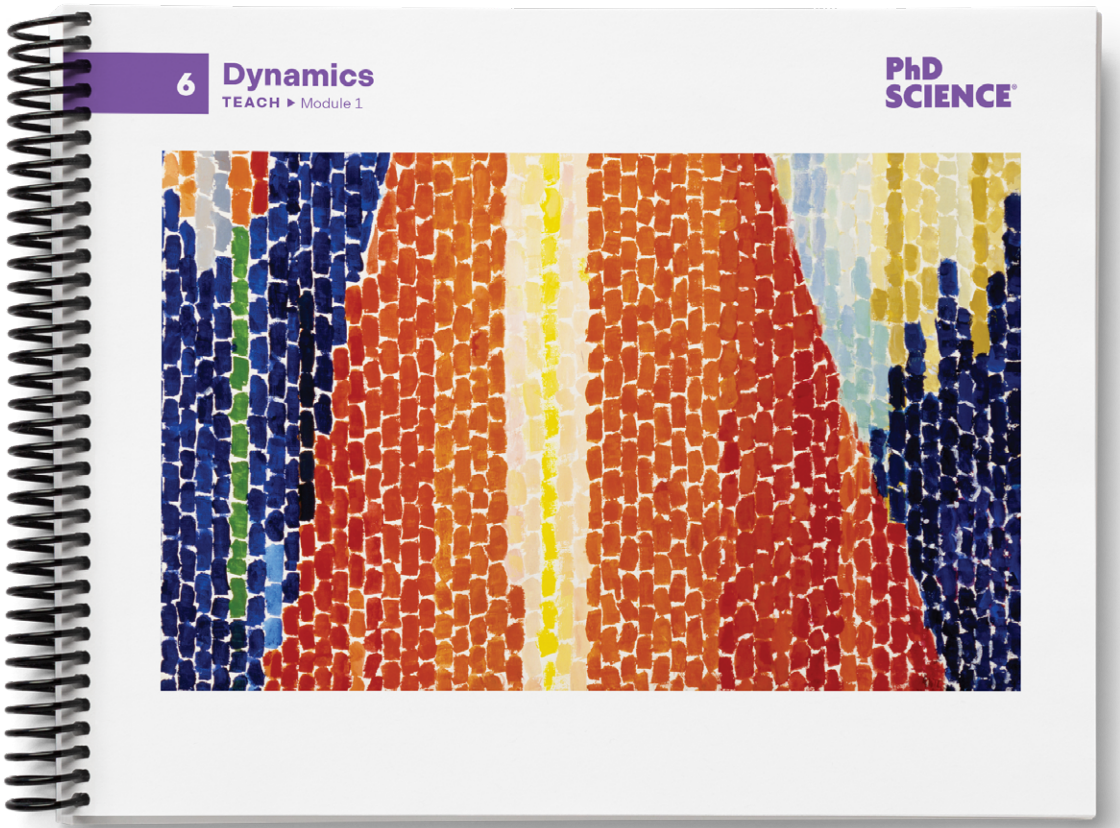
Level 6 Sample Companion

Level 6 Module 1

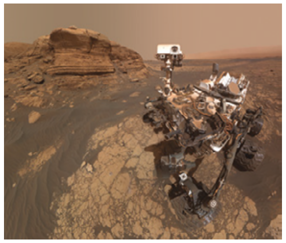
PhD Science® is a hands-on K–6 science program that sparks curiosity as students build enduring knowledge of how the scientific world works. Students think and act like real scientists as they ask questions, gather evidence, develop models, and construct explanations while investigating authentic phenomena.

This Sample Companion is a resource that will introduce you to the module and lesson structure that *PhD Science* follows. You will find detailed notes that will help familiarize you with our learning design and assist you in your review.



PhD SCIENCE®

Module Overview



MODULE OVERVIEW

DRIVING QUESTION 1

How did Curiosity get from Earth to Mars successfully?

INTRODUCTION

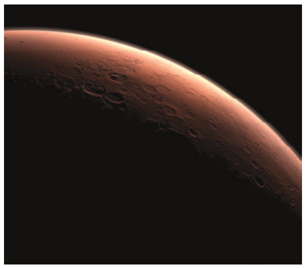
Background Information 2

Throughout this module, students study the anchor phenomenon, Curiosity's journey from Earth to Mars, to build an answer to the Driving Question: **How did Curiosity get from Earth to Mars successfully?** Students learn that NASA scientists and engineers designed the Curiosity rover to explore and gather data on Mars. They also learn that Curiosity carried more advanced scientific tools than previous rovers, making it the most massive rover sent to Mars at the time of its launch with the Atlas V rocket on November 26, 2011. Students find out that Curiosity traveled a carefully planned flight path before reaching its destination about 350 million miles and 8 months later. They also find out that scientists and engineers needed to develop a new landing system to reduce the speed of the spacecraft carrying Curiosity from 13,000 miles per hour to 2 miles per hour to safely land this very large, heavy rover on the surface of Mars.

This rich, authentic phenomenon drives student learning as students follow the different stages of Curiosity's journey, from Curiosity's launch to its travel through space to its landing on the surface of Mars. Throughout the module, students develop and revise models as they seek to explain how NASA scientists and engineers successfully launched and landed the largest rover to date on Mars. They begin by making sense of the forces involved in Curiosity's launch and then apply what they learn to explain how exhaust exerted a continuous upward force on Atlas V to launch Curiosity from Earth into space.

