Astraviator

SPACE WORKBOOK

UNIT 1 OF 8

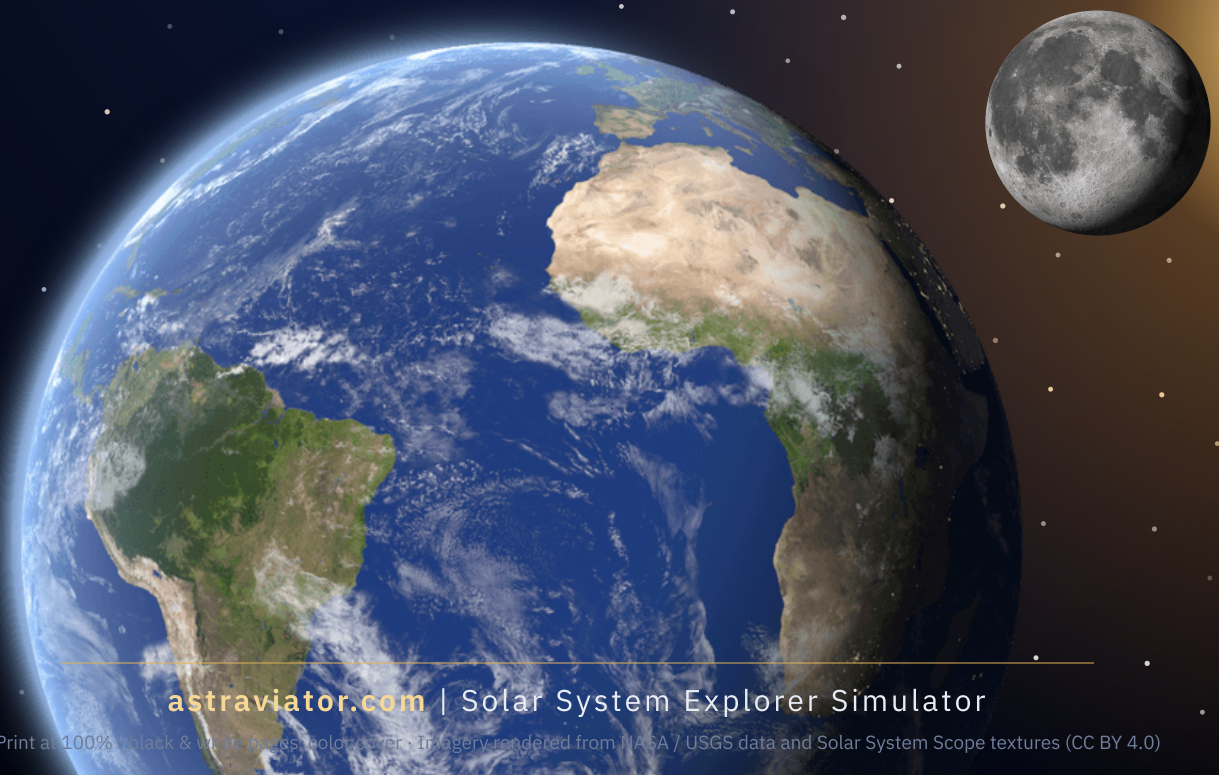
Earth, Moon & Sun

Days · Seasons · Moon phases · Eclipses · Tides

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 or color · 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.

Think First & Mission Briefing ★ EXPLORER

Think first! Before you read, fill in the first two columns. Come back to the last one when you finish the unit.

What I KNOW	What I WANT to know	What I LEARNED

Three bodies shape our days and nights: the **Sun**, the **Earth** and the **Moon**.

The **Sun** is a star, a giant ball of hot gas about 109 Earths wide. Its light takes about 8 minutes and 20 seconds to reach us.

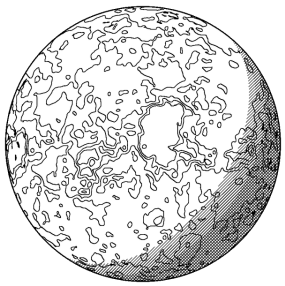
The **Earth rotates** once every 24 hours, giving us day and night, and **revolves** around the Sun once every 365 days. Its axis is tilted about 23.5°, which gives us the **seasons**.

