Astraviator

SPACE WORKBOOK

UNIT 4 OF 8

Moons, Dwarf Planets & Small Bodies

Moons · Dwarf planets · Asteroids · Comets

Puzzles · Math labs · Coloring · Experiments · Games

Ages 9–14 · three levels · answer key included

★ Explorer · ★★ Navigator · ★★★ Commander



astraviator.com | Solar System Explorer Simulator

Print at 100% · black & white pages, color cover · Imagery rendered from NASA / USGS data and Solar System Scope textures (CC BY 4.0)

FREE SIMULATOR

Scan to fly to the Moon

SOLAR SYSTEM EXPLORER

astraviator.com/explore

Assemble the rocket, launch, cross to the Moon and explore real space data. Play the free simulator in your browser, on a phone, tablet or computer: no install, no account.

SAFETY FIRST Children should do the experiments with an adult, using ordinary household materials and eye protection when asked. Never look directly at the Sun, never cap a bottle that fizzes, and do not point anything at people or pets. Adults are responsible for supervision and for deciding whether an activity is suitable for the child.

Point your phone’s camera at the code and tap the link.

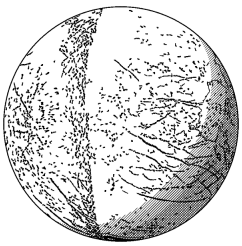
Field Guide: The Small Worlds ★ EXPLORER

Not every world is a planet. Our solar system is full of smaller worlds: **moons** that orbit planets, **dwarf planets**, rocky **asteroids** and icy **comets**.

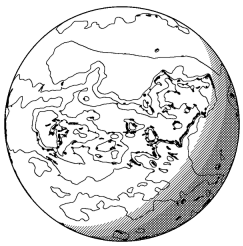
What is a dwarf planet? It orbits the Sun and is round, like a planet, but it has *not cleared its neighborhood* of other objects. Pluto and Ceres are dwarf planets.



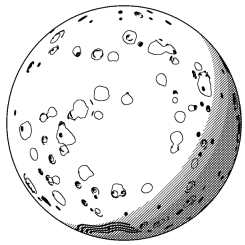
The Moon
Earth's only natural satellite. 2,159 mi wide. Gravity is about 1/6 of Earth's.



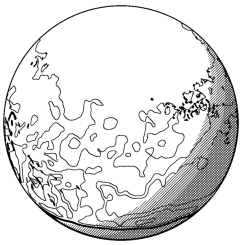
Europa
Moon of Jupiter. An icy crust covers a salty ocean.



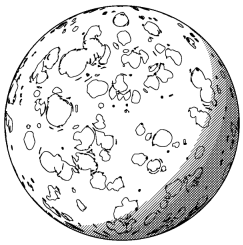
Titan
Moon of Saturn, 3,200 mi wide. Thick orange atmosphere and methane lakes.



Enceladus
Moon of Saturn, only 313 mi wide, with geysers at its south pole.



Pluto
Dwarf planet, 1,477 mi wide. Visited by New Horizons in 2015.



Ceres
Dwarf planet in the asteroid belt, 592 mi wide.

Asteroids are rocky leftovers from the birth of the solar system. Most orbit in the **asteroid belt** between Mars and Jupiter. **Comets** are dirty snowballs: when they get close to the Sun, they grow glowing tails. **Halley's Comet** returns about every 76 years.

Vocabulary to spot: moon · dwarf planet · asteroid · comet · crater · geyser · ocean · orbit

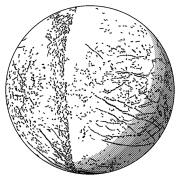
Who Am I? Draw the Lines ★ EXPLORER

Draw a line from each picture to the clue that matches it. Then write the name under the picture.



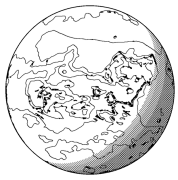
_____

A. I have a thick orange atmosphere and lakes of liquid methane.



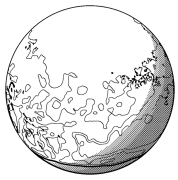
_____

B. I am a dwarf planet with a heart-shaped plain. A spacecraft flew by me in 2015.



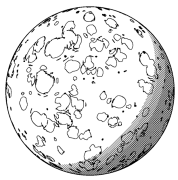
_____

C. Geysers of water ice spray from my south pole.



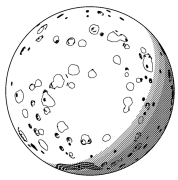
_____

D. Humans have walked on me.



_____

E. I am the biggest object in the asteroid belt, and a dwarf planet.



_____

F. A salty ocean hides under my icy crust.

★ Which clue could describe **two** of these worlds? Explain. _____

Sorting Hat: Planet, Dwarf, Moon, Asteroid or Comet?