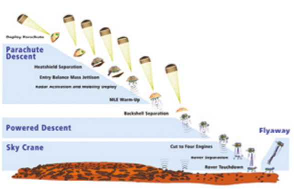
1. The Driving Question is a question developed at the beginning of a module that stimulates rich student discussion but may never be fully answered. It serves as motivation for student learning throughout the module. As students find satisfactory answers to Phenomenon Questions in each lesson, they make progress toward answering the module Driving Question. Over the course of the module, as students make sense of different aspects of the anchor phenomenon or related supporting phenomena and answer the Driving Question, they reflect on their progress by updating the anchor model and reviewing the questions on the Driving Question board. By the end of the module, students' public thinking about the anchor phenomenon, as captured on the anchor model and the Driving Question board, should demonstrate their incremental progress in explaining the anchor phenomenon and answering the Driving Question.

2. The Background Information subsection provides a deeper explanation of the anchor phenomenon and science topics covered in the module (including common misconceptions).



Next, students determine that after detaching from Atlas V, Curiosity continued to move at a nearly constant—and very fast—speed as the spacecraft carrying it traveled to Mars. Students investigate how NASA engineers planned a path for the spacecraft to meet Mars from Earth. While analyzing Curiosity's launch and travel through space, students identify patterns in forces and motion that help them build an understanding of Newton's three laws of motion.

Finally, students learn about the spacecraft's landing devices, which included a large parachute that greatly decelerated the spacecraft and allowed Curiosity to land on the surface of Mars safely despite its large mass. Students apply the lens of energy to examine how engineers considered both mass and speed when determining how to reduce the spacecraft's kinetic energy enough for a successful landing.



Content Boundaries and Rationale 1

Why are Newton's laws of motion not taught in order?

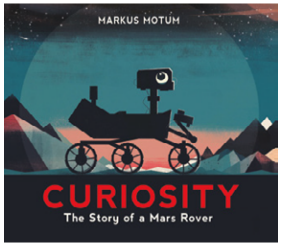
The module follows Curiosity's journey sequentially, from its launch to its journey through space to its landing on Mars. As a result, forces are introduced before motion, so concepts such as Newton's laws of motion are taught in the order that is most conducive to building student understanding of each part of Curiosity's journey from Earth to Mars. In Concept 1, the class develops a model to describe the forces involved in Curiosity's launch, including the net force on Atlas V (Newton's first law) and the force pair between Atlas V and its exhaust (Newton's third law). Students conduct an investigation to observe how the amount of force affects the speed of an object and how the mass of the object affects the force needed to reach the same speed (Newton's second law). Students continue to explore aspects of Newton's three laws as they make sense of the forces that caused Curiosity to launch into space.

In Concept 2, students focus on Curiosity's motion as it traveled through space. As they explore the relationship between net force and acceleration to explain the spacecraft's motion, students uncover an additional aspect of Newton's first law and add the term *acceleration* to their description of Newton's second law.

1 The Content Boundaries and Rationale subsection identifies boundaries of the Disciplinary Core Ideas and provides additional information about any content decisions made during development.

Why are both the US customary and metric systems of measurement sometimes used?

The metric system, or International System of Units (SI), is the standard system of measurement used by scientists and engineers in most parts of the world. This module asks students to think and solve problems like scientists and engineers, including by working with metric units. Given that students are likely more familiar with US customary measurements at this stage of their learning, at certain points in the module when metric units appear with large numbers (e.g., to express how far Curiosity traveled to Mars or how fast Atlas V was traveling at escape speed), the equivalent US customary measurement appears in parentheses to help students connect their new learning with their prior knowledge.



Additional Reading for Teachers 1

Many activities, investigations, and discussions throughout this module give students the opportunity to use their senses to explore phenomena. See the Supporting All Learners section of the Implementation Guide for information on how to support students with sensory disabilities. In addition, use the following resource to learn more about the phenomena and science concepts featured in this module.

- "Mars Curiosity Rover" from NASA Science (https://gmpbc.link/phd-ute-nasa-curiosity-rover)

1 The Additional Reading for Teachers subsection provides resources to deepen teachers' knowledge of the phenomena and concepts featured in the module.

FOCUS STANDARDS ①

The Module Objectives describe what students should know and be able to do by the end of this module.

MODULE OBJECTIVE | **Use patterns (CC.1)** from **the results of a planned investigation (SEP.3)** to determine that **the sum of the forces on an object cause (CC.1) a change in the object's motion (PS2.A)**.

SCIENCE AND ENGINEERING PRACTICES	DISCIPLINARY CORE IDEAS	CROSSCUTTING CONCEPTS
SEP.3: Planning and Carrying Out Investigations • **Plan an investigation** individually and **collaboratively, and in the design identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim**.	PS2.A: Forces and Motion • **The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change.** The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.	CC.1: Patterns • **Patterns can be used to identify cause and effect relationships.**

MODULE OBJECTIVE | **Use patterns (CC.1)** from **collected data (SEP.3)** to determine that **interacting objects exert equal and opposite forces on each other (PS2.A)**.

SCIENCE AND ENGINEERING PRACTICES	DISCIPLINARY CORE IDEAS	CROSSCUTTING CONCEPTS
SEP.3: Planning and Carrying Out Investigations • **Collect data to produce data to serve as the basis for evidence to answer scientific questions** or to test design solutions under a range of conditions.	PS2.A: Forces and Motion • **For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's Third Law).**	CC.1: Patterns • **Patterns can be used to identify cause and effect relationships.**

① The Focus Standards section communicates Module Objectives and NGSS Performance Expectations that the module is building toward.

PhD Science is designed around Module Objectives, teacher-facing statements that describe what students should know and be able to do by the end of a module, rather than NGSS Performance Expectations (PEs). The purpose for this distinction is that PEs provide examples for what students should be able to do by the end of a grade or grade-band, while Module Objectives specifically describe the standards that students master in each module. Module Objectives support teachers in planning instruction and provide valid and actionable information to teachers about student proficiency with all three dimensions of the NGSS.

