Stackable Instructionally-embedded Portable Science (SIPS) Assessments Project

Grade 5 Science
Unit 4 Sample Lesson "How Does My Constellation Move?"
Earth and Its Gravitational Force and Motion
September 2023

Unit 4: Earth and Its Gravitational Force and Motion
Sample Lesson: How Does My Constellation Move?
Suggested Time to Complete: 75 minutes

Purpose & Use Statement: This sample lesson was developed for state and local administrators and teacher leaders (e.g., curriculum directors, instructional facilitators, professional learning specialists) to (1) illustrate an example of an instructional lesson developed using a principled design approach, and (2) support accompanying process documentation about how to use the SIPS unit as an instructional framework to intentionally design high-quality lessons in an aligned curriculum, instruction, and assessment system. This sample lesson should be evaluated and refined, as necessary, to align appropriately with a standards-based curriculum, instruction, and assessment system prior to its use. Additionally, teachers should refine this lesson to meet the local, cultural, and individual needs of the students.

Desired Results

Overview of the Learning Goals

Students utilize a model of the Earth's sky to gather data on the visibility and position of constellations at their home location which they analyze and interpret to determine if some constellations are visible throughout the year. Students utilize this evidence to support an argument on why some constellations are visible at a location only at some part of the year.

Connections to Prior Learning

DCI

Prior Learning from K-2 (from NGSS Appendix E: DCI Progression within NGSS; pg. 7)

- When objects touch or collide, they push on one another and can change motion or shape.

- Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted. At night one can see the light coming from many stars with the naked eye, but telescopes make it possible to see many more and to observe them and the moon and planets in greater detail.

- Seasonal patterns of sunrise and sunset can be observed, described, and predicted.

Prior learning from this grade band (e.g., Grades 3 & 4):

o   Minimal/Not Applicable

CCC – Systems and System Models

- **Prior learning from K-2:** Students develop experience describing organisms (and other systems) in terms of their parts and considering how the parts work together to achieve a desirable goal for the organism (or system). [Appendix G]

  o   In K-ESS3-1, students work with modeling a system in which multiple plants and animals live in the same area and can satisfy their needs.

- **Prior learning from this grade band (e.g., Grades 3 & 4):** Students continue developing experience with considering systems in terms of their parts, with an additional emphasis on the idea that some behaviors of the system are enabled by the functioning of multiple parts working together. [Appendix G]

  o   In 3-LS4-4, students work with the idea that the plants and animals living in an ecosystem may be affected when the environment changes. In 4-LS1-1, students interrogate the functioning of plants (and/or animals) in terms of the organisms' structures that enable the activity of the larger system (i.e., the organism).

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CCC – Patterns

- **Prior learning from K-2** children recognize that patterns in both models and their natural world can be observed and used as evidence as they explore phenomena. [Appendix G]
  - In 1-ESS1-1, students use observations of the sun, moon, and stars to describe patterns that can be predicted.
- **Prior learning from this grade band (e.g., Grades 3 & 4):** Students continue to develop their understanding of patterns as they compare, contrast, sort, classify, and eventually make predictions based on their understanding of models and their natural world. [Appendix G]
  - In 4-PS4-1, students develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.

SEP- Developing and Using Models

- **Prior learning from K-2:** Students develop a basic understanding of a model as a representation of the thing (e.g., an object, event, or process), rather than the thing itself. They also gain experience in comparing and developing different models. [Appendix G]
  - Two PEs (K-ESS3-1 and 2-ESS2-2) are focused on using or developing to understand more about the Earth.
- **Prior learning from this grade band (e.g., Grades 3 & 4)**: Students continue developing their modeling skills and abilities by developing and revising different types of models, along with beginning to consider that models can have limitations. [Appendix G]
  - Three PEs (5-ESS2-1 and 5-PS3-1) focus on developing models to learn more about the Earth and/or the sun.

SEP- Analyzing and Interpreting Data

- **Prior learning from K-2:** Students use observations (firsthand or from media) to describe patterns and/or relationships in the natural and designed world(s) to answer scientific questions and solve problems. [Appendix F]
  - One PE (K-ESS2-2) focuses on constructing an argument to understand more about human impacts on the Earth.
- **Prior learning from this grade band (e.g., Grades 3 & 4):** Students continue analyzing and interpreting data to make sense of phenomena, using logical reasoning, mathematics, and/or computation. [Appendix F]
  - Two PEs (3-LS4-4 and 3-ESS3-1) focus on making claims about changes related to understanding Earth.