★★ NAVIGATOR cut-out

Cut out the cards at the bottom and paste each one in the right column.

Planet	Dwarf planet	Moon	Asteroid	Comet

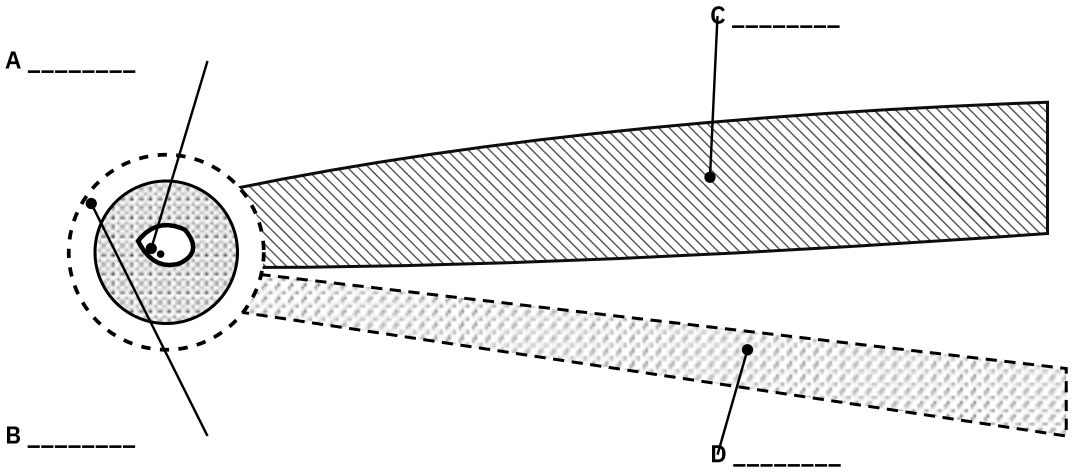
Mars	**Ceres**	**Titan**	**Enceladus**	**The Moon**
Vesta	**Halley's Comet**	**Europa**	**Earth**	**Pluto**

> Remember the dwarf-planet test: orbits the Sun · round · has NOT cleared its orbit. A moon orbits a planet.

★★ Ceres is round and orbits the Sun, but it shares the asteroid belt with millions of other objects. Why is it a dwarf planet and not a planet?

Comet Lab: Anatomy & Orbit ★ EXPLORER ★★ NAVIGATOR

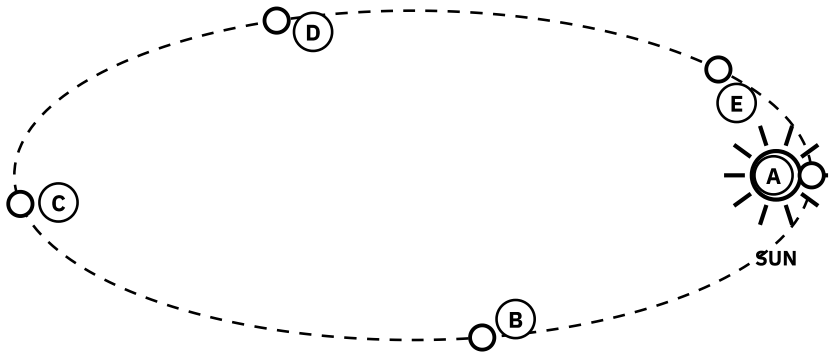
A comet is a ball of ice and dust. Near the Sun it heats up and sheds gas and dust. Label the parts with the word bank.



Nucleus (solid center) · Coma (glowing cloud) · Dust tail (curved) · Gas / ion tail (straight)

Draw the tails

A comet's tail always points **away from the Sun**, pushed by sunlight and the solar wind. Draw the tail at each position (A–E). Make it longest when the comet is closest to the Sun.



Not to scale.

1 Halley's Comet last passed the Sun in 1986 and returns about every 76 years. In which year will it return? 1986 + 75 ≈ _____. How old will you be then? _____

Small Worlds Word Search ★ EXPLORER

Find the 14 words. They can go in any direction, even backward.