The **Moon** orbits Earth once every 27 days, and its **phases** repeat every 29½ days. It always shows us the same face. Its gravity pulls on the oceans and makes the **tides**.

When the Moon, Earth and Sun line up, we get an **eclipse**.



The Moon

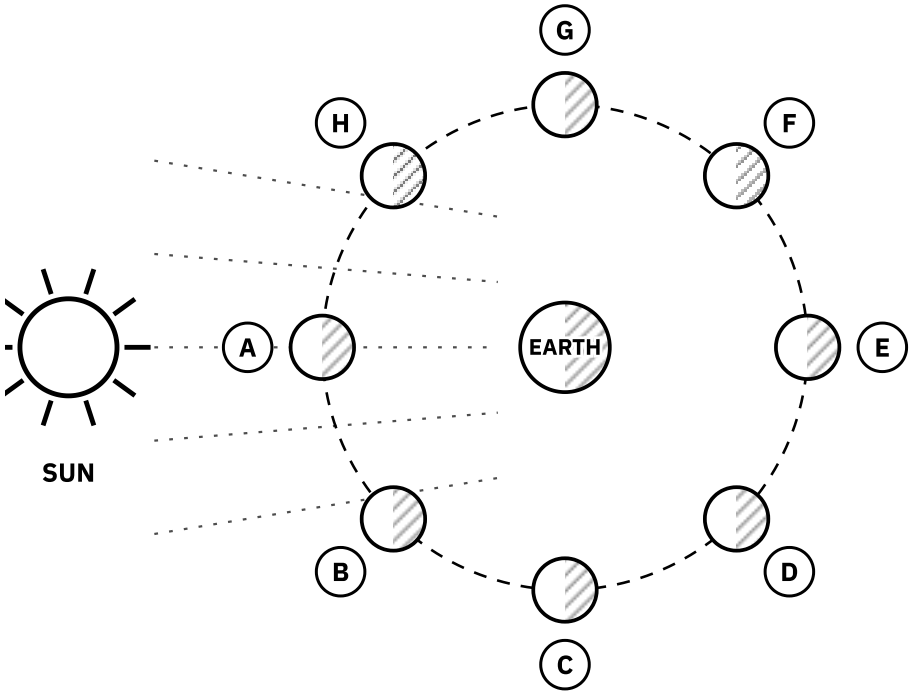


The Sun

	Sun	Earth	Moon
Width	864,000 mi	7,918 mi	2,159 mi
Distance from Earth	93 million mi	–	238,855 mi
Gravity (Earth = 1)	28	1	0.17

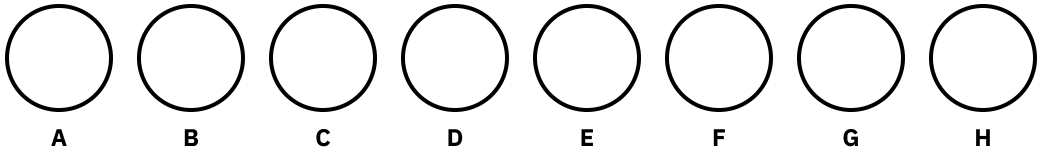
The Moon Goes Around ★★ NAVIGATOR

The Moon orbits Earth. Sunlight always lights up **half** of the Moon, but from Earth we see more or less of that lit half. Look at the diagram (seen from above the North Pole) and name each position.



New Moon · Waxing Crescent · First Quarter · Waxing Gibbous · Full Moon · Waning Gibbous · Last Quarter · Waning Crescent

What would each position look like from Earth? Shade the part of the Moon you could NOT see.



