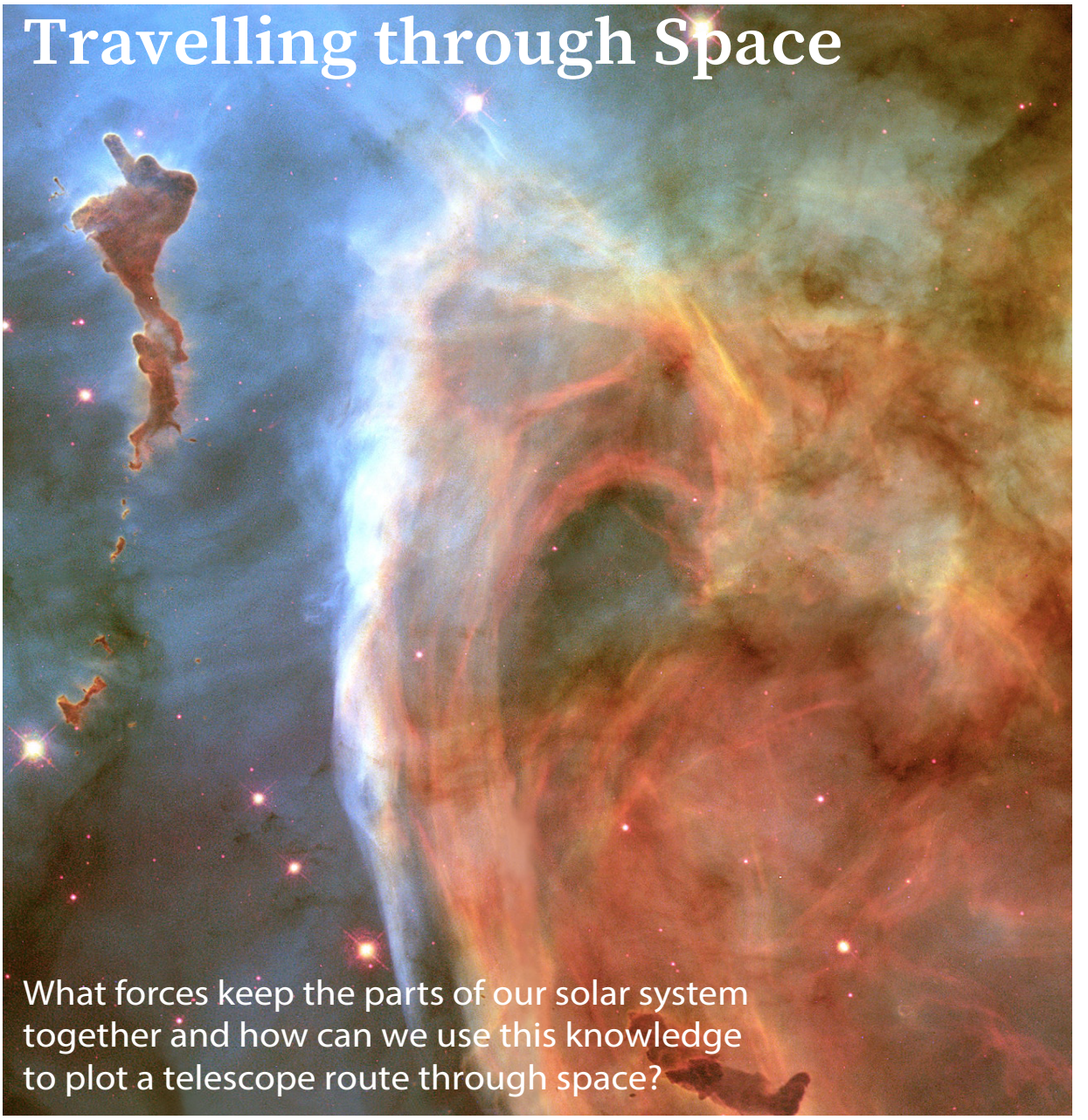
Stanford NGSS Integrated Curriculum
An Exploration of a Multidimensional World

UNIT 2

Travelling through Space



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

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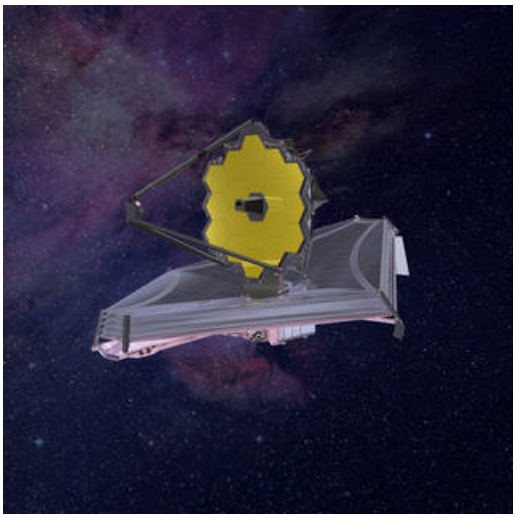
8th Grade Science Unit 2: Travelling Through Space
Culminating Project

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?*

Challenge

NASA has developed a new telescope, which they hope to launch into the solar system next year. What things will need to be considered to complete this mission efficiently and safely? Throughout the unit, your group will contribute to a class-wide model of our solar system—the phenomenon you were introduced to in the Lift-Off task. Using this model and new scientific concepts you learn, your group will then make an informed decision on the route you think the new telescope should take and how you will protect it as it moves through space. Once all groups have shown their routes within the class model, you will individually create a presentation that pitches your route, describing the forces and energy both used and encountered on this trip and justifying why your route is the best route. The format of this presentation is up to you (Prezi with a script, Powerpoint with a script, video, videotaped poster presentation, etc.)



Background on the New Telescope

NASA's new telescope will carry different science instruments to take pictures of and collect information about the physical characteristics and compositions of astronomical objects. One of the things it will look for is water and other clues about the potential habitability (ability to live) in another planetary system.

Instead of orbiting the Earth, as the current space telescope does, this telescope will orbit the sun! This gives it a spectacular view of objects in the solar system. With this view, it will be able to observe the water cycle on Mars, look at weather patterns on Saturn's moon Titan, hunt for new rings around the giant planets, and track different comets.

As you consider your route, consider that the telescope needs to get to the outside edge of the solar system, past all of the planets. Take a look at the image on the next page: This shows the desired location of the new telescope, but keep in mind that this drawing is not to scale, and in reality, planets are not organized in a straight line. Once in place, the telescope will orbit the sun as quickly as Earth does. This keeps the telescope in line with the Earth, offering it a unique vantage point, and allowing the Earth to protect the telescope from most of the light and heat from the sun.

