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

**Introduction**

In Task 1, students explored the energy involved in moving objects. Here, they transition away from the physics concepts involved to think about how their bodies are able to move objects. To begin to make this connection between their bodies and moving objects, students first explore the nervous system—specifically the pathway signals take in order for the body to sense and respond to its environment in the kinds of activities they are focusing on for their culminating projects. After engaging prior knowledge about the nervous system through a kinesthetic activity, students explore a variety of different sources to gather and synthesize information on nervous system pathways. Equipped with this new knowledge, students reassess the activity from the *Engage* and try to explain how the nervous system was working as they did that activity. By the end of this task, students will have a variety of new scientific terminology to describe the neural response in a reflex arc as well as the activity they chose for their culminating project.

**Alignment Table**

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| --- | --- | --- | --- |
| **Performance Expectations** | **Science and Engineering Practices** | **Disciplinary Core Ideas** | **Crosscutting Concepts** |
| **MS-LS1-8. Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.**[*Assessment Boundary: Assessment does not include mechanisms for the transmission of this information.*] | **Obtaining, Evaluating, and Communicating Information**   * Gather, read, and synthesize information from multiple appropriate sources. | **LS1.D: Information Processing**   * Each sense receptor responds to different inputs, transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories. | **Cause and Effect**   * Cause and effect relationships may be used to predict phenomena in natural systems. |
| **Supplementary Science and Engineering Practices**   * Developing and Using Models   + Develop and/or use a model to predict and/or describe phenomena. | | | |
| **Equity and Groupwork**   * Discuss information gathered from different sources. * Participate in roles in a nervous system simulation. * Engage in kinesthetic activities with a partner. | | | |
| **Language**   * Follow written procedures. * Read and apply definition cards to a visual diagram. * Extract and organize information from a video. * Use sequence language and new scientific terminology to develop a model of a process. | | | |

**Learning Goals**

This learning task asks students to gather and synthesize information that the body responds to stimuli by following a neural pathway. More specifically, the purpose is to:

* Engage prior knowledge of nervous system pathways through a kinesthetic activity called “Catch the Ruler”.
* Explore the nervous system by obtaining and synthesizing information from a variety of sources.
* Explain the neural response in the “Catch the Ruler” activity in the form of a flowchart.
* Use knowledge of nervous system pathways to explain what component is missing in a reflex arc.
* Apply knowledge of nervous system pathways to the activity chosen for the culminating project.

**Content Background for Teachers**

In this task, students are introduced to the nervous system and the role it plays in moving objects in different activities. To move objects, neurons (nerve cells) in the nervous system need to work together to send messages between the brain and the body.

The nervous system consists of two major systems—the central nervous system (CNS) and the peripheral nervous system (PNS). The CNS is made up of the brain and spinal cord and is responsible for processing information. The PNS is made up of sensory neurons, connected to sense organs (skin, nose, eyes, etc.) and motor neurons, connected to effector organs (glands and muscles). Communication between these two systems is essential to allow the body to sense stimuli from the environment, process the signal, and respond appropriately.

In this task, students are focusing on these components of the nervous system within context—in the pathway signals take in the nervous system. To sense and respond to the environment, a stimulus is first received by a sensory neuron in a sense organ. The sensory neuron then relays this message to the brain and/or spinal cord where it is processed. In the brain, this message can be stored as a memory and/or it can inform a response. In a response, the message will be sent from the brain to the spinal cord and out to a motor neuron, which is connected to an effector cell. This effector cell will carry out the response.

Students will play this out with a few different examples. In the “Catch the Ruler” game, the stimulus is the sight of the ruler falling. A sensory neuron in the eye receives this message, which is relayed to the brain and the decision is made to catch the ruler. This message is then sent out through the spinal cord to a motor neuron attached to a muscle cell in the hand, causing the fingers to close.

In the *Explore* nervous system simulation, the pathway is slightly different because of where the sensory neuron is located. In this case, a runner must feel the touch of their teammates hand to begin running. A sensory neuron in the hand receives this message, which is relayed to the spinal cord and up to the brain where the decision is made to catch the ruler. This message is then sent out again through the spinal cord to motor neurons attached to muscle cells in the legs, causing the runner’s legs to begin moving. In the “Catch a Ruler” game, the sensory receptor is in the eye, so the signal goes straight to the brain; the sensory receptor in the relay scenario is in the hand, so the signal must first travel up the spinal cord before it reaches the brain. This is an important distinction for students to notice in this task.

