**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 Lift-Off Task, students were introduced to the motivation behind this unit—charting a route for a new telescope through our solar system. Using their prior knowledge, they created lists of all the different things they think they might find in a solar system. However, in order to chart a route through the solar system, it is not enough to just know what is there—they must find out where things are and how they are laid out within the system. The best way to visualize such a large system is to create a model. In this task, students will practice modeling with the smaller sub-system of the Sun-Earth-Moon system. In doing so, they will discover explanations for a lot of the phenomena they experience on Earth, giving them a more complex picture of the solar system for their culminating project.

**Alignment Table**

|  |  |  |  |
| --- | --- | --- | --- |
| **Performance Expectations** | **Science and Engineering Practices** | **Disciplinary Core Ideas** | **Crosscutting Concepts** |
| **MS-ESS1-1 Develop and use a model** **of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.**[Clarification Statement: Examples of models can be physical, graphical, or conceptual.] | **Developing and Using Models**  * Develop and use a model to describe phenomena. | **ESS1.A: The Universe and Its Stars**  * Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models.  **ESS1.B: Earth and the Solar System**This model of the solar system can explain eclipses of the sun and the moon. Earth’s spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year. | **Patterns**  * Patterns can be used to identify cause-and-effect relationships. |
| **Equity and Groupwork**   * Use group roles to engage with models of various phenomena. * Work together to create a mini-video. | | | |
| **Language**   * Connect visual representations to verbal and written explanations. * Write an explanation with reasoning and evidence. | | | |

**Learning Goals**

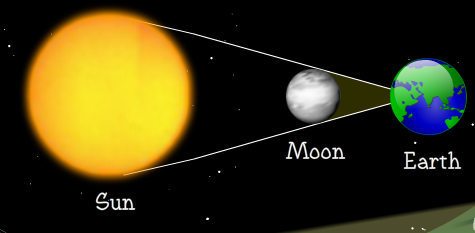
This learning task asks students to use and develop models to explain celestial phenomena. More specifically, the purpose is to:

* Engage prior knowledge of everyday experiences involving the Sun, Earth, Moon, and stars.
* Develop and use models to investigate these phenomena.
* Create a video model to explain how one phenomenon works.
* Use knowledge to explain a difference in seasons in different global locations.
* Apply knowledge of the Sun-Earth-Moon system to explain a sub-system of the solar system and identify limitations in a model.

**Content Background for Teachers**

This task dives into a specific subsystem in order to explain certain phenomena we experience on Earth and give students practice at modeling. In this task, students engage with five phenomena related to the Sun-Earth-Moon system: apparent motion of the sun in the sky, seasons, lunar phases, visibility of stars during different seasons, and eclipses. Students will find that all of these involve two main motions affecting Earth: its rotation around its axis and its rotation around the sun.

In Resource Card 1, students consider why the sun appears to move in an arc across the sky every day. This is not because the sun is actually moving, but because the Earth is rotating on its axis each day. This leads into Resource Card 2, in which students learn that the Earth is in orbit around the sun, but is always tilted slightly in the same direction. This means that at different times of year, sunlight will be angled more directly on certain parts of the Earth. These changes in sunlight intensity as the Earth orbits the sun throughout a year are what cause seasons. This becomes the basis of the scenario in the Elaborate.



Resource Cards 3 and 5 add the moon into the mix, which orbits the Earth. When the moon comes directly between the Earth and sun, it can cause an eclipse, or a blocking of the sun’s light, casting a shadow of darkness on some areas of the Earth. Resource Card 3 asks students to think about a more common phenomenon - lunar phases. Ultimately, the light of a full moon we see is because the moon is on the other side of the Earth and the sun is shining on it. When the moon is in between the sun and the Earth (but not covering the sun), the side of the moon facing us receives no direct sunlight—we see this as a new moon.