MODULE MAP 1

Anchor Phenomenon | Curiosity's Journey from Earth to Mars

Driving Question | How did Curiosity get from Earth to Mars successfully?

Anchor Phenomenon Introduction

This lesson introduces students to the anchor phenomenon, Curiosity's journey from Earth to Mars.

LESSON	ANCHOR PHENOMENON	DRIVING QUESTION	LESSON OBJECTIVE
1	Curiosity's journey from Earth to Mars	How did Curiosity get from Earth to Mars successfully?	**Develop a model to describe (SEP.2)** and explain **the changing motion of an object (PS2.A)** within **subsystems of a larger system (CC.4)**. Part 1: **Ask questions that arise from careful observation of a phenomenon (SEP.1)** involving **an object's changing motion (PS2.A)** within **subsystems of a larger system (CC.4)**. Part 2: **Develop a model to describe (SEP.2)** and explain **the changing motion of an object (PS2.A)** within **subsystems of a larger system (CC.4)**.

1 The Module Map provides a snapshot of what students are doing in each lesson. It includes the phenomenon students explore, the phenomenon question students seek to answer, the lesson objective, and the performance descriptors.

ASSESSMENT MAPS (1)

Each *PhD Science*® module includes a system of assessments designed to provide students with multiple and varied opportunities to demonstrate proficiency with the elements identified in the Module Objectives. The assessment maps in this section identify the lessons in which the elements that make up each Module Objective are assessed. For more information on the *PhD Science* approach to formative and summative assessment, see the Implementation Guide.

MODULE OBJECTIVE | **Use patterns (CC.1)** from **the results of a planned investigation (SEP.3)** to determine that **the sum of the forces on an object cause (CC.1) a change in the object's motion (PS2.A)**.

ELEMENT	FORMATIVE ASSESSMENT	SUMMATIVE ASSESSMENT
SEP.3: Planning and Carrying Out Investigations • **Plan an investigation** individually and **collaboratively, and in the design identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim**.	**Lesson 5** **Lesson 11**	**Lesson 12** **Lesson 13**
PS2.A: Forces and Motion • **The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change.** The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.	**Lesson 1** **Lesson 2** **Lesson 4** **Lesson 7**	**Lesson 6** **Lesson 7** **Lesson 9** **Lesson 13**
CC.1: Patterns • **Patterns can be used to identify cause and effect relationships.**	**Lesson 2** **Lesson 4** **Lesson 5** **Lesson 7**	**Lesson 6** **Lesson 7** **Lesson 9** **Lesson 10** **Lesson 13**

(1) The Assessment Maps show the lessons in which the NGSS elements of the Module Objectives are formatively or summatively assessed.

BUILDING KNOWLEDGE AND SKILLS ACROSS LEVELS

1

Throughout Level 6, students build knowledge and skills associated with the Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts.

Science and Engineering Practices

In Levels 3 through 5, students develop and revise simple models **(SEP.2)** to represent events and design solutions. In this module, students progress to developing and using models of unobservable mechanisms, such as the forces and energy involved in Curiosity's journey from Earth to Mars. In Levels 9 through 12, students advance to developing models to predict and show relationships between variables as well as between systems and their components.

In Levels 3 through 5, students plan and carry out investigations **(SEP.3)** that involve controlling variables. In this module, students progress to planning and carrying out investigations that also involve identifying independent and dependent variables. They use investigations to test solutions and to provide evidence to support explanations of the forces acting on Curiosity and the resulting motion. In Levels 9 through 12, students advance to carrying out investigations that provide evidence for and test various types of models.

Disciplinary Core Ideas

In Levels 3 through 5, students learn that an unbalanced force acting on an object results in a change in its motion **(PS2.A)**. They also explore how patterns in an object's motion can be used to predict the object's future motion. In this module, students apply this learning to realize that the mass of an object must be considered when predicting how an unbalanced force will affect the object's motion. Students identify that a stronger force was required to launch Curiosity, the most massive rover at the time of its launch. In Levels 9 through 12, students quantitatively apply Newton's second law to predict changes in the motion of a macroscopic object.

In Levels 3 through 5, students learn that the faster an object moves, the more energy it has **(PS3.A)**. In this module, students build on this understanding to identify that mass and speed affect an object's kinetic energy as they explain that Curiosity had more kinetic energy than other rovers during landing because of its fast speed and great mass. In Levels 9 through 12, students advance to describing the total energy of a system in terms of the motion and configuration of objects.

In Levels 3 through 5, students learn how energy can be converted from one form to another and how energy can be moved from one place to another by moving objects **(PS3.B)**. In this module, students investigate energy transfer during Curiosity's landing to discover that changes to and from each type of energy can be tracked through physical or chemical interactions. In Levels 9 through 12, students build the understanding that systems move toward energetically stable states.

1 The Building Knowledge and Skills Across Levels section describes the progression of student learning in each of the three NGSS dimensions.

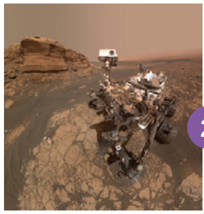
ADVANCE MATERIALS PREPARATION 1

Several activities in this module require advance preparation. See the lesson resources for more details on material preparation and instructions.