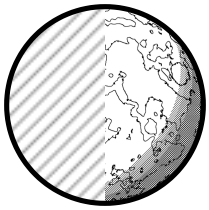
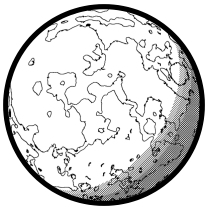
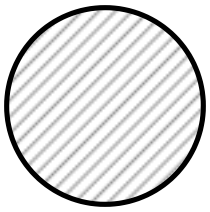
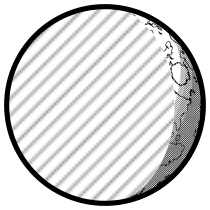
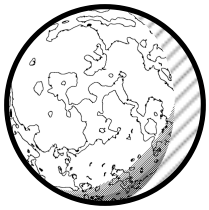
1. Which letter shows the Moon between Earth and the Sun? _____ What phase is it? _____

2. How many days from one New Moon to the next? _____ Hint: 29½ days.

Moon Phase Memory Game

★ EXPLORER cut-out

Cut out the 12 cards and mix them face down. Take turns flipping two cards: match each Moon picture with its name. The player with the most pairs wins.

Waning Gibbous	**Last Quarter**		
		**Waxing Crescent**	**Full Moon**
New Moon			**First Quarter**

Play it again with the whole cycle: put your cards in order from New Moon to Last Quarter.

Math Lab 1 · Day, Night & Time Zones

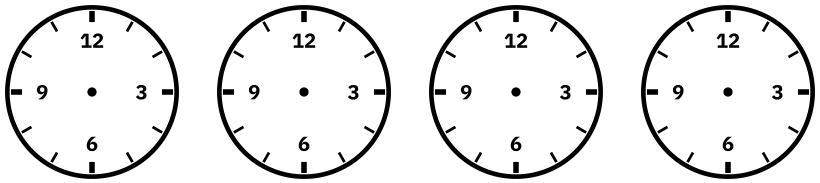
★★ NAVIGATOR ★★★ COMMANDER

Earth turns 360° in 24 hours. Different places face the Sun at different times, so the world is divided into **time zones**, each about 15° wide.

1. How many degrees does Earth turn in **one hour**? (360 ÷ 24) _____ ° In **6 hours**? _____ °

2. **US time zones.** It is **3:00 PM** in New York (Eastern). Each zone to the west is one hour earlier. Fill in the clocks:

New York (Eastern)	Chicago (Central)	Denver (Mountain)	Los Angeles (Pacific)
3:00 PM	_____	_____	_____



New York Chicago Denver Los Angeles

Draw the clock hands for each city.

3. A TV show starts at 8:00 PM Eastern. What time does it start in Los Angeles? _____

4. The continental US spans about 57° of longitude. How many time zones is that? (57 ÷ 15 = _____) → about _____ zones.

★★★ **How fast do you spin?** Earth's circumference at the equator is about 24,901 miles. Speed = distance ÷ time. At the equator you move _____ miles per hour (24,901 ÷ 24).

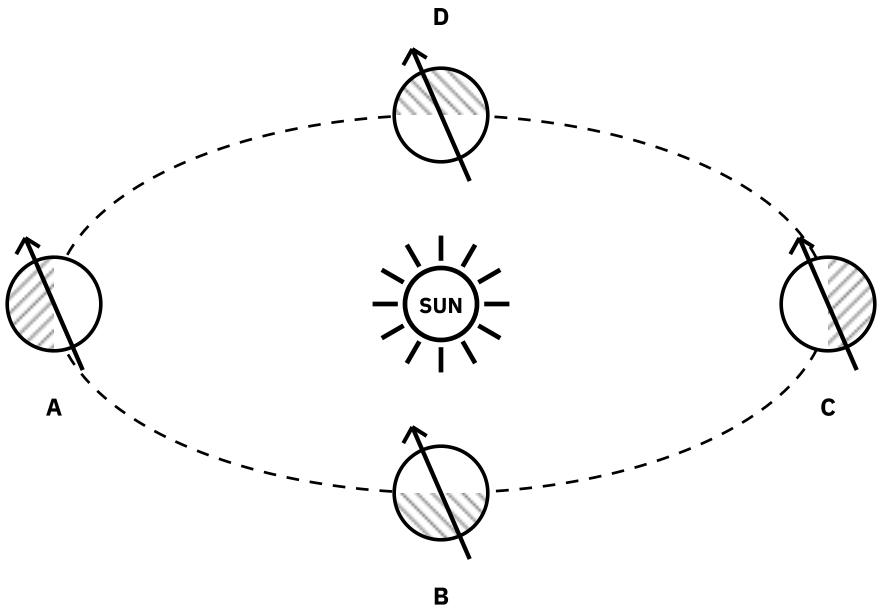
★★★ **How fast does Earth travel around the Sun?** Its orbit is about 584,000,000 miles long and takes 365 days. First change days to hours (365 × 24 = _____). Speed = _____ mph (584,000,000 ÷ hours).

