**Unit Essential Question:** *What forces keep the parts of our solar system together and how can we use this knowledge to plot a telescope route through space?*

**Introduction**

In the last task, students explored one invisible force—gravity—specifically looking at the role it plays in the motion of celestial objects in our solar system. In doing so, they were able to add to their visualization of the solar system as a whole, providing a rich context within which to plan their new telescope route. In this task, students examine another invisible force—magnetism—but more to think about how to protect the telescope itself as it travels through space and how it will then behave as a result. Students often conceive of magnetism as this invisible mystery force that makes objects appear to move on their own. To learn more about these invisible forces and fields, students will need to conduct investigations, analyzing and interpreting data to prove that these fields do indeed exist and can explain the phenomena they see. By the end of this task, students will not only be able to make some recommendations to create a strong magnetic field that protects their telescope, they will also be able to predict the subsequent behavior of the telescope due to its magnetic field.

**Alignment Table**

|  |  |  |  |
| --- | --- | --- | --- |
| **Performance Expectations** | **Science and Engineering Practices** | **Disciplinary Core Ideas** | **Crosscutting Concepts** |
| **MS-PS2-3**.**Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.**[Clarification Statement: Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or the effect of increasing the number or strength of magnets on the speed of an electric motor.] [*Assessment Boundary: Assessment about questions that require quantitative answers is limited to proportional reasoning and algebraic thinking.*] | **Asking Questions and Defining Problems**  * Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles. | **PS2.B: Types of Interactions**  * Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. | **Cause and Effect**  * Cause and effect relationships may be used to predict phenomena in natural or designed systems. |
| **MS-PS2-5. Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.** [Clarification Statement: Examples of this phenomenon could include the interactions of magnets, electrically-charged strips of tape, and electrically-charged pith balls. Examples of investigations could include first-hand experiences or simulations.] [Assessment Boundary: Assessment is limited to electric and magnetic fields, and is limited to qualitative evidence for the existence of fields.] | **Planning and Carrying Out Investigations**   * Conduct an investigation and evaluate the experimental design to produce data to serve as the basis for evidence that can meet the goals of the investigation. | **PS2.B: Types of Interactions**   * Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively). | **Cause and Effect**   * Cause and effect relationships may be used to predict phenomena in natural or designed systems. |
| **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.*] | **Developing and Using Models**  * Develop a model to describe unobservable mechanisms. | **PS3.A: Definitions of Energy**  * A system of objects may also contain stored (potential) energy, depending on their relative positions.  **PS3.C: Relationships Between Energy and Forces**  * When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. | **Systems and System Models**   * Models can be used to represent systems and their interactions – such as inputs, processes, and outputs – and energy and matter flows within systems. |
| **Supplementary Science and Engineering Practices**   * Analyzing and Interpreting Data   + Analyze and interpret data to determine similarities and differences in findings. | | | |
| **Equity and Groupwork**   * Work in specific group roles to conduct experiments. * Come to consensus on questions to investigate. * Work together to plan and conduct an exploration. | | | |
| **Language**   * Record observations. * Write lab conclusions based on data. * Ask questions related to data. * Depict scientific concepts in a model. | | | |

**Learning Goals**

This learning task asks students to gather evidence that magnetic fields exist at different strengths, caused by different factors. More specifically, the purpose is to:

* Make predictions about a mysterious phenomenon.
* Conduct investigations about invisible forces.
* Use data as evidence for the existence of fields between objects not in contact with each other.
* Use cause and effect relationships to predict how objects not in contact with each other may behave.
* Evaluate an experimental design.
* Ask questions about data and conduct an exploration to determine the factors that affect the strength of magnetic fields.
* Complete a model to illustrate the relationship between arrangement of magnets and potential energy in a magnetic system.
* Apply knowledge of magnetic fields to create a protective magnetic field around the new telescope and predict the behavior this will cause.