Lastly, students consider how the stars appear to change at different points in the year. On any given evening, you are only able to see the stars that are in the opposite direction to the sun because this is the direction you face at night. All the stars that are “behind” the sun are only viewable during the day; however, because of we can only see stars at night, we never actually see these. Because the Earth orbits the sun, the visible stars will change throughout the year. In this investigation, students might also notice that stars, just like the sun, appear to move across the sky at night. This is again due to the rotation of Earth in a day.

In gaining all this content knowledge through the use of models, students will better be able to understand the interacting pieces of a system and will be able to use these modeling skills in the next task. For more information on any of these concepts, please see the resource cards associated with this task.

**Academic Vocabulary**

* Season
* Eclipse
* Lunar Phase
* Sun
* Earth
* Moon
* Axis
* Rotation
* Orbit
* Angle

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

6 Days

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

**Materials**

* Unit 2, Task 1 Student Version

Explore

* Station Cards 1 - 5: two - three per station
* Stations 1, 2, and 5: Computers/Tablets (Make sure interactives/videos work)
* Station 3: Styrofoam ball with embedded toothpick and light source (ex: lamp)

Explain (Per Group)

* Styrofoam Balls of varying size
* Skewers/Toothpicks
* Light sources of varying brightness
* Rubber band
* Marker
* Device with video capabilities

Evaluate

* Project Organizer Handout

**Instructions**

**Engage**

1. Introduce Task 1: In the Lift-Off task, we used space telescope images to help us make lists of what we think is in our solar system. 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: However, to prepare to launch a telescope through space, we don’t just need to know what is in our solar system, but where they are in our solar system. The best way to visualize something so huge is by creating **models**. Before creating a model of our whole solar system, you are going to practice with a very important sub-system—the Sun-Earth-Moon system. Understanding how this system works helps to explain a lot of the phenomena you experience on Earth!

* Now pass out their Task 1 student guide.
* This transition paragraph, which is also present on their student guide, introduces students to the science and engineering practice that they will focus on throughout the unit—**Developing and Using Models**. More specific information about how students develop and use models is provided throughout this task.

1. In pairs, have students make predictions about the science behind some phenomena they experience on Earth. These phenomena will be weaved throughout the entirety of the task. This activity allows students to begin engaging with the crosscutting concept of **Patterns**, as students use their own prior knowledge of various patterns to predict cause-and-effect relationships. They will come back to these relationships as they collect evidence over the course of the task.

* We recommend doing this activity in pairs so students have the space to voice all their own ideas, but also have a partner to brainstorm with if they are having trouble thinking of ideas.
* Share out ideas in a class-wide discussion, emphasizing to students that “correct” answers are not important at this point. The use of equity sticks is encouraged for more equitable participation in class-wide discussions like these (See “How To Use This Curriculum” for more details).

**Explore**

1. Now that students have made predictions, they need to gather more information on the science behind these phenomena.
   * All of the stations will give students practice at **Using Models** to investigate different phenomena they experience on Earth. As they use the models, students are gathering evidence of different **Patterns** that they can use to explain how the Sun, Earth, and Moon interact to cause these phenomena.
2. 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, make sure everyone understands the task, and facilitate discussion.
   * Ask the Materials Manager to handle any resources needed to complete the task, including computer resources.
   * 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 conclusions in their student guides.
3. Set up 5 stations around the room (you may want to have duplicate stations depending on the number of student groups you have). At each station, lay out 2-3 copies of one station card and any other resources necessary (see materials list above).

* Students will circulate between the stations to gather information. It is recommended that you set a specific time for each station (ex: approximately 7 minutes) so students really spend time doing deep analysis of the data.
* Walk around and listen to the kind of evidence students are discussing.
  + Try not to provide any explicit analysis, but you may point out parts of the information or simulation to focus on if students are struggling. Students may need explicit help with navigating the simulations.
  + The discussion questions provided on the station cards are meant to provide facilitation and scaffolding for collection of information.
* Students should fill out the information collection table in their student guide in order to record and organize their findings.
* \*Note: For Station 3 (Shapes of the Moon): if you are short on materials or ability to create a dark space, you can have students watch a video of a teacher acting out the model. The link is in the “Sources” section on that resource card.