O I X J N A T I T H Z J C R S
K J W N Y R Z E J V W M V H G
E A T A O C E R E S J E F N P
K I A E T V G N E V H T L Z J
C T I C U Y W T N E T E Q D F
N S L O L N R T C Q B O A N C
D Z Q E P O M I E H G R P L P
D A C E X O C B L W I S O O O
A S O R G M M R A K N W R F K
I T M C R W X O D L A G U Z D
Q E E S W Q C P U S G O E I M
I R T W V F V W S N Y P X K Z
W O G J J X Q C Y E R N L U Y
U I D T R E S Y E G X X X F M
W D T B C R A T E R B J T K U

- ☐ ASTEROID
- ☐ CERES
- ☐ COMET
- ☐ CRATER
- ☐ ENCELADUS
- ☐ EUROPA
- ☐ GEYSER
- ☐ METEOR
- ☐ MOON
- ☐ OCEAN
- ☐ ORBIT
- ☐ PLUTO
- ☐ TAIL
- ☐ TITAN

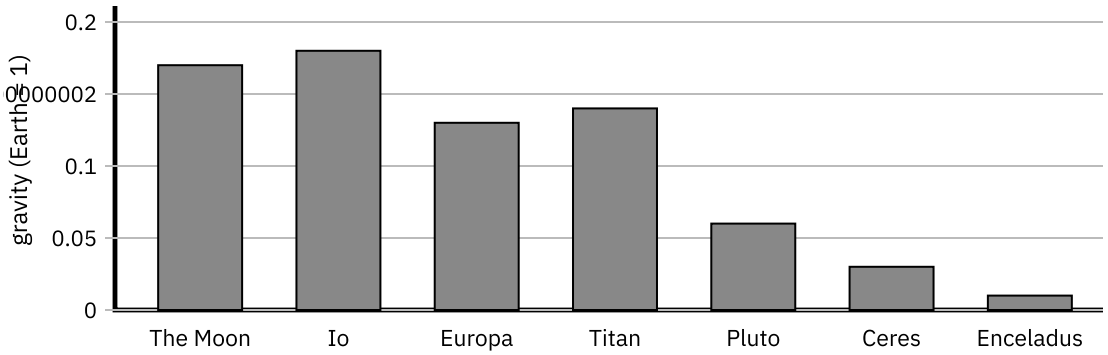
Secret challenge ★★: Write a riddle for one of the words and give it to a friend to solve.

Math Lab 1 · Light Weights, High Jumps ★★ NAVIGATOR

On small worlds gravity is weak. Use **weight on Earth × gravity** and **jump on Earth ÷ gravity**. Our astronaut weighs **90 lb** and jumps **2 ft** on Earth. Round to one decimal.

World	Gravity (Earth = 1)	Weight (lb)	Jump (ft)
The Moon	0.17	_____	_____
Io	0.18	_____	_____
Europa	0.13	_____	_____
Titan	0.14	_____	_____
Pluto	0.06	_____	_____
Ceres	0.03	_____	_____
Enceladus	0.01	_____	_____

Gravity ranking



1. Which world has the weakest gravity? _____ The strongest? _____

2. On Enceladus you could jump _____ feet high! Why would it be risky to jump on such a small world? (Hint: escape velocity is tiny.) _____

3. A 160 lb astronaut with a 140 lb suit visits the Moon (gravity 0.17). Total weight on the Moon: _____ lb

Math Lab 2 · Journey to Pluto ★★★ COMMANDER

The spacecraft **New Horizons** launched in January 2006 and flew past Pluto on July 14, 2015. It traveled about **3,000,000,000 miles** in about **9.5 years**.

1. How many hours is 9.5 years? (9.5 × 365 × 24 = _____ hours)

2. Average speed = distance ÷ time = 3,000,000,000 ÷ _____ ≈ _____ miles per hour

3. A jet airliner flies about 550 mph. How many times faster than a jet is New Horizons? _____

4. At the flyby, Pluto was about 3 billion miles from Earth. A radio signal travels at 186,282 miles per second. How many seconds does a message take? _____ How many hours? _____