**Content Background for Teachers**

This task exposes students to a new non-contact force – magnetic force. Specifically students begin to learn about magnetic fields, or the areas where an object exhibits a magnetic influence. For students, these are the invisible forces and fields that can explain why objects not in contact can do things like “float” and move away from each other.

Most students will come to this lesson with a basic experiential understanding of magnets. For example, they might know that magnets can attract or repel depending on the “sides” put together. They might also know that not all materials are attracted to magnets, just some. These ideas will be reaffirmed in Station 1 of the Explore, solidifying that there is some invisible force at play, but only between some objects.

Something that students may not be familiar with is a magnetic field. Around every magnet, there is an invisible field called a magnetic field. This field is what attracts items, like paper clips and nails to the magnet. In magnetic fields, objects are affected along things called magnetic field lines. Magnetic poles are the points where the magnetic field lines begin and end. For example, the poles on Earth are where our planet’s field lines originate and come together. Although the magnetic field is invisible, an experiment with iron filings in the Explore can indicate where it is because the iron filings line up with the field.

When students conduct experiments about these magnetic fields, they will find that the field lines will be different depending on the type of magnet used. They will also see that the field lines spread out from the north pole and circle back around to the south pole, but the iron filings tend to concentrate at the poles because that is where the field is the strongest. While these are great two-dimensional visuals for students, it is important to emphasize that magnetic fields are really three-dimensional.

Students also start to experiment with electromagnets in the last lab station of the Explore. Unlike permanent magnets, this station uses non-magnetized metal connected to a wire conducting electric current. This, in turn, generates a magnetic field. In the lab, students will notice that a wire-wrapped nail alone does not attract paperclips. However, once connected to a battery, the wire-wrapped nail can attract paperclips.

This same lab station also allows students to begin to think about what factors affect the strength of a magnetic field. Increasing the coils of a wire will strengthen the magnetic field. Increasing the strength of the battery will also strengthen the magnetic field. More simply, decreasing the distance between a magnet and magnetic object will increase the magnetic field. Something else to consider is that only some materials are magnetic—materials like iron, steel, nickel, and cobalt.

The last concept students explore in this task is how the arrangement of objects interacting at a distance can affect the different amounts of potential energy stored in a system. While this can be related to many scenarios, it also can be applied to magnetism. In any system of magnets, there is magnetic potential energy, the amount of which depends on how the magnets are arranged with respect to each other. When the magnets are rearranged, this magnetic potential energy can change. If the magnetic potential energy increases, then the kinetic energy of the objects in the system will decrease, and vice versa. For example, when two carts with magnets attached push each other apart, there would be a decrease in magnetic potential energy and an increase in kinetic energy.

**Academic Vocabulary**

* Magnet
* Orient
* Battery
* Magnetic field
* Kinetic Energy
* Potential Energy
* Attraction
* Repulsion

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

4.5 – 6.5 Days

* Engage: 0.5 period
* Explore: 1-2 periods
* Explain: 1 period
* Elaborate: 1-2 periods
* Evaluate and Reflection: 1 period

**Materials**

* Unit 2, Task 4 Student Version

Engage

* Projector and Computer

Explore

* Station Cards 1-4 (2 copies for each station)
* Station 1
  + 2 Bar magnets
  + Various objects of different materials, some magnetic and some not
* Station 2
  + Paper clip
  + Piece of Thread
  + Tape
  + Small bar or horseshoe magnet
* Station 3
  + Ziploc Bag
  + 3x5 index cards
  + Iron filings
  + Paper Clip
  + 2 Bar Magnets
* Station 4
  + 5 feet insulated copper wire
  + 6-volt battery
  + D-size battery
  + Large iron nail
  + Paper clips

Explain

* Critique, Correct, and Clarify Handout (Optional)

Elaborate

* All materials from the Explore (one set of all materials for each group)