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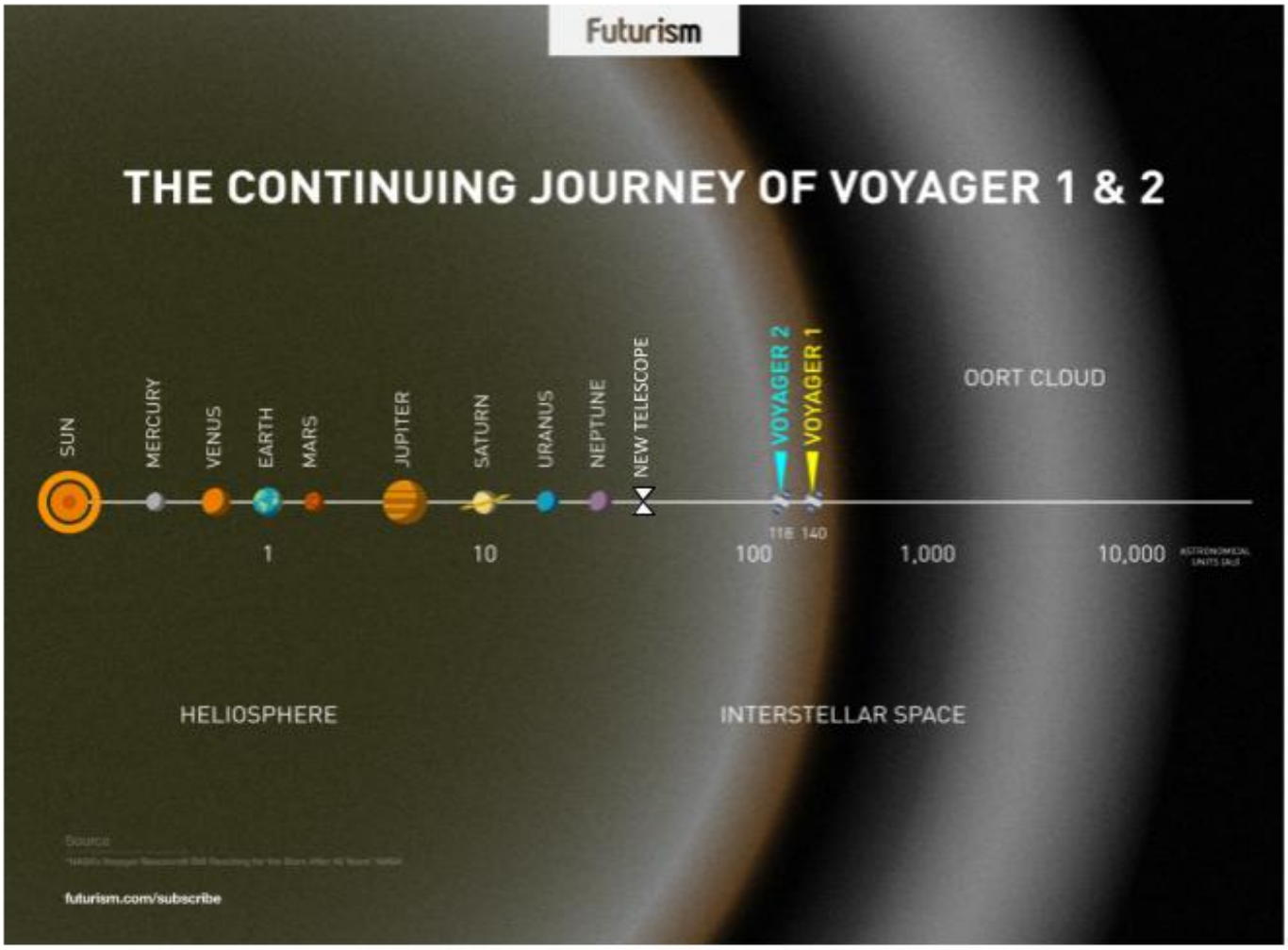

https://futurism.com/nasa-voyager-spacecrafts-still-going-strong-40-years-later/

If we want the telescope to function for a long time, we need to protect the telescope from solar wind in space. Solar wind is a constant stream of electrically charged particles that flow from the sun and carry its magnetic field out into the solar system. When you plan your telescope route, you will also need to come up with a way to protect the telescope from solar wind.

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Group Project Criteria for Success

Your group's route presentation within the class model should:

- ❑ Show and describe your contribution to the class-wide model of the solar system. Include information about the following:
  - The name of your planet
  - The actual size and the scaled size of your planet
  - The actual distance and the scaled distance from the sun
  - The mass of your planet

- ❑ Show and describe a potential route for the telescope within the class-wide model.
  - Explain what information in the tasks led your group to choose this route.

- ❑ Recommend the best way to create a protective magnetic field around the telescope.
  - Show and explain how passing by different planets in your route might affect the telescope.

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Individual Project Criteria for Success

Your pitch presentation should:

- ❑ Give background on the solar system, including what is in the solar system.
  - Describe the scale you used for the solar system model.
    - As an example, explain the data you used to make your assigned planet to scale.
  - Draw a model that shows the layout of the solar system and how objects move in the solar system.
    - Explain how the solar system began and how these forces continue to hold the parts of the system together to create this layout.

- ❑ Pick at least one phenomenon from each of the following lists:
  1. Pick one: Seasons, lunar phases, **and/or** eclipses of the sun and moon
  2. Pick one: **AND** apparent motion of the sun, moon, **and/or** stars in the sky
  - Draw or create a model of the Sun-Earth-Moon system to show what is happening in each phenomenon.
  - Use patterns from the model to explain why we experience each phenomenon on Earth.

- ❑ Show and describe your group's proposed route for the telescope.
  - Justify your choice in route: Use gravity to argue why the telescope needs to stay farther away from some planets, but not others. Use evidence from Task 3 to support your reasoning.

- ❑ Describe how your group plans to protect the telescope.
  - Cite data from Task 4 to convince non-scientific audiences that any magnetic field you create is real even though they cannot see them.
  - Describe the best ways to strengthen the magnetic field around the telescope.
    - Identify the questions you needed to investigate in Task 4 to gather this information.
  - Passing by planets with different magnetic fields will affect the telescope. Select a planet with a large magnetic field and draw a model to show and explain how passing by this planet would affect the telescope.
    - On your model, label when the telescope contains the most potential magnetic energy and when it has the most kinetic energy and explain why this is the case.

- ❑ Pitch Presentation Qualities
  - Uses visual aids (posters, diagrams, etc), as necessary
  - Is organized logically
  - Is interesting to the audience
  - Practices good oral presentation skills, if applicable

8th Grade Science Unit 2: Travelling Through Space
Culminating Project

Pitch Presentation Peer Review Feedback

Complete after you have a full first draft of your pitch presentation.

Pitch Presentation Owner's Name	
Pitch Presentation Reviewer's Name	

Review the following sections of the Pitch Presentation:

- ❑ Give background on the solar system, including what is in the solar system.
  - Describe the scale you used for the solar system model.
    - As an example, explain the data you used to make your assigned planet to scale.
  - Draw a model that shows the layout of the solar system and how objects move in the solar system.
    - Explain how the solar system began and how these forces continue to hold the parts of the system together to create this layout.

