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# Mathematics Readers—Level 6

## This sample includes the following:

**Teacher's Guide Cover** (1 page)
**Table of Contents** (2 pages)
**How to Use This Product** (5 pages)
**Lesson Plan** (11 pages)
**Reader** (17 pages)

To Create a World in which Children Love to Learn!

Grade 6

Teacher Created Materials PUBLISHING

# MATHEMATICS READERS

# Teacher's Guide

# Table of Contents

## Introduction



## Unit 1: Number and Operations



## Unit 2: Ratio and Proportion



## Unit 3: Rational Numbers



## Unit 4: Expressions and Equations

## Unit 5: Geometry, Measurement, and Data



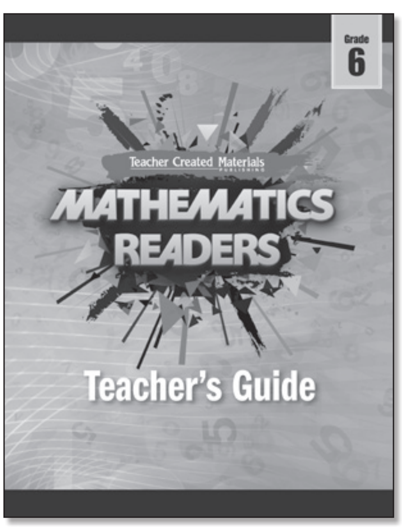
## Appendix

# How to Use This Product

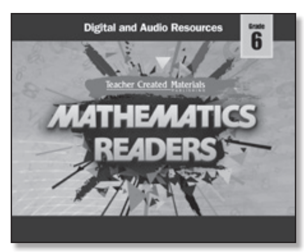
## Kit Components

### 6 copies of 20 books


### Teacher's Guide



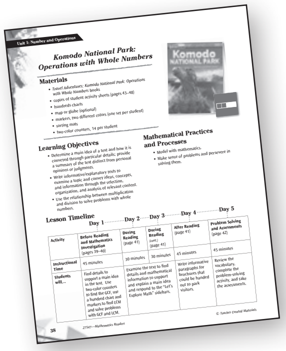

### Digital and Audio Resources




# How to Use This Product *(cont.)*

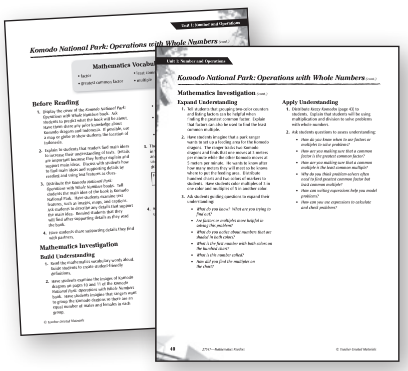
## Teacher's Guide

Each five-day lesson sequence is organized in a consistent format for ease of use.



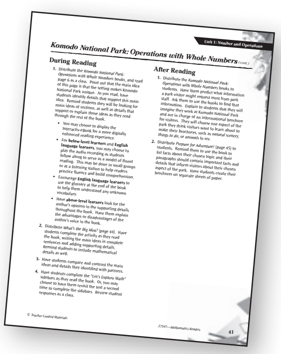
### Overview

- The overview page includes learning objectives, a materials list, and a suggested timeline for each lesson.



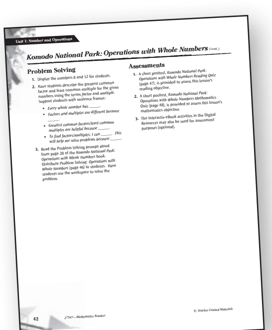
### Day 1

- Students are introduced to the book and the math concept or skill.
- Students build, expand, and apply understanding of the math skill with concrete, representational, and abstract activities.



### Days 2, 3, and 4

- Students complete reading and writing activities, as well as the "Let's Explore Math" sidebars.



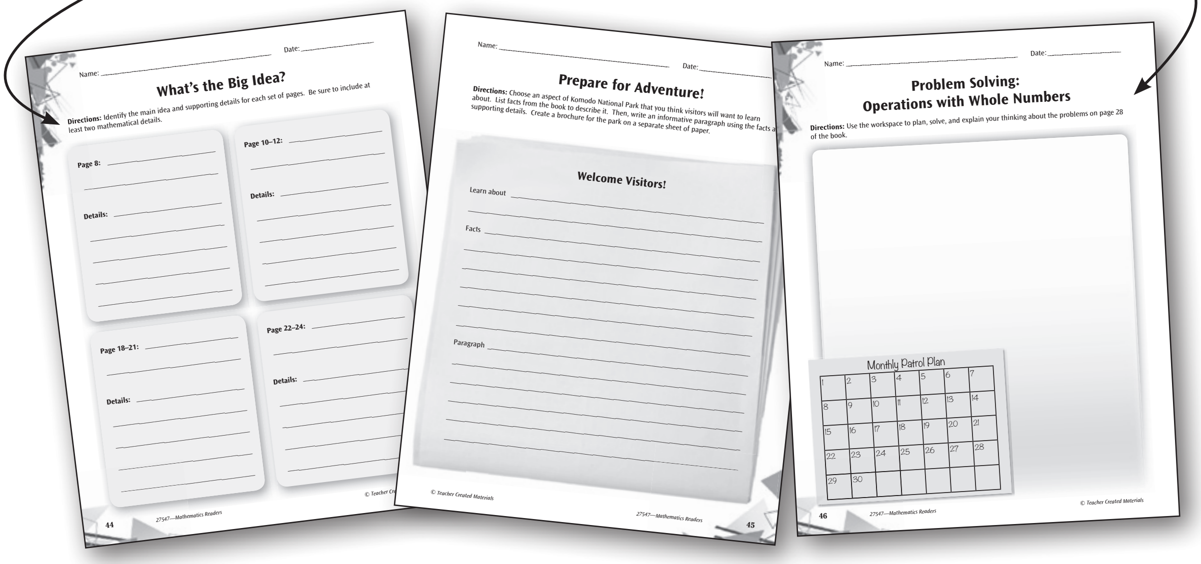
### Day 5

- Students take what they've learned and apply it in context in the Problem-Solving activity.
- Students take the reading and mathematics assessments.

# How to Use This Product *(cont.)*

## Student Activity Sheets and Assessments

clear directions and activities that promote higher-order thinking skills



Name: Date:

What's the Big Idea?

Directions: Identify the main idea and supporting details for each set of pages. Be sure to include at least two mathematical details.

Page 8: Details:

Page 10–12: Details:

Page 18–21: Details:

Page 22–24: Details:

Name: Date:

Prepare for Adventure!

Directions: Choose an aspect of Komodo National Park that you think visitors will want to learn about. List facts from the book to describe it. Then, write an informative paragraph using the facts and supporting details. Create a brochure for the park on a separate sheet of paper.

Welcome Visitors!

Learn about

Facts

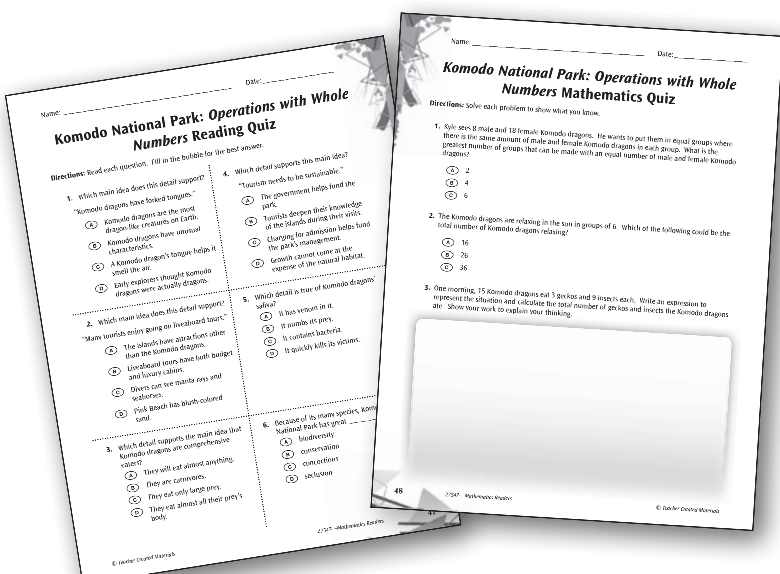
Paragraph

Name: Date:

Problem Solving: Operations with Whole Numbers

Directions: Use the workspace to plan, solve, and explain your thinking about the problems on page 28 of the book.

reading and math quizzes with text-dependent questions



Name: Date:

Komodo National Park: *Operations with Whole Numbers* Reading Quiz

Directions: Read each question. Fill in the bubble for the best answer.

1. Which main idea does this detail support? "Komodo dragons have forked tongues."
   - A Komodo dragons are the most dragon-like creatures on Earth.
   - B Komodo dragons have unusual characteristics.
   - C A Komodo dragon's tongue helps it smell the air.
   - D Early explorers thought Komodo dragons were actually dragons.
2. Which main idea does this detail support? "Many tourists enjoy going on liveaboard tours."
   - A The islands have attractions other than the Komodo dragons.
   - B Liveaboard tours have both budget and luxury cabins.
   - C Divers can see manta rays and seahorses.
   - D Pink Beach has blush-colored sand.
3. Which detail supports the main idea that Komodo dragons are comprehensive eaters?
   - A They will eat almost anything.
   - B They are carnivores.
   - C They eat only large prey.
   - D They eat almost all their prey's body.
4. Which detail supports this main idea? "Tourism needs to be sustainable."
   - A The government helps fund the park.
   - B Tourists deepen their knowledge of the islands during their visits.
   - C Charging for admission helps fund the park's management.
   - D Growth cannot come at the expense of the natural habitat.
5. Which detail is true of Komodo dragons' saliva?
   - A It has venom in it.
   - B It numbs its prey.
   - C It contains bacteria.
   - D It quickly kills its victims.
6. Because of its many species, Komodo National Park has great
   - A biodiversity
   - B conservation
   - C concoctions
   - D seclusion

Name: Date:

Komodo National Park: *Operations with Whole Numbers* Mathematics Quiz

Directions: Solve each problem to show what you know.

1. Kyle sees 8 male and 18 female Komodo dragons. He wants to put them in equal groups where there is the same amount of male and female Komodo dragons in each group. What is the greatest number of groups that can be made with an equal number of male and female Komodo dragons?
   - A 2
   - B 4
   - C 6
2. The Komodo dragons are relaxing in the sun in groups of 6. Which of the following could be the total number of Komodo dragons relaxing?
   - A 16
   - B 26
   - C 36
3. One morning, 15 Komodo dragons eat 3 geckos and 9 insects each. Write an expression to represent the situation and calculate the total number of geckos and insects the Komodo dragons ate. Show your work to explain your thinking.