Key Vocabulary

Students build conceptual meaning with and use key tier II and tier III vocabulary terms as they make sense of phenomena and phenomena-based design problems. This is not an exhaustive list of terms, and should be reviewed and modified by educators, as appropriate.

- Celestial sphere
- Horizon
- Revolution

- Constellation
- Moon
- Rotation

- Cycle
- Orbit

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Targeted Stage 1 Learning Goals

Acquisition Goals (AG)

A17: Analyze and interpret data on the visible constellations at a location to determine if some constellations are visible throughout the year
A18: Engage in argument from evidence on why some constellations are visible at a location only at some part of the year

Common Core State Standards (CCSS):

W.5.1	MP.4
5.G.A.2	

Enduring Understandings (EU)/ Essential Questions (EQ):

EU2/EQ2	EU3/EQ3
EU4/EQ4	

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
☒ Analyze & Interpret Data ☐ Ask Questions ☐ Construct Explanations ☐ Define Problems ☐ Design Solutions ☒ Develop & Use Models ☐ Engage in Argument from Evidence ☐ Mathematics & Computational Thinking ☐ Obtain, Evaluate, & Communicate Information ☐ Plan & Carry Out Investigations	☒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)	☐ Cause & Effect ☐ Energy & Matter ☒ Patterns ☐ Scale, Proportion, & Quantity ☐ Stability & Change ☐ Structure & Function ☒ Systems & System Models

⌖ **Formative Assessment Opportunities**

Monitoring	Success Criteria	Possible Instructional Adjustments
• As students share their thinking around models and modeling, the teacher should listen for students' understanding of what a model is, what a model is not, the limitations of models, and ideas on how a model simplifies the real world. • Observe students' abilities to make observations and document the position of astronomical objects as they create sky charts that show movement over time.	Students can: • Identify similarities and differences between a model and the real world. • Analyze and interpret astronomical data through the creation of sky charts. • Identify patterns of stellar motion from analysis of star charts. • Make observations while revolving around an object and connect those observations with real-world phenomena.	• Utilize scaffolding questions to chunk the differences and similarities between the model and the real-world and direct student focus to key characteristics. • Provide alternative instructions using screen captures and large print to support students using Stellarium. • Place students in heterogeneous groups to provide advanced students the opportunity to teach and share their knowledge

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- Listen as students discuss their thinking to the analysis questions.

- Observe and listen as students identify patterns within data and make connections between the patterns, other real-world phenomenon, and their own sun-Earth model.

- Review annotated drawings to check for student understanding of how position impacts what is observed and for connections to real-world phenomena.

- Describe patterns in data to determine if some constellations are visible throughout the year.

- Represent data about the visibility of constellations to determine if some constellations are visible throughout the year.

- Use data to support conclusions about whether or not some constellations are visible throughout the year.

and to provide additional support for students who need scaffolds.

- Reduce instructions and guidance for advanced students.

- Encourage motivated and advanced students to gather real-world data using sextants.

- Provide students with a poster or representation of what needs to be included in an annotated drawing.

Instructional Plan

Lesson Overview

In this lesson, students conduct an investigation to gather data about how their stars move in the sky over an evening, a month, and several years. Students plot the location of their constellation on maps of the sky and analyze these maps to find patterns in how the stars move about but return to the same location. After gathering this data, students use a model of the sun-Earth system, with the students being the Earth, to model the movement of the Earth around the sun to see how the Earth's revolution impacts what we see in the night sky. Students record all of this evidence in their scientific notebook to use to support their design of a sun-Earth model.

Materials & Set-Up

- Digital device with access to the internet and the ability to open Stellarium.org.

- Basketball or another large round object.

Handouts: *Tracking Your Constellation Over a Day* (*Appendix A*)

Anchor or Investigative Phenomenon: In *Does Spinning Explain Why My Constellation Moves?,* students found evidence that constellations rotate about the sky, but that they also move, with some disappearing altogether only to reappear later in the year. But, this movement isn't explained by the rotating Earth.

Driving Question: Why do constellations move across the sky and sometimes disappear only to reappear later?