5. **Call planner.** Ana lives in Miami (Eastern) and her friend Ben lives in Seattle (Pacific). Ana's school ends at 3:30 PM. What time is it for Ben? _____ Ben wants to call at 7:00 PM his time. What time is it for Ana? _____

> Why do we not feel this speed? Discuss with a friend: we move along with Earth, the same way you do not feel a smooth car ride.

Why Do We Have Seasons? ★★ NAVIGATOR

Seasons are **not** caused by Earth being closer to or farther from the Sun. They happen because Earth's axis is **tilted 23.5°**. When the Northern Hemisphere leans *toward* the Sun, it gets more direct light and longer days: **summer**.

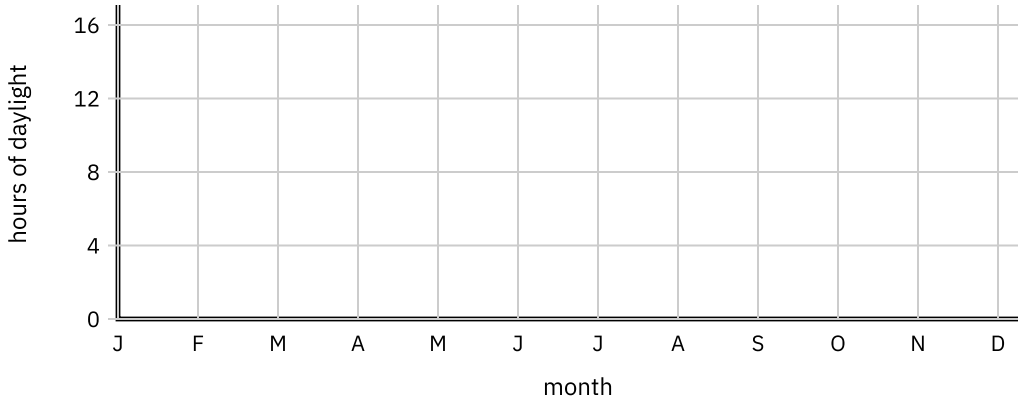


Not to scale. The axis always points the same way in space.

1 In which position is it **summer** in the Northern Hemisphere? _____ **Winter**? _____ **Spring** (Earth moves counterclockwise from winter)? _____ **Fall**? _____

Plot the daylight (about 40° N, like Denver or Philadelphia)

Hours of daylight each month: Jan 9.6 · Feb 10.6 · Mar 11.9 · Apr 13.3 · May 14.5 · Jun 15.0 · Jul 14.6 · Aug 13.5 · Sep 12.2 · Oct 10.8 · Nov 9.8 · Dec 9.3



2 Which month has the most daylight? _____ The least? _____ How many more hours is the longest day than the shortest? _____

3 It is July in Texas (hot summer). What season is it in Argentina? _____ Why? _____

Eclipse Detective ★★ NAVIGATOR

Solar eclipse



The Moon passes between the Sun and Earth. Its shadow falls on Earth.

Lunar eclipse



Earth passes between the Sun and the Moon. Earth's shadow falls on the Moon.

Safety first! Never look at the Sun, even during an eclipse, without special eclipse glasses. A lunar eclipse is safe to watch with your eyes.

1. The dark center of a shadow is the **umbra**; the lighter outer part is the **penumbra**. Label them on one of the diagrams with arrows.

2. Which Moon phase happens during a **solar** eclipse? _____ During a **lunar** eclipse? _____

3. If the Moon passes between the Sun and Earth every month at New Moon, why don't we have a solar eclipse every month? (Hint: the Moon's orbit is tilted about 5° compared with Earth's orbit.)

4. **Try it!** In a dim room, use a flashlight (Sun), a ball (Earth) and a smaller ball (Moon). Make each kind of eclipse and draw what you see. (Draw what you see on the back of this page.)

Sun & Moon Word Search ★ EXPLORER

Find the 14 words. They can go forward, backward, down or diagonally.