LESSON PART	TIME IN ADVANCE	PREPARATION TIME	INVESTIGATION	DESCRIPTION
Lesson 4 Part 2	1 to 2 days	Time range varies	Balloon rockets	Identify a large space for each group where 5 meters of fishing line can extend horizontally without interfering with anything. If necessary, move the investigation to an alternative location with more space, such as a school gymnasium.
Lesson 7 Parts 1 and 2	1 to 2 days	Time range varies	Forces and motion simulation	Ensure that each student has access to a device for a digital activity for the Lesson 7 Parts 1 and 2 forces and motion simulation.
Lesson 8 Parts 2 and 3	1 to 2 days	Time range varies	Reference frames	In Lesson 8 Parts 2 and 3 each group requires a 2 m × 2 m flat area to complete an investigation with reference frames. If there is not enough space in the classroom, find a large space, such as a school gymnasium, where enough reference frames can be assembled. Students will use the reference frames for two lesson parts in a row, so assemble them in a location where they can remain for a few days if possible.
Lesson 10 Part 2	1 to 2 days	Time range varies	Energy transfer model	Ensure that each student has access to a device for a digital activity for the Lesson 10 Part 2 energy transfer model.

1 The Advance Materials Preparation section identifies and briefly describes module activities and investigations that require advance preparation. The intent is to give teachers a snapshot of activities and investigations that will require them to take special steps to prepare in advance of a lesson.

Lesson 1



Introduction

LESSON 1 CURIOSITY'S JOURNEY FROM EARTH TO MARS

1

2 **Anchor Phenomenon** | Curiosity's journey from Earth to Mars.

Driving Question | How did Curiosity get from Earth to Mars successfully? 3

OVERVIEW 4

In this lesson our teacher reads us a story about Curiosity, a rover that was sent to Mars to explore its surface. The story leads us to ask many questions about the detailed planning that went into Curiosity's launch from Earth, its travel through space, and its landing on the surface of Mars. We wonder how Curiosity got from Earth to Mars successfully.

Later we will determine that an upward net force on the Atlas V rocket caused Curiosity to move from its launchpad during launch.

5 **Lesson Objective**

Develop a model to describe (SEP.2) and explain **the changing motion of an object (PS2.A)** within **subsystems of a larger system (CC.4)**.

Performance Descriptors 6

Part 1: **Ask questions that arise from careful observation of a phenomenon (SEP.1)** involving **an object's changing motion (PS2.A)** within **subsystems of a larger system (CC.4)**.

Part 2: **Develop a model to describe (SEP.2)** and explain **the changing motion of an object (PS2.A)** within **subsystems of a larger system (CC.4)**.

1 Each lesson is organized around a specific aspect of the anchor phenomenon or a supporting phenomenon that students explore.

In Level 6, lesson parts should take from 40 to 70 minutes to implement.

The first lesson of a module is designed to introduce students to the anchor phenomenon they will make sense of and explain throughout the module. In this lesson, students are introduced to aspects of the anchor phenomenon that elicit wonder and encourage students to use their background knowledge to develop initial explanations. In doing so, classes develop an initial model that attempts to answer the module driving question. Then, students organize their questions related to the anchor phenomenon on the Driving Question board.

2 The module anchor phenomenon is a rich, multilayered scientific phenomenon that can motivate instruction throughout an entire module or a large portion of a module. This phenomenon drives the module because students need to uncover targeted Disciplinary Core Ideas to develop a satisfactory explanation for how the phenomenon works.

At the beginning of each module, students explore the anchor phenomenon and use their background knowledge and experiences to develop an initial anchor model to explain the anchor phenomenon. This framing practice generates questions that drive students to explore the anchor phenomenon and other related phenomena as they progress in the module.

3 A Driving Question guides the learning throughout a module. A Phenomenon Question guides student learning throughout a lesson.

4 The Overview section of a lesson provides teachers with a snapshot of the lesson to come. It includes

- Lesson Navigation—a short description of how the lesson coherently fits in the overall module storyline.
- Lesson Objective and Performance Descriptors
- Standards Addressed table
- Summary Box—a snapshot of the phenomenon and the Phenomenon Question for the module.

5 Every lesson in *PhD Science* includes a three-dimensional Lesson Objective. Lesson Objectives describe the student actions over the course of a lesson and include NGSS elements, the pieces of the NGSS that we combine to describe what students will do and come to know by the end of the lesson.

6 Performance Descriptors are included for each lesson part and describe the elements developed in each of those parts.

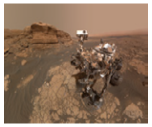
Performance Descriptors communicate how the learning goals of each lesson part build towards the Lesson Objective.

Formative assessments (or Checks for Understanding) that appear in each lesson evaluate the elements claimed in the Lesson Objectives and Performance Descriptors.

STANDARDS ADDRESSED 1

SCIENCE AND ENGINEERING PRACTICES	DISCIPLINARY CORE IDEAS	CROSSCUTTING CONCEPTS
SEP.1: Asking Questions and Defining Problems • **Ask questions that arise from careful observation of phenomena, models, or unexpected results, to** clarify and/or **seek additional information**. SEP.2: Developing and Using Models • **Develop a model to describe unobservable mechanisms.**	PS2.A: Forces and Motion • **The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change.** The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.	CC.4: Systems and System Models • **Systems** may interact with other systems; they **may have sub-systems and be a part of larger complex systems**.

1 Standards Addressed provides a summary of the Disciplinary Core Ideas, Science and Engineering Practices, and Crosscutting Concepts addressed within the lesson. Bold text indicates the part of the element addressed in the lesson.



PART 1 of 2

PREPARE 10 minutes or less

1 Complete the following preparation before this lesson part. Find the full materials list and preparation instructions in the Lesson 1 Preparation Resource.

Videos (5 minutes or less)

Meet the people web page (5 minutes or less)

Preparation Notes

1 Each lesson has a Preparation Resource that contains instructions for all necessary preparation the teacher must complete before teaching each part of the lesson.

MATERIALS 1

The table lists materials needed for each section of Part 1.

