Earth and Space Systems:
Earth, Orbits, Solar System, Patterns

A MySci Unit of Instructional Materials

unit 23

Our Place in the Universe

mySci™

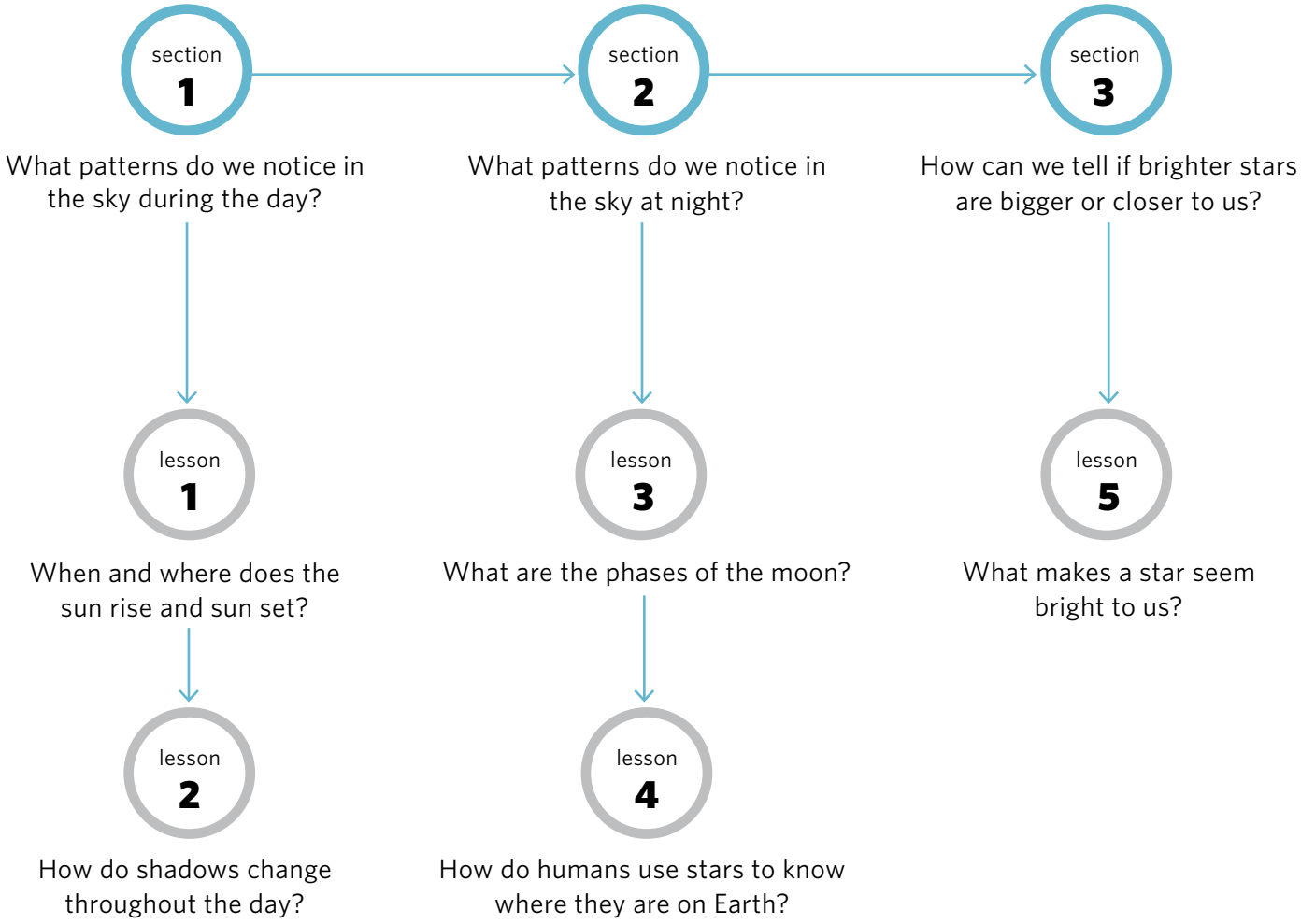
hands on science for elementary students

MySci Project-Based Curriculum Unit Structure

Unit 23

Our Place in the Universe (An Integrated Unit on Space Systems)

DESIGN CHALLENGE:
What do we need to know to determine if a model of the universe is accurate?



section 1

What Patterns Do We Notice in the Day Sky?

Lesson 1: When and where does the sun rise and set?

LEARNING TARGETS

- By observing sunrises and sunsets, humans can determine and predict the length of days and seasons.
- There are more hours of sunlight in the summer due to the tilt of the earth on its axis.

SUMMARY

The students explore sunrise/sunset charts to determine the length of daylight hour variation throughout the year, and its causes.