  - ➢ Positive Comment:

  - ➢ Constructive Comment:

- ❑ Pick at least one phenomenon from <u>each</u> of the following lists:
  1. Pick one: Seasons, lunar phases, **and/or** eclipses of the sun and moon
  2. Pick one: **AND** apparent motion of the sun, moon, **and/or** stars in the sky
  - Draw or create a model of the Sun-Earth-Moon system to show what is happening in each phenomenon.
  - Use patterns from the model to explain why we experience each phenomenon on Earth.

  - ➢ Positive Comment:

  - ➢ Constructive Comment:

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- ❑ Show and describe your group's proposed route for the telescope.
  - Justify your choice in route: Use gravity to argue why the telescope needs to stay farther away from some planets, but not others. Use evidence from Task 3 to support your reasoning.

  ➢ Positive Comment:

  ➢ Constructive Comment:

- ❑ Describe how your group plans to protect the telescope.
  - Cite data from Task 4 to convince non-scientific audiences that any magnetic field you create is real even though they cannot see them.
  - Describe the best ways to strengthen the magnetic field around the telescope.
    - Identify the questions you needed to investigate in Task 4 to gather this information.
  - Passing by planets with different magnetic fields will affect the telescope. Select a planet with a large magnetic field and draw a model to show and explain how passing by this planet would affect the telescope.
    - On your model, label when the telescope contains the most potential magnetic energy and when it has the most kinetic energy and explain why this is the case.

  ➢ Positive Comment:

  ➢ Constructive Comment:

- ❑ Pitch Presentation Qualities
  - Uses visual aids (posters, diagrams, etc), as necessary
  - Is organized logically
  - Is interesting to the audience
  - Practices good oral presentation skills, if applicable

  ➢ Positive Comment:

  ➢ Constructive Comment:

8th Grade Science Unit 2: Travelling Through Space
3-Dimensional Individual Project Rubric

Overview: The following rubrics can be used to assess the individual project: a pitch presentation for a proposed telescope route. Each rubric is aligned to one section of the *Individual Project Criteria for Success*, located on your Culminating Project Student Instructions. Use these rubrics to see if you are doing your best work on your individual project.

Rubric 1: Student describes a background on the solar system, including an explanation of the scale for their class solar system model.

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student describes an **inaccurate** background on the solar system **AND/OR** includes an **inaccurate** explanation of the scale for their class solar system model.	Student describes a **partial** background on the solar system, including an **accurate but general** explanation of the scale for their class solar system model.	Student describes a **complete** background on the solar system, including an **accurate but general** explanation of the scale for their class solar system model.	Student describes a **complete** background on the solar system, including an **accurate and specific** explanation of the scale for their class solar system model.

Rubric 2: Student draws a model to show the layout and motions of the solar system and explains the forces that hold the parts of the system together.

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student draws an **inaccurate** model to show the layout and motions of the solar system **and/or inaccurately** explains the forces that hold the parts of the system together.	Student draws an **accurate** model to show the layout and motions of the solar system and **generally** explains **at least one of the** forces that hold the parts of the system together.	Student draws an **accurate** model to show the layout and motions of the solar system and **accurately** explains **one of the** forces that hold the parts of the system together.	Student draws an **accurate** model to show the layout and motions of the solar system and **accurately** explains the forces that hold the parts of the system together.

Rubric 3: Student draws a model of the Sun-Earth-Moon system and uses patterns from the model to explain why we experience a phenomenon on Earth.

- Use for each of the two models you make.

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student draws an **inaccurate** model of the Sun-Earth-Moon system **and/or** uses patterns from the model to **inaccurately** explain why we experience a phenomenon on Earth.	Student draws an **accurate** model of the Sun-Earth-Moon system and uses patterns from the model to **incompletely** explain why we experience a phenomenon on Earth.	Student draws an **accurate** model of the Sun-Earth-Moon system and uses patterns from the model to **accurately but generally** explain why we experience a phenomenon on Earth.	Student draws an **accurate** model of the Sun-Earth-Moon system and uses patterns from the model to **accurately and completely** explain why we experience a phenomenon on Earth.

8th Grade Science Unit 2: Travelling Through Space

3-Dimensional Individual Project Rubric

Rubric 4: Student argues why the telescope needs to stay farther away from some planets but not others, supporting with evidence from Task 3.

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student **inaccurately** argues why the telescope needs to stay farther away from some planets but not others.	Student **accurately** argues why the telescope needs to stay farther away from some planets but not others, supporting with **no** evidence from Task 3.	Student **accurately** argues why the telescope needs to stay farther away from some planets but not others, supporting with **one piece** of evidence from Task 3.	Student **accurately** argues why the telescope needs to stay farther away from some planets but not others, supporting with **multiple sources** of evidence from Task 3.

Rubric 5: Student predicts that any magnetic field they create will be present even though we cannot see them, citing data to back up this claim.

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student predicts that any magnetic fields they create will be present even though we cannot see them, but uses **no** data to back up this claim.	Student predicts that any magnetic field they create will be present even though we cannot see them, using **general trends in** data to back up this claim.	Student predicts that any magnetic field they create will be present even though we cannot see them, using **general trends and one specific source of** data to back up this claim.	Student predicts that any magnetic field they create will be present even though we cannot see them, using **accurate and specific** data **from multiple sources** to back up this claim.

Rubric 6: Student describes the best ways to strengthen the magnetic field around the telescope and identifies relevant questions that were investigated to gather this information.

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student **inaccurately** describes way**(s)** to strengthen the magnetic field around the telescope and does not identify relevant questions that were investigated to gather this information.	Student **accurate**ly describes way**(s)** to strengthen the magnetic field around the telescope **but does not** identify relevant questions that were investigated to gather this information.	Student **accurate**ly describes **a** way to strengthen the magnetic field around the telescope and identifies **a** relevant question that was investigated to gather this information.	Student **accurate**ly describes **multiple** ways to strengthen the magnetic field around the telescope and identifies relevant question**s** that were investigated to gather this information.

8th Grade Science Unit 2: Travelling Through Space

3-Dimensional Individual Project Rubric

Rubric 7: Student draws a model to show and explain how passing by planets with different magnetic fields will affect the telescope.

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student draws an **inaccurate** model to show and explain how passing by planets with different magnetic fields will affect the telescope.	Student draws an **accurate** model to **generally** show how passing by planets with different magnetic fields will affect the telescope. OR Student **accurately explains** how passing by planets with different magnetic fields will affect the telescope.	Student draws an **accurate** model to **generally** show **and explain** how passing by planets with different magnetic fields will affect the telescope.	Student draws an **accurate** model to **accurately** show and explain how passing by planets with different magnetic fields will affect the telescope.

Rubric 8: Student labels a telescope model to show moments of most potential magnetic energy and most kinetic energy and explains the interaction of these forms of energy within the magnetic system.