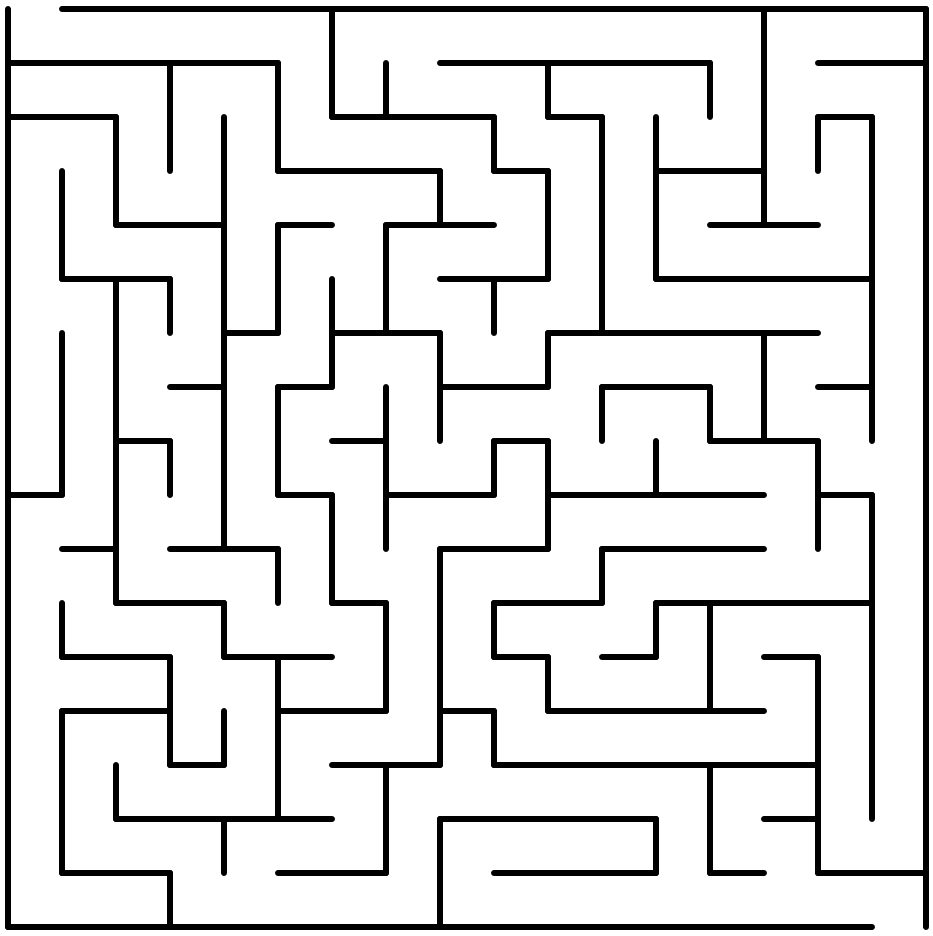
5. **Compare.** Apollo astronauts reached the Moon (238,855 miles) in about 3 days. How many miles per hour is that? (238,855 ÷ 72 = _____) mph

Time capsule question

Pluto takes 248 Earth years to orbit the Sun once. Since its discovery in 1930, has Pluto finished even one orbit? 1930 + 248 = _____ . What does that mean for the year 2026? _____

Asteroid Belt Maze ★★ NAVIGATOR

Your spacecraft starts at the top-left and must reach **Ceres** at the bottom-right. Don't touch the walls (the asteroids)!



Belt facts

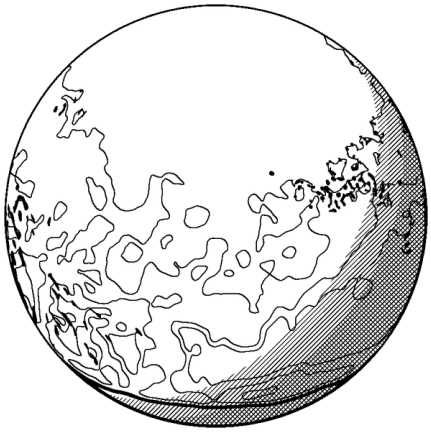
- It lies between Mars and Jupiter.
- Asteroids are usually hundreds of thousands of miles apart, so spacecraft rarely come close to one.
- All its asteroids together weigh less than the Moon.

1. The belt is about 2.2 to 3.2 AU from the Sun. How wide is it in AU? _____ In miles (1 AU = 93,000,000 mi)? _____

Pluto: Planet or Dwarf Planet? ★★ NAVIGATOR

Clyde Tombaugh discovered Pluto in 1930, and for 76 years it was called the ninth planet. In 2006 astronomers agreed on a new definition of **planet**: it must orbit the Sun, be round, and have **cleared its orbit** of other objects. Pluto did not pass the last test, so it became a **dwarf planet**.

