**Unit Essential Question:** *How do our bodies produce and use the energy needed to move objects?*

**Introduction**

In the Lift-Off task, students explored an example of their bodies putting an object in motion by kicking a kickball. Before students delve into how the body is involved in this action, we first want them to understand the science behind the motion itself. In this task, students explore how the kinetic energy of an object changes when energy is transferred or transformed to or from the object. Through investigations, they will learn that they are able to identify these changes in kinetic energy by noticing observable features, such as motion, temperature, or sound. They are even able to predict an object’s kinetic energy by making observations of its potential energy. By the end of this task, students will be able to use scientific vocabulary to construct an argument about what is happening in their investigations in terms of energy. This will help them explain what would be needed to change the motion of the object in their chosen activity for their culminating project.

**Alignment Table**

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| **Performance Expectations** | **Science and Engineering Practices** | **Disciplinary Core Ideas** | **Crosscutting Concepts** |
| **MS-PS3-5. Construct, use, and present arguments 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.*] | **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.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. | **Energy and Matter**   * Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). |
| **Supplementary Science and Engineering Practices**   * Planning and Carrying Out Investigations   + Conduct an investigation […] to produce data to serve as the basis for evidence that meet the goals of the investigation. | | | |
| **Equity and Groupwork**   * Discuss and compare observations with partners and group members. * Participate in group roles to conduct an investigation and gather data. | | | |
| **Language**   * Follow a lab procedure. * Read and annotate an article. * Critique and correct a claim (optional). * Construct a written argument, using scientific vocabulary and experimental evidence. | | | |

**Learning Goals**

This learning task asks students to investigate collisions and explain them in terms of kinetic energy changes and energy transfer. More specifically, the purpose is to:

* Engage prior experience to show how changes in kinetic energy can be associated with changes in observable features, like temperature.
* Explore another investigation of kinetic energy transfer with a focus on the relationship to potential energy.
* Explain how energy is involved in both the *Engage* and *Explore* investigations.
* Use knowledge of kinetic energy and observable features to explain a real-life phenomenon.
* Apply knowledge of kinetic energy and energy transfer to the motion of the object in their chosen activity.

**Content Background for Teachers**

In this task, students explore the concept of energy to understand why objects move and behave as they do. To move an object, a force is required. When a force is applied to an object, this causes the energy of that object to change. For example, when you push a table, you are applying a force. This changes the energy of the table, making it move.



This kind of motion energy is called kinetic energy. Kinetic energy can be transferred between objects, like when a bat collides with a baseball. Kinetic energy can also be transformed into other kinds of energy, like when car brakes heat up (increased thermal energy) as they slow down a wheel (decreased kinetic energy). In this task, students will explore examples of both kinetic energy transfer and kinetic energy transformation.

Students will be able to find evidence of kinetic energy changes by looking for some key observable features—change in **motion**, **temperature**, or **sound**. In their investigations, students will identify these features to support the argument that when the kinetic energy of an object changes, energy is either transferred or transformed.

In the *Engage* investigation, for example, students notice that an increase in hand motion (kinetic energy) corresponds with an increase in temperature (thermal energy). This is an example of energy transformation.

In the *Explore* investigation, students add another element to their understanding of energy—potential energy. Students observe that if they put the ball at a higher position on the ramp, it will knock over more pennies in the stack at the bottom of the ramp. When the ball is placed in the higher position, it has more potential energy because of gravity, which can then be converted into more kinetic energy once the ball is released. Thus, upon collision, this ball will transfer more kinetic energy to the pennies and knock more over. This is an example of energy transfer.