# How to Use This Product *(cont.)*

## Pacing and Instructional Setting Options

The following pacing and instructional setting options show suggestions for how to use this product. *Mathematics Readers* is flexibly designed and can be used in tandem with a core curriculum within a mathematics block, literacy block, or both. Teachers should customize pacing according to student need (instruction may need to be extended over more days) and the teacher's preferred instructional frameworks, such as Guided Math or Guided Reading. This suggestion reflects one lesson per book for each of the 20 books. Each lesson spans 5 instructional days and requires 30–45 minutes, for a total of approximately 65 hours over the course of 100 days.

| **Day** | **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|---|
| **Activity** | Before Reading and Mathematics Investigation | During Reading | During Reading *(cont.)* | After Reading | Problem Solving and Assessments |
| **Instructional Time** | 45 minutes | 30 minutes | 30 minutes | 45 minutes | 45 minutes |

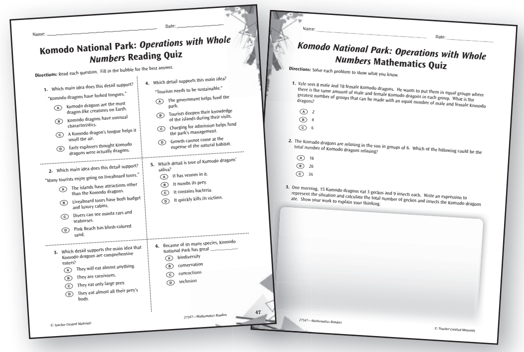
| ***Mathematics Readers* within the Guided Math and Balanced Literacy Frameworks** |
|---|
| **Classroom Environment of Numeracy and Literacy**—The books in *Mathematics Readers* contribute to an environment of numeracy and literacy by immersing students in real-world connections to mathematics and by giving students the opportunity to learn outside of content-area silos. |
| **Whole-Class Instruction**—The Before Reading activity in each *Mathematics Readers* lesson is a great opportunity to activate students' prior knowledge and capture their interest in a topic. |
| **Small-Group Instruction**—The lessons in *Mathematics Readers* offer flexibility that allows students to complete Before Reading, Mathematics Investigation, During Reading, and After Reading activities in small groups or any other preferred instructional setting, depending on student need. These activities have differentiation suggestions and targeted objectives and give students time to work with manipulatives and models. |
| **Workshop**—The During Reading, After Reading, and Problem-Solving activities in each *Mathematics Readers* lesson can be completed during Math or Reading Workshop, in centers or at workstations, depending on students' previous learning experiences and their need for teacher support. |
| **Conferencing**—The Problem-Solving activity and assessments in each *Mathematics Readers* lesson offer multiple opportunities for teachers and students to confer about concepts and ideas. |
| **Assessment**—*Mathematics Readers* offers multiple formative and summative assessment opportunities. Teachers can gain insight into student learning through reading and mathematics quizzes, small-group observations, analysis of written assignments, and a culminating activity. |

# How to Use This Product *(cont.)*

## Assessment

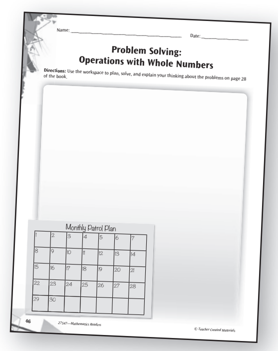
*Mathematics Readers* offers multiple assessment opportunities. You can gain insight into student learning through reading and mathematics quizzes, small-group observations, analysis of written assignments, and a culminating activity. These formal and informal assessments provide you with the data needed to make informed decisions about what to teach and how to teach it. This is the best way for you to know who is struggling with various concepts and how to address difficulties that students are experiencing with the curriculum.

**Mathematics and Reading quizzes**—At the end of each lesson in this Teacher's Guide are two quizzes—one to assess the reading objective and one to assess the mathematics objective. These short assessments include text-dependent questions and may be used as open-book evaluations.




Mathematics and Reading Quizzes

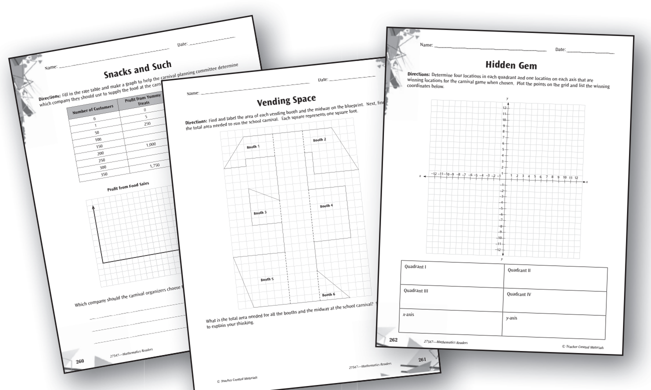
**Problem-Solving activity**—Each lesson includes a multistep problem-solving activity that can be used to assess understanding of the mathematical concepts or skills.




Problem-Solving Activity

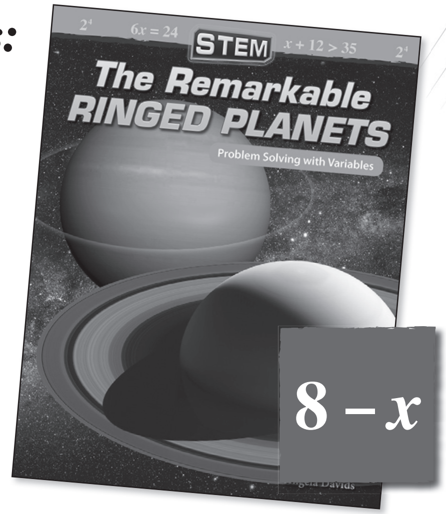
**Culminating activity**—The culminating activity asks students to apply what they have learned throughout the units in an engaging and interactive way. Students use what they have learned to create new ideas in a real-life context.

**Progress monitoring**—There are several points throughout each lesson when useful evaluations can be made. These evaluations can be made based on group, paired, and individual discussions and activities.




Culminating Activity

# *STEM: The Remarkable Ringed Planets: Problem Solving with Variables*




## Materials

- *STEM: The Remarkable Ringed Planets: Problem Solving with Variables* books
- copies of student activity sheets (pages 164–169)
- notecards, 18 per student
- plastic cups, 4 per student

## Learning Objectives

- Trace and evaluate the argument and specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not.
- Write arguments to support claims with clear reasons and relevant evidence.
- Solve problems with variables by writing expressions, equations, and inequalities representing real-world contexts.

## Mathematical Practices and Processes

- Model with mathematics.
- Make sense of problems and persevere in solving them.

## Lesson Timeline

| | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 |
|---|---|---|---|---|---|
| **Activity** | **Before Reading and Mathematics Investigation** (pages 160–161) | **During Reading** (page 162) | **During Reading** *(cont.)* (page 162) | **After Reading** (page 162) | **Problem Solving and Assessments** (page 163) |
| **Instructional Time** | 45 minutes | 30 minutes | 30 minutes | 45 minutes | 45 minutes |
| **Students will…** | Find and evaluate claims made in everyday life. Use cups, notecards, and bar models to represent, write, and solve equations and inequalities. | Identify claims made in the book, find supporting details, and respond to the "Let's Explore Math" sidebars. | | Defend opinions by writing a persuasive paragraph. | Review the vocabulary, complete the problem-solving activity, and take the assessments. |

# *The Remarkable Ringed Planets: Problem Solving with Variables* (cont.)

## Mathematics Vocabulary

- equation
- inequality
- variable

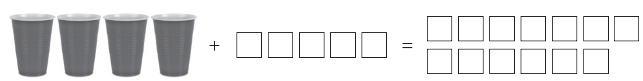
## Before Reading

1. Quickly review the word *claim*. Choose a cleaning product (bathroom, kitchen, glass, floor, etc.). Ask students to think of claims made by the advertisements for this cleaning product and write them on the board.
2. Using the list, have students brainstorm how consumers could find evidence to support or refute these claims.
3. Explain that authors also make claims in texts, and these claims need support or evidence. Encourage students to share why support is needed and what might be the result if an author's claim offers no evidence.
4. Distribute *The Remarkable Ringed Planets: Problem Solving with Variables* books to students, and have them quickly preview the text. Read the summary on the back together, and have students look for claims the author makes. Ask students questions, such as: *Where will the evidence be found? Can all these claims be proven? Which can/cannot?*

## Mathematics Investigation

### Build Understanding

1. Read the mathematics vocabulary words aloud. Guide students to create student-friendly definitions.
2. Have students examine the images of Saturn's rings on pages 12–13 of *The Remarkable Ringed Planets: Problem Solving with Variables* book. Tell students that four spacecraft have orbited Saturn. Write an expression to show that each spacecraft took the same number of photographs.
   - *If you do not know the number of photographs, what do you use in the expression?*
   - *What operation will be performed in your expression?*
   - *How do you write an expression?*
3. Have students imagine they are researching photos taken from space. Explain that four students each find the same number of photos. The teacher gives the group 5 additional photos. There are now a total of 13 photos. Distribute plastic cups to represent the number of spacecraft ($x$) and notecards to represent the number of photos. Have students create the equation. Have students solve the equation using the cups and notecards.



   - Have **above-level learners** write an equation to represent the cups and notecards and include steps used to solve the problem.
   - Ensure that **English language learners** know that each cup represents the number of spacecraft ($x$) and each notecard represents 1 photograph.
4. Ask students guiding questions to build understanding:
   - *How many cups do you need?*
   - *What strategy did you use to solve the equation?*
   - *Is there only one way to solve the equation? How do you know?*
   - *How many photographs did each student find? How do you know?*

# *The Remarkable Ringed Planets: Problem Solving with Variables* *(cont.)*

## Mathematics Investigation *(cont.)*

### Expand Understanding

1. Tell students that using cups and notecards is one method of representing and solving equations. Symbols and numbers can also be used to represent a given situation.
2. Display the bar model for students. Explain that the diameter of Jupiter is about 11 times that of Earth's. Have students use the bar model to write an equation using *E* for the diameter of Earth and *J* for the diameter of Jupiter. Next, have students calculate the diameter of Jupiter if the diameter of Earth is about 7,900 miles.

| *J* | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *E* | *E* | *E* | *E* | *E* | *E* | *E* | *E* | *E* | *E* | *E* |

3. Ask students guiding questions to expand their understanding:
   - *What do you know? What are you trying to find?*
   - *How does the bar model help you solve the problem?*
   - *What equation did you write?*
   - *What operation did you include in your equation? How do you know it is the correct operation?*

### Apply Understanding

1. Distribute *Project Projections* (page 164) to students. Explain that students will write equations and inequalities to represent real-world situations and use them to solve problems using different strategies.
2. Ask students questions to assess understanding:
   - *How do you write an equation? What must you include?*
   - *What strategy do you use to solve equations?*
   - *How do you write an inequality? What must you include?*
   - *How do you graph an inequality on a number line?*
   - *What is the difference between an equation and an inequality?*

# *The Remarkable Ringed Planets: Problem Solving with Variables* (cont.)

## During Reading

1. Distribute *The Remarkable Ringed Planets: Problem Solving with Variables* books and *Claims and Evidence* (page 165) to students. Make sure students understand the directions and have them turn to page 4. Read the page together, and have students find a claim the author made (e.g., People have always been interested in the skies.). Encourage them to share their ideas, and have them each choose one to write on their activity sheets. Then, have students find evidence that supports the claim independently.
2. Allow students time to read the book and complete the activity.
    - You may choose to display the Interactiv-eBook for a more digitally enhanced reading experience.
    - For **below-level learners** and **English language learners**, you may choose to play the audio recording as students follow along to serve as a model of fluent reading. This may be done in small groups or at a listening station to help readers practice fluency and build comprehension.
    - To activate prior knowledge, have **below-level learners** make a list of things they know about planets and space. Have them share their lists with partners.
    - Challenge **above-level learners** to find out more about a topic from the book that is of particular interest to them (historical astronomers, planets, James Webb telescope, etc.)
3. Have students complete the "Let's Explore Math" sidebars as they read the book, or you may choose to have them revisit the text a second time to complete the sidebars. Review student responses as a class.

## After Reading

1. Distribute *The Remarkable Ringed Planets: Problem Solving with Variables* books to students. Have students turn to page 22 and discuss scientists' future plans for space exploration. Be sure students talk about the time, money, and resources needed for future missions, as well as the goals.
2. Distribute *Space Exploration: Yay or Nay?* (page 166) to students. Make sure students understand the prompt, discussing as necessary. Give them time to write their persuasive paragraphs.

# *The Remarkable Ringed Planets: Problem Solving with Variables* *(cont.)*

## Problem Solving

1. Explain to students that Mars has 2 times as many moons as Earth and that Uranus has at least 27 moons.
2. Have students describe how to represent these situations using the terms *equation*, *inequality*, and *variable*. Support students with sentence frames:
   - *A mathematical sentence with an equal sign is an ______.*
   - *A mathematical sentence with > or < is an ______.*
   - *If there is a missing value in an equation or inequality, one should use a ______. I know this because ______.*
3. Read the Problem Solving prompt aloud from page 28 of *The Remarkable Ringed Planets: Problem Solving with Variables* book. Distribute *Problem Solving: Variables* (page 167) to students. Have students use the workspace to solve the problem.

## Assessments

1. A short posttest, *The Remarkable Ringed Planets: Problem Solving with Variables Reading Quiz* (page 168), is provided to assess this lesson's reading objective.
2. A short posttest, *The Remarkable Ringed Planets: Problem Solving with Variables Mathematics Quiz* (page 169), is provided to assess this lesson's mathematics objective.
3. The Interactiv-eBook activities in the Digital Resources may also be used for assessment purposes (optional).

Name: ______________________________ Date: ______________

# Project Projections

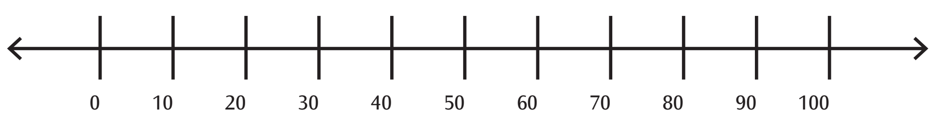
**Directions:** Sam is working on his science report. Help Sam write and solve equations and inequalities so he can finish his report.