Sample Student Information Collection Chart

|  |  |  |
| --- | --- | --- |
|  | **Observations: What does this model tell you about the Sun-Earth-Moon system?** | **Discussion Questions** |
| **Resource Card 1: Sun’s Movement Through the Sky** | *This tells us that the sun does not actually move, but rather the Earth rotates on its axis once in a day, which makes the sun look like it is moving.* | 1. What did people previously believe about the movements of Sun and Earth?   *They previously believed that the sun orbited the Earth.*   1. Is the sun actually moving or are you moving?   *The sun is not moving; we are moving because the Earth is moving.*   1. How can you explain why the sun appears to be moving through the sky during a day?   *The Earth is rotating on its axis, so your orientation to the sun is changing throughout the day.*   1. How is the model at the end of this video limited (inaccurate in some ways)?   *It is limited because it is not drawn to scale and the Earth is not tilted on its axis.* |
| **Resource Card 1: Seasons** | *This tells us that the Earth orbits the sun at a tilt, which causes different intensities of sunlight on different areas throughout the world. This creates seasons.* | 1. Does the Earth stay in one place throughout the year? If not, describe its motion and location in the solar system?   *It moves throughout the year, in an orbit around the sun.*   1. Why does the angle of the sun at noon seem to change at different months throughout the year?   *The Earth is tilted so the angle of the sun in an area depends on which hemisphere is angled toward the sun. Because Earth orbits around the Earth, this changes for an area throughout the year.*   * 1. How does this create seasons? (Hint: Read the drop-down box entitled “About Seasons” if you are stuck).   *The axis is tilted, so parts of the Earth that receive more direct sunlight changes throughout the year. This causes seasons.*   1. What do you notice about the angle of Earth?   *It is tilted on its axis.*   1. How do you think this affects the seasons in different hemispheres (halves) of the world?   *This means that when light is shining more directly on one half, it is shining less directly on the other half. That is why Melbourne and New York have different seasons at the same time.* |
| **Resource Card 3: Shapes of the Moon** | *It tells me that the different lunar phases we see are because of where the moon is in its orbit, in relation to the sun. We only see the moon when the light from the sun shines on it. If it is between the Earth and sun and doesn’t receive direct sunlight, you don’t see a moon.* | 1. No matter where the moon is in its orbit around the Earth, how much is lit up?   *Half of it.*   * 1. Where does the light source come from?   *The sun.*   1. When the moon is between the Earth and the sun, what do you observe from Earth’s perspective?   *You can’t see any of the moon.*   * 1. What type of moon do you think this is (Full Moon, Crescent Moon, Quarter Moon, New Moon)?   *New Moon.*   1. When the Earth is between the moon and the sun, what do you observe from Earth’s perspective?   *You can see the whole moon.*   * 1. What type of moon do you think this is (Full Moon, Crescent Moon, Quarter Moon, New Moon)?   *Full Moon*   1. Does the shape of the moon actually change? If not, what is actually happening?   *The shape of the moon does not change. It is always a sphere, but we only see the part that is lit up.* |
| **Resource Card 4: Changing Stars in the Sky** | *This resource shows me that Earth’s orbit around the sun has yet another effect. It allows us to only see certain stars at certain times of year.* | 1. Take a look at the image above. On a summer night, what stars are visible? Why do you think those are the ones that are visible?   *Sagittarius, Lyra, and Hercules. These are the only ones visible because they are in the direction you are facing at night during that time of year.*   1. Why wouldn’t you be able to see Orion and Canis Major on a summer night? (Hint: at what time of day do you view stars?)   *You can’t see those stars because you would face them during the day time and you can’t see stars during the day time.*   1. Can this phenomenon be explained by the rotation of Earth on its axis OR the rotation of the Earth around the sun? Explain how.   *This is explained by the rotation of Earth around the sun; that is why the stars you see changes throughout the year. The fact that the stars appear to move throughout the night is due to the rotation of Earth on its axis.* |
| **Resource Card 5: Eclipses** | *This tells us that one way they interact is when the moon orbits around the Earth, it can occasionally block the sun. This is called an eclipse.* | 1. This picture is not drawn to scale, but helps you to compare the relative sizes of the Earth, sun, and moon. What is the biggest object in this picture?   *The sun.*   1. A solar eclipse happens when the sun is completely blocked by the moon. How could that be possible if the sun is so much larger?   *The moon is much closer to Earth than the sun, causing it to look the same size from Earth.*   1. How often does this phenomenon occur?   *About once every 18 months.*   1. How do the motions of the Earth, sun, and moon make this possible?   *The Earth orbits the moon, and the moon orbits the sun, causing the moon to occasionally be in the path between the Earth and sun.* |