Evaluate

* Project Organizer Handout

**Instructions**

**Engage**

1. Introduce Task 4: In the last task, you thought about one non-contact force that may affect your telescope route—gravity. 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 4: Throughout this unit, you have thought a lot about the solar system as a whole in order to inform your decision on the best route for the new telescope. To ensure a successful mission, we also need to think about the telescope itself. Today we are going to learn about another non-contact force so we can better understand how the new telescope will behave in space and how we can protect it while in space.
   * Now pass out their Task 4 student guide.
3. Unlike contact forces from last unit, the forces students are studying today are invisible to students, making the concepts all the more difficult to grasp. To introduce students to these invisible forces, have them watch the following video: https://www.youtube.com/watch?v=LLIIYtnDups.
   * When projecting the video, make sure that students do not see the title of the video, as we don’t want to reveal the term “magnetism” just yet.
4. After students watch the video, have them discuss the questions that follow in pairs. These questions ask them for both observations and a prediction for how it is possible that objects seem to be floating and moving on their own.
   * Emphasize to students that there is no right answer and that this is a prediction that they will build on throughout the task.
   * Share out a few responses to the questions using equity sticks (See “How to Use This Curriculum” for more information).

**Explore**

1. In this activity, students engage in the practice of **Planning and Carrying Out Investigations**, as they conduct investigations to produce data that can serve as evidence that magnetic fields do exist. Based on their observations, students then analyze the data for similarities and differences, which will help them figure out that objects that aren’t touching each other behave in this way because of magnetic fields. Thus, students are also engaging in the practice of **Analyzing and Interpreting Data.**
2. Set up four stations around the room with the materials outlined in the Materials section and copies of the station cards. For large class sizes, we recommend making two of each station so the amount of students at each station allows for all students to engage.
3. Assign roles to each group. You may use whatever roles you prefer. We recommend the use of the Materials Manager, Facilitator, Harmonizer, and Recorder.
   * Ask the Facilitator to read the directions and to make sure everyone understands the task.
   * Ask the Materials Manager to handle any resources 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 observations and analysis in their student guides.
4. Give students a set amount of time with each station. We recommend at least 10 minutes per station for students to really explore and process.
   * As students conduct the four experiments outlined in the station cards, they should be recording their observations and drawings, and answering the discussion questions in their student guides.
   * The purpose of the discussion questions is to guide data analysis. You will notice students using language and drawing diagrams relating to the crosscutting concepts of **Cause and Effect** and **Systems and System Models**, as students think about the interacting parts of a magnetic system, particularly how different factors affect the flow of energy and matter in these invisible fields.
5. Below is an outline of the four stations as well as a sample Data Analysis Chart.
   * Station 1 - Exploring Invisible Forces: This station introduces students to the basics of magnets—attraction vs. repulsion and the different types of materials that are attracted to magnets.
   * Station 2 – Testing the Strength of an Invisible Force: This station gives students more exposure to a field between objects not in contact, but adds the effect of distance on the strength of the magnetic force.
   * Station 3 – Exploring Invisible Fields: This station allows students to see the actual pattern of the different magnetic fields, represented with iron filings.
   * Station 4 – Creating Invisible Fields: This station shows students how magnetic fields are created with electricity and allows them to experience with factors that affect the strength of the field (number of coils, battery size).