1. Sam finds that the mass of Jupiter is 2.5 times the mass of all planets combined. Write an equation using *J* for Jupiter and *m* for mass of all planets.

2. Sam is making a scale model of the solar system. If he makes the mass of the other planets equal to 5 grams, what size should he make the mass of Jupiter? Use the equation you wrote in problem #1 to find the answer. Show your work to explain your thinking.

3. Saturn has more than 60 moons. Write an inequality using *m* for number of moons to represent the number of moons Saturn has.

4. Plot the number of Saturn's moons on the number line.




5. Sam learns that Neptune has 7 times as many moons as Mars. Write an equation using *n* for number of Neptune's moons and *m* for number of Mars moons.

6. Solve the equation from problem #5 if Mars has 2 moons. Show your work to explain your thinking.

Name: ____________________ Date: ____________

# Claims and Evidence

**Directions:** Write one claim the author makes in each of the text sections. Find evidence to support each claim.

1. pages 4–5

   **Claim:** ____________________

   **Evidence:** ____________________

2. pages 6–9

   **Claim:** ____________________

   **Evidence:** ____________________

3. pages 10–13

   **Claim:** ____________________

   **Evidence:** ____________________

4. pages 14–17

   **Claim:** ____________________

   **Evidence:** ____________________

5. pages 18–21

   **Claim:** ____________________

   **Evidence:** ____________________

6. pages 22–25

   **Claim:** ____________________

   **Evidence:** ____________________

Name: ______________________________ Date: ______________

# Space Exploration: Yay or Nay?

**Directions:** Space exploration requires a lot of time, resources, and money. Do you think space exploration should continue? Why or why not? Write a paragraph explaining and defending your opinion on the subject. Be sure to support your opinion using information from the book.

Name: ____________________ Date: ____________

# Problem Solving: Variables

**Directions:** Use the workspace to plan, solve, and explain your thinking about the problems on page 28 of the book.

### Giant Star

- There is a giant star in the middle of the new system.

### Distances

- Frank's planet is twice as far from the giant star as Dee's planet.
- The distance of Giovanna's planet from the giant star is represented by $g > f + d$.

### Sizes

- The radius of Dee's planet is represented by $d = f$.
- Giovanna's planet's radius is two times the radius of Dee's planet.

### Moons

- The number of moons that Dee and Giovanna's planets have are related by $d > g$.
- The number of moons that Frank's planet has is represented by $f = d + 2$.

Name: ____________________ Date: ____________

# *The Remarkable Ringed Planets: Problem Solving with Variables* Reading Quiz

**Directions:** Read each question. Fill in the bubble for the best answer.

**1.** Which statement is *not* evidence for the claim that people have always been interested in the sky?

- (A) Prehistoric carvings show the change of the moon.
- (B) Scientists have learned planets have differing numbers of moons.
- (C) Stars were used to help people travel across the seas.
- (D) People studied the stars and planets to know when to plant crops.

**2.** This statement from the text is evidence for which claim?

"Use the telescopes there to see stars, planets, and even the rings around the planets."

- (A) People at observatories can answer your questions.
- (B) Some astronomers make their own telescopes.
- (C) You can learn more about the solar system.
- (D) The universe is always expanding.

**3.** Which is evidence for the claim that Neptune's moon, Triton, is unusual?

- (A) It was discovered two weeks after Neptune.
- (B) It is similar in size to Pluto.
- (C) It may have been a large mass that was pulled in by Neptune's gravity.
- (D) It circles Neptune in the opposite direction that the planet rotates.

**4.** Which statement is *not* evidence for the claim that Jupiter is big?

- (A) Over 1,300 Earths could fit inside Jupiter.
- (B) Jupiter and Earth are almost 400 million miles apart.
- (C) Every planet in the solar system could fit inside Jupiter.
- (D) Jupiter's equator is 3.5 times longer than Earth's.

**5.** Which is evidence for the claim that scientists want to know more about the rings of Neptune and Uranus?

- (A) Scientists propose to fly a ship into Uranus's atmosphere to gather information.
- (B) Scientists do not know as much about these two planets.
- (C) Only the Voyager 2 mission has flown to the planets.
- (D) Studying planets helps people know why the solar system exists.

**6.** Saturn's rings might have formed when ____________ crashed into the moons.

- (A) galaxies
- (B) particles
- (C) asteroids
- (D) geysers

Name: ______________________________ Date: ________________

# *The Remarkable Ringed Planets: Problem Solving with Variables* Mathematics Quiz

**Directions:** Solve each problem to show what you know.

**1.** Mars ($m$) has 1 more moon than Earth ($e$). Which equation represents the situation?

(A) $m = e + 1$

(B) $m + e = 1$

(C) $m + 1 = e$

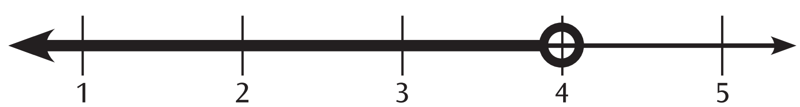
**2.** The diameter of the sun ($s$) is 109 times the diameter of Earth ($e$). Choose the equation that represents the diameter of the sun.

(A) $e = 109s$

(B) $e = 109 + s$

(C) $s = 109e$

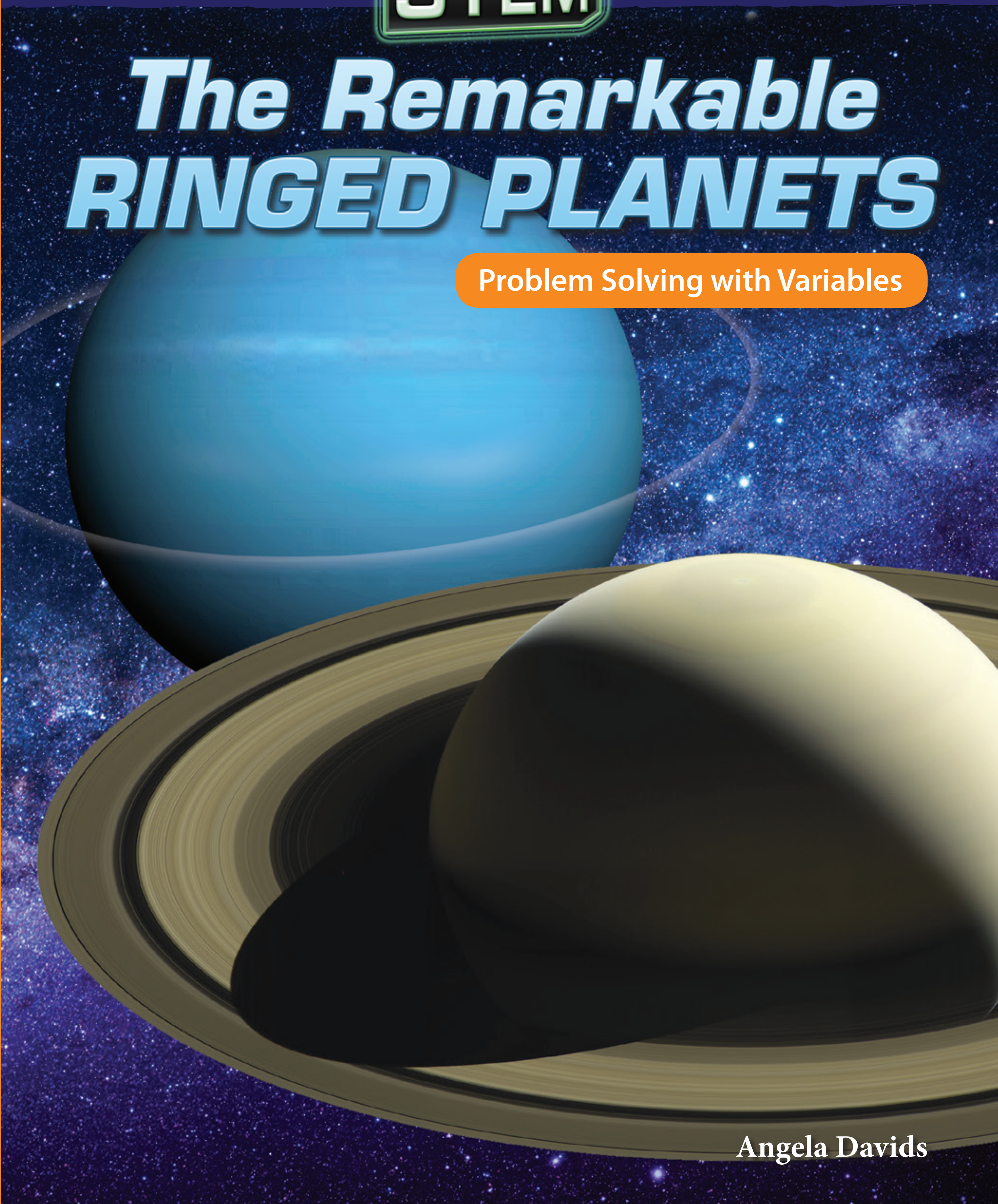
**3.** The number line represents the number of photos of Saturn that Heather can include in her science report. Write an inequality for the number line and find two values that make the inequality true. Explain your thinking.



$2^4$ $6x = 24$ STEM $x + 12 > 35$ $2^4$

# The Remarkable RINGED PLANETS

## Problem Solving with Variables



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# Table of Contents

# A Universe to Discover

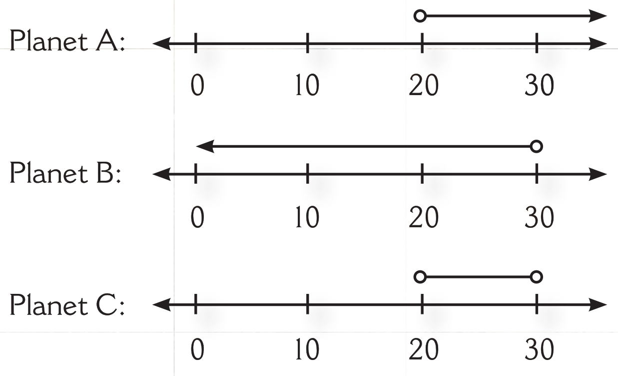
This ancient stone inscription shows the sun, the moon, and Venus.

Since prehistoric times, people have looked up and wondered what is beyond Earth. What is in the night sky? How does it affect people on Earth? The fascination began early. **Archaeologists** have found carvings in stones and bones that date as far back as 32,000 BC. These carvings show that ancient people tracked changes in the moon. Throughout history, people have studied the stars and the planets to know when to plant crops or when to travel to seek food. They used stars to navigate over land and across seas. Scientists still look beyond Earth to learn more about the universe. They have learned that while Earth has only one moon, some planets have none and some have over 50. One area some scientists are now studying is the rings of the planets.

When most people think of a planet with rings, they get a clear image of Saturn in their heads. Those rings were discovered by **astronomer** Galileo Galilei in 1610. Hans Lippershey of the Netherlands is credited with the invention of the telescope in 1608; however it was Galileo who made the invention—and Saturn—famous. But there are three other planets in our solar system with rings. Imagine the amazement of astronomers and **physicists** when they saw spacecraft photos that proved there were rings around other planets. The scientists were brimming with questions. How many rings do each of these planets have? What are the rings made of? How old are the rings? Scientists got to work to find out.

## LET'S EXPLORE MATH

Imagine that a scientist observes three planets through a telescope. She estimates the number of moons each planet has and records her findings on number lines.




1. Write two inequalities to represent the number of moons Planets A and B have. Use $m$ to stand for the number of moons.
2. What do you know about the number of moons Planet C has?

# Jupiter: Planet King

Jupiter is the largest planet in our solar system. Its name comes from the highest god in Roman mythology. It is easily recognized by its giant red spot. The spot is a windstorm of gases that swirl at 400 miles (644 kilometers) per hour. Astronomers first saw that famous spot by telescope in the 1600s. It took almost four hundred more years for scientists to discover Jupiter's rings. Finally, in 1979, the *Voyager 1* spacecraft was sent into space by the National Aeronautics and Space Administration (NASA). Photos from that trip showed scientists Jupiter's rings for the first time.

## How Big Is Big?

Jupiter is massive! All the planets in our solar system can fit inside of it at one time. Jupiter is like a huge gumball machine that can hold more than 1,300 Earths. It measures almost 273,000 mi. (440,000 km) around at its **equator**. In comparison, Earth is 24,900 mi. (40,073 km) around. That means someone would have to travel around Earth more than 10 times to equal the distance of traveling around Jupiter once.