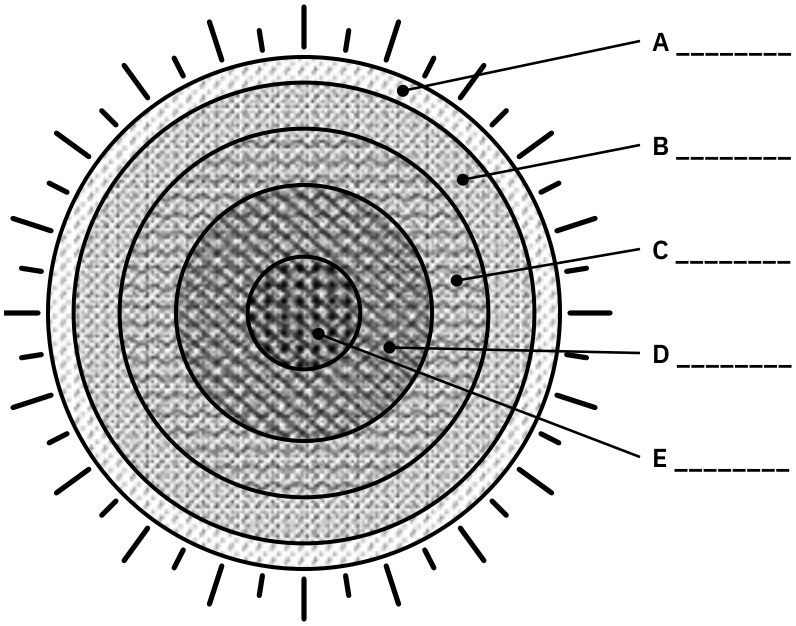
R D U I J R E S P I L C E O Z
C O Y H S Q N I T I B R O J O
R F N O S A E S C B E A T H Q
E S J E D R H U K T I L T E C
S B Z P H A S E C V S I X A H
C H O Q I Q Q F L U J Z S F I
E H P O Z S U O B B I G E U G
N P A R A N U L D B M D X Q N
T G O J E Y X Q A Z O A C G X
O T T F A L J X F Y O Z I W H
Z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

- ☐ AXIS
- ☐ CRESCENT
- ☐ EARTH
- ☐ ECLIPSE
- ☐ GIBBOUS
- ☐ LUNAR
- ☐ MOON
- ☐ ORBIT
- ☐ PHASE
- ☐ SEASON
- ☐ SHADOW
- ☐ SUN
- ☐ TIDE
- ☐ TILT

Bonus ★★: Choose three words and write a sentence about the Sun, Earth or Moon with each one.

Inside the Sun

★★ NAVIGATOR ★★★ COMMANDER



The Sun has layers. Label the diagram with the words in the bank and **color** it with warm colors, hottest in the middle.

Corona · Photosphere (surface) · Convection zone · Radiative zone · Core

Not to scale. The core is about 27 million °F; the surface is about 10,000 °F.

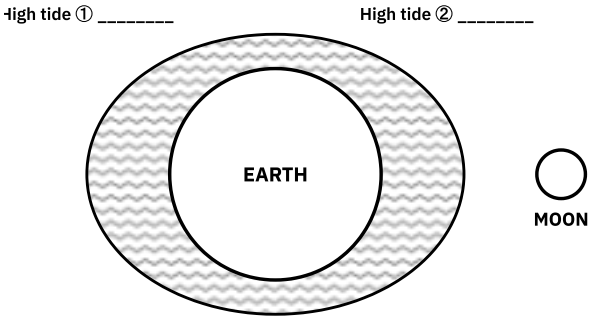
Sun math

1. How many Earths wide is the Sun? (864,000 ÷ 7,918 = _____) About _____ Earths.
2. Sunlight travels at 186,282 miles per second. The Sun is 93,000,000 miles away. How many seconds does its light take to reach us? _____ s ÷ 60 = about _____ minutes.
3. Moonlight really is sunlight bouncing off the Moon (238,855 miles away). How long does the light from the Moon take to reach us? _____ seconds
4. If the Sun disappeared right now, how long would we keep seeing it shine? _____ Explain: _____
5. **Temperature converter.** The Sun's surface is about 5,500 °C. In °F: 5,500 × 9 ÷ 5 + 32 = _____ °F. Its core is about 15,000,000 °C, which is about _____ °F.
6. The Sun has about 333,000 times the mass of Earth. If Earth weighed 1 pound, the Sun would weigh _____ pounds.