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student **inaccurately** labels a telescope model to show moments of most potential magnetic energy and most kinetic energy.	Student **accurately** labels a telescope model to show moments of most potential magnetic energy and most kinetic energy **but does not** explain the interaction of these forms of energy within the magnetic system.	Student **accurately** labels a telescope model to show moments of most potential magnetic energy and most kinetic energy and **generally** explains the interaction of these forms of energy within the magnetic system.	Student **accurately** labels a telescope model to show moments of most potential magnetic energy and most kinetic energy and **specifically** explains the interaction of these forms of energy within the magnetic system.

8th Grade Science Unit 2: Travelling Through Space
Project Organizer

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?*

You will be developing a model of the solar system and proposing the best route a new telescope should take through space. After each task, you will return to the table below to organize what you learn as you go through the unit. By the end of the four tasks, you will have all this information to use for your culminating project. For each activity, be sure to include answers to **ALL** the questions provided.

Lift-Off Task: Our Solar System	You will be launching a new telescope into our solar system, so we need to know what is out there. What do you think our solar system consists of?
Task 1: A Sun-Earth-Moon Model	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?

8th Grade Science Unit 2: Travelling Through Space

Project Organizer

Task 2: A Solar System Model	To plan a route for the new telescope, you will need to know more than just the Sun-Earth-Moon System and more than just a list of total parts; you will need a specific layout. Draw a sketch of your class solar system model, including where the new telescope needs to arrive. ❑ In captions, explain the scale you used for your assigned planet within the model. ○ What data did you use? ○ How does it compare to other planets in the solar system model?

8th Grade Science Unit 2: Travelling Through Space

Project Organizer

Task 3: Gravity in the Galaxies	Even though you already have the layout of the solar system, you now know that these objects don't just remain stationary…they move because of gravity! Based on what you've learned about mass, gravity, and motion, draw a potential route for the new telescope on the sketch you made in the Task 2 section above. Then in this section: ❒ Explain why the solar system is laid out the way it is: what is the role of gravity in the solar system? ❒ Use your model and data from the task to explain how gravity might affect the new telescope as it moves through space. ❒ Justify your route by explaining why you stay farther away from some planets, but not others.

8th Grade Science Unit 2: Travelling Through Space

Project Organizer

Task 4: Invisible Forces	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 the arrangement of objects and potential energy, how might the telescope be affected as it passes these different planets?

8th Grade Science Unit 2: Travelling Through Space
Lift-Off Task: Our Solar System

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?*

Until 400 years ago, all that we knew about our solar system came from observations with the naked eye. This made it really difficult to know what was in our solar system, how these objects were arranged, and how they moved throughout the system. Now we have telescopes that can take pictures to help us learn more about the solar system. Make observations about the images provided by your teacher to help spark any prior knowledge you have about our solar system.

Part A: If you wanted to know about our solar system, what questions would you ask? Individually record any questions you would need to ask to get a better understanding of our solar system.

Part B: As a group,

- Discuss what questions each member wrote on his or her list.
- On a large piece of poster paper:
  - Write the phrase “Our Solar System” in the middle of your poster and draw a circle around it.
  - Around the circle, record the questions that were similar across your group members.
  - Draw lines to link together questions that relate to each other.
  - Draft possible answers to the questions, using your prior knowledge. Connect these to the questions on your poster.
- Post your group poster on the wall.
- Walk around and look at each groups’ ideas.

8th Grade Science Unit 2: Travelling Through Space
Lift-Off Task: Our Solar System

Part C: As a whole class,

- Construct a class concept map with the phenomenon in the middle: "Our Solar System".
  - Decide which key questions you want to have on the concept map.
  - Draw lines with arrows between two key questions to show that there is a relationship.
  - Make as many connections as you can between the questions on the concept map.
- It's important for everyone to share their ideas and it's okay if you don't agree.
- You will revise and add new questions and information to this concept map as you learn more about our solar system.

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?*

Connecting to the Culminating Project

You will be developing a model of the solar system and proposing the best route a new telescope should take through space. You will be launching the new telescope into our solar system, so we need to know what is out there. What do you think our solar system consists of?

This should be completed individually in your Project Organizer.

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?*

Reflection

Individually reflect on the Lift-Off Task, using the questions provided:

1. At the beginning of this task, you made a list of all the questions you have about the solar system. Look back at your list: think about the questions your peers asked that you did not initially write down. How are their questions different from the ones you originally asked?

8th Grade Science Unit 2: Travelling Through Space
Lift-Off Task: Our Solar System

2. In this unit, we will be focusing on four crosscutting concepts:
    - **Patterns**: patterns can be used to identify cause and effect relationships.
    - **Cause and Effect**: cause and effect relationships may be used to predict events.
    - **Scale, Proportion, and Quantity**: scaled models can be used to study time, space, or energy systems that are too large or too small.
    - **Systems and System Models**: models can be used to represent systems and their interactions.

   Looking at your class concept map, give one example of how a crosscutting concept came up in today's task.

3. Now that you understand what project you'll be working on over the course of this unit, what else do you need to know? What additional questions do you have?

8th Grade Science Unit 2: Travelling Through Space
Task 1: A Sun-Earth-Moon Model

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?*

Engage

At the end of the Lift-Off task, we used our prior knowledge to brainstorm what is in our solar system. However, to prepare to launch a telescope through space, we don't just need to know what is in our solar system, but where objects 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!

In pairs, make predictions about the science behind some of the phenomena you experience on Earth:

1. Why does your shadow grow shorter and then longer throughout a day?

2. Why is it colder in winter in and warmer in summer in California?

3. Why does the moon appear as a different shape in the sky on different nights?

4. Why can we see some stars for only a portion of the year?

5. How is it possible that an area of the world can go temporarily dark in the middle of the day?

8th Grade Science Unit 2: Travelling Through Space

Task 1: A Sun-Earth-Moon Model

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?*

Explore

Using Models: To learn more about the Sun, the Moon, and the Earth, and how they interact, you will need to gather more information. With your group, use the models at the stations to help you investigate the phenomena from the Engage. Record your analysis in the chart below:

	Observations: What does this model tell you about the Sun-Earth-Moon system?	**Discussion Questions**
Resource Card 1: Sun's Movement Through the Sky		1. What did people previously believe about the movements of Sun and Earth? 2. Is the sun actually moving or are you moving? 3. How can you explain why the sun appears to be moving through the sky during a day? 4. How is the model at the end of this video limited (inaccurate in some ways)?

8th Grade Science Unit 2: Travelling Through Space

Task 1: A Sun-Earth-Moon Model

Resource Card 2: Seasons		1. Does the Earth stay in one place throughout the year? If not, describe its motion and location in the solar system? 2. Why does the angle of the sun at noon seem to change at different months throughout the year? a. How does this create seasons? 3. What do you notice about the angle of Earth? a. How do you think this affects the seasons in different hemispheres (halves) of the world?