Jupiter is the fifth farthest planet from the sun. It is about five times farther from the sun than Earth is. As Jupiter and Earth travel around the sun, they move closer and farther away from one another. Earth and Jupiter are almost 400 million mi. (644 million km) apart when they are at their closest point during **orbit**.

### LET'S EXPLORE MATH

Jupiter has the shortest day in the solar system. One day, defined as the time it takes for Jupiter to **rotate** once, is only about 10 hours. Choose all the expressions that represent the number of hours that pass on Jupiter when *d* days have passed.

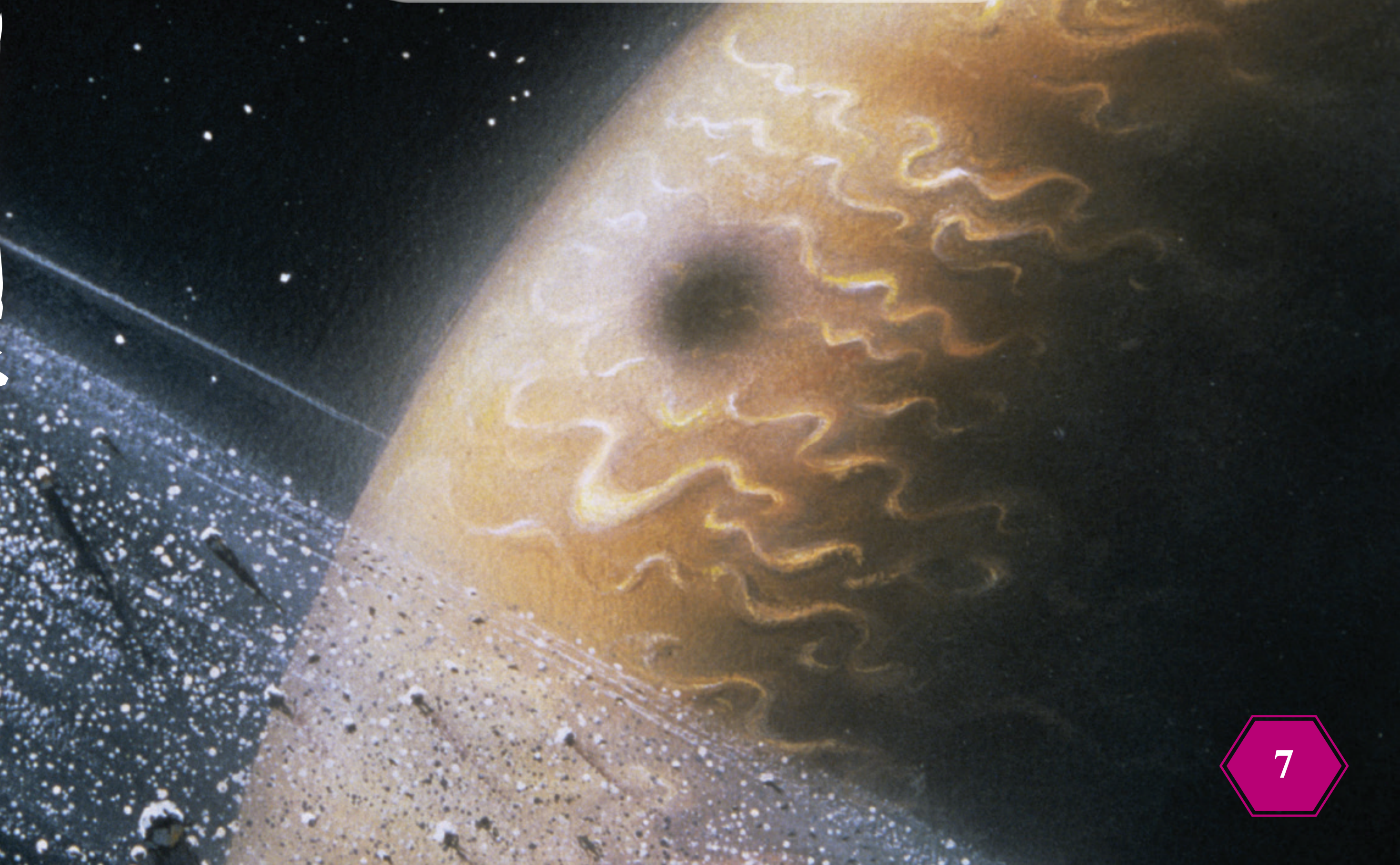
**A.** $10d$

**B.** $24d$

**C.** $\frac{d}{10}$

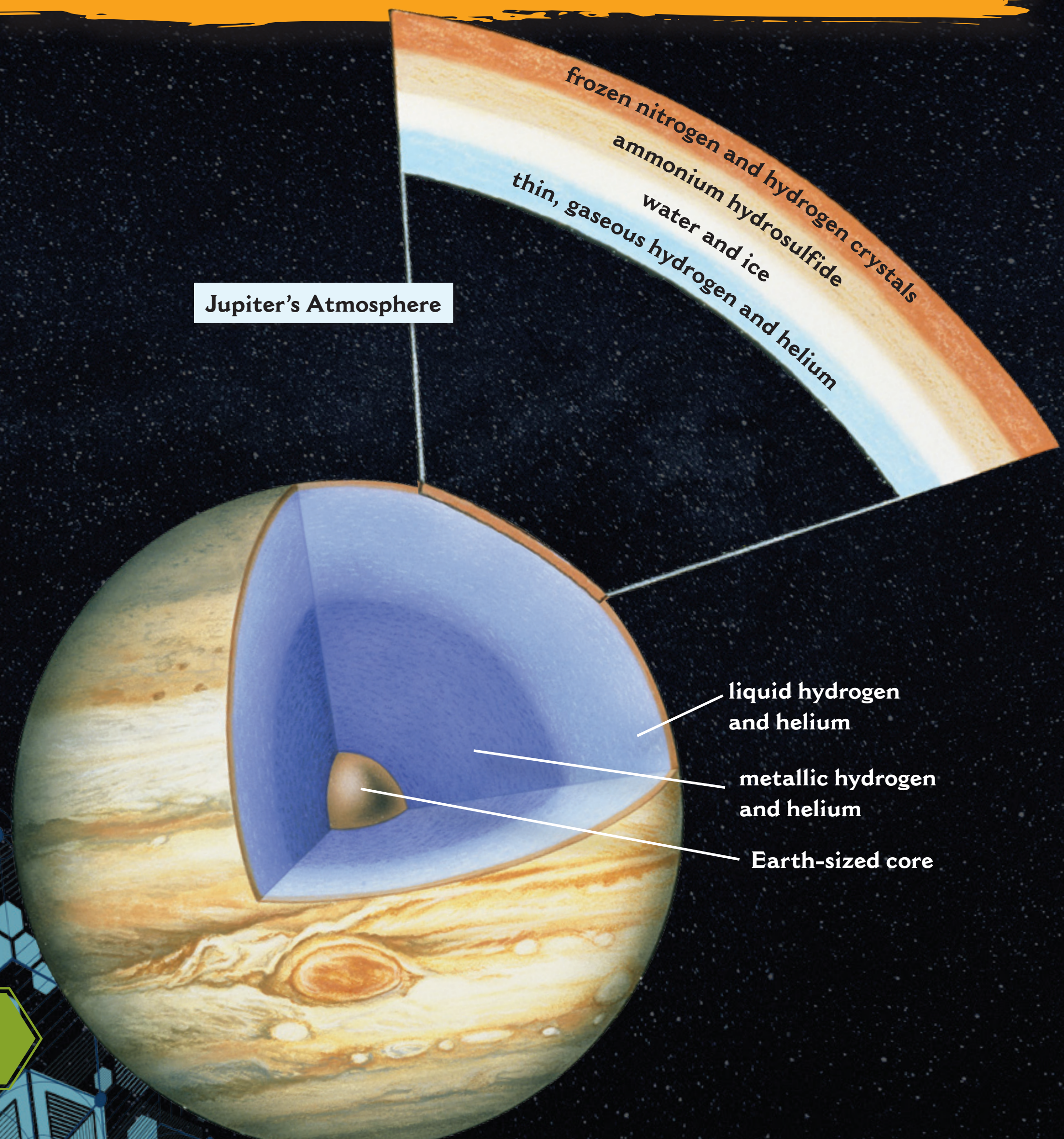
**D.** $d \times 10$

**E.** $5d + 5d$



Jupiter can be called a cousin of the sun. About 4.5 billion years ago, gas and dust created a cloud that would form the sun and the rest of the solar system. The sun was made from much of this cloud, and the planets came from the leftovers. Jupiter's **atmosphere** makes up most of the planet, since Jupiter does not have a firm "ground" like Earth does. Like the sun, Jupiter is mostly made up of hydrogen, followed by helium and other gases. However, the sun is a star, not a planet. Though Jupiter is made up of the same gases as stars, it never grew large enough or hot enough to create the energy of a star.

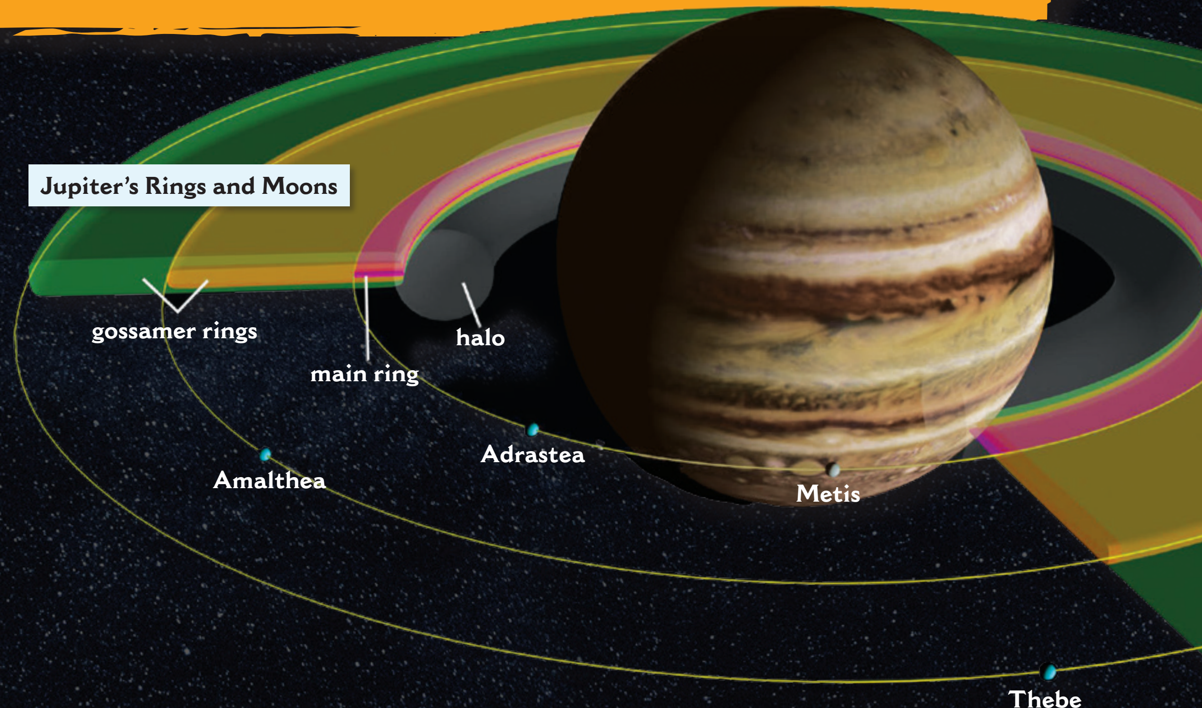
Jupiter's Atmosphere




## Surprise! It Has Rings!

NASA first launched a spacecraft to Jupiter in 1972. But, it was a 1979 photo from the *Voyager 1* spacecraft that captured Jupiter's thin rings. Everyone was shocked. The dust **particles** that form the rings appeared only when they were backlit by the sun. The *Galileo* spacecraft that orbited Jupiter from 1995 to 2003 gathered new data. It showed that **meteoroids** were colliding into Amalthea, Thebe, Adrastea, and Metis—the closest of Jupiter's 79 moons. Dust from these collisions is what created Jupiter's four rings. Scientists call the two outer rings *gossamer rings* and the thick inner ring the *halo*. The ring in between those is called the *main ring*.