Sample Data Analysis Chart

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| --- | --- | --- |
|  | **Observations and Drawings** | **Discussion Questions** |
| **Station 1: Exploring Invisible Forces** | *I noticed that when you put one side of the bar magnets together, they attract, but when you put them the other way, they push away from each other. I also noticed that only some objects move towards the magnets and others do not.* | 1. How did orienting the two magnets different ways affect how they moved? Why do you think this happened?   *When oriented one way, the magnets moved towards each other. When oriented the other way, the magnets moved away from each other. I know from previous science classes that there are positive and negative sides to a magnet. When like sides are together, they repel. When opposite sides are together, the attract.*   1. What conclusions can you make about the different objects tested?   *Only metal objects seemed to be attracted to the magnet, specifically…(answers will vary based on objects provided).*   1. Do all objects have this “invisible force” acting on them? If not, which ones?   *No, only some objects, the ones stated above.* |
| **Station 2: Testing the Strength of an Invisible Force** | *I observed some invisible force attracting the metal paper clip to the magnet. This only worked when the paper clip was close enough to the magnet; otherwise it would fall.* | 1. How do you think the magnet is able to move the paper clip without touching it?   *There is an invisible force that attracts the metal paper clip to the magnet.*   1. Is the magnet always able to move the paper clip? If not, what factor affects when the magnet can move the paper clip or not?   *No, sometimes the paper clip falls. This happens when the magnet is placed too far from the paper clip. Distance is the factor that affects magnet strength.* |
| **Station 3: Exploring Invisible Fields** | *I observed nothing to happen when the iron filings were placed on the paper clip. However, when the iron filings were placed on different magnets, they formed different patterns, all coming out of two points and connecting to each other.* | 1. The fields we have been exploring are invisible, but the iron filings allow us to see the pattern of the field. How did these filings differ in the different scenarios you conducted above?   *They differ depending on the type of magnet (descriptions will vary based on types of magnets provided).*   1. Where do you see the most filings? This is where the field is the strongest.   *At the ends (poles)* |
| **Station 4: Creating Invisible Fields** | *I observed that the wire-wrapped nail alone could not pick up any paper clips, but once the wire was connected to a battery, it could. When we added more coils or increased the battery strength, the nail could pick up even more paper clips.* | 1. Does the invisible force exist between just the wire-wrapped nail and the paper clips?   *No.*   1. How were you able to create the invisible force between the wire-wrapped nail and the paper clips?   *We connected the ends of the wires to two ends of a battery.*   1. What factors do you think might affect the strength of the invisible force?   *Answers will vary, but students may later investigate the amount of coils in the wire and the type of battery.* |

1. Optional: Conduct a class-wide discussion outlining the main things students learned from each of the lab stations.
   * Again, we recommend use of equity sticks when calling on students to create a more equitable discussion (See “How to Use This Curriculum” for more details).

**Explain**

1. Now that students have collected lab evidence of magnetic forces and fields, it is time for them to put all this evidence together. In this section, students answer a series of lab questions in pairs to draw conclusions about what the data shows, explain how this conclusion can be used to predict the behavior of other similar scenarios, and to evaluate the experiments.
2. For question 1, students are asked to write a conclusion based on multiple lab experiences. Below is a sample of an advanced response, as well as optional sentence frames to provide students for language support:
   * Advanced Sample Student Response: Invisible fields exist between some objects not in contact with each other, creating forces that cause objects to look like they are moving on their own. In Station 1, when two magnets are placed close together or a magnet is placed near a metal object, they are attracted together. When two magnets are placed close together with the opposite orientation, they are repelled apart. In Station 2, a magnet can make a paper clip “float,” but only at a certain distance apart. In Station 3, when iron filings are placed on a magnet, they form a pattern that represents this invisible field. In Station 4, when the wire around a nail is connected to a battery, the nail is able to attract metal paper clips. All of these examples from the labs are evidence that there is an invisible field that exists between some objects, mainly magnets. The field causes some force to be exerted on the objects, such as attracting certain objects or repelling certain objects. This explains why we see objects “floating” or moving on their own. According to the evidence, this only seems to be the case at a certain distance and for certain substances.
   * Optional Sentence Frames