**Academic Vocabulary**

* Energy
* Force
* Motion
* Speed
* Kinetic Energy
* Transfer
* Transform
* Temperature
* Sound
* Potential Energy

**Time Needed (Based on 45-Minute Periods)**

3.5 Days

* Engage: 0.5 period
* Explore: 0.5 period
* Explain: 1 period
* Elaborate: 0.5 period
* Evaluate and Reflection: 1 period

**Materials**

* Unit 1, Task 1 Student Version

Explore (Per group)

* Books or other items that can be stacked
* Ball/Marble
* Pipe insulation, cut open to make a track
* 20 pennies

Evaluate

* Project Organizer Handout

**Instructions**

**Engage**

1. Introduce Task 1: In the Lift-Off task, you explored an example of our bodies putting an object in motion. Think about what you were still wondering about at the end of the last task (look back if you need to). What questions do you still have?
   * Before you pass out their student guide, give students time to reflect individually or with a partner about the questions they recorded at the end of the last task. Share a few of these out as a class, using facilitating questions to guide students toward questions that relate to this task.
2. Transition to Task 1: But what influences the motion of an object, like a kickball? Before we delve into how our bodies are involved, today we will explore the science behind the actual motion of objects.
   * Now pass out their Task 1 student guide.
3. Students begin this task by investigating a simple action that they have likely done before—rubbing their hands together. Following the directions in their student guide, students will rub their hands together slowly and then quickly, making observations of sensations at the different speeds and thinking about why the observations are different.
   * All students should conduct the investigation, but they can discuss their observations and comparisons in pairs before recording in their student guide.
   * Share out a few comparisons and hypotheses that students come up with. There are no right answers. Most students will notice that rubbing their hands faster creates more heat, which is exactly the observable feature we hope they notice. Hypotheses will vary, but many will likely mention friction or some other kind of energy transfer as the reason for this temperature difference.

**Explore**

1. In the *Engage* investigation, students saw that a change in motion was associated with a change in temperature. This set the stage for them to begin to understand the observable features (e.g., motion, sound, temperature) associated with changes in kinetic energy. In this activity, they will continue to build upon this knowledge by investigating how changing a ball’s position changes the amount of kinetic energy it has, as evidenced by the amount of pennies it knocks over.

* This activity gives students practice at the supplementary SEP of **Planning and Carrying Out Investigations** as they conduct investigations to produce data that can serve as evidence for changes in kinetic energy. Students are also implicitly emphasizing the crosscutting concept of **Energy and Matter** as they experience changes in potential and kinetic energy in this investigation.

1. Introduce the investigation by reading aloud and/or projecting the experimental question: How does changing the position of a ball on a ramp affect the amount of stacked pennies it knocks over at the bottom of the ramp?

* Have students individually make a prediction to this question, using the sentence frame in their student guide. You may wish to have them discuss the reasoning behind their prediction with a partner.

1. Distribute the investigation materials outlined in the Materials List above and review the experimental set-up shown in their student guide. Then assign roles to each group. You may use whatever roles you prefer. We recommend the use of the Facilitator, Materials Manager, Harmonizer, and Recorder.
   * Ask the Facilitator to read the directions and to make sure everyone understands the task.
   * Ask the Materials Manager to gather the materials needed to complete the task.
   * Ask the Harmonizer to make sure that everyone contributes their ideas and that everyone’s voice is heard.
   * Ask the Recorder to make sure the group is recording their data in their Student Guide.

**Track:** Half of a length of pipe insulation

**Risers**: Books or other items that are flat and can be stacked

**Target:** One stack of 20 pennies

**Ball/Marble**

1. Student groups release a marble from two different heights on the ramp. They should record the amount of pennies knocked over each time.

* Optional: students may try more height variations than just top of ramp and middle of ramp.

1. Once all groups have completed the investigation, debrief their data in pairs. Students should find that placing the ball higher results in more pennies knocked down. Encourage them to hypothesize why that might be. Use facilitating questions to guide students toward the idea that the higher-positioned ball must have had more energy to allow it to knock over more pennies.

* We encourage using equity sticks to foster more equitable participation in class-wide discussions like these (See “How To Use This Curriculum” for more details).