In 2015, the New Horizons probe flew past and revealed mountains of water ice, a huge heart-shaped plain of nitrogen ice and a blue haze. Its largest moon, **Charon**, is about half its size.



Pluto, seen by New Horizons (our drawing)

The planet test

	Orbits the Sun?	Is round?	Cleared its orbit?	So it is a…
Earth	_____	_____	_____	_____
Pluto	_____	_____	_____	_____
Ceres	_____	_____	_____	_____

1 Charon is 751 miles wide and Pluto is 1,477 miles wide. What fraction of Pluto's width is Charon? (751 ÷ 1,477 = _____) About _____

Debate: should Pluto be a planet?

2 Choose a side and write your argument with two reasons.

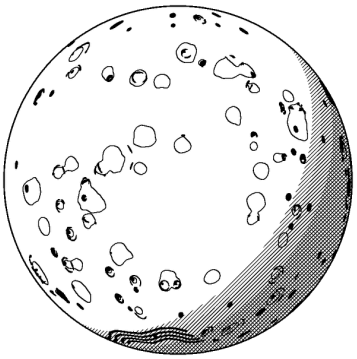
Cryovolcano Experiment: Geysers of Enceladus

★★ NAVIGATOR

SAFETY Do this with an adult, outdoors or over a sink, and wear eye protection. **Never put a cap, cork or lid on the bottle** : the gas needs to escape. Do not taste the mixture.

You need

- A small plastic bottle (or cup)
- Modeling clay or play dough
- Baking soda (2 tablespoons)
- Vinegar (1/4 cup) with blue food coloring
- A drop of dish soap
- A tray to catch the mess



Enceladus: geysers of water ice spray from cracks near its south pole.

Do it

1. Mold clay around the bottle to make an icy moon, leaving the opening free.
2. Put the baking soda and the soap in the bottle.
3. Pour in the blue vinegar and step back!

1 **Observe.** What happened when the vinegar met the baking soda?

2 **Draw** your cryovolcano in action in the box and add arrows showing where the “ice” flies.

3 On Enceladus, geysers shoot salty water, ice grains and simple chemicals into space from an ocean under the ice. Why do scientists find this exciting?

Safety: eye protection for younger students; do it outdoors or on a tray.

Small Worlds Bingo

★ EXPLORER cut-out

One player reads a clue from the list; the others cover the answer on their board with a button or paper piece. First to cover a whole row, column or diagonal wins!

BINGO · 1

Ceres	The Moon	Europa
An asteroid	A geyser	A crater
A comet tail	Pluto	Titan

BINGO · 2

The Moon	Enceladus	An asteroid
Ceres	Pluto	Titan
Halley's Comet	A comet tail	Europa

BINGO · 3

Titan	Europa	A comet tail
Ceres	Halley's Comet	An asteroid
The Moon	Io	Pluto

BINGO · 4

Halley's Comet	A crater	An asteroid
The Moon	A comet tail	Ceres
A geyser	Io	Enceladus

Caller's clues (cut out and shuffle)

I orbit Earth. Astronauts have walked on me.

A salty ocean may hide under my ice.

I have lakes of liquid methane and thick orange haze.

My geysers spray ice from my south pole.

My volcanoes make me the most volcanic world.

I am a dwarf planet with a heart-shaped plain.

I am the largest object in the asteroid belt.

I come back about every 76 years.

I am a rocky leftover from the early solar system.

I always point away from the Sun.

I am a bowl-shaped hole made by an impact.

I shoot water from underground.

Logic Lab: Moon Sudoku ★★★ COMMANDER

Fill the 6×6 grid so that each row, each column and each 2×3 box has all six worlds once: **Mo** = Moon, **Eu** = Europa, **Ti** = Titan, **En** = Enceladus, **Pl** = Pluto, **Ce** = Ceres.

	Ti	**Mo**		**Eu**	
En	**Eu**		**Ti**		**Pl**
Ce		**En**	**Eu**		**Mo**
Ti		**Eu**	**Ce**		**En**
Mo			**Pl**	**En**	
	En	**Pl**			