Jupiter's Rings and Moons

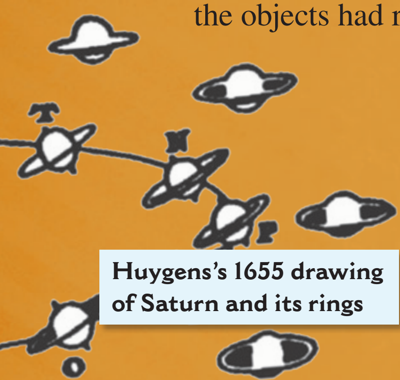



This photo of Jupiter's rings was taken by the *Galileo* spacecraft.

# Saturn: The Most Famous Rings of All

Galileo's drawing

Saturn's rings have been a mystery for more than four hundred years. It began in 1610, when the most famous astronomer in history spotted them. Through his telescope, Galileo saw a large circle with two smaller circles on each side. His best guess was that Saturn had a moon to the left and a moon to the right. He made his next discovery in 1612, when these "moons" seemed to disappear. Two years after that, Galileo discovered that the objects had returned. This time, he described them as handles or arms. In 1616, Galileo drew Saturn with a thick ring around it.



Huygens's 1655 drawing of Saturn and its rings

The next detective in the great mystery of Saturn's rings is Christiaan Huygens (HOY-gunz). By 1655, telescopes could help people see much farther. With a telescope he designed, Huygens saw Saturn's rings clearly. They were not attached to Saturn as some believed. When Huygens saw the rings, he thought they were solid. For about two hundred years, most scientists agreed.

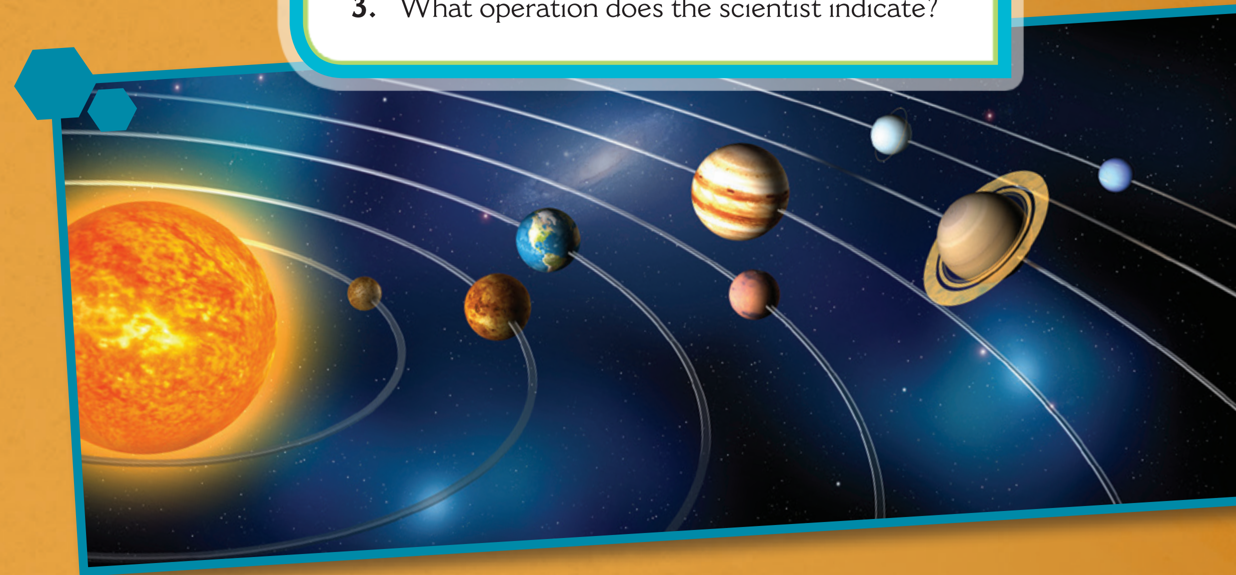
In the mid-1800s, a few astronomers questioned Huygens's theory. They noted that they could see through Saturn's rings, so the rings could not be solid. Next, physicist James Clerk Maxwell wrote an essay about his opinion. He said two centuries of observations showed that the rings had changed in size. Therefore, they could not be solid. In 1895, astronomers William Campbell and James Keeler confirmed that the rings are actually made up of many small particles.

Galileo Galilei 1610 | Christiaan Huygens 1655 | James Clerk Maxwell 1859 | William Campbell 1895 | James Keeler

## LET'S EXPLORE MATH

Saturn's distance from the sun is farther than Earth's. To determine Saturn's distance from the sun, a scientist writes the equation $s = 9.5e$.

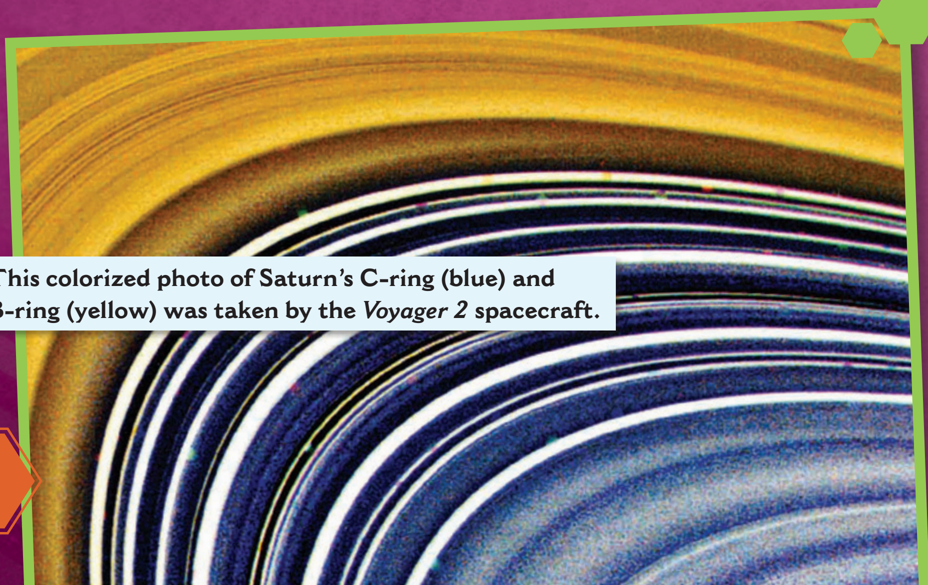
1. What do the variables $s$ and $e$ mean?
2. What does 9.5 mean?
3. What operation does the scientist indicate?



Four spacecraft have orbited Saturn. The *Cassini-Huygens* is the most recent, which launched in 1997 to study the planet, its moons, and its rings. It made it to Saturn in 2004. Photographs revealed a sea of **methane** gas on Titan, one of Saturn's moons. Scientists also learned there are water vapor **geysers** on another of Saturn's moons, Enceladus.

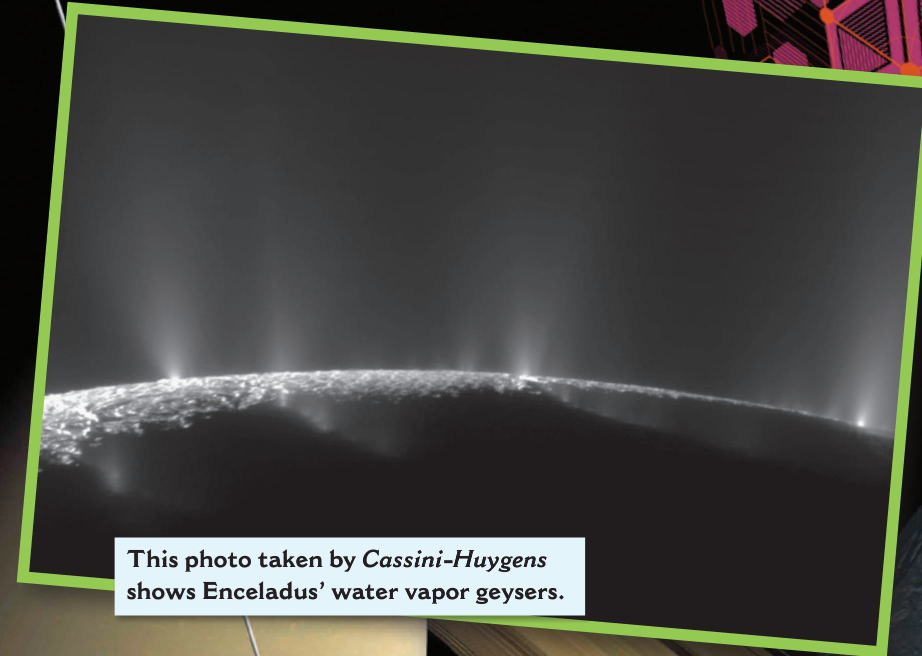
Before *Cassini-Huygens*, scientists already knew that Saturn's rings were made mostly of particles of ice, plus some rock and dust. They had observed that pieces of the rings could be small like grains of salt or as large as buildings. But *Cassini-Huygens* showed scientists that the rings are constantly moving. Gravity pulls the particles into seven distinct rings, so from Earth they appear stationary. *Cassini-Huygens* showed that the rings can ripple like waves and the edges can twist up or down.

Scientists still disagree on how the rings formed. Some say that any of Saturn's moons could have collided with each other or that **asteroids** and meteoroids crashed into the moons. Then, the **debris** from these collisions formed the rings. Other scientists believe that those pieces of debris might rejoin to form new moons, so the particles wouldn't spread far enough to enter the rings. Scientists cannot be sure how the rings were made. Did they form with our solar system 4.5 billion years ago? Probably not. Data from the *Cassini-Huygens* mission say that Saturn's rings may be as young as 100 million years old. Saturn never stops surprising everyone!

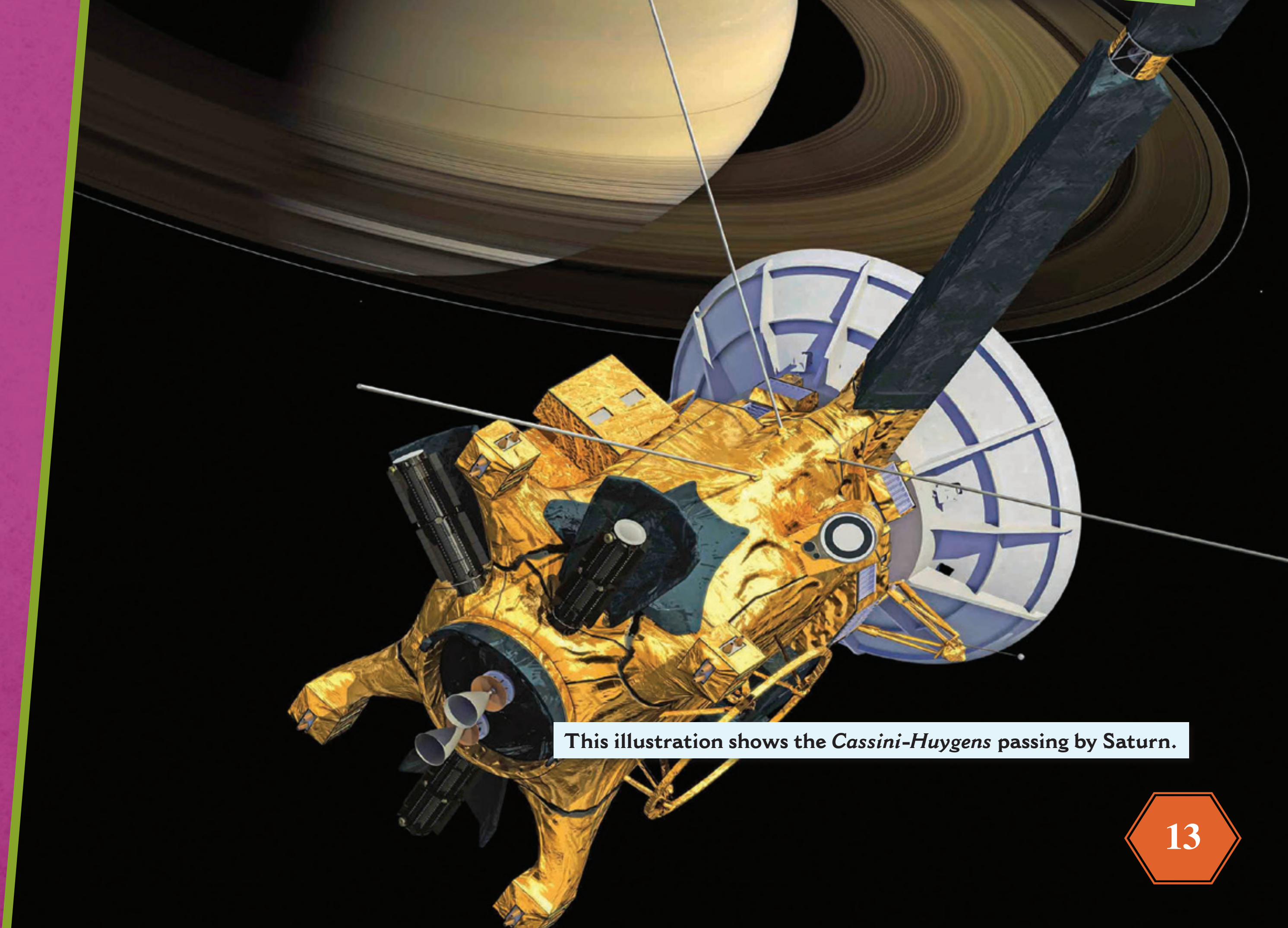


This colorized photo of Saturn's C-ring (blue) and B-ring (yellow) was taken by the *Voyager 2* spacecraft.





