unit 1: Forces and Energy

Anchor Phenomenon	Problematization/Investigative Strategy for the Unit
In this unit, the anchor phenomenon is about collisions between a ball and another object (person, golf club, ground, etc.). The teacher may start with an image (or video) of a soccer ball colliding with a player's face. A compelling image can be used as a starting point for discussions about collisions in various sports, the effects of those collisions on an object's motion, and the factors that affect the forces and corresponding changes in motion. • Video of the ball/face collision: [https://youtu.be/On1CsbTwlDs?t=155]	The investigative strategy is based on a design challenge of designing head/face protection for a soccer player. Because investigations and experiments on collisions between a ball and a player are not feasible to do in a classroom context, students will use an egg as a model of the player and the ground as a model of the colliding object. Thus, the design challenge is the classic egg drop challenge, with the context of collisions in sports as the context. Many resources for the egg drop challenge exist, including: • Egg Drop - Science World [https://www.scienceworld.ca/resource/egg-drop/ience World] • Egg Drop Challenge - Museum of Science and Industry (msichicago.org) [https://www.msichicago.org/science-at-home/hands-on-science/egg-drop-challenge/]

Segment 3 Overview

Students engage with the SEPs of designing investigations and analyzing data to develop graphical representations of the relationships between mass and velocity and kinetic energy. Students use these representations as evidence to develop and use models of how kinetic energy changes during collisions. Students use evidence in evaluating different models and use their model to develop solutions to the problem of controlling damage during a collision.

Instructional Segment 3 assessment evidence focuses on a student's ability to demonstrate understanding of the nature of kinetic energy, kinetic energy and the relationships between mass, speed, and kinetic energy, and its interactions with objects and their motion. Students are assessed on their ability to construct explanations, use data, plan investigations, and design solutions related to kinetic energy.

Lesson Title	Lesson Description
Investigating How Speed and Mass Affect the Motion and Energy of an Object	Collisions involve more than just forces; the colliding objects possess energy which is released in different forms during the collision. In this investigation, students copy the important experiment of

	French Physicist and Philosopher Émilie du Châtelet (https://www.wowstem.org/post/émilie-du-châtelet-kinetic-energy-experiment). Instead of telling students this, the teacher presents students with the challenge and asks them to brainstorm ideas on how to find the amount of energy something has when it crashes into Earth. As a class, students brainstorm ideas to model the experimental design process. Students first drop a mass from different heights into clay and then measure the distance traveled into the clay. This will allow them to qualitatively compare the speed and energy. Speed can be calculated by using V = √(gh) where g is 10 m/s^2 and h is the height. The depth of the collision will provide students with a way of measuring the energy after each fall. After conducting the experiment with a constant mass and changing height, students should repeat the process but vary the mass and keep the height constant. A version of the NOVA movie, Einstein's Big Idea can also be found at https://youtu.be/V64toYdH9hU. The segment on Émilie du Châtelet begins at 55:00. Ideally, students design their own experiment for this setup, but that can be challenging. One idea may be to present students with an introduction using the PBS special Einstein's Big Idea (https://www.pbs.org/wgbh/nova/video/einsteins-big-idea/), which provides an interesting introduction and shows the experiment in action. A modification could be asking students to create their own energy experiment to verify findings using different materials. After collecting the data, students graph their data in a scatter plot. They should find a linear relationship between mass and energy. Students may struggle with recognizing the non-linear pattern between speed and energy. Many students will plot a trend line and not see the curve. Before students write their analysis and conclusion, the teacher should facilitate a discussion about the data. If possible, students can post their data points in a shared spreadsheet and the teacher can plot the data points and use the scatterplot to drive the discussion. The teacher facilitates a class discussion where students use evidence from the graph and work to find the pattern. At some point, the teacher may need to introduce the idea of non-linear patterns and should share several graphs that show non-linear relationships (cyclical wave patterns from weather, population curves, etc.).
Moving Energy	Using stations, students engage with multiple short hands-on activities, videos, reading passages, and other media to explore the relationship between mass and kinetic energy (KE) further. This provides students with a chance to check their understanding with a field of experts outside the classroom. As students work through the stations, they record key takeaways and notes in their science journals. They also fill out a C-E-R organizer based on a claim about the relationship between mass and kinetic energy. The teacher can refer to the resource list for potential sources for simulations, reading passages, and videos. Students could also read about kinetic energy in core textbooks. As students conduct their research on KE, they should record key takeaways in science journals. To make this activity more challenging, students could be tasked with conducting research on their own. For

	students who need accommodations, the teacher may consider different levels of reading, reducing the resources to the most essential, and providing multiple paths of understanding the content.
Modeling Kinetic Energy	Students create a set of models that demonstrate the relationship between mass and kinetic energy, and the relationship between speed and kinetic energy. Students' models should be informed by their data and data analysis from prior investigations in this unit. Students are tasked with creating two models: • Model 1 should explain how balls with different masses moving at similar speeds will have different kinetic energies. • Model 2 should show how a ball will have different values of kinetic energy depending on its speed. Students use their models to make new predictions. Using a rubric that the teacher provides to help students evaluate their models, students assess how their model demonstrates the relationship of mass, speed, and kinetic energy in a similar scenario. For example, if a model compares the kinetic energy of a baseball and a softball, then students discover how the model predicts the kinetic energy of a soccer ball moving at a similar speed. Students use their findings to advance a claim about the relationships between mass, speed, and kinetic energy and use their model as evidence to support their claim.