Fun fact: the Sun holds 99.8% of all the mass in the solar system.

Tides: Ocean Clock

★★ NAVIGATOR ★★★ COMMANDER



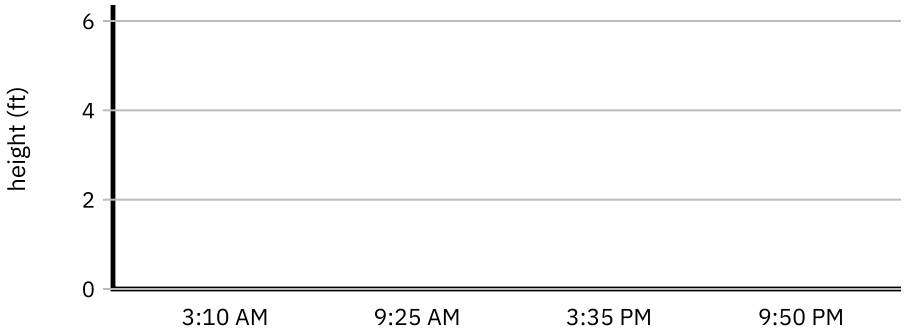
Not to scale. The Moon pulls the ocean toward it, and also a bulge on the far side.

The Moon's gravity pulls on Earth's oceans. Water bulges toward the Moon and on the opposite side, so most beaches have **two high tides** and **two low tides** each day. The Sun adds a smaller pull: when Sun, Earth and Moon line up (New or Full Moon), tides are strongest (**spring tides**); at the quarter moons they are weakest (**neap tides**).

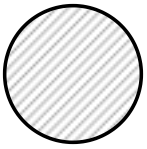
Read the tide table (sample beach)

Time	3:10 AM	9:25 AM	3:35 PM	9:50 PM
Tide	High	Low	High	Low
Height (ft)	5.8	0.6	5.5	0.9

1. How long is it from the first high tide to the second one? _____ (3:10 AM to 3:35 PM)
2. What is the tidal range (highest minus lowest)? _____ ft
3. Tides arrive about 50 minutes later each day. When will the first high tide be tomorrow? _____
4. Draw the four tide heights as bars below.



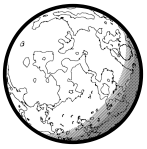
Strong or weak tides?



New Moon
spring / neap: _____



First Quarter
spring / neap: _____



Full Moon
spring / neap: _____



Last Quarter
spring / neap: _____

Shadow Clock Experiment ★★ NAVIGATOR

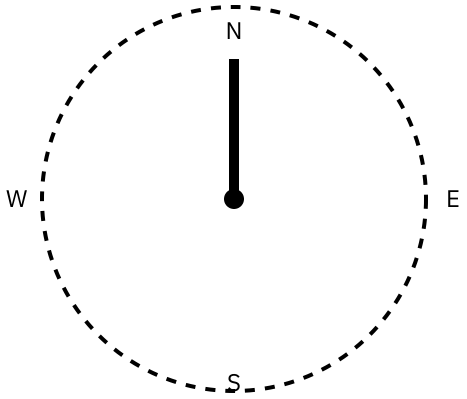
SAFETY Do this with an adult. **Never look directly at the Sun** : look only at the shadow on the ground.

You need

- A sunny day and a flat spot outside
- A straight stick or pencil in a lump of clay
- Chalk or tape
- A ruler and a watch

Do it

1. Stand the stick upright and mark its base.
2. Every hour, mark the tip of its shadow and measure its length.
3. Note the time next to each mark.



Draw each shadow here, with its time.