8th Grade Science Unit 2: Travelling Through Space

Task 1: A Sun-Earth-Moon Model

Resource Card 3: Shapes of the Moon		1. No matter where the moon is in its orbit around the Earth, how much is lit up? a. Where does the light source come from? 2. When the moon is between the Earth and the sun, what do you observe from Earth's perspective? a. What type of moon do you think this is (Full Moon, Crescent Moon, Quarter Moon, New Moon)? 3. When the Earth is between the moon and the sun, what do you observe from Earth's perspective? a. What type of moon do you think this is (Full Moon, Crescent Moon, Quarter Moon, New Moon)?

8th Grade Science Unit 2: Travelling Through Space

Task 1: A Sun-Earth-Moon Model

Resource Card 4: Changing Stars in the Sky		1. Take a look at the image. On a summer night, what stars are visible? Why do you think those are the ones that are visible? 2. 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?) 3. Can this phenomenon be explained by the rotation of Earth on its axis OR the rotation of the Earth around the sun? Explain how.

8th Grade Science Unit 2: Travelling Through Space

Task 1: A Sun-Earth-Moon Model

Resource Card 5: Eclipses		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? 2. 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? 3. How often does this phenomenon occur? 4. How do the motions of the Earth, sun, and moon make this possible?

8th Grade Science Unit 2: Travelling Through Space

Task 1: A Sun-Earth-Moon Model

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?*

Explain

Developing and Using Models: In groups, make a physical model of the Sun-Earth system, using the following materials.

- Styrofoam Balls of varying size
- Skewers/Toothpicks
- Light sources of varying brightness
- Rubber band
- Marker

Patterns: Use the patterns you observed in the stations to explain why we experience phenomena on Earth that were described in the Engage. In groups,

1. Pick one of the following phenomena that we experience on earth: sun moving through the sky, changing shadows, seasons, changing stars in the sky, or eclipses.
2. Make a mini-movie explaining why this phenomenon happens, using the physical model you just created. You may use the space below to plan your movie.

8th Grade Science Unit 2: Travelling Through Space
Task 1: A Sun-Earth-Moon Model

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?*

Elaborate

Patterns: A friend from California is planning her winter break vacation in December. She decides that she wants to visit New Zealand to go skiing. Why is this a bad idea? In a short paragraph below, individually explain to your friend why she should not go to New Zealand to ski in December. Use information from previous activities to support your reasoning. You may wish to also draw a diagram to illustrate your point.

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?*

Evaluate: Connecting to the Culminating Project

You will be developing a model of the solar system and proposing the best route a new telescope should take through space. 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?

This should be completed individually in your Project Organizer.

8th Grade Science Unit 2: Travelling Through Space

Task 1: A Sun-Earth-Moon Model

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?*

Reflection

Individually reflect on Task 1, using the questions provided:

1. 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 were your predictions fairly close to the real reason? Pick one where your prediction was far off and write a revised response here.

2. 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?

3. Now that you have learned about a sub-system of our solar system, what questions do you still have?

8th Grade Science Unit 2: Travelling Through Space
Task 2: A Solar System Model

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?*

Engage

In the last task, you made a model of the sub-system of the solar system that we are most familiar with, the Sun-Earth-Moon system. The type of model we made helped us to understand the science behind many phenomena we experience on Earth. The model you will build in this task serves a different purpose. To prepare to launch the new telescope through space, we need to know the layout of the whole solar system *to scale*. As you know, the solar system is huge! If we want to visualize where things are in the solar system, we are going to have to scale objects down, or reduce them to a much smaller size.

Scale, Proportion, and Quantity: Before we make a model of the solar system to scale, let's explore this idea of scale. Individually:

- Put a dot below that represents you and where you are right now.
- Pick a friend or family member who lives somewhat nearby.
    - Now put a dot somewhere below representing where your friend or family member lives.
- Now think of someone who lives far away.
    - Given the distance between you and your "close" friend/family member, where on the paper would you put your "far" friend/family member?
    - Does the dot have to go off the paper? How far off?

Congratulations! You just made your first attempt at creating a scale model. A scale model shows real objects with all the sizes reduced or enlarged by a certain amount, known as the scale. Today, you will be exploring the real sizes of objects in the solar system so you can reduce them by a certain amount for your scale model.

8th Grade Science Unit 2: Travelling Through Space
Task 2: A Solar System Model

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?*

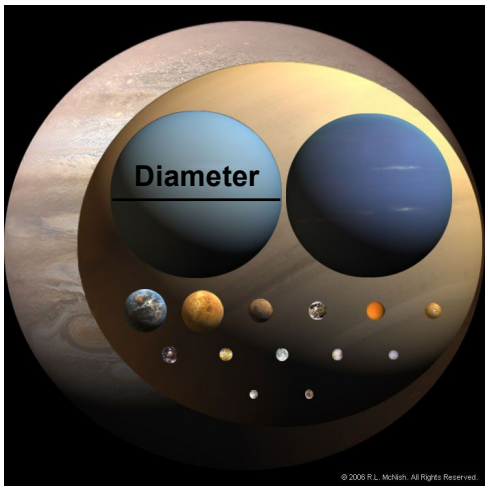
Explore

In the Lift-Off Task, you brainstormed parts of a solar system, but to truly understand the layout, we need to **analyze and interpret data** that gives us more information on these parts and how they are arranged. With your group, analyze the information below, which you will use for your solar system model later in this task.

Source of data: https://nssdc.gsfc.nasa.gov/planetary/factsheet/

Part I: Diameters of Different Planets

1. This illustration shows the planets in relative size. What do you think relative size means?



http://lpb.fieldofscience.com/2009/11/solar-systemto-scale.html

Analyze the data below, which shows the diameters of the different planets (and stars) in kilometers.

Sun	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune
1,391,000	4879	12,104	12,756	6792	142,984	120,536	52,118	49,528

2. What is the largest and smallest body in the solar system?

3. What do you notice about the size of the planets? Make some observations based on similarities and differences you see.

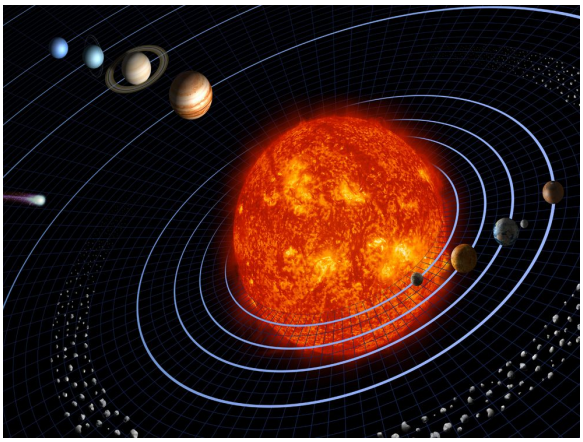
8th Grade Science Unit 2: Travelling Through Space

Task 2: A Solar System Model

4. Why does this information matter to create a solar system model and plan a route for the new telescope?

Part II: Orbital Radii of Different Planets

1. The illustration to the right shows the planets in relative distance from the sun. What do you think relative distance means?



https://www.nationalgeographic.org/activity/planetary-size-and-distance-comparison/

We know that all planets orbit the sun, but we are not quite sure in what format. Analyze the data below to learn more about each planet's distance from the sun as it orbits. The data is in Astronomical Units (AU). An AU is a unit of length that is roughly equal to 150 million kilometers, the average distance from the Sun to the Earth.