This photo taken by *Cassini-Huygens* shows Enceladus' water vapor geysers.



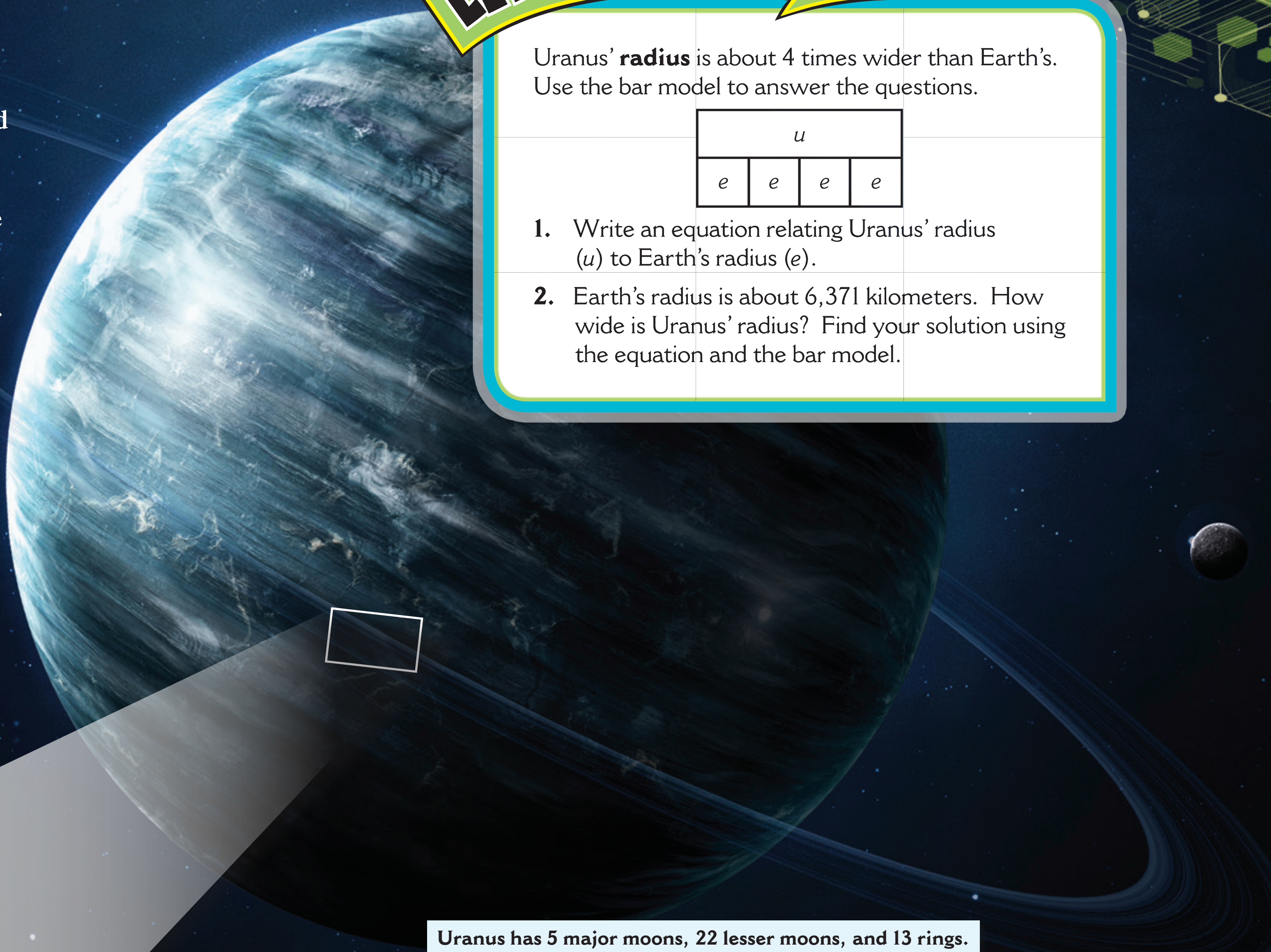
This illustration shows the *Cassini-Huygens* passing by Saturn.

# Uranus: The Tilted Planet

In 1781, William Herschel became the first person to determine that Uranus (YUR-uh-nuhs) was a planet. At first, he thought it was either a comet or a star, like many other people did. By making more detailed observations of its orbit through a telescope, he concluded that it was a planet. Since the planet was nearly invisible to the bare eye, it was the first one to be discovered since ancient times. Herschel quickly became famous for his discovery. Johann Elert Bode confirmed it was a planet in 1783. Uranus was almost named after King George III. It would have been called Georgium Sidus. Instead, the planet was named after the Greek sky god.

Uranus is 4.5 billion years old. It is easy to identify in photos because of its bluish-green color and pale rings. The planet's 13 rings are made mostly of dust. It takes 84 Earth years for Uranus to orbit around the sun. Winter at its north pole is 21 years of darkness, and summer is 21 years of light. Like Earth, the spring and fall have both daytime and nighttime in a single day. Each day (one rotation) lasts 17 hours and 14 minutes.


This illustration shows how the particles that make up Uranus' rings would look up close.


Uranus has 5 major moons, 22 lesser moons, and 13 rings.

## Let's Explore Math

Uranus' **radius** is about 4 times wider than Earth's. Use the bar model to answer the questions.

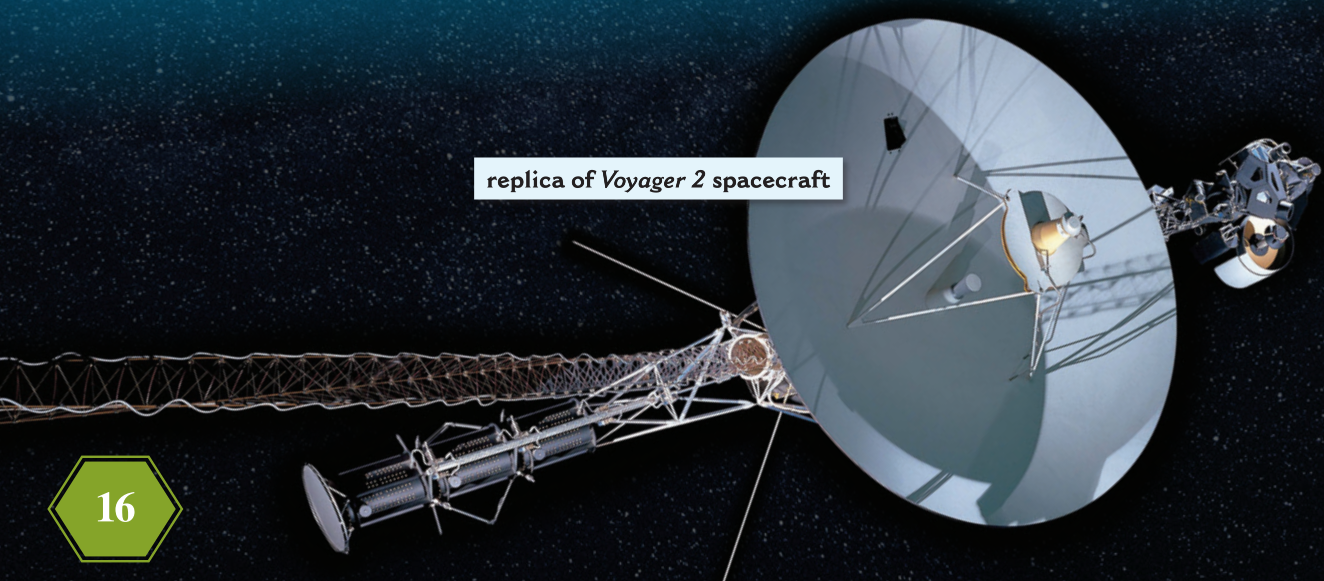
| *u* | | | |
|---|---|---|---|
| *e* | *e* | *e* | *e* |

1. Write an equation relating Uranus' radius ($u$) to Earth's radius ($e$).
2. Earth's radius is about 6,371 kilometers. How wide is Uranus' radius? Find your solution using the equation and the bar model.

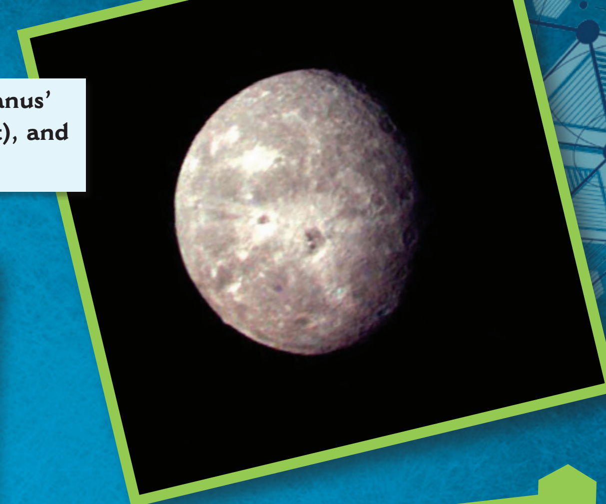
Uranus’ 13 rings are tilted at about a 90-degree angle, just like the planet is. People may imagine Earth’s equator looking like a belt around a pair of pants. Uranus’ equator looks more like a Ferris wheel. Scientists have long wondered why Uranus is tilted. Some believe that two or more objects crashed into Uranus and pushed it on its side. An older theory is that an Earth-sized object (or maybe even larger) collided with Uranus. A collision may also be why this planet rotates from east to west instead of west to east like all other planets (except for Venus). No one is sure what really happened.

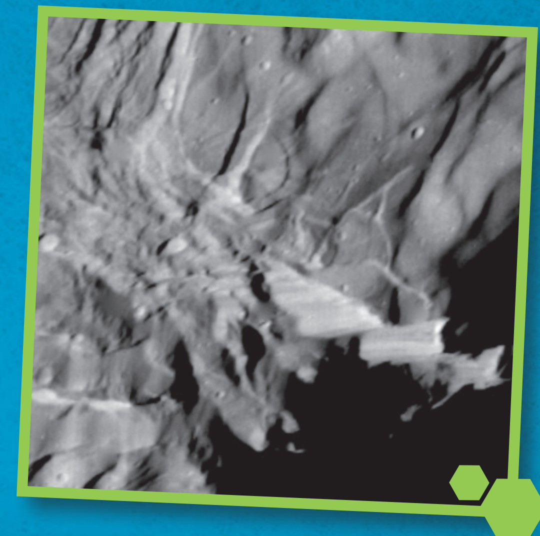
A team of scientists in Australia first discovered several rings around Uranus in 1977. However, most of what is known about the planet comes from *Voyager 2*—the only spacecraft to fly near there. It took *Voyager 2* nine years to pass Uranus. It took about 5.5 hours to fly by Uranus and the spacecraft provided information about its weather, the surfaces of its moons, and its rings. *Voyager 2* also took thousands of photos that continue to amaze scientists.

Recently, NASA proposed a new flight to Uranus and Neptune, the two planets farthest from the sun. Scientists believe that these two planets may have been closer to the sun once. But something happened and they moved away about four billion years ago. NASA thinks a new flight could help scientists learn more about how the solar system formed and changed.



replica of *Voyager 2* spacecraft





*Voyager 2* took these photos of three of Uranus’ major moons—Oberon (top), Miranda (left), and Titania (bottom)—in 1986.

NASA scientists assigned different colors to this photo to represent different parts of Uranus’ atmosphere.

# Neptune: The Ice Planet

Four astronomers helped discover Neptune. First, Italian astronomer Galileo sketched Neptune's position in the sky. Looking into his small telescope, he guessed it was a star. Scientists didn't learn anything new about Neptune for more than two hundred years.