ENGAGE

Ask the class: *Can some of you tell me when your birthday is?* (Take a few responses.) *Who thinks their birthday has the potential for the most sunlight? Why? What do we have to know to find out the answer?* Have the students write the answer in their science journal. When they finish, have the students discuss their answer in a group, then have the group report to the class.

EXPLORE

Ask the class: *How could we find out exactly how much sun there was or will be on your birthday?* (Take several responses.) If no one suggests a sunrise/sunset chart, ask them of anyone has seen on the weather report when they announce the time of sunrise and set. Several weather sources have the times in a chart format on their websites. Here are two with midwest times:

Sunrise/Sunset Times http://www.timeanddate.com/worldclock/astronomy.html?n=64&month=1&year=2014&obj=sun&afl=-11&day=1

Sunrise/Sunset Charts http://www.almanac.com/astronomy/rise/NC/%252F2014-05-9

> ***Activity:*** Print out the sunrise/sunset chart from the internet and give them to the students. Have them find their birthday on it. Have the student find the time of sunrise and sunset on their day. Next have them find the number of hours they will have daylight, between sunrise and sunset. Have the students fill out the Birthday Sunlight Hours activity sheet (Appendix i).

MYSCI MATERIALS:

Birthday Sunlight Hours activity sheet

Sunrise or Sunset Pictures at My House Chart, copies

TEACHER PROVIDES:

Chart paper

Science journal

Computer with Internet access

Teaching Tip:

Look for similar answers, such as "the days are longer in the summer", "the sun shines more in the summer", etc.

Teaching Tip:

The chart is written in 24-hour clock time. The students will need to know that 1300=1:00pm, 1400=2:00pm, 1500=3:00pm, 1600=4:00pm, 1700=5:00pm, 1800=6:00pm, etc. For example, my birthday, Nov 19th, the sun rises at 7:06 and sets at 1701, or 5:01pm. I will get 9 hours and 54 minutes of sunshine.

EXPLAIN

Ask the class: *Who has the most hours of sunlight? How many? Who had the shortest? How does that compare with what you wrote earlier in your science notebook? Some of you said that the sun shines longer in the summer than the winter. Can you explain how that happens?*

> ***Activity:*** Have the students draw a picture in their science notebooks of how the position of the earth and sun affect the amount of sunlight. Watch:
>
> Why are there Seasons? https://www.youtube.com/watch?v=3eFqZWX8nTo
>
> Reason for Seasons https://www.youtube.com/watch?v=at2eKI_aLQk

ELABORATE

Ask the class: *Where does the sun rise and set? How could we find out?*

Print and pass out the Sunrise or Sunset Pictures at My House Chart (in Appendix ii). Students should take the chart home and keep track of the sunrise or sunset for one month.

EVALUATE

Have the students go back to their drawings and add details and labels: axis, equator, 23.5 degree tilt, sun, earth, sun rays, summer, winter, spring and fall, orbit.

Lesson 2: How do shadows change during the day?

LEARNING TARGET

The length and direction of shadows change during a day according to the position of the sun to the gnomon.

SUMMARY

The students make sundials and record the change in shadows during a school day.

ENGAGE

Ask the class: *Does anybody know what time it is? How do you know? How did people tell time before there were clocks?*

> ***Engineering Connection:*** Ask: *Has anyone heard of a sundial?* Watch the video on the history of sundials: What is a Sundial http://www.youtube.com/watch?v=tI0GqYJha1Q

EXPLORE

Tell the class: *We are going to make sundials, with a partner.* Here are the directions:

1. Make a gnomon pattern from the example. Refer to the latitude table to determine the correct angle to mark — 45˚ is marked as an example. Cut out the gnomon from this pattern.
2. Fold pattern along the dashed line so that the flaps A and B are on either side of the gnomon. These flaps will allow the gnomon to stand on its own.
3. Tape the gnomon to the middle of the paper plate. If the gnomon remains floppy, then tape a popsicle stick to it to provide support.

EXPLAIN

Discuss observations of shadow lengths. Questions might include:

How do shadow lengths change during the day? (The shadows show the sun's movement throughout the day.) *Why do they change?* (Same answer).

Is there a pattern to where the shadows fall and their lengths? (West to east, since the sun "moves" from east to west, shorter in the middle of the day) *Why is there a pattern?*

Is the Sun directly overhead at any time? (Only on the equator is the sun directly overhead, otherwise, it is a little north or south of directly overhead.)

Why is the shortest shadow around noon? (Sun is more directly overhead.)

EVALUATE

Pass out the Sun, Shadows and Earth Assessment (Appendix iv). Have the students fill it out, and then discuss answers.

MYSCI MATERIALS:

Gnomon template

Skewer

Cardstock

Labels

Compasses

Copies of the Sun, Shadows and Earth Assessment (Appendix iv)

Flashlights

TEACHER PROVIDES:

Science notebook

Computer with Internet access

Teaching Tip:

Start early in the morning. Place the sundial outdoors, with the gnomon pointing North. **(Some students might need a review on using a compass.)** Record the outline of the gnomon's shadow, stick a dot in the middle of the shadow, and record the time next to it. Repeat this process each hour.

section 2

What Patterns Do We Notice in the Night Sky?