Sun	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune
0	0.39	0.72	1.00	1.52	5.20	9.58	19.2	30.1

2. Orbital radius is ultimately the average distance each planet maintains from the sun as it orbits. Why do you think scientists use AU for an orbital radius instead of kilometers?

3. Why does this information matter to create a solar system model and plan a route for the new telescope?

8th Grade Science Unit 2: Travelling Through Space

Task 2: A Solar System Model

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?*

Explain

To help us visualize the different routes the new telescope may take through our solar system, we need to make a physical **model**. But our solar system is huge! Thus, our models will have to be **scale** models, or a representation of the solar system that is much smaller but still maintains accurate size relationships between the different objects.

You also may have noticed that the sizes of the planets were measured in kilometers, whereas the distances between planets and the sun were measured in Astronomical Units (Remember, 1 AU = 150 million kilometers!). Unfortunately, it is not realistic for us to use the same scale, so for the sake of this model, we will be using two different scales – one for planet size and one for orbital radii.

Part I, Using Mathematics and Computational Thinking: With your group, use the following ratios to help you figure out the proportions of your solar system model and record in the chart below:

Size of Body (Ratio: 1000 km = 1 cm)

	Sun	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune
Actual Size (km)	1,391,000	4879	12,104	12,756	6792	142,984	120,536	52,118	49,528
Model Size (cm)	*Not to scale in your model. Why?*								

Distance from Sun (Ratio: 1 AU = 10 cm)

	Sun	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune
Actual Distance (AU)	0	0.39	0.72	1.00	1.52	5.20	9.58	19.2	30.1
Model Distance (cm)	0								

8th Grade Science Unit 2: Travelling Through Space

Task 2: A Solar System Model

Part II, Scale, Proportion, and Quantity: Your teacher will now assign you one of the planets to be in charge of for your class solar system model, which you will keep returning to for the rest of the unit. For your assigned planet, your group is in charge of the following tasks:

- Create a physical model of the planet, using materials your teacher has provided
  - Remember to size your planet based on your math above!
  - Label your planet with its name and actual size.
- Place your planet model in the right location in your class "solar system".
  - Cut a string to model the correct distance from the Sun, according to your math above.
  - Label your string with the actual distance from the sun.

Use the space below to plan your planet model before constructing.

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?*

Elaborate

Watch the following video of another solar system model: https://www.youtube.com/watch?v=Kj4524AAZdE. In partners, discuss and respond to the following questions.

1. **Developing and Using Models:** Every model has limitations, some more than others.
   a. How were most of the models in the Task 1 stations limited, according to the beginning of this video?

   b. How is your class solar system model limited?

8th Grade Science Unit 2: Travelling Through Space

Task 2: A Solar System Model

2. Why don't we often see true scale models of the solar system?

3. How were these individuals able to create the first truly scaled model of the solar system? Describe the model (size, materials, etc.)

    a. **Scale, Proportion, and Quantity:** How did they check to see if the parts of their model were the correct proportions to create an accurate scale?

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?*

Evaluate: Connecting to the Culminating Project

You have begun developing a model of the solar system so you can propose the best route a new telescope should take through space. To plan a route for the new telescope, you will need to know more than just the Sun-Earth-Moon System and more than just a list of total parts; you will need a specific layout. Draw a sketch of your class solar system model, including where the new telescope needs to arrive.

- ✓ In captions, explain the scale you used for your assigned planet within the model.
    - What data did you use?
    - How does it compare to other planets in the solar system model?

This should be completed individually in your Project Organizer.

8th Grade Science Unit 2: Travelling Through Space

Task 2: A Solar System Model

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?*

Reflection

Individually reflect on Task 2, using the questions provided:

1. At the beginning of this task, you were asked to make a scale drawing showing locations around you. Look back at your drawing: how is this similar to the solar system model you made in this task? What makes your solar system model a better scale model than this first drawing?

2. In this task, we focused on the crosscutting concept of:
    - **Scale, Proportion, and Quantity**: scaled models can be used to study time, space, or energy systems that are too large or too small.

   Where did you see examples of **Scale, Proportion, and Quantity** in this task?

3. Now that you have created a class model of our solar system, what questions do you still have?

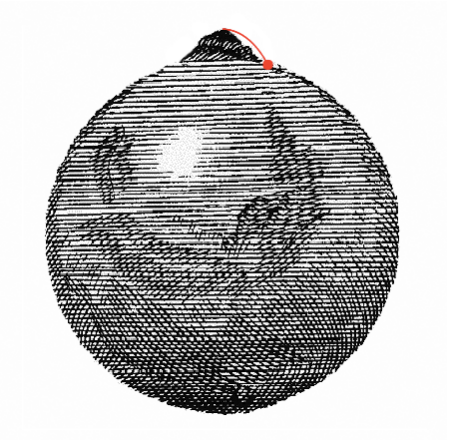
8th Grade Science Unit 2: Travelling Through Space
Task 3: Gravity in the Galaxies

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?*

Engage

In the last task, you made a model of the entire solar system, so you could begin to see the different routes the new telescope may take when it is launched. However, the parts of our solar system are not motionless…they move! In this task, you will explore what factors affect motion within our solar system.

1. Isaac Newton was very curious about what affects the motion of celestial bodies in our solar system. He presented a thought experiment called "Newton's Cannonball," in which he imagines a cannon on top of a very high mountain. Newton said that logically, the cannonball should follow a straight line away from Earth, in the direction it was fired, instead of falling.



   a. Do you agree? Why or why not?

2. **Developing and Using Models:** In pairs, use the following simulation to engage with Newton's cannonball thought experiment: http://physics.weber.edu/schroeder/software/NewtonsCannon.html.

   a. If you set it to 1500 m/s, what happens? Explain why you think it moves this way.

   b. The moon orbits at 7,300 m/s. If you set the cannonball to this speed, what happens? Why is this different from the first setting?

   c. Now set it to 8000 m/s. What happens? How would you describe the relationship of an object's speed and the force of gravity when it comes to orbits?

8th Grade Science Unit 2: Travelling Through Space
Task 3: Gravity in the Galaxies

3. **Systems and System Models**: You already learned about gravity in Unit 1. Gravity is defined as the force that attracts objects towards physical bodies that have a lot of mass. Based on this definition, what object in our solar system do you think has the largest gravitational pull?

    a. How do you think this can explain the ways objects move in the solar system?