Time	9:00	10:00	11:00	12:00	1:00	2:00	3:00
Shadow length (in)							
Direction							

1. When was the shadow shortest? _____ The Sun was highest then, around **solar noon**.

2. Which way did the shadow move: from west to east, or east to west? _____ Why?

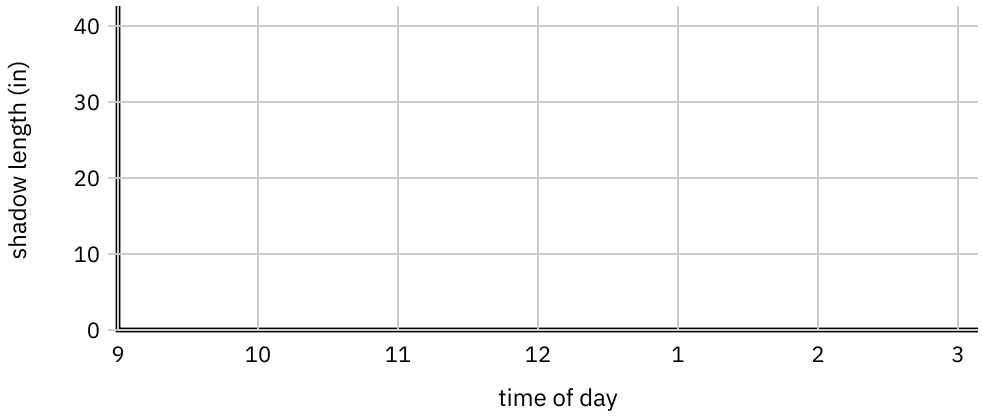
_____

_____

3. Make a graph of shadow length against time on a separate sheet. What shape do you get?

_____

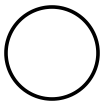
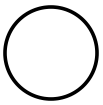
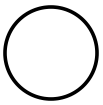
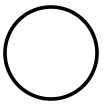
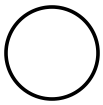
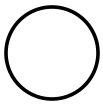
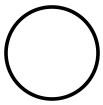
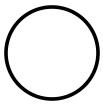
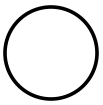
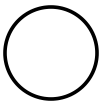
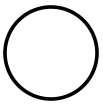
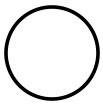
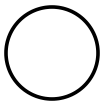
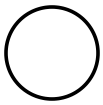
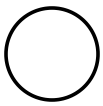
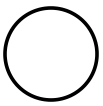
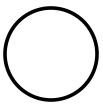
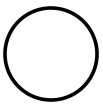
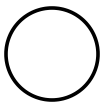
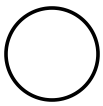
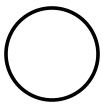
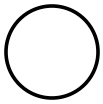
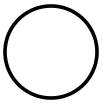
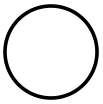
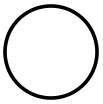
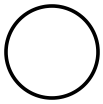
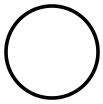
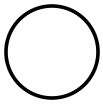
Graph your results



Safety: never look directly at the Sun.

My Moon Journal ★ EXPLORER ★★ NAVIGATOR

For 4 weeks, look at the Moon each evening (when you can see it). Shade the part you **cannot** see and write the date. Cloudy? Write “clouds”.

Day 1  Date: _____	**Day 2**  Date: _____	**Day 3**  Date: _____	**Day 4**  Date: _____	**Day 5**  Date: _____	**Day 6**  Date: _____	**Day 7**  Date: _____
Day 8  Date: _____	**Day 9**  Date: _____	**Day 10**  Date: _____	**Day 11**  Date: _____	**Day 12**  Date: _____	**Day 13**  Date: _____	**Day 14**  Date: _____
Day 15  Date: _____	**Day 16**  Date: _____	**Day 17**  Date: _____	**Day 18**  Date: _____	**Day 19**  Date: _____	**Day 20**  Date: _____	**Day 21**  Date: _____
Day 22  Date: _____	**Day 23**  Date: _____	**Day 24**  Date: _____	**Day 25**  Date: _____	**Day 26**  Date: _____	**Day 27**  Date: _____	**Day 28**  Date: _____

1. What pattern did you notice?

_____

2. Which phase did you see on day 1? _____ On day 15? _____

Logic Lab: Sudoku & the Great Coincidence

★ EXPLORER ★★★ COMMANDER

A · Sky sudoku ★

Each row, column and 2×2 box must have **Su** (Sun), **Mo** (Moon), **Ea** (Earth) and **St** (Star) once.