Lesson 3: What are the phases of the moon?

LEARNING TARGET

The moon appears to have different phases, full, waning, waxing, quarter, crescent, and new due to its rotation around the Earth and sun.

SUMMARY

Students make models of the moon and its phases.

ENGAGE

Say to the class: *In the last lesson we talked about things we could see in the sky during the day. Now lets talk about the sky at night. What have we noticed?*

> ***Activity:*** Have the students work in groups to come up with lists of things they have seen in the night sky. Have each group give one word at a time, and write it on a chart. The next group has to give a different word.

EXPLORE

Ask the class: *Has anyone noticed what happens to the moon? How does it change during month? Why does it look different to us?*

> ***Activity:*** Pass out the skewers and balls, and flashlights to groups of students. Have them experiment with the materials to try and demonstrate the different phases of the moon. Have groups share with the class.

EXPLAIN

Watch Moon Phases https://www.youtube.com/watch?v=nXseTWTZlks then What is a Moon Phase? https://www.youtube.com/watch?v=79M2lSVZiY4

> ***Activity:*** Have the groups go back and try to represent the different phases using the skewers, balls and flashlights.

ELABORATE

Offer extra credit for any student who will follow the moon for one month. Tell them they will need to pick a spot in front or back of their house where they can see the moon, and draw the outline of the house or other nearby landmark nearby. Every evening at the same time (very important), they should draw where they see the moon and what it looks like. They should draw the moon phases on the same piece of paper.

EVALUATE

Download the moon chart for the current year from Astronomical Applications http://aa.usno.navy.mil/data/docs/RS_OneYear.php and copy.

MYSCI MATERIALS:

Skewers
Styrofoam balls
Moon Phase Chart strips
Flashlights
Black grease pencils
Observing Where the Sun Sets handout

TEACHER PROVIDES:

Science journal
Computer with Internet access

Teaching Tip:

Possible words include: stars, moon, comets, meteors, satellites, clouds rings around the moon, falling stars, jets, etc.

Assessment: Pass out the moon phase strips and the current moon chart to pairs of students. Have the students find a particular month. Have them fill out the moon phase strip.

1. Fill out the days of the month in the squares below the moons.
2. Using the moon chart for this year, first identify where the full moon and new moon fall on the moon strip.
3. Color the new moon in with a grease pencil. Then find the quarters and color them accordingly.
4. Then the students can make the crescent and moon shapes of the month.

Lesson 4: How do humans use stars to know where they are on Earth?

LEARNING TARGETS

- Certain stars and groups of stars are visible in the night sky at different times of the year and are dependent where you are on Earth.
- Using tools to measure the zenith and altitudes, humans learned how to recognize the patterns of stars.

SUMMARY

The students will explore how astronomers used sextants to observe the position of stars and constellations.

ENGAGE

Watch What is a Sextant? https://www.youtube.com/watch?v=QXeEAQtC75g

Discuss what it must have been like to have no lights, tv, or any other distractions besides looking at the night sky.

EXPLORE

In order to follow and map the stars, people developed a sextant. This tool allowed them to record where stars were at different times of the year, or in different places on earth.

> ***Activity:*** Pass out the materials and diagram for making the sextant. Have the students cut out the protractor to glue on the card stock and use the diagram for directions. Then have the students practice recording the angles of objects visible from the classroom windows or on the playground, such as trees, flag poles, rooftops etc. Have the students record the zenith and altitude angles and direction (using the compasses) of the outdoor objects.

EXPLAIN

Watch How to Navigate with a Sextant https://www.youtube.com/watch?v=snTZYKjBNPs and discuss how people navigated by the stars. Read *Star Gazers*.

ELABORATE

Have the students take their sextants home and record the angles and direction of the moon or a star with their sextants.

> ***Alternate Elaborating Activity:*** Using Websites on Women in Astronomy http://astro.berkeley.edu/~gmarcy/women/history.html, have students research women and people of color who were/are astronomers or astronauts.

EVALUATE

Pick out objects in the schoolyard such as a tall tree or flagpole, or the edge of the building. Give the students the altitudes of those objects and have them find the spot in the schoolyard where those measurements were taken.

MYSCI MATERIALS:

Star Gazers, by Gail Gibbons

Sextant materials

Sextant diagram

Protractor diagram

Compasses

TEACHER PROVIDES:

Science notebooks

Computer with Internet access

Warning:

Do not let the students look at the sun through their sextants! It could damage their eyes.