Understanding this difference in pathway will also help prepare students for the *Elaborate* scenario—a reflex arc. In a reflex arc, the message skips the brain and goes straight from sensory neuron to spinal cord to motor neuron. This is why you are able to pull your hand away so quickly when you touch a hot surface. For more information on any of these topics, please see the resources provided in the *Explore* section.

**Academic Vocabulary**

* Nervous System
* Stimulus
* Response
* Sensory Neuron
* Motor Neuron
* Brain
* Spinal Cord
* Central Nervous System
* Peripheral Nervous System
* Pathway

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

4.5 Days

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

**Materials**

* Unit 1, Task 2 Student Version

Engage

* Ruler (per pair)

Explore

* Nervous System Definition Cards and Scissors (per person)
* Nervous System Video and Simulation Instructions (per group)
* Computers (per group) or Projector/Speakers (per class)
* Optional: Role Cards for Nervous System Simulation

Elaborate

* Optional: Reflex Hammer (Per Pair)

Evaluate

* Project Organizer Handout

**Instructions**

**Engage**

1. Introduce Task 2: In Task 1, you explored the energy involved in moving different objects, like a kickball. 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 2: But how are you able to kick a kickball? How does your body move objects in these specific activities?
   * Now pass out their Task 2 student guide.
3. Students begin this task by experiencing how they can sense and respond to their environment through a simple game—“Catch the Ruler”. Frame the game as a challenge: the goal is to catch the ruler with less than 7 cm left at the bottom. You may wish to offer a prize for any student who is able to do it (keeping in mind that catching a ruler with less than 7 cm at the bottom is impossible).
   * Pass out a ruler to each pair of students and have them follow the procedure in their student guides. We recommend modeling the process before students do it in pairs.
   * After both partners have practiced the game, have them debrief the questions on their student guide in partners before debriefing as a class.
     + There are no right answers for the first question, but students should observe that none of them were able to catch the ruler with less than 7 cm left at the bottom of the ruler. Students might come up with hypotheses like, “there is not enough time for us (e.g., our brains to process).” The second question is intended to elicit any prior knowledge students have on the nervous system, so responses will vary.
     + 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).

**Explore**

1. To help students understand what happened in the “Catch the Ruler” game, they first need to gather and synthesize information about the nervous system. In groups, students will analyze resources in three different modalities (words and visuals, video, and simulation). To synthesize information, students will take guided notes in the graphic organizer provided in their student guide.

* This activity gives students practice at the SEP of **Obtaining, Evaluating, and Communicating Information** as they gather, read, and synthesize information from multiple appropriate sources.
* Because of the style of notetaking, students are also practicing the supplementary SEP of **Developing and Using Models** as they construct annotated diagrams to describe a nervous system pathway.

1. We recommend providing the *Nervous System Definition Cards* to each student so that they can manipulate them as they want in this activity and can keep them for reference.

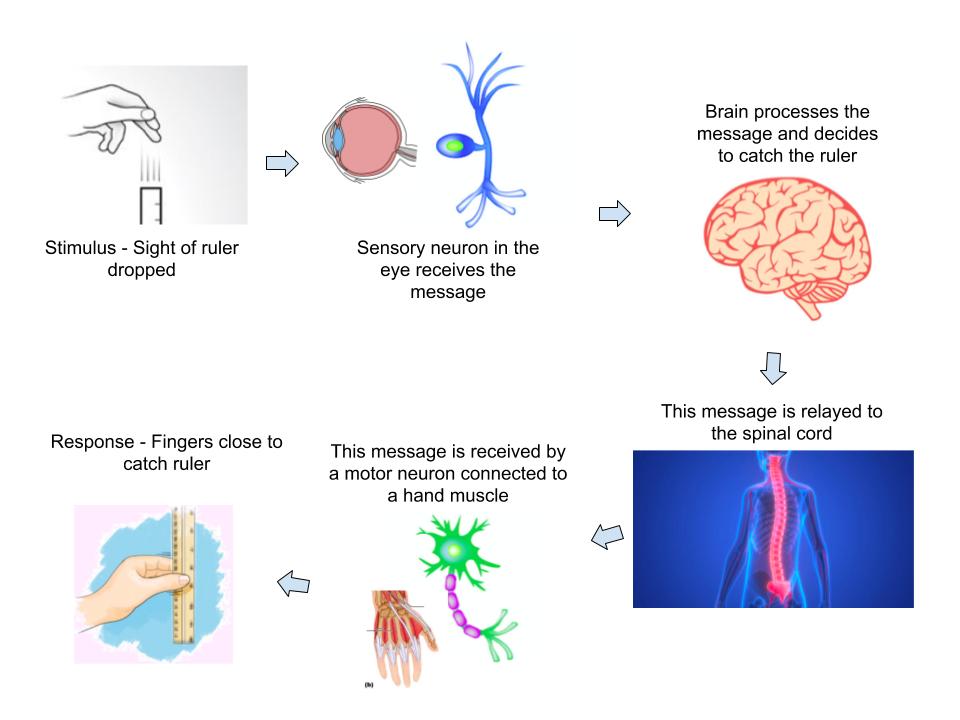
* If you decide to guide this activity as a whole class, you can show the video and give instructions for the simulation as a class.
* If you run this activity more independently in groups, distribute computers and handouts, and assign roles to each group. You may use whatever roles you prefer. We recommend the use of the Facilitator, Materials Manager, Harmonizer, and Recorder.
  + 1. Ask the Facilitator to read the directions and to make sure everyone understands the task.
    2. Ask the Materials Manager to gather the materials needed to complete the task.
    3. Ask the Harmonizer to make sure that everyone contributes their ideas and that everyone’s voice is heard.
    4. Ask the Recorder to make sure the group is recording their notes in their Student Guide.