**Explain**

1. Thus far, students have seen examples of changes in kinetic energy during energy transfers. However, they have not had the scientific vocabulary to fully understand and explain what they observe. In this *Explain*, students will read an article about energy that provides students with the vocabulary they need to construct an argument about the energy involved in their investigations.
2. First have students individually read and annotate the article about energy in their student guides.
   * This article emphasizes the CCC of **Energy and Matter**, as students learn how energy can take different forms (potential, kinetic, thermal, etc.) and have different observable features (temperature, motion, or sound).
   * Optional: To help students process what they have read, have them brainstorm and practice explaining another example of kinetic energy and energy transfer in pairs.
   * Take questions about the article, as needed.
3. Using the scientific vocabulary and concepts they learned from the article, students then individually construct an argument that explains how energy is involved in both the *Engage* and *Explore* investigations.
   * Students should support their argument with data from the investigations as well as scientific reasoning using the following terms: transfer, transform, kinetic energy, potential energy, motion/move, and temperature. This allows students explicit practice in the SEP of **Engaging** **in Argument From Evidence**.
4. Optional scaffold: Conduct a Critique, Correct, and Clarify language exercise in pairs before students write their own arguments. We recommend using equity sticks to share out a few pair’s critiques as a class before they move on to independently writing an improved claim in their student guides. An example protocol and graphic organizer is provided below:

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| --- |
| **Critique, Correct, and Clarify: Energy in Motion**  Prompt: Construct an argument to explain the role of energy in both the *Engage* and *Explore* investigations. Include scientific terms and data from the investigations.  In pairs:   1. Critique: Analyze the claim below. Identify the error(s) or things that aren’t clear. Share your ideas with a partner.   *Kinetic energy is the type of energy involved in both investigations.*   1. Correct: Individually write an improved claim in your student guide. 2. Clarify: Describe how and why you corrected the claim. |

Optional Sentence Stems to Provide:

|  |  |
| --- | --- |
| **Claim** | In both investigations,…  This is shown by… |
| **What evidence and scientific reasoning do you have to support your claim?** | In both investigations,…  …which is the definition of…  In the *Engage* investigation…  This led to…  …which we could observe as…  \_\_\_ energy was transformed into \_\_\_ energy.  \_\_\_ energy was transferred from \_\_\_ to \_\_\_.  This was shown by…  In the *Explore* investigation…  When the ball collided with the pennies,… |

Sample Explanation

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| --- | --- |
| **Claim** | In both investigations, the kinetic energy of objects changes as energy is transferred between objects or transformed into other kinds of energy. This is shown by changes in observable features, like motion and temperature. |
| **What evidence and scientific reasoning do you have to support your claim?** | In both investigations, there is energy in motion, which is the definition of kinetic energy. In the *Engage* investigation, increasing hand motion led to more kinetic energy being transformed into thermal energy, which we could feel as a greater temperature. In the *Explore* investigation, placing the ball higher on the ramp gave it more potential energy, which was transformed into more kinetic energy as it moved down the ramp. When this ball collided with the pennies, it had more kinetic energy to transfer to the pennies, causing more pennies to move. |

1. We recommend students do this task individually as it can be a good option for formative assessment. Collect student work to identify trends in students’ ability to use scientific vocabulary and experimental evidence to support an argument about kinetic energy and energy transfer. See “How to Use This Curriculum” for strategies on utilizing formative assessment data to provide feedback to students and inform classroom instruction.

**Elaborate**

1. Now that students understand the relationship between kinetic energy and energy transfer between objects, they are ready to apply it to a real-life scenario.
2. Read the scenario aloud as a class: A car’s wheel is spinning at a rapid speed while it is parked. The driver wants to know why there is so much smoke. How can you explain this to the driver?

* Optional: Show a video of this phenomenon so students have a visual context.

1. Students then discuss this scenario with a partner and craft a response together in their student guides.

* Debrief briefly as a class. Students should be able to explain that the wheel spinning at a rapid speed has a lot of kinetic energy. As the wheel moves against the pavement, it creates friction and some of that kinetic energy is transformed into thermal energy, resulting in heat and smoke.
* Again, we encourage using equity sticks to foster more equitable participation in class-wide discussions like these (See “How To Use This Curriculum” for more details).