Formal Assessment Title	Assessment Description
Kinetic Energy vs. Mass/Speed Investigation	Using provided materials, students plan an investigation to gather data that demonstrates the relationship between KE and mass and/or speed.

NGSS PE(s) Code(s) & Description(s)
MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. [Clarification Statement: Emphasis is on balanced (Newton's first law) and unbalanced forces in a system, qualitative comparisons of forces, mass, and changes in motion (Newton's second law), frame of reference, and specification of units.] [Assessment Boundary: Assessment is limited to forces and changes in motion in one dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.]

AG(s) Code(s) & Description(s)
A13. Apply the scientific idea of kinetic energy (energy of motion) to design an object, tool, process, or system.
A16. Plan an investigation to gather data that demonstrates the relationship between KE and mass and/or speed.

Evidence Statement(s)

- Identify the purpose of the investigation, which includes providing evidence to describe the relationship between kinetic energy and mass and/or speed.
- Identify dependent and independent variables, as well as what variables should be controlled to examine a problem involving the relationship between kinetic energy and mass and/or speed.
- Select and determine which instruments will provide accurate and precise data to carry out an investigation regarding how changing the speed and/or mass affect the motion and kinetic energy of an object.
- Describe the experimental procedure necessary to investigate how changing the speed and/or mass affect the motion and kinetic energy of an object.

Phenomenon or Phenomenon-rooted Design Problem

- Kinetic energy of an object is the energy that it possesses due to its motion and the kinetic energy of an object depends upon its mass (kinetic energy increases as mass increases) as evidenced by the release and movement of a bowling bowl without force being applied. This phenomenon is also addressed through two investigations that experiment with kinetic energy given different conditions and variables.

General Scenario Description

Students are introduced to phenomena related to kinetic energy and conservation of energy that leads to designing an investigation to determine the relationship of mass and KE using a provided setup and lab materials.

Chain of Sensemaking

- Students state the purpose of a described kinetic energy investigation.
- Students are given a set of available lab materials to set up and conduct the investigation and identify the materials as an independent variable, a dependent variable, or a constant variable.
- Students are provided with a list of available measuring tools and describe which measuring tools will provide accurate and precise data.
- Students describe and explain data considerations when planning an investigation to ensure fair testing and accurate results.
- Students are given conditions for a second kinetic energy investigation and from a given set of available lab materials to set up and conduct the investigation, identify each of the materials as an independent variable, a dependent variable, or a constant variable.
- Students describe differences between what is being measured and demonstrated in the first investigation compared to the second investigation.

Work Products

- Fill-in-the Blank
- Tables

- Extended Response

Application of Universal Design for Learning-based Guidelines to Promote Accessibility (https://udlguidelines.cast.org/)

Multiple Means of Engagement	Multiple Means of Representation	Multiple Means of Action & Expression
☒ Context or content ☒ Age appropriate ☒ Appropriate for different groups ☒ Makes sense of complex ideas in creative ways ☒ Vary the degree of challenge or complexity within prompts	☒ Provide visual diagrams and charts ☒ Make explicit links between information provided in texts and any accompanying representation of that information in l illustrations, equations, charts, or diagrams ☒ Activate relevant prior knowledge ☐ Bridge concepts with relevant and simple analogies and limited use of metaphors ☐ Highlight or emphasize key elements in text, graphics, diagrams, formulas ☐ Use outlines, graphic organizers, unit organizer routines, concept organizer routines, and concept mastery routines to emphasize key ideas and relationships ☒ Give explicit prompts for each step in a sequential process	☒ Solve problems using a variety of strategies ☒ Sentence starters ☒ Embed prompts to "show and explain your work"

Targeted PE(s) Code(s) and Alternate Conception(s)

- **MS-PS2-2.** Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. [Clarification Statement: Emphasis is on balanced (Newton's first law) and unbalanced forces in a system, qualitative comparisons of forces, mass, and changes in motion (Newton's second law), frame of reference, and specification of units.] [Assessment Boundary: Assessment is limited to forces and changes in motion in one dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.]
    - **Common Alternate Conceptions**
        - Different types of motion—rest, constant velocity, and constant acceleration—are the same.
        - If speed increases, then acceleration must be increasing as well.
        - Contact/field forces and net forces are the same.
        - Forces must be exerted on a system in order for the system to maintain motion.

- If the sum of all forces adds to zero, then the object must be at rest.
- Any force on an object must be in the direction of movement.
- Individual forces, not their sum, determine the motion of an object.
- If an object is moving, the sum of all forces cannot equal zero.
- Constant speed, not constant acceleration, results from constant force.
- An object can have a force within it that keeps it moving.

Unit 3 Vocabulary

- Motion (direction of, change in)
- Force (net, balanced, unbalanced, peak, normal, force pairs, field, contact, noncontact, opposite, direction of, strength, attractive)
- Mass
- Impact
- Accurate
- Precise
- Collision
- Kinetic energy
- Variables (dependent, independent, control)