SECTION	STUDENT MATERIALS	CLASS MATERIALS
Launch	None	None
Learn: Read About Curiosity's Mission	None	☐ *Curiosity: The Story of a Mars Rover* (Motum 2017) (1)
Learn: Read About Curiosity's Journey to Mars	☐ Science Logbook (1 per student)	☐ *Curiosity: The Story of a Mars Rover* (1) ☐ Chart paper and marker for class chart
Learn: Build Driving Question Board	☐ Science Logbook (1 per student) ☐ Marker and sticky note for Driving Question board (1 of each per student)	☐ Chart paper, marker, and sticky notes for Driving Question board

MATERIALS REUSE

The list identifies disposable and prepared materials to save for reuse in the module.

- ☐ Driving Question board, marker, and sticky notes (for all lessons)

1 The Materials table provides a list of student and teacher materials needed in each section of each lesson part.

LAUNCH 10 to 15 minutes

Students share prior knowledge of and questions about Mars to develop a personal connection with the Curiosity rover mission. Students' questions about Curiosity prepare them for the introduction of the anchor phenomenon through a text.

1. **Elicit students' prior knowledge of and questions about Mars as they observe a photograph of Mars.**

   Display the photograph of a stargazer.

Anchor Framing

Point out the bright point of light above the stargazer and tell students that it is the planet Mars. Then ask the following questions.

What do you notice about Mars in the night sky?

What do you think the surface of Mars looks or feels like?

What do you wonder about the surface of Mars?

***Responses may** vary. Listen for students to share prior knowledge of Mars and questions they have about Mars.*

Tell students that people have been observing and wondering about Mars, just like them, for hundreds of years.

Performance Descriptor

Ask questions that arise from careful observation of a phenomenon (SEP.1) involving **an object's changing motion (PS2.A)** within **subsystems of a larger system (CC.4)**.

Agenda | 50 to 70 minutes

LAUNCH | 10 to 15 minutes

1

LEARN | 40 to 55 minutes

- Read About Curiosity's Mission (20 to 25 minutes)
- Read About Curiosity's Journey to Mars (10 to 15 minutes)
- Build Driving Question Board (10 to 15 minutes)

Teacher Note

In Level 7, students study the Solar System in depth. This module focuses on only Earth and Mars. As needed, support students in understanding that Mars is a planet in space and is a close neighbor to Earth.

1 Each lesson part contains an Agenda and is organized into these sections:

Launch—the lesson part opening, which engages students as they begin thinking about the lesson phenomenon

Learn—the heart of the lesson part, during which students develop new knowledge and apply prior knowledge to explore phenomena

Land—the lesson part closing, in which students reflect on what they have learned

Explain that people have not yet visited Mars but that different journeys, also known as missions, are being planned. Then display the photograph of Curiosity along the right side of the photograph of Mars.

Reveal that the first photograph shows just one small section of the second photograph. Explain that this machine, the Curiosity rover, took this photograph of itself on Mars by using its robotic arm. Explain that Curiosity is one of several moving robots that people have sent to Mars to help prepare for human missions.

3. **Show students a video of Curiosity landing on Mars to elicit questions about Curiosity's purpose and significance.**

2

Tell students they will watch a video about the moment Curiosity landed on Mars. Play the Curiosity milestone video (https://gmpbc.link/phd-ute-curiosity-milestone), and then ask students the following question.

What do you notice and wonder about people's reactions to Curiosity landing on Mars?

Listen for *students to comment on and ask questions about Curiosity's purpose and significance.*

Summarize that Curiosity's landing on Mars was a very important moment in history. Suggest that students read about Curiosity to learn more about the rover's purpose and significance.

1

Teacher Note
For information on NASA's plans for human missions to Mars, visit the NASA Science Mars Exploration website (https://gmpbc.link/phd-ute-nasa-mars-exploration). If students are unfamiliar with NASA, explain that NASA is the US government agency that explores space.

Language Support
Students will encounter the term *rover* throughout the module. Consider discussing other meanings of *rover*, such as a person who spends their time wandering, and how the term is used in space exploration.

1 Sidebar Teacher Notes are used throughout the curriculum to provide teachers with guidance related to science content knowledge, pedagogy, progression of student learning, and usage of anchor visuals throughout the module.

2 Videos are used strategically throughout the curriculum as a way for students to access and understand complex phenomena and concepts.

LEARN 40 to 55 minutes

Read About Curiosity's Mission | 20 to 25 minutes

Students use a text to gather information about Curiosity's complex mission to Mars. They learn why the National Aeronautics and Space Administration (NASA) sent Curiosity to Mars and begin to ask questions about the anchor phenomenon: Curiosity's journey from Earth to Mars.

4. **Introduce a text about Curiosity, and have students identify the purpose and significance of Curiosity's mission.** 1

   Introduce *Curiosity: The Story of a Mars Rover* by Markus Motum (2017). Tell students they will now hear a reading from *Curiosity* and that they should listen for information about why Curiosity was sent to Mars. Then read aloud pages 3 through 19. After reading, ask students the following questions.

   Why was Curiosity sent to Mars?

   What made Curiosity's mission different from previous missions to Mars?

   Listen for *responses that mention the following ideas:*

   - *Curiosity looked for evidence of ancient life on Mars.*
   - *Curiosity observed the weather and surface of the planet.*
   - *Curiosity was larger and more advanced than previous rovers.*

   Summarize that at the time Curiosity's mission began, it was the largest, most advanced rover ever sent by NASA to Mars to collect data and make observations.

5. **Show students teams of NASA employees who work on Mars rover missions, and have students reflect on the large, diverse team structure.**

   Invite students to consider the team of people who worked on the complex Curiosity mission.

   What do you wonder about the number of people needed to send this advanced rover to Mars?

   What kinds of jobs do you think these people have?

Language Support
After reading an important, unfamiliar word that students cannot define through context or morphological clues, pause to provide a familiar synonym or to define the word and use it in an example sentence. Then reread the sentence containing the word, and continue reading the text aloud. Appendix C identifies terms from *Curiosity* that may be unfamiliar to students.