Teaching Tip:

To use the sextant, make sure the string is hanging on the left side of the straw. Make your sextant read at a 45-degree angle. Make your sextant read at a 90-degree angle. Now look at something far away, just the top of it, like a tree or a flagpole. Have your partner read what angle the string is hanging down by and record.

section 3

How Can We Tell if Brighter Stars are Bigger or Closer to Us?

Lesson 5: What makes a star seem bright to us?

LEARNING TARGET

Star brightness is not necessarily connected to their distance from Earth; the size and intensity of its mass also determines its brightness.

SUMMARY

The students explore the relationships between distance and brightness of stars using models.

ENGAGE

Ask the class: W*hy do some stars look brighter than others in the night sky? Explain your thinking*. Students write thoughts in their notebooks. Share out with class.

EXPLORE

Ask the class: *Is bigger brighter?*

> ***Activity:*** Complete and discuss *Page Keeley Probe, Uncovering Student Ideas in Science 'Which is Bigger?* page 199

EXPLAIN

Ask the class: *Can the brightness of a star tell us about its distance from Earth? Explain your thinking*. Students write thoughts in their notebooks. Share out with class.

> ***Learning Target:*** Tell the class: *The thing we notice first about stars is that some look brighter or dimmer. You might think the brighter ones are closer to us and the dimmer ones are further away from us. Astronomers have learned that stars vary a lot in the energy, and therefore the amount of light, they produce.*

This is a simple demonstration activity to prove that the apparent brightness of a star cannot be used to judge its distance from Earth.

1. Place the small flashlight on a desk or table near the front of the room.
2. Place the large flashlight on a desk or table near the back of the room.
3. Have the students gather at the front of the room so they can all see both flashlights easily.
4. Turn on both flashlights.
5. Darken the room.
6. Observe and compare the apparent brightness of the two flashlights.
7. Move the two flashlights back and forth until they both appear to have the same brightness.

MYSCI MATERIALS:

2 flashlights (1 large and 1 small)

Batteries

Black construction paper (8x11-30 sheets)

White colored crayons

Analyzing the Star Chart

Page Keeley Probe, Uncovering Student Ideas in Science 'Which is Bigger? page 199

TEACHER PROVIDES:

Notebook/journal

Additional colored pencils

Computer with Internet access

Ask the class: *If you didn't know which flashlight was which, would you be able to tell which one produced the most light?*

> ***Learning Target:*** Take several student's thoughts about using brightness to determine distance before going into the following discourse:
>
> *This is one of the most fundamental questions about the stars. Is it bright because it is close, or is it bright because it is intrinsically bright? This is why astronomers must know the distance to a star. Without knowing the distance, it's hard to get meaningful information about the other properties of the star. Some stars look bright because they are very near the Sun. Others look equally bright but are many times further away from the Sun. These more distant stars are extraordinarily bright. Without knowing the distance it's impossible to distinguish between the two.*

The two flashlights can be compared to the stars Sirius and Rigel. Sirius is about twice as bright as Rigel, but Rigel is almost 100 times further away than Sirius. Sirius is about 27 times as powerful as the Sun, but Rigel has the power of many thousands of Suns. Sirius looks very bright because it is close. If Rigel were as close as Sirius it would be blindingly bright.

ELABORATE

Ask the class: *Does the temperature of stars have anything to do with their brightness?* Students write thoughts in their notebooks. Share out with class.

EVALUATE

Pass out the Star brightness charts.

Instruct the students: *Look at this star chart, then discuss it with a shoulder partner. Fill out the Diagram on the second page. What does this diagram tell you and what does it not tell you?* Discuss as a class.

Ask: *Thinking about the information from the star chart, if you were to create your own constellation how would you represent star distance in a drawing?* Students write thoughts in their notebooks. Students will use the black construction paper to create their constellations.

> ***Assessment:*** The student will create a constellation with a minimum of 5 stars (and name their stars) no two stars can be at the same distance. They must create their stars by incorporating various brightness levels of stars that represent how far away they are from Earth. Students will present their constellations to the class pointing out star names and their distances from Earth and how they decided the distance from Earth.
>
> Students will use Hertzsprung Russell Diagram to complete the worksheet, in Appendix vii.

Teaching Tip:

Website for teacher information on constellations and great websites for students: Good Sites for Kids: Astronomy http://www.goodsitesforkids.org/Astronomy.htm

For additional information on using the flashlights to show star brightness: Star Luminosity http://www.education.com/science-fair/article/demonstrate-stars-luminosity-brightness/