St	**Mo**		**Ea**
	Ea		
			Su
Ea		**Mo**	

B · The Great Coincidence ★★★

The Sun and the Moon look about the same size in our sky. Why? Let's compare numbers.

	Sun	Moon	Sun ÷ Moon
Width (mi)	864,000	2,159	_____
Distance from Earth (mi)	93,000,000	238,855	_____

1. The Sun is about _____ times wider than the Moon, and also about _____ times farther away.

2. Because the two numbers are almost equal, the Moon can just cover the Sun in a total solar eclipse. Do you think this is luck? Discuss.

_____

_____

C · Odd one out ★★

1. Sun · Moon · Earth · lamp (which one makes its own light?) → _____ because _____

2. spring · summer · tide · winter → _____ because _____

3. umbra · penumbra · phase · shadow → _____ because _____

3. Fun fact: the Moon moves away from Earth about 1.5 inches every year. In a billion years total eclipses will stop. Why? _____

Create · The Moon Legend ★ EXPLORER

Long ago, people made up stories to explain why the Moon changes shape. Write your own legend and illustrate it!

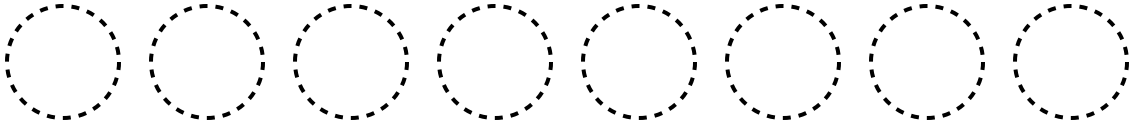
ILLUSTRATION

Title: _____

Write a Moon poem or song

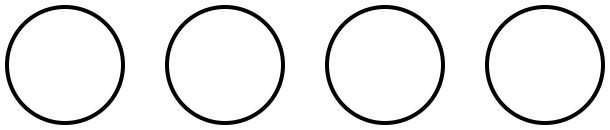
Design a Moon-phase mobile

Draw each phase on a paper circle, cut them out and hang them in order on a string.



Unit Review · Mission Check ★ EXPLORER ★★ NAVIGATOR ★★★ COMMANDER

1 **Draw** how the Moon looks at each phase (shade the dark part):



New First Quarter Full Last Quarter

2 **True or false?** Fix the false ones. a) Seasons happen because Earth is closer to the Sun in summer. T / F _____

b) A lunar eclipse happens at Full Moon. T / F _____

c) We always see the same side of the Moon. T / F _____

3 **Calculate.** It is 10:00 AM in Chicago. What time is it in Los Angeles? _____ How many degrees does Earth rotate in 5 hours? _____ °

4 **Read the table.** High tide at 4:00 AM (6.0 ft) and low tide at 10:15 AM (0.4 ft). The tidal range is _____ ft. About what time will the next high tide be? _____

5 **Explain.** Why is the Sun hot but the Moon only reflects light?

_____

_____

6 **Compare.** Write one way a solar eclipse and a lunar eclipse are the same and one way they are different.

_____

_____

8 **Match** each word to its meaning (write the letter). rotate ____ · revolve ____ · umbra ____ · tide ____

A. travel around another body · B. spin on an axis · C. the dark center of a shadow · D. the rise and fall of the ocean

7 **Predict.** How would seasons change if Earth's axis were not tilted at all?

_____

_____

Mission Log ★ EXPLORER

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

☐ I can name the eight Moon phases in order.

☐ I can explain why we have day and night.

☐ I can explain why we have seasons.

☐ I can tell a solar eclipse from a lunar eclipse.

☐ I can explain what causes tides.

☐ I can work out time differences between time zones.

☐ I can measure and graph shadow lengths.

☐ I can compare the Sun, Earth and Moon using numbers.

My favorite activity was

Something new I learned

A question I still have about space

UNIT 1
EARTH, MOON & SUN
★ ★ ★
MISSION COMPLETE

Signed: _____
Date: _____

The Space Workbook series

You have **Mission 1**. 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	**★ YOU ARE HERE**
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	☐
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	☐
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