**Explain**

1. Students then use all the information they have gathered to make a mini-video explaining one phenomenon using a physical Sun-Earth-System model they create.
   * Here students are moving away from merely using models to **Developing Models** in order to describe one specific phenomenon. Students will use the patterns they observed in the stations to explain why we experience a phenomenon on Earth. This reinforces the crosscutting concept of **Patterns** as students use patterns to identify a cause-and-effect relationship.
2. First, have students build their models in groups, using the materials listed on their student guides.
3. Then have groups make a mini-video, using their model to explain how one of the phenomena works (except for lunar phases since they made a model as part of the station).
   * We highly recommend students develop a plan on their student guides before moving on to record a video. If desired, you may require students to submit these plans as a checkpoint before moving on to video recording.
4. Once complete, these videos provide an excellent resource to be used throughout the unit.

* Optional: Select the most accurate and engaging video for each phenomenon (for lunar phases, you can use the video link on the resource card). Present each of the videos as a review before moving on to the next task or at the end of the unit before they begin working on their group culminating project.

**Elaborate**

1. This last scenario takes what they have learned and applies it to a real-life scenario that they may actually find useful one day. In this scenario, a friend from California is trying to take a December ski trip in New Zealand. Students explain why this is a bad idea, using **Patterns** from the task’s activities to explain their cause-and-effect reasoning.
   * In their response, students should discuss that this is not a good time to ski in New Zealand because while it is winter in California, it is actually summer in New Zealand. This is because California is in the northern hemisphere and New Zealand is in the southern hemisphere. While there is less direct sunlight on California in December, the tilt of the Earth means there is more direct sunlight on New Zealand in December.
2. We recommend students do this individually as it can serve as a good formative assessment for this task.
   * Collect student work to identify trends in students’ ability to use patterns from the stations to explain why there is no skiing in New Zealand in December. See “How to Use This Curriculum” for strategies on utilizing formative assessment data to provide feedback to students and inform classroom instruction.
3. 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: models, the sun-earth-moon system, and how they experience celestial phenomena on Earth.
* 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:
  + **Patterns**: These could be phrases such as, “has in common with” “shares,” “is also shown in,” “is the same as,” “looks the same as,” 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 1 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: In order to plan a route through the solar system for the new telescope, you will need to know what it looks like. The best way to imagine what it looks like is to create a model. To prepare you to construct a full solar system model, you have practiced this skill by creating a Sun-Earth-Moon system model. In the process, you have discovered the science behind many things you experience on Earth!
   * Draw a sketch of your Sun-Earth-Moon model with labels.
   * Use your model to describe at least two of the phenomena explored in this task.
   * What are the limitations of the model you have drawn? In other words, how does it not accurately represent the Sun-Earth-Moon system?

**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 predictions about the science behind various phenomena. Look back at your predictions: for which ones was your prediction fairly close to the real reason? Pick one where your prediction was far off and write a revised response here.
* In this task, we focused on the crosscutting concept of **Patterns**: Patterns can be used to identify cause-and-effect relationships. Where did you see examples of **Patterns** in this task?
* Now that you have learned more about a sub-system of our solar system, 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.