Standards

	NGSS	GLEs
Content	**5-PS2-1.** *Support an argument that the gravitational force exerted by Earth on objects is directed down.* **5-ESS1-1.** *Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from Earth.* **5-ESS1-2.** *Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.* **PS2.B. Types of Interactions** *The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center. (5-PS2-1)* **ESS1.A. The Universe and its Stars** *The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth. (5-ESS1-1)* **ESS1.B. Earth and the Solar System** *The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. (5-ESS1-2)*	**Strand Six: Composition and Structure of the Universe and Objects Within it** *1. The universe has observable properties and structure* *A. The Earth, Sun, and Moon are part of a larger system that includes other planets and smaller celestial bodies* *a. Observe and identify the Earth is one of several planets within a solar system that orbits the Sun* *b. Observe and identify the Moon orbits the Earth in about a month* *Identify that planets look like stars and appear to move across the sky among the stars* *B. The Earth has a composition and location suitable to sustain life* *Describe physical features of the planet Earth that allows life to exist (e.g., air, water, temperature) and compare these to the physical features of the Sun, the Moon, and other planets* *2. Regular and predictable motions of objects in the universe can be described and explained as the result of gravitational forces* *B. The apparent position of the moon, as seen from Earth, and its actual position relative to Earth change in observable patterns* *Sequence images of the lit portion of the Moon seen from Earth as it cycles day-to-day in about a month in order of occurrence* *C. The regular and predictable motions of the Earth and Moon relative to the Sun explain natural phenomena on Earth, such as day, month, year, shadows, moon phases, eclipses, tides, and seasons* *a. Identify that the Earth rotates once every 24 hours* *b. Relate changes in the length and position of a shadow to the time of day and apparent position of the Sun in the sky, as determined by Earth's rotation* *c. Relate the apparent motion of the Sun, Moon, and stars in the sky to the rotation of the Earth*
Applied Engineering, Technology and Science Practices	**Patterns** *Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena. (5-ESS1-2)* **Cause and Effect** *Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1)* **Scale, Proportion, and Quantity** *Natural objects exist from the very small to the immensely large. (5-ESS1-1)* *Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. (5-ESS1-2)* *Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3)* *Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem. (3-5-ETS1-2)*	**Strand Seven: Scientific Inquiry** *1. Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking* *B. Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations* *a. Make qualitative observations using the five senses* *b. Determine the appropriate tools and techniques to collect data* *c. Use a variety of tools and equipment to gather data (e.g., hand lenses, magnets, thermometers, metric rulers, balances, graduated cylinders, spring scales)* *d. Measure length to the nearest centimeter, mass to the nearest gram, volume to the nearest milliliter, temperature to the nearest degree Celsius, force/weight to the nearest Newton* *e. Compare amounts/measurements* *f. Judge whether measurements and computation of quantities are reasonable*

Standards *continued*

	NGSS	GLEs
Applied Engineering, Technology and Science Practices		**Strand Seven: Scientific Inquiry *continued*** *C. Scientific inquiry includes evaluation of explanations (laws/principles, theories/models) in light of evidence (data) and scientific principles (understandings)* *a. Use quantitative and qualitative data as support for reasonable explanations* *b. Use data as support for observed patterns and relationships, and to make predictions to be tested* *c. Evaluate the reasonableness of an explanation* *Analyze whether evidence supports proposed explanations* *D. The nature of science relies upon communication of results and justification of explanations* *a. Communicate the procedures and results of investigations and explanations through:* • *oral presentations* • *drawings and maps* • *data tables* • *graphs (bar, single line, pictograph)* • *writings* **Strand Eight: Science, Technology, & Human Activity** *2. Historical and cultural perspectives of scientific explanations help to improve understanding of the nature of science and how science knowledge and technology evolve over time* *A. People of different gender and ethnicity have contributed to scientific discoveries and the invention of technological innovations* *a. Research biographical information about various scientists and inventors from different gender and ethnic backgrounds, and describe how their work contributed to science and technology*

STEM CONNECTIONS

Engaging All Learners
- *Invite students to discuss experiences they have had studying the sky*
- *Introduce men and women, young and old, who have explored the solar system, studied astronomy, gone to space (Neil deGrasse Tyson)*

Career Connections
- *Invite ideas about what astronomers think about and study when designing equipment for living in space*

STEM Capable Learning
- *Affirm student observations (as scientists)*
- *Affirm student use of relevant vocabulary*
- *Affirm design ideas about studying the universe*

Birthday/Sunlight Hours

Section 1, Lesson 1

Name: _____ **Date:** _____

When is your birthday? _____

1. Does your birthday usually have a lot of daylight? Yes No

2. Explain why you chose "yes" or "no".

_____

_____

_____

_____

3. What season is your birthday? _____

(After the Explaining and Elaborating Question Discussions)

4. Do you still agree with your answer to number 1? Why or why not?

_____

_____

_____

_____

5. Why does the length of daylight change throughout the year?

_____

_____

_____

_____

Draw an illustration explaining number 5 on the back of this paper.

Sunrise or Sunset Pictures at My House

Section 1, Lesson 1

Name: _____ **Date:** _____

Pick one spot at your house where you can see the sunrise or set. Draw an outline of what you see, like the rooftop or trees. Every day at sunrise or sunset, draw where you see the sun, in relation to the rooftop or trees.