* Lab Conclusion:
  + \_\_\_\_ causes the interactions we see between objects not in contact with each other.
  + Objects not in contact with each other can sometimes appear to \_\_\_. This is because there are…
* Evidence and Reasoning
  + In Station 1, when \_\_\_\_, this causes \_\_\_\_.
  + In Station 2, a magnet can…
  + In Station 3, when \_\_\_\_, this causes \_\_\_\_.
  + In Station 4, when \_\_\_\_, this causes \_\_\_\_.
  + All of these examples from the labs are evidence that…
  + In each of these pieces of evidence...
  + The field causes…
  + This explains why we see…
  + According to the evidence, this only happens when…
* You may wish to highlight the writing skill of incorporating evidence, using the “Critique, Correct, and Clarify” language strategy. First, have students read the prompt in pairs. Then provide students with the following template to do a “Critique, Correct, and Clarify” focusing on the incorporation of evidence. We recommend having them do their analysis of the sample individually, then discuss and write an improved explanation in pairs, and debrief their reasoning as a class.
  + Once complete, collect student work to identify trends in students’ ability to draw conclusions using lab evidence. See “How to Use This Curriculum” for strategies on utilizing formative assessment data to provide feedback to students and inform classroom instruction.

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| **Critique, Correct, and Clarify: Interactions Between Distant Objects**  In pairs:   1. Critique: Analyze the response for how well it incorporates **evidence**.   *1. Invisible fields exist between some objects not in contact with each other, creating forces that cause objects to look like they are moving on their own.*  *a. I know this because in the stations, objects would be attracted to each other or repelled away from each other even though they weren’t touching. Sometimes, you could even use materials to visualize the field. This proves that there are fields between objects and explains why objects appear to float or move on their own.*   1. Correct: Write an improved explanation in your student guide. 2. Clarify: Describe how and why you corrected the response. |

1. For question 2, students are asked to write some general rules about how objects not in contact can interact based on what they experienced in the investigations.

* This emphasizes the crosscutting concept of **Cause and Effect** as students use cause-and-effect relationships they have identified in the labs to predict how other objects may behave in similar circumstances.
* Students will write a variety of rules, but below is a list of possible student responses:
  + - When you put two magnets together, sometimes they attract and sometimes they push away, depending on the side.
    - Only some materials are attracted to magnets, such as iron and nickel.
    - Magnetic fields only attract objects for a certain distance.
    - Magnetic fields are strongest at the poles.
    - Magnetic fields can be created with electricity.
    - The strength of a magnetic field depends on certain factors.
* You may wish to provide some sentence frames:
  + - When you put two magnets together…
    - Only some materials…
    - Magnetic fields can…
    - Magnetic fields are strongest…
    - Magnetic fields can be created by…
    - The strength of a magnetic field depends on…
    - Magnetic fields only…

**Elaborate**

1. In the Explore, students started to test factors that affect the strengths of magnetic fields. This Elaborate asks groups of students to take that exploration a bit further. This will be crucial to their culminating project, as they will be asked to make recommendations for a protective magnetic field around the telescope.

* At this point, introduce students to the term of magnetic fields, and explain that this is what scientists call the invisible fields students have been exploring throughout this task.

1. Question 1 asks students to evaluate the investigation for whether it was able to produce the data needed to conclude what factors affect the strength of magnetic fields. This aligns with one aspect of the science and engineering practice of **Planning and Carrying Out Investigations**.
2. Question 2 has students look back at data from Stations 2 and 4. From that data, they should make a list of questions they still need to ask in order to determine what factors affect the strength of magnetic fields.

* These could be questions such as: How do we know when the magnetic field is strong? What materials are more attracted to the magnets and what materials are not attracted? How does the size of the battery affect the strength of the magnetic field? How does the number of coils in the wire affect the strength of the magnetic fields?
* We recommend having students first generate questions as a group, but then share them all out to create a class list. This can lead to a discussion of how they might go about testing some of these questions.
* This activity gives students specific practice in the science and engineering practice of **Asking Questions** as they attemptto determine the factors that affect the strength of electric and magnetic forces and frame a hypothesis based on their observations.

1. Question 3 has students use their questions to do a small exploration, using all the materials from the lab stations. They will be able to put their questions to the test and then draw some conclusions that will inform their recommendations for the new telescope. For a more traditional approach, you may wish to collect the main questions from the discussion above and run these investigations as class-wide demonstrations.