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?*

Explore

Newton's Cannonball is just one thought experiment, which Isaac Newton used to hypothesize about the role of gravity in the motion of planets. Since then, scientists have used new technology to collect much more data that examines how objects move in the solar system. From this data, scientists have created models that not only describe current motions in the solar system but also how they started.

Systems and System Models: With your group, explore the models below to form your own idea of how different parts of the solar system interact and why. Answer the discussion questions that follow to help you describe each model.

Model 1: Simulating the Formation of Our Solar System

How did our solar system come to look the way it does? Before we simulate how the solar system was formed, we need to get some background. About 4.5 billion years ago, a dense cloud of gas and dust collapsed, forming a swirling disk of material. At the center, gravity pulled more and more material in until the pressure was so great that chemical reactions began releasing tons of energy. The sun was born from this interaction, using up 99% of the matter. However, matter farther out was also clumping together, forming larger objects. Some became planets, dwarf planets, and large moons. Others never quite came together and are part of the asteroid belt.

Instructions:

1. Visit the online simulation: http://www.nowykurier.com/toys/gravity/gravity.html
2. In the bottom left corner, click on "Huge" and then click "Generate proto disk (slow start)" to begin the simulation.
3. Observe for approximately 30 seconds.

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Task 3: Gravity in the Galaxies

Discussion Questions:

1. What appears to be happening?

2. What does this model imply as the main reason all of the planets orbit the sun?

Model 2: Simulating an Orbit with Our Bodies

This model simulates the motion of one planet in the solar system, so you can get a better feel for orbits.

Instructions:

1. Have one group member stand in the center holding one end of the rope. This person will represent the "Sun" and will not move from that spot, but will rotate in a circle for the sake of this activity (Note: the sun does not actually rotate in reality).
2. Have another group member hold the other end of the rope behind their back and start walking away from the motionless "Sun." This person will represent the "planet."
3. The second group member continues moving with the rope pulled taut until a full orbit is made around the "Sun".

Discussion Questions:

1. When the rope becomes taut, what happens?

2. How does the pull of the rope affect the direction and motion (orbit) of the "planet"?

3. What do you think the force of the rope pulling on the "planet" represents?

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Task 3: Gravity in the Galaxies

Model 3: Simulating A Factor That Affects Solar System Movement

Now that we have a better idea of how our solar system formed and an example of a planet's orbit, it's time to think about what factors affect these motions. Here we revisit a model from last unit.

Instructions:

1. Visit the online pHET simulation entitled "Gravity and Orbits": https://phet.colorado.edu/en/simulation/gravity-and-orbits
2. Launch the simulation and select "Model."
3. Click the selection showing the Sun, Earth, and Moon. Then click the boxes to show *Gravity Force* and *Path.*
4. Experiment with different masses of the Sun and Earth.

Discussion Questions:

1. How does the mass of the Sun impact the orbit of the Earth? Use an example from the simulation.

2. How does the mass of the Earth affect the Moon? Use an example from the simulation.

3. We learned in the last unit that mass affects gravitational force. But how does this work in the solar system? Use examples from the simulation to explain how mass affects gravitational force in the solar system.

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?*

Explain

Using Models: The following video shows a simulated solar system, created from authentic data on the solar system: https://www.youtube.com/watch?v=9R5P9Y9gRYY. Use the previous models to individually explain this simulation, describing the role of gravity in the motions within the solar system. In your explanation, you may want to:

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Task 3: Gravity in the Galaxies

- Describe the orbits of the planets,
  - Including what they are all orbiting around
  - And why they are all in orbit
- Describe what factors affect these orbits

Make sure to use evidence from the models of the *Explore* to back up your explanation!

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?*

Elaborate

Do you remember the data table below from Unit 1? Similar to Model 3, it shows how mass affects gravitational pull.

Body	Mass of the Body (kg)	Time it takes the same rock to impact the surface from 100 meters away
Earth	$5.98 * 10^{24}$	4.51 seconds
Mercury	$3.30 * 10^{23}$	7.35 seconds
Venus	$4.87 * 10^{24}$	4.72 seconds
Mars	$6.42 * 10^{23}$	7.33 seconds

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Task 3: Gravity in the Galaxies

Jupiter	$1.90 * 10^{27}$	0.90 seconds
Saturn	$5.69 * 10^{26}$	1.38 seconds
Uranus	$8.68 * 10^{25}$	2.04 seconds
Neptune	$1.02 * 10^{26}$	1.97 seconds
Pluto	$1.29 * 10^{22}$	17.53 seconds
Moon	$7.35 * 10^{22}$	11.10 seconds
Sun	$1.99 * 10^{30}$	0.42 seconds

1. With your group, use **mathematics and computational thinking** to calculate the rate at which the rock falls on different planets.

Show your math for at least one rate. You may use mental math for the rest of the rates, if you choose.

Body	Rate Rock Falls (m/s)
Earth	
Mercury	
Venus	
Mars	
Jupiter	
Saturn	
Uranus	
Neptune	
Pluto	
Moon	
Sun	

2. **Developing Models:** Return to your solar system model. For your group's assigned planet, label it with the mass and the rate it takes a rock to fall 100 meters.

8th Grade Science Unit 2: Travelling Through Space
Task 3: Gravity in the Galaxies

3. **Engaging in Arguments From Evidence**: Adding the mass of each planet makes our solar system model more useful in planning the best route for the new telescope. Individually, construct an argument explaining why this information improves your model. Use the data above and any of the *Explore* models to back up your argument.

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?*

Evaluate: Connecting to the Culminating Project

You have developed a model of the solar system and will now begin to brainstorm the best route a new telescope should take through space. Even though you already have the layout of the solar system, you now know that these objects don't just remain stationary…they move because of gravity! Based on what you've learned about mass, gravity, and motion, draw a potential route for the new telescope on the sketch you made in the Task 2 section. Then in this section:

- ✓ Explain why the solar system is laid out the way it is: what is the role of gravity in the solar system?
- ✓ Use your model and data from the task to explain how gravity might affect the new telescope as it moves through space.
- ✓ Justify your route by explaining why you stay farther away from some planets, but not others.

This should be completed individually in your Project Organizer.

8th Grade Science Unit 2: Travelling Through Space
Task 3: Gravity in the Galaxies

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?*

Reflection
Individually reflect on Task 3, using the questions provided:

1. At the beginning of this task, you used a thought experiment to think about why planets might move the way they do in our solar system. Look back at your responses: after learning everything you have about gravity, how would you add to or revise your responses? Use information from the models to improve your explanation of Newton's thought experiment.

2. In this task, we focused on the crosscutting concept of:
    - **Systems and System Models**: models can be used to represent systems and their interactions.

   Where did you see examples of **Systems and System Models** in this task?

3. Now that you have used and developed models to describe the movement of celestial bodies in our solar system, what questions do you still have?