TIME:	**TIME:**	**TIME:**	**TIME:**	**TIME:**
TIME:	**TIME:**	**TIME:**	**TIME:**	**TIME:**
TIME:	**TIME:**	**TIME:**	**TIME:**	**TIME:**
TIME:	**TIME:**	**TIME:**	**TIME:**	**TIME:**

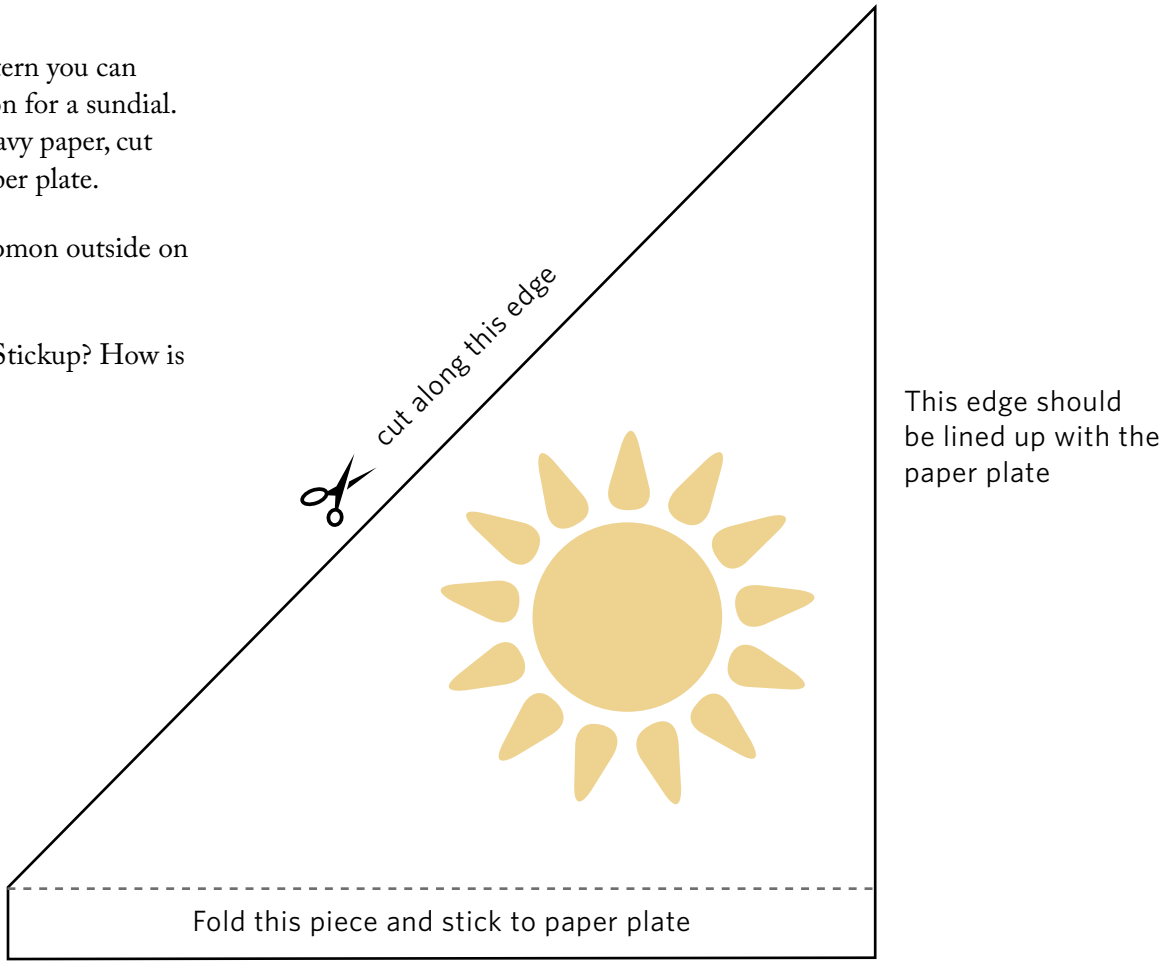
A Sample Design For a Sundial

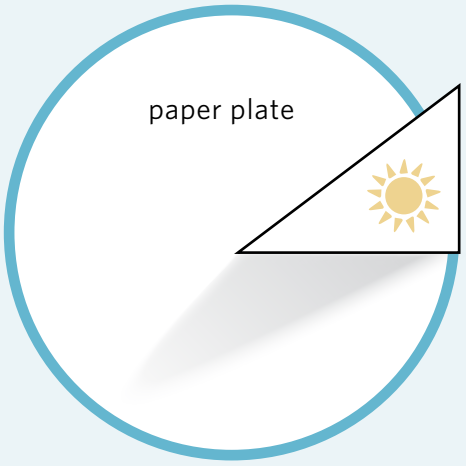
Section 1, Lesson 2

On the right is a pattern you can use to make a gnomon for a sundial. Just photocopy to heavy paper, cut out, and tape to a paper plate.