Teacher Note
Curiosity does not have page numbers. Consider writing small page numbers in the text or using sticky tabs to mark pages where readings begin. For example, the reading in this lesson starts on page 3, which begins, "Wherever you are in the world …."

Extension 2
Students can learn more about the Mars Science Laboratory mission that sent Curiosity to Mars by viewing NASA's Mars Curiosity Rover web page (https://gmpbc.link/phd-ute-nasa-curiosity-rover).

1. Some modules include one or more core texts that students interact with to support their learning. Core texts are used throughout the program to introduce scientific information or to help frame students' thinking about science concepts and phenomena. The *Teach* book also provides strategies for teachers to make the core text accessible to all students.

   The PhD Science Book is a custom, authentic informational text for students that is used as the core text throughout all modules in Level 6.

2. Extension notes describe natural and grade level–appropriate activities that extend the lesson's learning for some or all students. Extension activities are always new activities that extend beyond the time allotted for the lesson. They may be activities that students perform or that teachers demonstrate.

Tell students they will watch a video to learn more about the NASA employees who send rovers to Mars. Explain that the video shows employees who worked on a more recent Mars rover, Perseverance. Play the behind the spacecraft video (https://gmpbc.link/phd-ute-behind-the-spacecraft). Then display the meet the people web page on NASA's website (https://gmpbc.link/phd-ute-nasa-meet-the-people), and explore the short biographies as a class.

As a class, discuss the following questions.

How are the NASA team members similar? How are they different?

What do you notice about their jobs?

Why do you think large teams of people are needed for rover missions?

Listen for *responses related to the following ideas:*

- *A diverse team of scientists and engineers work together on a rover mission.*
- *Large teams are needed for rover missions because of the complexity of the missions.*

Reveal that thousands of people from diverse backgrounds and with a variety of skills work together on complex Mars rover missions. Reread page 15 of *Curiosity*, and point out that despite detailed planning by large teams of skilled people, before Curiosity's launch, half of humanity's missions to Mars had ended in failure. Have students Think–Pair–Share in response to the following prompts to elicit questions about Curiosity's successful journey from Earth to Mars.

2 **Differentiation: Support**

Consider using strategic, flexible grouping throughout the module.

- Pair students who have different levels of proficiency with the three dimensions.
- Pair students who have different levels of English language proficiency.
- Join pairs to form small groups of four.
- As applicable, complement any of these groupings by pairing students who speak the same native language.

What might make a rover's journey from Earth to Mars difficult?

What questions do you have about Curiosity's journey from Earth to Mars?

Spotlight on Nature of Science 1

In this activity, students develop an understanding of the following NGSS Nature of Science element:

Science Is a Human Endeavor

- Men and women from different social, cultural, and ethnic backgrounds work as scientists and engineers.

Teacher Note

Think–Pair–Share is a collaborative conversation routine in which students think about a question or prompt and then discuss their ideas with a partner before sharing a response with the class. This routine gives students time to consider their response before sharing. For more information, see the Instructional Routines section of the Implementation Guide.

1 Spotlight Notes explain how a lesson activity relates to one or more specific Disciplinary Core Ideas; Science and Engineering Practices; Crosscutting Concepts; Nature of Science; and/or Engineering, Technology, and Applications of Science elements. These notes can also include educative information about instructional supports related to the identified elements.

2 In-line and sidebar Differentiation notes are included throughout *PhD Science*. These notes provide teachers with strategies to support students as they engage with lesson content and work to meet lesson learning objectives. Differentiation notes provide examples of how teachers may scaffold instruction to support specific learning needs.

Acknowledge students' questions, and then inform students that they will explore Curiosity's journey from Earth to Mars throughout the module. Suggest that students continue reading *Curiosity* to learn more about Curiosity's journey to Mars.

Read About Curiosity's Journey to Mars | 10 to 15 minutes

Students use the text to identify the many details of the NASA team's plan to get Curiosity from Earth to Mars. This activity prepares students to develop questions about Curiosity's launch, travel through space, and landing, which they can then use to build a Driving Question board.

6. Read *Curiosity*'s remaining pages, and have students identify the detailed planning required to get Curiosity to Mars.

LESSON 1 ACTIVITY GUIDE

Tell students they will now hear another reading from *Curiosity* and that as they listen, they should record in their Science Logbook details of the NASA team's plan to get Curiosity from Earth to Mars successfully. Then read aloud pages 20 through 47 of *Curiosity*, pausing often to give students the opportunity to record information.

After reading, invite students to share some of the details they recorded. Capture student responses on a class chart.

***Responses may** vary. Listen for responses that include details about the following stages of Curiosity's journey.*

- *Curiosity's launch from Earth into space*
- *Curiosity's travel through space to Mars*
- *Curiosity's landing on Mars*

1 If students do not provide details for all three stages of Curiosity's journey from Earth to Mars, reread pages 22–23 for information about Curiosity's launch, pages 8–9 and 24–25 for information about Curiosity's travel through space, and pages 34–35 for information about Curiosity's landing.

Confirm that the NASA team had to make many plans for Curiosity to successfully launch, travel through space, and land on Mars.

Teacher Note
Pages 30–31 and 34–35 contain many detailed captions. Consider reading only the larger text on pages 30, 34, and 35 in addition to the text on page 31.

1 The Look/Listen for Checkpoint indicates a critical moment of student sense-making in the module. The checkpoint tells teachers that they should not transition to the next activity in the lesson until they can identify evidence of student understanding.