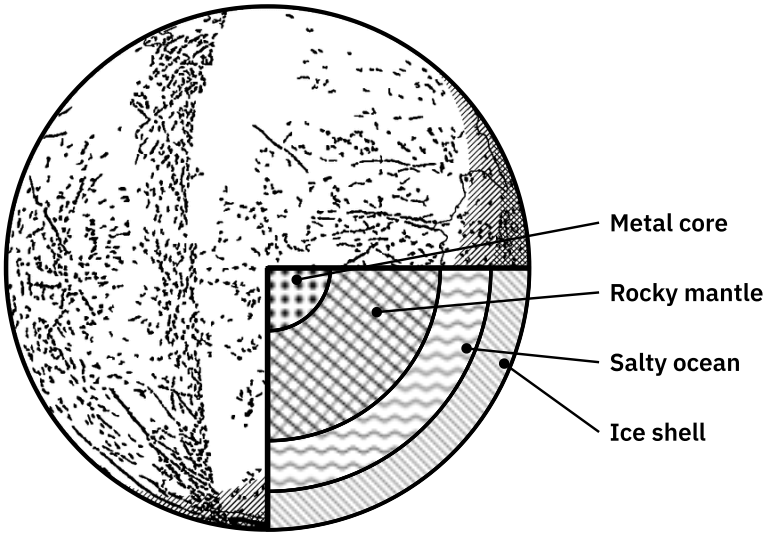
Mystery world ★★

Read the clues and name the world:

1. I orbit Saturn. I am bigger than Mercury. I have thick orange air. I am _____.
2. I am a dwarf planet. I live in the asteroid belt. I am the biggest object there. I am _____.
3. I orbit Jupiter. My ocean is under an icy shell. I am the fourth smallest of the big four moons. I am _____.

Create · A Base on Europa

★ EXPLORER ★★ NAVIGATOR



Scientists think Europa has a deep salty ocean under an ice shell. Imagine you must build a research base here!

Not to scale.

Design your base

DRAW your base here (surface and underwater parts)

1. **What does your crew need?** Tick what your design provides: ☐ air ☐ water ☐ power ☐ warmth ☐ food ☐ radio contact with Earth ☐ protection from radiation

2. Name your base and describe how it works:

Unit Review · Mission Check

★ EXPLORER ★★ NAVIGATOR ★★★ COMMANDER

1. **Define** in your own words: dwarf planet _____ comet _____

2. **Match** (write the letter): Europa ___ Titan ___ Enceladus ___ Pluto ___
   A. geysers · B. heart-shaped plain · C. salty ocean under ice · D. methane lakes

3. **True or false?** a) A comet's tail points toward the Sun. T / F b) Pluto is a planet. T / F c) Gravity on Titan is weaker than on Earth. T / F

4. **Calculate.** A 100 lb student visits Europa (gravity 0.13). Weight: _____ lb

5. **Calculate.** Halley's Comet last appeared in 1986. About what year will it come back? _____

6. **Explain.** Why might scientists want to explore Europa or Enceladus?

7. **Compare.** How are an asteroid and a comet alike? How are they different?

8. **Create.** Draw a comet in the box and label its nucleus and tail.

Mission Log ★ EXPLORER

Check the boxes when you can do each one. Color a star for each section you enjoyed.

☐ I can tell planets, dwarf planets, moons, asteroids and comets apart.

☐ I can name moons with oceans and geysers.

☐ I can explain why Pluto is a dwarf planet.

☐ I can label the parts of a comet and say which way its tail points.

☐ I can calculate weight and jump height on small worlds.

☐ I can work out the speed of a spacecraft.

☐ I can use clues to solve a sudoku and riddles.

☐ I can design a base for a distant moon.

My favorite activity was

Something new I learned

A question I still have about space

UNIT 4
SMALL WORLDS
★ ★ ★
MISSION COMPLETE

Signed: _____
Date: _____

The Space Workbook series

You have **Mission 4**. There are **8 missions** in all: each one is a complete set of puzzles, math labs, games and experiments, and each works on its own.

1	**Earth, Moon & Sun** Phases, time zones, seasons, eclipses, tides	☐
2	**Rocky Planets** Mercury, Venus, Earth and Mars	☐
3	**Giant Planets** Jupiter, Saturn, Uranus and Neptune	☐
4	**Moons, Dwarf Planets & Small Bodies** Pluto, Ceres, comets, asteroids and icy moons	**★ YOU ARE HERE**
5	**Rockets, Orbits & Missions** SLS, orbits, Morse code, spacecraft	☐
6	**Stars, Constellations & Galaxies** Light-years, star maps, galaxies, black holes	☐
7	**Life Beyond Earth** Habitable zones, extremophiles, exoplanets	☐
8	**Astronaut Life** Training, spacewalks, food, living in orbit	☐
+	**Field Guide** The 29 destinations of the Solar System Explorer	in the Complete Workbook

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