1. Return to the whole-class concept map from the Lift-Off Task.
   * In small groups, have students brainstorm new concepts and new connections that they have learned in this task, as well as any new questions that have come up for them. Then have groups share these aloud in a class-wide discussion and add to the class concept map. The use of equity sticks is encouraged for more equitable participation in class-wide discussions (See “How To Use This Curriculum” for more details).
     + Some facilitating questions to ask students are: What new ideas/concepts do you want to add to the map? What connections do you want to add or change? What is your reason for that addition/revision? What connections can we make between the questions/ideas already on the map? What new questions do you have about the phenomenon?
     + Draw circles around each question and boxes around each concept.
     + Write connector words to describe connections between the concept boxes.
     + For this task, students may begin to connect some of their previous question circles to concept boxes about the following: motion of objects, kinetic energy, and energy transfer or transformation.
   * Have students analyze the additions to the class concept map for as many examples of this task’s crosscutting concept as they can find. Once a student has identified the crosscutting concept, you can trace the circle in the corresponding color (decided on in the Lift-Off task). We recommend asking students to share key words that helped them identify the crosscutting concept for that concept or question. Some identifying words students might look for are:
   * **Energy and Matter**: These could be phrases such as, “energy is transferred/flows,” “is conserved,” “is important for,” “is needed,” etc.

* Once again, the purpose of this concept map is to facilitate generation of student questions, promote language development, and support understanding of the science content throughout the unit. Allowing students to ask their own questions and use their own words to make meaning of the concepts will not only help them make deep connections about science content, but will also help their oral and written language development.

**Evaluate: Connecting to the Culminating Project**

1. Usually, we recommend that students independently complete their project organizer. However, at this point, it is important that the group make a decision about what activity they want to focus on for their culminating project. Once this is decided, students independently fill out the Task 1 section of the Unit 1 Project Organizer in class. Revisions can be done for homework, depending upon student’s needs and/or class scheduling.
2. Students have been asked to teach people how their bodies make the movement of objects possible in a specific activity. Their prompt is as follows: Your presentation will involve demonstrating an activity and explaining the science behind an object’s motion. As a group, first decide on an activity that puts an object in motion to focus on for your culminating project. Then individually,

* Describe how an object moves in your group’s chosen activity.
* Explain what you would need to change the motion of the object (e.g., make it go faster/slower or farther/closer). Describe how this changes the object’s kinetic energy.
  + Cite evidence from your argument or investigations to support your explanation.

**Reflection**

1. At the end of the task, ask students to reflect on what they have learned over the course of this task by answering the following three questions in their student guide:

* At the beginning of this task, you were asked to make observations when you rubbed your hands together. This experiment showed one type of observable feature associated with kinetic energy. Based on what you learned throughout the task, what are all the different observable features associated with kinetic energy?
* In this task, we focused on the crosscutting concepts of **Energy and Matter**: Energy may take different forms. Where did you see examples of **Energy and Matter** in this task?
* Now that you have learned more about the science of moving objects, what questions do you still have?

1. There are no right answers, but encourage students to look back at their student guides and their class concept map. They should not change their initial responses, but rather use this reflection space to add to their ideas and questions based on what they have learned through this task. By generating more of their own questions, students continue to engage in sense-making of the phenomenon and gathering knowledge and skills for their final projects.

**Assessment**

1. You may collect students’ Project Organizer and assess using:

* *Criteria of your choice.* We recommend using the 3-Dimensional Assessment matrix at the beginning of this document to inform your criteria.
* This can be a formative tool to periodically look for trends in student understanding after the completion of a task. You can then use this formative data to inform any re-teaching as necessary.

1. You may also give students time to make revisions with one of the two options:

* Students may make changes to their Project Organizer according to your comments OR
* Ask students to exchange Project Organizers with a partner and give partners 5 minutes to give written feedback. Then allow students time to make changes to their work according to the feedback.