10. Discuss the subsystems that made up Curiosity's journey from Earth to Mars.

Point out that Curiosity's journey from Earth to Mars was a large and complex system. Remind students that systems are made up of many interacting parts. Tell students that some complex systems, such as Curiosity's journey, are made up of smaller systems, or subsystems. Identify the three categories on the Driving Question board (launch, travel through space, and landing) as subsystems of Curiosity's journey from Earth to Mars.

Invite students to ask additional questions about subsystems of Curiosity's journey they have not yet considered. Record these questions on sticky notes and add them to the Driving Question board.

11. Develop the Driving Question and have students record this question in the Knowledge Tracker in their Science Logbook.

Point out that students can't yet explain how Curiosity moved from Earth to Mars and how NASA made plans for its motion. Identify this gap in student understanding, and introduce the Driving Question: **How did Curiosity get from Earth to Mars successfully?** Ask students to record the Driving Question in the first section of their Knowledge Tracker. Write the Driving Question at the top of the Driving Question board.

1

Language Support

Students will encounter the terms *system* and *subsystem* throughout the module. Providing the Spanish cognate for *system* (*sistema*) may be helpful. If needed, provide students with examples of familiar systems made up of subsystems, such as a school (system) made up of classrooms (subsystems).

Teacher Note

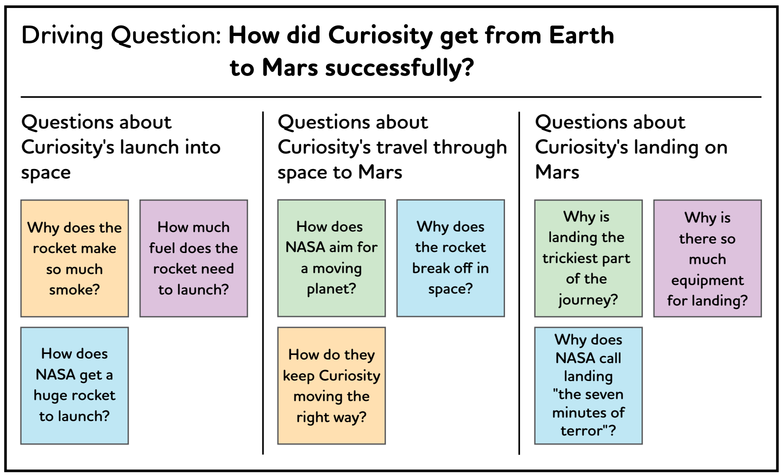
Students update their Knowledge Tracker in every lesson to record what they figure out in the lesson and how that new understanding may help them answer the Driving Question. This process makes visible for students how the activities they engage in allow them to better understand the anchor phenomenon.

1 Language Supports can be found throughout the modules. In-line and sidebar Language Supports provide guidance for teachers, including Spanish cognates and best practices for supporting English language development.

12. Post the Driving Question board in a visible location.

Students will update and revisit the Driving Question board throughout the module. Allow space to post sample student work along the way.

Sample Driving Question board: (1)



Language Support

Use students' own words when recording questions and related phenomena on the Driving Question board and when adding labels and explanations to the anchor model. Student language on anchor visuals may include everyday language and students' home language. As students learn new terminology throughout the module, consider updating student language on the anchor visuals to identify connections between new terminology and concepts students previously described.

(1) The Driving Question board allows students to capture and organize their questions about the anchor phenomenon and related phenomena. These questions help drive students' explorations throughout a module.

1 **Check for Understanding**

Ask questions that arise from careful observation of a phenomenon (SEP.1) involving **an object's changing motion (PS2.A)** within **subsystems of a larger system (CC.4)**.

EVIDENCE	NEXT STEPS
Listen for indications of the following in students' questions: • Questions seek additional information (SEP.1) about Curiosity's launch, travel, and landing (CC.4). • Questions seek additional information (SEP.1) about the causes of changes in Curiosity's motion throughout its journey from Earth to Mars (PS2.A).	If students need support to generate questions, elicit student questions about Curiosity's motion during each part of its journey with prompts such as the following: • What questions do you have about how Curiosity moved from Earth and into space? • What questions do you have about how Curiosity traveled through space? • What questions do you have about how Curiosity landed on Mars?

Tell students that they will continue to explore and ask questions about Curiosity's journey from Earth to Mars in the next lesson part.

1 Checks for Understanding are formative assessments that occur throughout modules and provide teachers with the opportunity to monitor students' learning. They include evidence statements to help teachers gauge students' understanding as well as next steps to monitor students' progress towards lesson objectives and provide teachers with direction for clear support on needed remediation.

LEARN 30 to 40 minutes

Develop Initial Models | 15 to 20 minutes

Students develop initial models to show how they think Curiosity got from Earth to Mars successfully. Initial models of anchor phenomena allow students to communicate their initial ideas and identify gaps in their knowledge and also provide teachers insight into student ideas.

1

1. **Support students as they create initial models in the Knowledge Tracker in their Science Logbook to begin answering the Driving Question.**

   Explain to students that developing models is one way to explore a phenomenon, such as Curiosity's journey from Earth to Mars. Explain that students will develop an initial model in the Anchor Model section of their Knowledge Tracker to begin answering the Driving Question: **How did Curiosity get from Earth to Mars successfully?** Explain that student models should show Curiosity's motion during its journey, as well as what might have caused changes to Curiosity's motion. Instruct students to include labels, arrows, or other details to explain their thinking.

   As students work independently, circulate to ask probing questions, such as those that follow, that challenge students to consider more deeply their initial ideas about the anchor phenomenon.

   - **How did Curiosity move during each part of its journey?**
   - **What caused Curiosity's motion during launch? During its travel through space? During its landing?**
   - **How can you show the causes of Curiosity's motion in your model?**

Performance Descriptor

Develop a model to describe (SEP.2) and explain **the changing motion of an object (PS2.A)** within **subsystems of a larger system (CC.4)**.