1. For the relay race simulation, you may want to provide groups with role cards so it is clear what role they are playing: “sensory neuron”, “motor neuron”, “spinal cord”, and “brain”.

* We recommend giving groups an opportunity to discuss which component of the nervous system they will start with. Once a group is ready, they can raise their hand to request a “stimulus”.
* Your role as the teacher will be to act as the “stimulus” by tapping the group member’s hand that represents the “sensory neuron”. Each group should indicate which group member you should start with; if they don’t indicate the “sensory neuron”, ask a facilitating question and give them more time to discuss before returning to their group.
* Observe the way students are passing along the neural impulse, asking more facilitating questions to guide them as necessary.
  + The order should be: Stimulus (teacher) > sensory neuron > spinal cord > brain > spinal cord > motor neuron (leads to running response).
  + This activity is a good option for formative assessment. Observe student groups to identify trends in students’ ability to accurately demonstrate a neural pathway. See “How to Use This Curriculum” for strategies on utilizing formative assessment data to provide feedback to students and inform classroom instruction.
* Have one or two groups demonstrate and narrate their neural pathway to the entire class as a class debrief.

**Explain**

1. Now that students have an understanding of the nervous system, they are able to return to the “Catch a Ruler” game and better explain what is happening. In this portion of the task, students individually draw a flowchart of the process that allowed them to catch the ruler and use this flowchart to explain why no one was able to catch the ruler with less than 7 cm remaining.
2. As students draw their flowchart, encourage them to reference the *Nervous System Definition Cards* to give them an idea of what to include. They should also refer back to their graphic organizer from the *Explore* for additional information. Below is a sample model:



1. The second question asks students to use their new knowledge to explain why no one was able to catch the ruler quickly enough to have less than 7 cm at the bottom.
   1. This helps students emphasize the CCC of **Cause and Effect** as students use the cause and effect relationships above to predict why such fast responses are impossible.
   2. Students should be able to explain that such a fast response is not possible because the body must go through all these steps of the nervous system pathway, which takes time.
2. 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 show cause and effect relationships in a nervous system pathway and use the relationships to predict why such fast responses are impossible. See “How to Use This Curriculum” for strategies on utilizing formative assessment data to provide feedback to students and inform classroom instruction.