* For factors that increase the strength of a magnetic field, students will identify things like increasing the number of wire coils, increasing battery voltage, or using objects that have magnetic materials like iron, copper, nickel, cobalt, or steel.

1. Question 4 asks students to apply these conclusions to the protection of their telescope. In doing so, students are using identified cause-and-effect relationships to predict how a strong magnetic field can be created. This specifically emphasizes the crosscutting concept of **Cause and Effect.**
2. Question 5: In exploring how different materials and magnets interact, students will also be experimenting with the arrangement of magnets. This question links old concepts of kinetic and potential energy to magnetic systems. In every magnetic system, there is magnetic potential energy, which depends on how the magnets are arranged with respect to each other. Here, students will use lab observations to complete the model provided. When magnets are pushing each other apart, there is a decrease in potential energy and an increase in kinetic energy. When magnets are attracting towards each other, there is an increase in potential energy and a decrease in kinetic energy.

* This gives practice at **Developing and Using Models** to describe unobservable mechanisms while also emphasizing the crosscutting concept of **Systems and System Models** as students complete a model to show interactions and energy flow within a magnetic system.
* While students should discuss these questions with their group, we highly recommend debriefing as a class, as these are complex concepts.

1. Question 5 asks students to put these concepts together and take it a little further to apply to their culminating project. Once the telescope has a magnetic field, it will then interact with planets that have magnetic fields. Here students make a prediction of how the telescope might behave as it passes planets with magnetic fields.

* Because they understand attraction and repulsion, they should make some prediction about the telescope spinning and changing its orientation.

1. Use one or both of the following resources to solidify these concepts with students:

* <https://www.windows2universe.org/physical_science/magnetism/bar_magnet_interactive.html>: This interactive shows a bar magnet and a compass, but can be used to represent a planet with a magnetic field and the new telescope: Keep the bar magnet (planet with magnetic field) in one place and move the compass (the new telescope) on a route past the bar magnet. Ask students to notice how the telescope behaves as it moves past the planet. Students should hypothesize that their new telescope will spin as it moves past planets with magnetic fields.
* <https://www.youtube.com/watch?v=G_uKt2i2jvc>: This video does a great job at summing up everything students have learned about magnetism. Like the interactive above, it also helps students to see that their telescope will likely spin as it moves past planets with magnetic fields.
* After students engage with these resources, you may want them to revisit their responses to Question 5.

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: another non-contact force—magnetic fields.
* Have students analyze the additions to the class concept map for as many examples of this task’s crosscutting concepts 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, “which results in,” “which causes,” “that explains why,” “is due to,” etc.
  + **Systems and Systems Models**. These could be phrases such as, “is a part of” “connects to,” “interacts with,” “is made up of,” “works together with,” 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 4 section of the Unit 2 Project Organizer in class. Revisions can be done for homework, depending upon student’s needs and/or class scheduling.
2. Students have been tasked with developing a model of the solar system and proposing the best route a new telescope should take through space. Their prompt is as follows: We need to protect the new telescope from solar wind as it travels through space. Scientists say that the new and best protection is to create a magnetic field around the telescope. But how do we do this? Use what you have learned to make some recommendations for a protective magnetic field.

* How will we know a magnetic field has been created? We can’t see them, so what evidence is there that magnetic fields exist?
* What kinds of factors affect the strength of magnetic fields?
  + What questions did you have to investigate to find out this information?
* Research magnetic fields on different planets. Based on what you learned about arrangement of objects and potential energy, how might the telescope be affected as it passes these different planets?

**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 made predictions for how objects could possibly float and move without touching them. Look back at your initial prediction: after learning everything you have about magnetic forces and fields, how can you add to your prediction?
* In this task, we focused on the crosscutting concepts of **Cause and Effect**: cause and effect relationships may be used to predict events, and **Systems and System Models:** models can be used to represent systems and their interactions. Where did you examples of **Cause and Effect** and **Systems and System Models** in this task?
* Now that you have learned about the role of magnetic fields in your telescope route, 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.
2. 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.