Agenda | 40 to 55 minutes

LEARN | 30 to 40 minutes

- Develop Initial Models (15 to 20 minutes)
- Develop Anchor Model (15 to 20 minutes)

LAND | 10 to 15 minutes

Differentiation: Support

If students need support with modeling, explain that models use images and words to explain an event or process that people can observe. Further explain that models show both what people can see and cannot see. Suggest that students begin by using arrows to show how Curiosity moved during each part of its journey.

1 Students record each lesson's Phenomenon Question in their Knowledge Tracker. This practice supports students in recognizing and making connections between the lesson-level phenomena they explore throughout the module. At natural points in each lesson, students reflect on what they have learned and how that information may help them answer the Driving Question.

Pre-Assessment

Develop a model to describe (SEP.2) and explain **the changing motion of an object (PS2.A)** within **subsystems of a larger system (CC.4)**.

EVIDENCE	NEXT STEPS
Look for the following in students' models: • Models show Curiosity's motion during its launch, travel, and landing (CC.4). • Models show forces to explain (SEP.2) changes in Curiosity's motion (PS2.A).	At this point, students do not need to draw accurate models to explain Curiosity's motion. Note whether students depict prior knowledge of net force, gravity, or acceleration, as well as how they represent these unobservable mechanisms in their models. Future lessons will introduce and revisit these concepts.

2. **Give students time to compare the** 1 **ial models in the Knowledge Tracker in their Science Logbook.**

   Have students participate in a Gallery Walk instructional routine to compare their model of Curiosity's journey from Earth to Mars with their classmates' models. Encourage students to look for similarities and differences between the models and to add more details to their own model.

Develop Anchor Model | 15 to 20 minutes

Students use ideas from comparing their initial models to inform the development of the anchor model. The anchor model will serve as an artifact of student understanding and will be used throughout the module as students reflect on and update their explanation of the anchor phenomenon

3. **Develop the class anchor model.**

   Explain that the first step in finding the answer to the Driving Question is to create an anchor model. Work together to develop an anchor model that begins to answer the Driving Question: **How did Curiosity get from Earth to Mars successfully?** Invite students to share important details they think the anchor model should include. As students share, ask the rest of the class to use nonverbal signals

Teacher Note

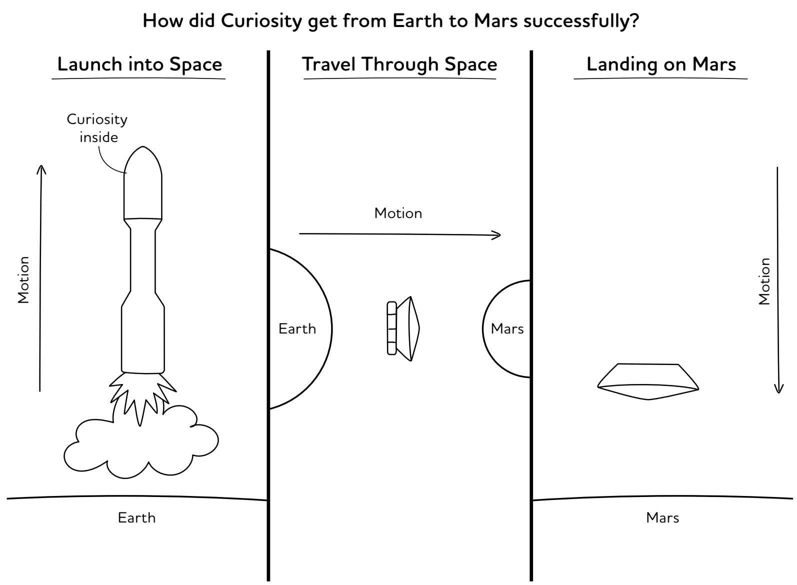
A Gallery Walk is a written response routine that deepens student engagement and understanding. Students display their work around the room or at workstations and then circulate to view, discuss, and record observations about one another's work.

1 Gallery Walk is a common instructional routine found throughout *PhD Science*. An instructional routine is a classroom procedure that supports the development of content knowledge and academic skills in an engaging and active way. Notes in the Teacher Edition introduce new instructional routines and establish guidelines for students. The routines suggested help students think about science in different ways to build content knowledge, deepen understanding, and develop critical-thinking skills. The Implementation Guide has more information about the instructional routines used in *PhD Science*.

to indicate whether they agree that each new detail helps answer the Driving Question.

Record students' ideas about what caused Curiosity's motion on sticky notes and add them to the anchor model. Explain that students will add the causes of Curiosity's motion to the anchor model after they gather evidence of Curiosity's motion in future lessons.

Sample anchor model: 1



Curiosity's journey from Earth to Mars had three parts: its launch from Earth into space, its travel through space to Mars, and its landing on the surface of Mars.

Teacher Note

Later in the module, students may notice that Curiosity followed a curved trajectory through space instead of the straight path depicted in the anchor model.

Curiosity's trajectory was curved because of the Sun's gravitational force. In Level 7, students learn more about the gravitational forces that occur between celestial bodies. At this level, students do not need to explain or accurately depict Curiosity's curved path through space.

1 The anchor model is a visual representation of students' explanation of the anchor phenomenon. This explanation grows and changes throughout a module as students apply new learning. Building this explanation and reflecting on unexplained processes or events reinforces the motivation for students' explorations.

The *Teach* book includes sample anchor models that are intended for guidance, not exact replication.

1 **HW Suggested Homework**

Point out that there are many more examples of related phenomena than the ones students listed on the Driving Question board. Tell students to identify and record additional examples of moving objects they notice outside of school. Students may identify examples from direct observations or from media sources such as books, online resources, or television.

1 Suggested Homework provides optional opportunities for applying and extending science learning outside of school or in their communities.