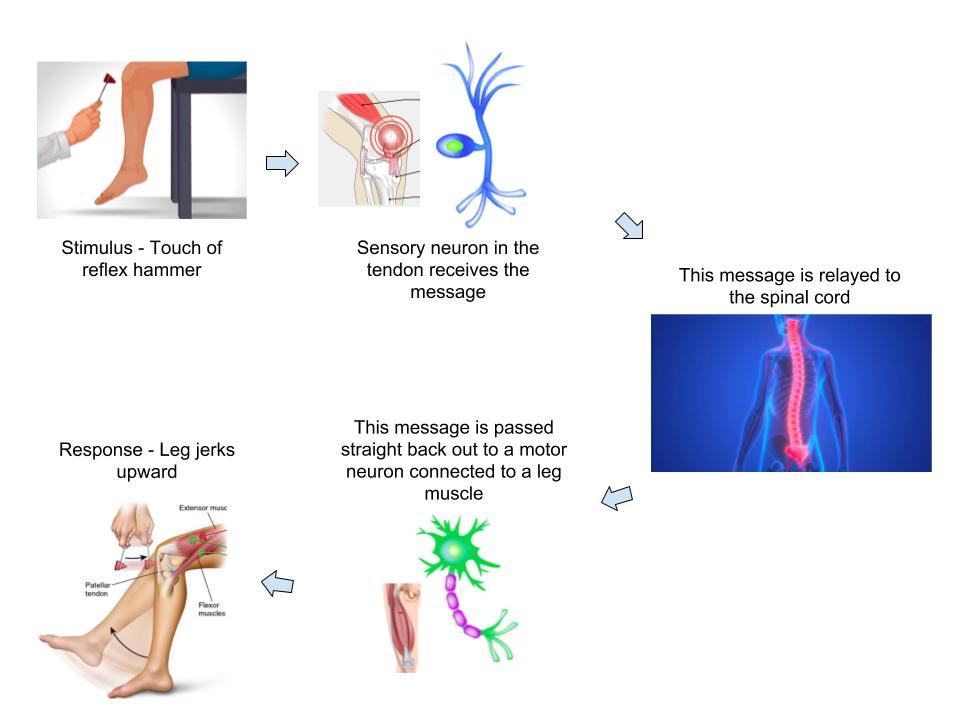
**Elaborate**

1. For the body to accomplish an action, like catching a ruler, it must sense the object and make a decision to take action. However, sometimes the body takes action without a conscious decision. In this section of the task, students apply what they have learned about typical nervous system pathways to try to make sense of another scenario—a reflex arc.

* This again allows students to emphasize the CCC of **Cause and Effect** as they use the cause and effect relationships they have identified in previous sections of the task to try to explain neural responses that happen more quickly.

1. First have students experience a reflex arc on their own—the patellar reflex or the knee-jerk reflex. Students follow the procedure on their Student Guides in partners, using either the side of their hand or a reflex hammer to stimulate a knee-jerk reaction.
2. After students have completed the demonstration, have them discuss and respond to the questions in their student guide.

* The knee-jerk reaction is almost instantaneous, so students must consider how such a response can happen so quickly and without thinking about it. They should use logic to infer that if the nervous system pathway in “Catch the Ruler” takes a certain amount of time, then this nervous system pathway must somehow be shorter to be able to happen so quickly. The fact that there is no conscious decision also provides an extra hint that the brain might be the step that is skipped.
* Below is a sample model of this reflex arc:



1. We recommend debriefing this activity as a class by co-constructing a class reflex arc model after students have completed their own in pairs. This is also a helpful video to review reflex arcs if students still need additional support: <https://www.youtube.com/watch?v=c-dD0N53QRg> (Stop at 1:10).

* To highlight the slight variety in nervous system pathways, it is also helpful to display models of all three scenarios explored in this task (“Catch the Ruler”, “Relay Race”, “Knee-Jerk Reflex”). Conduct a Think-Pair-Share asking students to notice any differences between the three scenarios and describe reasons for these differences. For example:
  + Catch the Ruler: The pathway goes straight from the sensory neuron to the brain because the sense organ in this case is the eye, which is adjacent to the brain.
  + Relay Race: The pathway goes from the sensory neuron first to the spinal cord and then the brain because the sense organ in this case is the hand.
  + Knee-Jerk Reflex: This pathway skips the brain and goes straight from sensory neuron to spinal cord to motor neuron. This allows for a quick response.
    - Give students an opportunity to think about why our bodies have developed a reflex response (Hint: quickly removing hand from a hot stove).
* 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: the nervous system pathway that allows the body to sense and respond to its environment in different activities.
   * 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:
   * **Cause and Effect:** These could be phrases such as, “that results in,” “that causes,” “that explains why,” “is due to,” 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. Students independently complete the Task 2 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 and brochure will include showing how the body’s nervous system allows it to move objects in your chosen activity.

* Describe the nervous system pathway involved in your chosen activity. You may draw a flowchart, like you did in this task, or describe the pathway in a numbered list or paragraph.

**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 describe the process you thought your body was going through to catch a ruler. Look at the flowchart you drew in the *Explain* after learning more about the nervous system. How does your first description in the *Engage* differ from your later description in the *Explain*? What did you learn over the course of this task?
* In this task, we focused on the crosscutting concepts of **Cause and Effect**: Cause and effect relationships can be used to predict phenomena. Where did you see examples of **Cause and Effect** in this task?
* Now that you have learned more about nervous system pathways, 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.