In the United Kingdom, astronomer John Couch Adams worked on a complex math problem about the path Uranus takes around the sun. In France, Urbain-Jean-Joseph Le Verrier was doing the same thing. The two men did not know they were working on the same problem. They both came up with the same answer. Both thought there could be a large, unknown planet pulling on Uranus. That planet's **gravitational force** could cause Uranus to go off track. Adams and Le Verrier took their theory and used it to make new predictions. Each thought he knew where to find the mystery planet.

## The Moment of Discovery

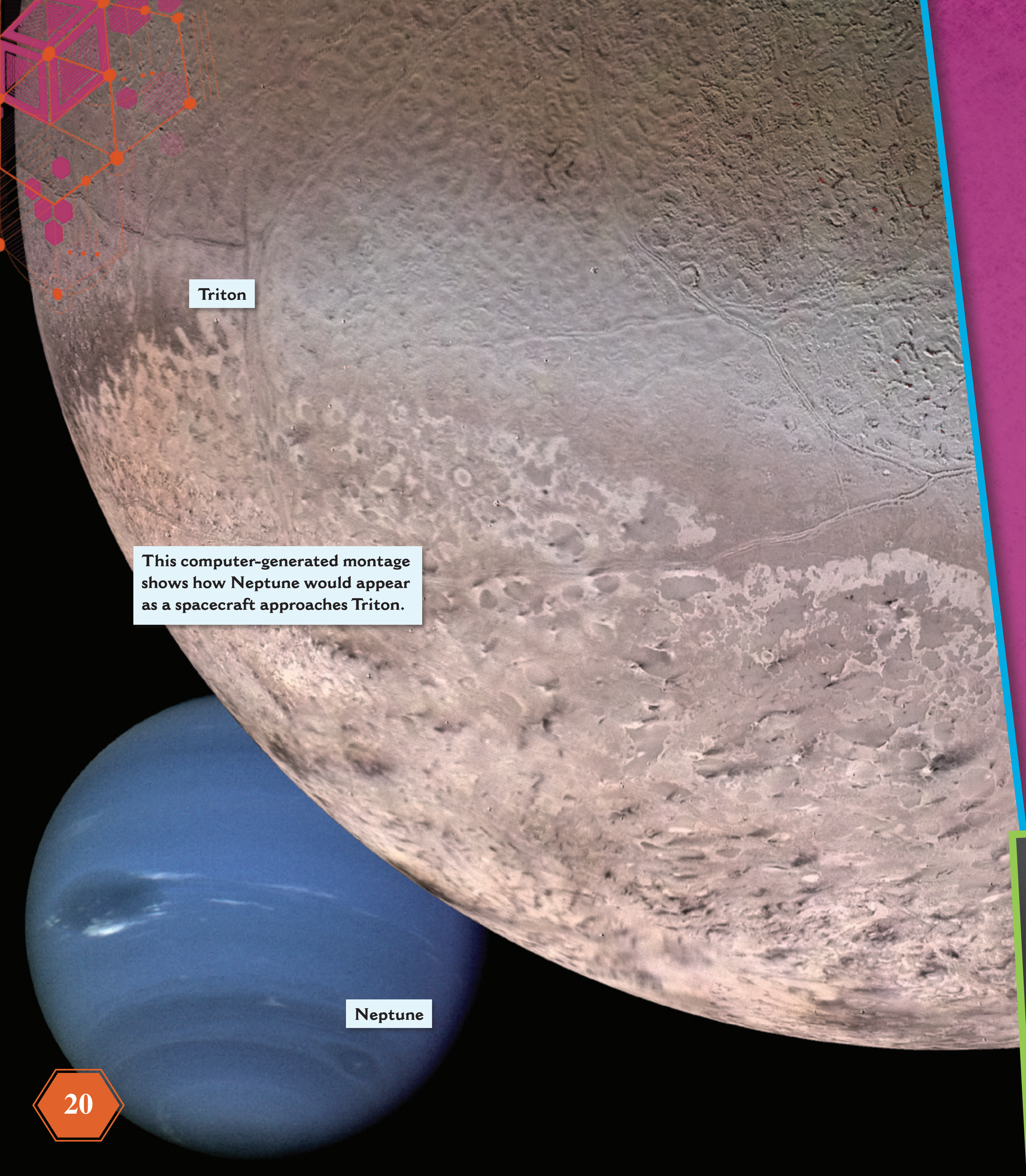
Adams shared his findings but did not publish them because his colleagues didn't think they were important. Meanwhile, Le Verrier sent his calculations to German astronomer Johann Gottfried Galle. Based on Le Verrier's calculations, Galle easily found Neptune in one day. He is the person given credit for its discovery. The date was September 23, 1846.

Galileo Galilei
1610

John Couch Adams
1845

Urbain-Jean-Joseph Le Verrier

Johann Gottfried Galle
1846



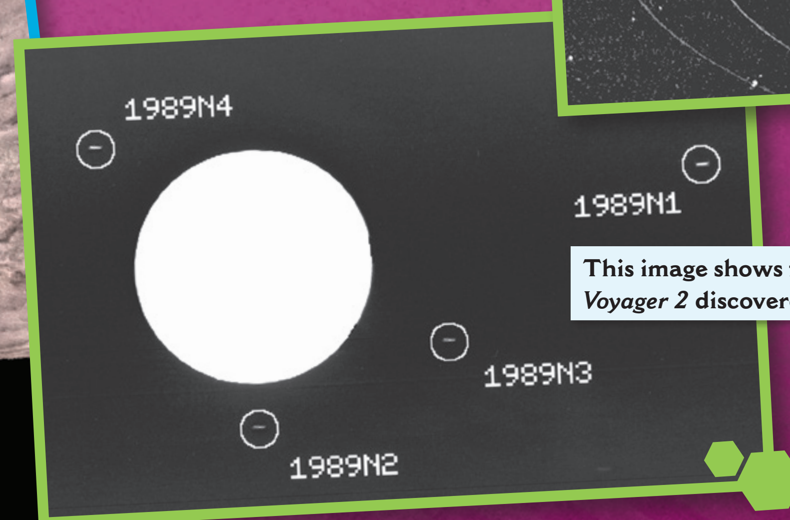

This computer-generated montage shows how Neptune would appear as a spacecraft approaches Triton.

## An Unusual Moon

Neptune's discovery quickly led to another. William Lassell was an amateur astronomer. He found the moon Triton just over two weeks after Galle discovered Neptune. Triton is the largest of Neptune's 13 confirmed moons. Triton is similar in size to the dwarf planet Pluto. There is evidence that this moon may actually have been a large mass that Neptune pulled in with its gravity. Now, it circles Neptune in the opposite direction that Neptune rotates. It is the only large moon in our solar system that does that. Astronomers didn't find another one of Neptune's moons for 103 years.

NASA's *Voyager 2* made the next big discovery in 1989 when, after 12 years in space, it became the only spacecraft to fly by Neptune. The 2.9 billion mi. (4.7 billion km) trip was worth it! Thanks to *Voyager 2*, scientists discovered five new moons and four rings. They also found that Triton is the coldest known planetary body in the solar system. It is so cold that Triton has volcanoes that spew out chunks of ice instead of molten lava!

This *Voyager 2* image shows Neptune's outermost ring clumping into three arcs.




This image shows four of the five moons *Voyager 2* discovered around Neptune.

# The Future of Exploration

Imagine the thrill for the thousands of space scientists who continue to seek and discover. They are busy preparing for missions that are planned. They are also researching ideas for missions they want to do.

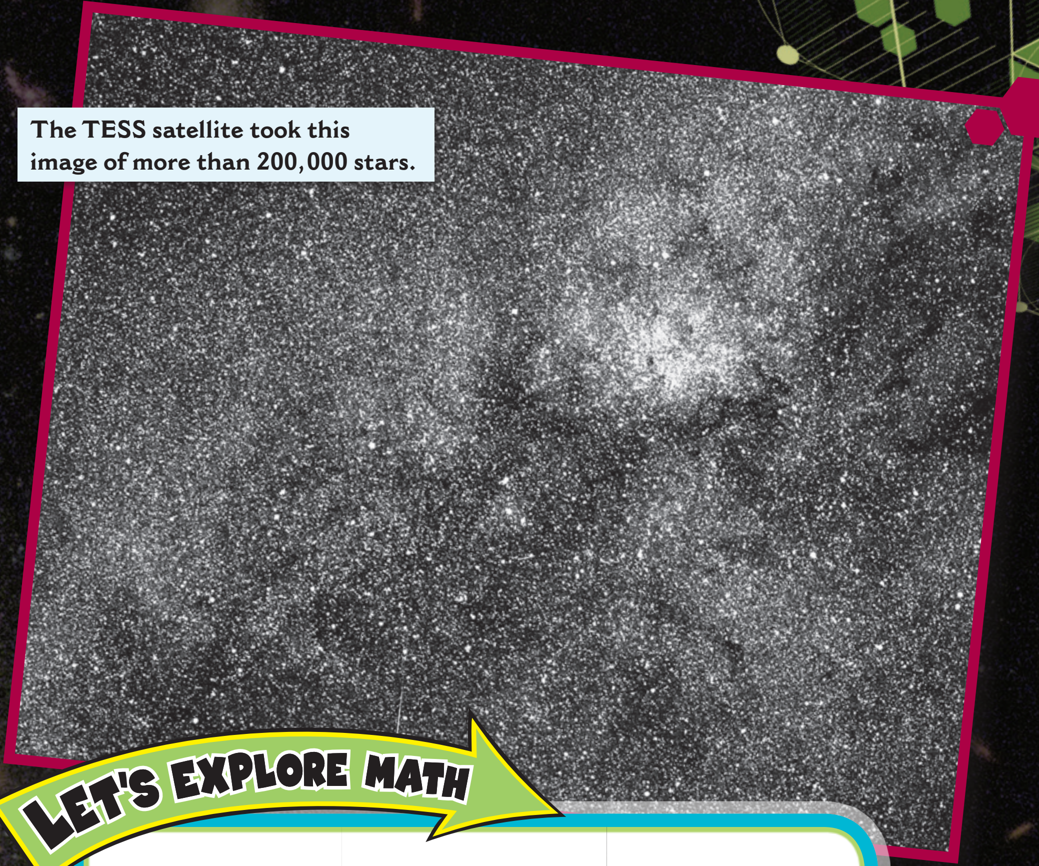
In April 2018, NASA sent a **satellite** (called TESS) into space to capture when stars dim. When stars temporarily seem to lose some brightness, the cause can be a planet orbiting that star. The TESS satellite can capture photos of over 200,000 stars at a time! Scientists expect to locate more than 1,500 new planets from this satellite's two-year mission.

## Missions to Jupiter and Saturn

The *Europa Clipper* is a proposed mission to search for proof of living things on one of Jupiter's moons, Europa. **Microscopic** organisms might be living in Europa's icy ocean. If living things can survive there, there could be life on other moons and planets. Scientists say this could be the closest we will come to finding the answer.

Researchers have also proposed five trips to Saturn. One of those, called SPRITE, would dive into Saturn's atmosphere. The mission would last just 90 minutes. Scientists hope to learn about what gases are in Saturn's atmosphere. This and other data could help in understanding how the solar system formed.


Artists at NASA created this travel poster imagining life on Europa.

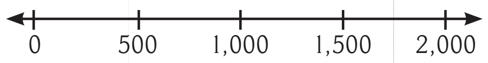


The TESS satellite took this image of more than 200,000 stars.

**LET'S EXPLORE MATH**

Scientists expect to locate more than 1,500 new planets using the TESS satellite.

1. Write an inequality to represent the situation. Use $p$ to stand for the number of new planets.
2. Graph the inequality on a number line like this one.

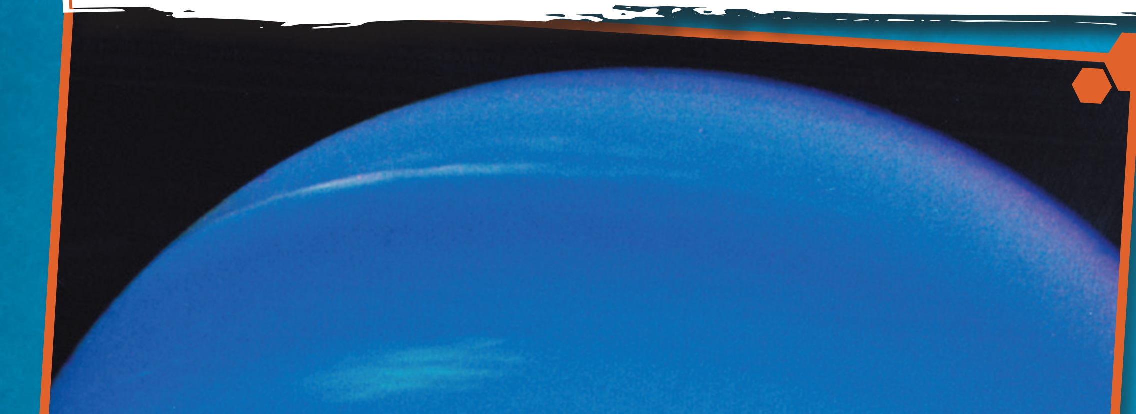



3. **a.** What are three values that make the inequality true?