8th Grade Science Unit 2: Travelling Through Space
Task 4: Invisible Forces

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?*

Engage

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. Scientists say that the new and best protection for objects in space is to create magnetic fields around them. But how do we do this? Today we are going to learn about another non-contact force—magnetic fields—so we can better understand how to protect the new telescope and predict how it will behave in space as a result of this protection.

The forces we are studying today are invisible to us! In pairs, watch the following video that also seems to show some invisible force at work and make some predictions about the mysterious floating objects: https://www.youtube.com/watch?v=LLIIYtnDups.

1. What do you observe as you watch the video?

2. The objects in the video appear to be floating and moving on their own! Make a prediction: how is this possible?

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Task 4: Invisible Forces

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?*

Explore

Planning and Carrying Out Investigations: To learn more about these invisible forces, we need to conduct investigations. In groups, visit the lab stations to try and figure out how objects that aren't touching each other could possibly behave in this way. Record your observations, drawings, and data analysis in the table below:

	Observations and Drawings	Discussion Questions
Station 1: Exploring Invisible Forces		1. How did orienting the two magnets different ways affect how they moved? Why do you think this happened? 2. What conclusions can you make about the different objects tested? 3. Do all objects have this "invisible force" acting on them? If not, which ones?
Station 2: Testing the Strength of an Invisible Force		1. How do you think the magnet is able to move the paper clip without touching it?

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Task 4: Invisible Forces

		2. 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?
Station 3: Exploring Invisible Fields		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? 2. Where do you see the most filings? This is where the field is the strongest.
Station 4: Creating Invisible Fields		1. Does the invisible force exist between just the wire-wrapped nail and the paper clips? 2. How were you able to create the invisible force between the wire-wrapped nail and the paper clips?

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Task 4: Invisible Forces

		3. What factors do you think might affect the strength of the invisible force?

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?*

Explain

In the stations, you conducted investigations to find out more about these invisible forces that cause mysterious interactions between objects that are not in contact. In partners, use the following questions to draw conclusions about your lab:

1. Use the lab data to come to a conclusion: What causes the interactions we see between objects not in contact with each other?

    a. Explain how you know: What are multiple examples of specific evidence in the lab stations that support this conclusion?

8th Grade Science Unit 2: Travelling Through Space

Task 4: Invisible Forces

2. **Cause and Effect**: Based on what you saw in the investigations, write 2-3 general rules that will describe to others how different objects can interact when they are not touching.

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?*

Elaborate

In the Explore, you began to test factors that affect the strengths of these invisible fields, also known by scientists as magnetic fields. This is crucial information for your culminating project! In order to protect the new telescope as it travels through space, you will need to make some recommendations for a protective magnetic field around the telescope. In groups, answer the following questions:

1. **Planning and Carrying Out Investigations**: Did the data you gathered in the investigations provide enough evidence about what affects the strength of magnetic fields? Why or why not?

2. **Asking Questions**: Look back at your data from Stations 2 and 4. What testable questions can you ask to determine what factors affect the strength of these magnetic fields?

8th Grade Science Unit 2: Travelling Through Space

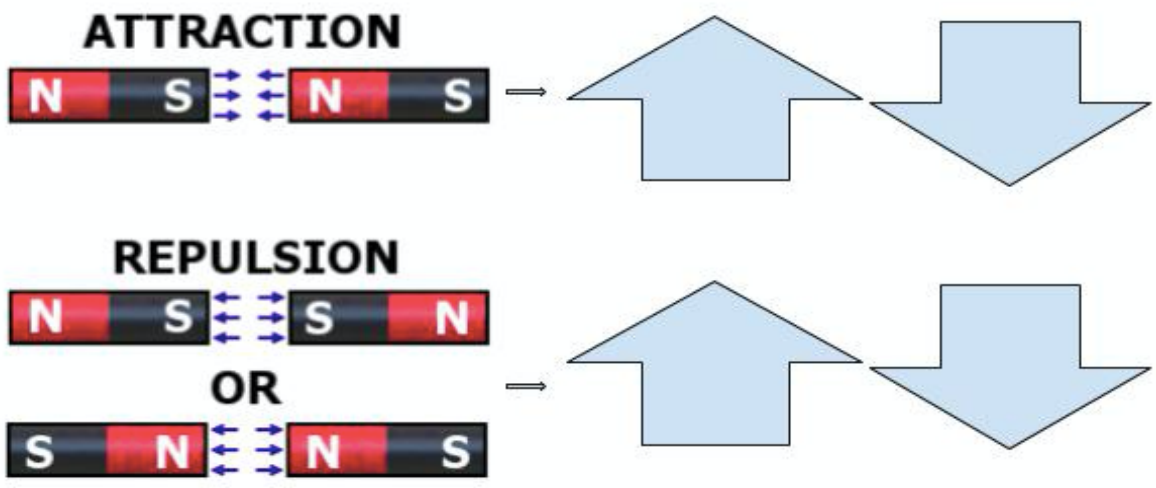
Task 4: Invisible Forces

3. Let's do some small experiments to help you test out some of these questions. Your teacher will provide you with all of the materials from the Explore. Use the various materials to test your questions above to determine how to create the strongest magnetic fields.
    a. Based on the test data you have collected, write a hypothesis to the following question: What factor(s) create the strongest magnetic fields?

    b. How do you know?

4. **Cause and Effect:** Apply this conclusion to the protection of the new telescope: What can you do to create a strong magnetic field around your telescope?

5. **Systems and System Models:** We know that when kinetic energy, or energy in motion, decreases, potential energy increases, and vice versa. In any system of magnets, there is magnetic potential energy. In your experiments, how did rearranging the magnets change the magnetic potential energy of the systems? Complete the **model** (diagram) below to illustrate this relationship by filling in the blue arrows with the phrases "kinetic energy" and "potential energy".



6. Taking it further: You have figured out ways to create a strong protective magnetic field around your telescope. However, this will mean it is magnetic and can thus be influenced by planets that have magnetic fields! Make a prediction for how you think the telescope might now behave as it passes planets with magnetic fields.

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?*

Evaluate: Connecting to the Culminating Project

You are developing a model of the solar system and proposing the best route a new telescope should take through space. 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 the arrangement of objects and potential energy, how might the telescope be affected as it passes these different planets?

This should be completed individually in your Project Organizer.

8th Grade Science Unit 2: Travelling Through Space

Task 4: Invisible Forces

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?*

Reflection

Individually reflect on Task 4, using the questions provided:

1. 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?

2. In this task, we focused on the crosscutting concepts of:
    - **Cause and Effect**: cause and effect relationships may be used to predict events.
    - **Systems and System Models**: models can be used to represent systems and their interactions.

   Where did you see examples of **Cause and Effect** and **Systems and System Models** in this task?

3. Now that you have learned about the role of magnetic fields in your telescope route, what questions do you still have?