Plan to take your gnomon outside on the next sunny day.

How is this like the Stickup? How is it different?





south →

Aim your gnomon towards the south. Soon, you will be able to see the shadow cast by the gnomon onto the paper plate. Mark every hour and you will have made a sundial!

Sun, Shadows and Earth Assessment

Section 1, Lesson 2

Name: _____ **Date:** _____

1. The apparent motion of the Sun is that it rises in the _____ and sets in the _____ .

A. north, south

B. east, west

C. west, east

D. south, north

2. Why does the Sun appear to move across the sky each day?

A. The Sun is orbiting the Earth.

B. The Earth is orbiting the Sun.

C. The Sun is rotating on its axis.

D. The Earth is rotating on its axis.

3. The Earth's rotation on its axis takes _____ .

A. 1 day

B. 1 week

4. Earth's revolution takes about _____ .

A. 365 days

B. six months

5. The imaginary straight line drawn through the earth around which the earth rotates is the *(fill in the blank)*

_____ .

6. At which of the following times will a shadow be shortest?

A. 8:00 AM

B. Noon

C. 10:00 AM

D. 2:00 PM

7. How long would a complete day (including daytime and nighttime) on Earth be if it did not spin on its axis?

A. 24 hours

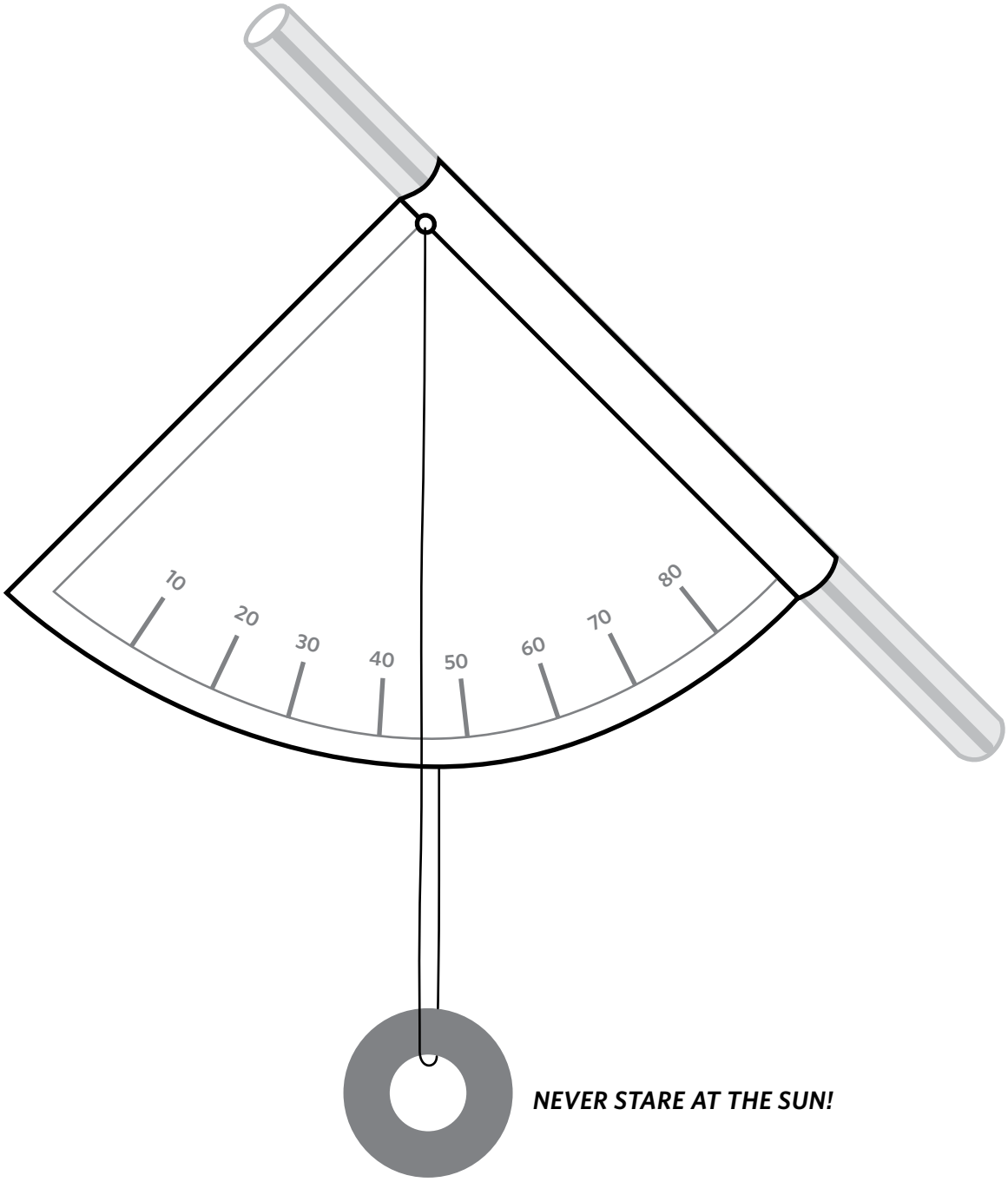
B. 1 month

C. 3 months

D. 1 year

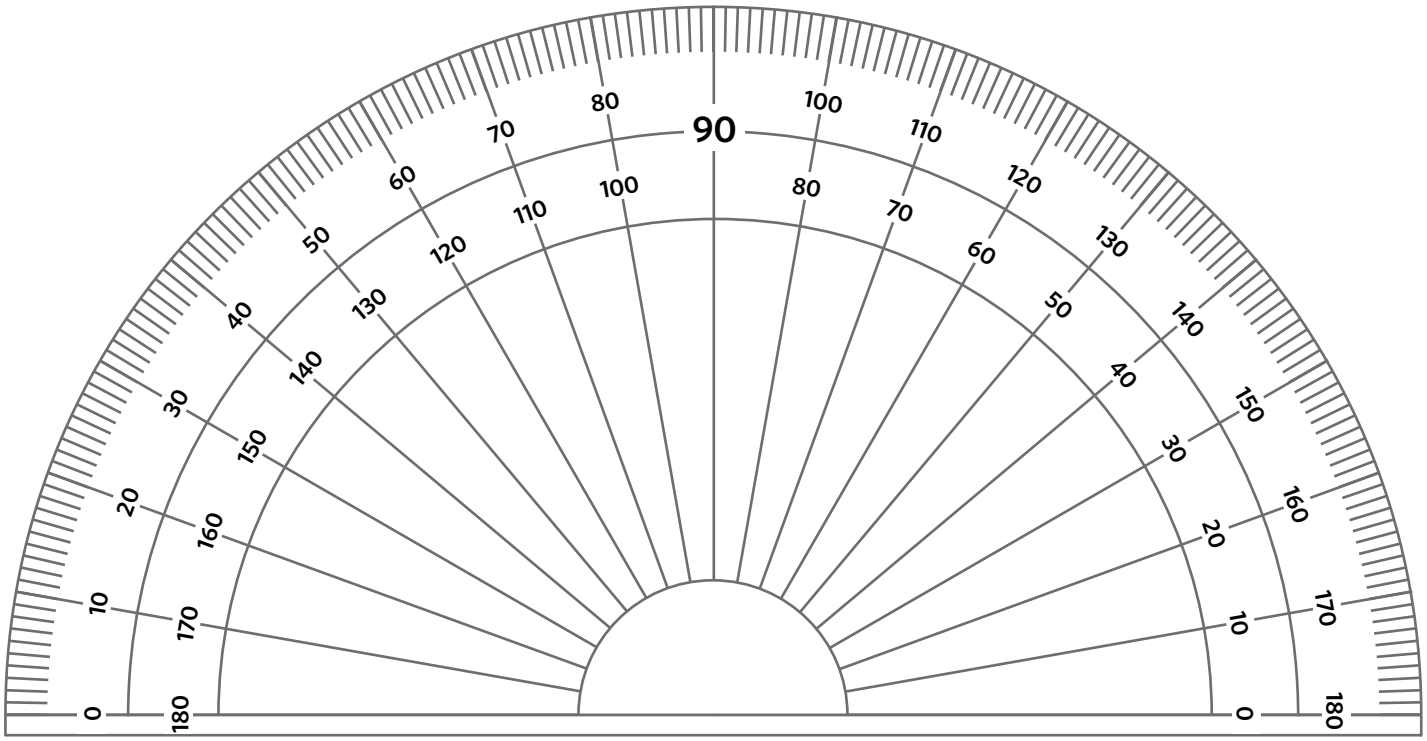
Sextant Diagram

Section 2, Lesson 4



Protractor Diagram

Section 2, Lesson 4



Analyzing the Star Chart

Section 3, Lesson 5

Name: _____ **Date:** _____

STAR NAME	COLOR	APPARENT BRIGHTNESS (The lower the number, the brighter the object)	TEMPERATURE IN KELVINS	LUMINOSITY (Times brighter than the sun)
SUN	white	-26.74	5,778	1
SIRIUS	white	-1.46	10,300	25
ALDEBARAN	orange	+.87	4,000	500
BETELGEUSE	orange-red	+.50	3,650	7,500
POLARIS	white	+1.97	6,015	2.200
ARCTURUS	orange	-.04	4,290	150
RIGEL	blue	+.38	11,000	120,000

Can you put the stars from the Star Chart on this graph? Draw them where you think they go and then color them.