   **b.** What are three values that make the inequality untrue?

## Missions to Neptune and Uranus

Since Neptune and Uranus are so far away, scientists don't know as much about these planets as they do about others. Just one mission, *Voyager 2*, has flown by these planets. Scientists want to know how these icy planets formed. They want to learn more about their rings. By studying one or both of these planets, more can be learned about how and why our solar system exists. One idea is to have a spacecraft fly by the planets closely and quickly. Another proposal is to have a ship dive directly into Uranus' atmosphere to gather information. The atmosphere would destroy the ship, but the data captured would give scientists information they can use for decades.



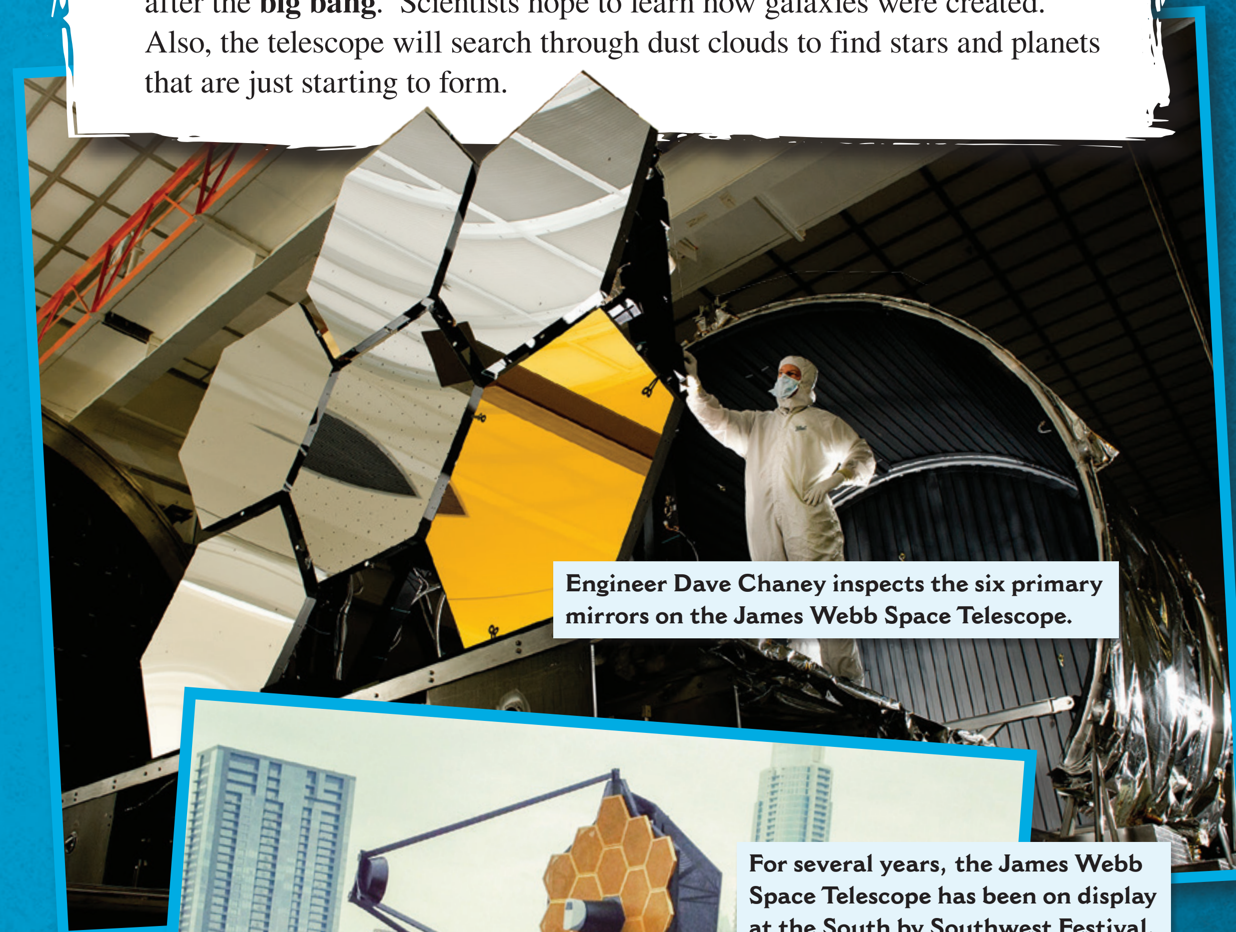
*Voyager 2* image of clouds in Neptune's atmosphere

Dr. Bonnie Buratti and Dr. Fran Bagenal speak about *Voyager 2*'s Neptune mission and the future of space travel.



## The James Webb Space Telescope

Some of the most detailed space exploration will be with the world's largest space telescope. Scheduled to be launched in spring 2021, the James Webb Space Telescope can monitor more than one hundred objects at once. For up to a decade, it will search for the first **galaxies** created after the **big bang**. Scientists hope to learn how galaxies were created. Also, the telescope will search through dust clouds to find stars and planets that are just starting to form.



Engineer Dave Chaney inspects the six primary mirrors on the James Webb Space Telescope.

For several years, the James Webb Space Telescope has been on display at the South by Southwest Festival.

# The Search Never Ends

People have always looked to the skies. And they have been fascinated by what they could see and what they couldn't see. Many discoveries were made hundreds of years ago using basic telescopes. Think of all the possibilities scientists can discover today using new technology. Scientists work hard to make telescopes that can see deeper into space. They design spacecraft that can travel farther. Satellites and the internet let scientists share pictures and videos instantly. Then they work together.

Looking beyond Earth is thrilling! You can learn more about the solar system right now. Visit an **observatory**. Use the telescopes there to see stars, planets, and even the rings around the planets. Ask lots of questions—the people who work at observatories want to share their passion for space with everyone.

If there isn't an observatory near you, join an astronomy club or become an amateur astronomer. Some amateur astronomers and clubs even make their own telescopes to monitor the skies!

There's always more to learn about our solar system and galaxy. The universe is always expanding. Keep learning to expand your "space sense" and never stop exploring!

Galileo's telescope

A man looks at the Zeiss Telescope at the Griffith Observatory.

## LET'S EXPLORE MATH

Imagine that students in a school's astronomy club spotted 120 different stars last semester. This semester, they spot 20 additional stars at each meeting.

1. Write an equation to represent the total number of stars spotted. Use $s$ to stand for the total number of stars and $m$ to stand for the number of meetings.
2. How many total stars have been spotted after the sixth meeting?

## Problem Solving

The sun is actually a giant star. Scientists are studying whether there might be more giant stars in the universe that are similar to our sun. Imagine that Dee, Frank, and Giovanna are scientists who discover a new giant star. Each scientist spots a new planet orbiting this star. They give their research notes to their assistants, using *g* to stand for Giovanna's planet, *f* to stand for Frank's planet, and *d* to stand for Dee's planet.

The scientists request that the assistants draw a map showing their discoveries. Use the research notes to draw a possible map on graph paper, with circles representing the giant star and planets and points representing moons. Let 1 unit on the graph paper stand for 10,000 kilometers. Then, use the equations, inequalities, and numbers of kilometers to write a summary for the scientists, proving that your map is a reasonable possibility.

### Giant Star

- There is a giant star in the middle of the new system.

### Distances

- Frank's planet is twice as far from the giant star as Dee's planet.
- The distance of Giovanna's planet from the giant star is represented by $g > f + d$.

### Sizes

- The radius of Dee's planet is represented by $d = \frac{1}{3}f$.
- Giovanna's planet's radius is two times the radius of Dee's planet.

### Moons

- The number of moons that Dee and Giovanna's planets have are related by $d > g$.
- The number of moons that Frank's planet has is represented by $f = d + 2$.

# Glossary

**archaeologists**—people who study materials that cultures leave behind

**asteroids**—thousands of small, rocky bodies that circle around the sun

**astronomer**—a person who studies stars, planets, and other objects in outer space

**atmosphere**—the whole mass of gases that surround a planet or star

**big bang**—a huge expansion that might have happened when the universe began

**debris**—the pieces left behind after something has been destroyed

**equator**—an imaginary circle around the middle of a planet that is equidistant from the north and south poles

**galaxies**—large groups of stars that make up the universe

**geysers**—springs that shoot out hot water and steam

**gravitational force**—a force that pulls two objects toward each other

**meteoroids**—small chunks of rock or iron that travel through space

**methane**—an odorless, colorless gas

**microscopic**—something so small that it can only be seen with a microscope

**observatory**—a special building for studying stars, planets, weather, and more

**orbit**—the curved path that something (such as a planet) follows around something else (such as the sun)

**particles**—very small pieces of something

**physicists**—people who study matter and energy and how they interact

**radius**—the distance from the center of a circle to any point on the circle

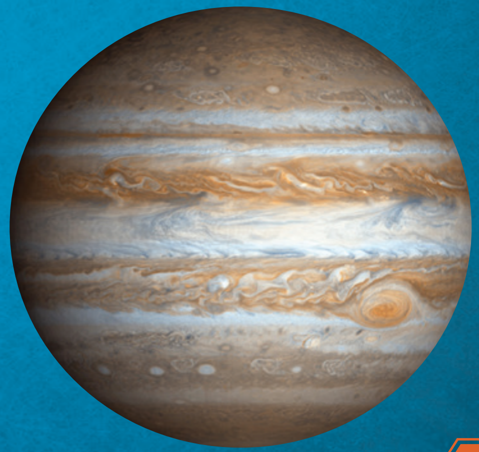
**rotate**—move in a circular motion around a point

**satellite**—an object in space that orbits another object



# Index





# Answer Key

**Let's Explore Math**

**page 5**

1. **Planet A:** $m > 20$;
   **Planet B:** $m < 30$
2. Planet C has between 20 and 30 moons.

**page 7**

A, D, E

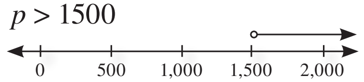
**page 11**

1. Saturn's distance from the sun is *s*; Earth's distance from the sun is *e*.
2. Saturn's distance from the sun is 9.5 times farther than Earth's.
3. multiplication

**page 15**

1. $u = 4e$
2. 25,484 km

**page 23**

1. $p > 1500$
2. 

3. **a.** Examples: *1,501*; *1,600*; *2,000*

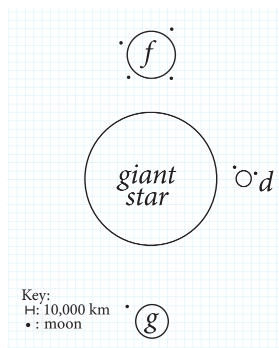
   **b.** Examples: *0*; *5*; *1,250*. Values less than 0 are not realistic for the situation.

**page 27**

1. $s = 120 + 20m$
2. 240 stars

**Problem Solving**

Answers should include a map and justification of the map's accuracy. Example: *The giant star is in the middle of the system. Frank's planet is 40,000 km away from the giant star (20,000 × 2 = 40,000) and Giovanna's planet is 70,000 km away from the giant star (70,000 > 40,000 + 20,000). Dee's planet's radius is 10,000* $\frac{1}{3}$ *× 30,000 = 10,000). Giovanna's planet's radius is 20,000 km (2 × 10,000 = 20,000). Dee's planet has 2 moons (2 > 1). Frank's planet has 4 moons (2 + 2 = 4).*




# Math Talk

1. How are expressions, equations, and inequalities different?
2. Describe a problem situation that can be solved with the equation $8n = 56$. What does the variable represent in your situation?
3. How can number lines help show solutions of inequalities?
4. Mrs. Olivo's classroom has 4 more student tables than Mr. Hadid's classroom. Aina writes the expression $4t$ to represent the situation. What is Aina's error, and how can she correct it?
5. Fiona finds out that the school field trip to the planetarium will cost each student less than $30. She writes the inequality $c < 30$ to represent the situation. Which values make the inequality true but are not realistic? Why?
6. When might astronomers need to use equations and inequalities?