	Teacher Does	Students Do

Engage

☑ Introduce object, event, phenomenon, problem, or question

☑ Build background knowledge

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☑ Facilitate connections

Explore

☑ Explore object, event, phenomenon, problem, or question
☑ Guided exploration with hands-on activities

The teacher opens class with the question, "We saw that our constellation moves around the sky. How can we find out if there is a pattern to how it moves?" The teacher encourages students to record their thinking in their notebooks before turning and talking about their thinking as a class. If time allows, the teacher encourages students to share their ideas on what we might do.

The teacher shares with students that instead of going outside every night for the next several years to answer this question, they are going to use the online tool Stellarium to gather and advance time quickly. The teacher introduces the lesson as follows, "Stellarium is a model. That means that it is close, but not quite the same as real life. How is it not quite like the real world?" Some possible ideas and answers that students can give are: You can "turn off" the sun/sky. You can fast forward or go backward. There are no clouds. There isn't light pollution from the ground. New satellites that haven't been launched and are not part of the app when we look into the future.

The teacher encourages students to share their thinking and to recognize that this model, like all models, does have some limitations, but it

Students record their thinking about how they could investigate finding patterns in the movement of stars. They turn and talk with a peer about their ideas before sharing with the class and having a brief discussion.

Students use a device with internet access to use the digital planetarium simulator Stellarium. As a class, students discuss how a model like Stellarium is both similar to and different from the real world.

🎯 Students observe the teacher as they model how to use Stellarium to track an object over time and how to plot the position of that object using a blank sky chart. Students follow along and chart the motion of the teacher selected object on their own sheet.

🎯 Working in small groups or pairs, students use Stellarium to track the movement of a star in their constellation over the course of one night, one month, and five years. As students plot their points on their one-day map, they label each point with a time. As they plot their points on their one-month map, they label each point with a date. As they plot their five-year map, they label each point with a month and year.

🎯 After completing their plots, students answer the analysis questions that are

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can provide us with a lot of information that we wouldn't otherwise be able to find.

At this point in the unit, it is likely that most students have used Stellarium. However, some may not be familiar with it and may need support in finding and using the tools. The teacher may need to modify this section of the lesson to support students using Stellarium's time/date tool, the atmosphere tool, moving the view of the sky, and highlighting particular stars for easy tracking.

It is likely that students are not familiar with the azimuthal grid tool (instead of the equatorial grid tool, note students do not need to know the projection type, azimuthal, as part of this. To keep the language simple, the teacher may want to call the blank azimuthal charts "Sky charts." The use of the azimuthal grid on Stellarium helps students by drawing skylines based on their current location, allowing them to track the movement relative to their personal observation point.). The teacher passes out to students a copy of Blank Sky Chart or uses the resources in *Appendix A*. Students look at the chart and then look at the azimuthal grid on Stellarium. Students need to use this tool as part of the data gathering. Using the moon or other large object as an example, the teacher demonstrates to students how to turn on the grid, how to select an object

included in the handout and discuss as a class what their data shows and what they think it might mean.

Following the class discussion, students go outside to a large open area where the teacher has drawn a large circle on the ground. Students stand in the circle and turn their back to the center, drawing what they see in front of them. They move ¼ of the way around the circle and again, turn away from the center and draw what they see in front of them. Students repeat this process three more times so they have a total of 5 drawings with the first and last both occurring at the same spot on the circle.

Students examine their drawings and discuss what they think it might mean and how it might inform their sun-Earth model. Students record evidence they think will help improve their model in their scientific notebooks.

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that is part of their constellation, and how to plot a star on their blank sky chart. The class models tracking the moon by marking dots to represent the location on the sky chart.

Students work in small groups or pairs to create sky maps that show how one star in their constellation moves around the sky for each hour for one 12-hour period, each night at the same time for one month, and on the first of the month at midnight for five years. As students plot their points on the map, they label each point and draw connecting lines to show how the dots connect. Students do not need to be perfect with the location of their stars in the sky but should try and be as close as possible. For example, if the star is near a corner, students should draw it near a corner and not in the center of the box.

After students have completed the data collection and answered the questions, the teacher facilitates a class discussion about the evidence they found and how that connects to their sun-Earth model.

Next, the teacher draws a large circle in a large open space, large enough for everyone in the class to stand on. The teacher places a basketball or other large round object in the center. The teacher explains to students that this is another

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model and the ball is in the center to represent the sun. Each student represents the Earth. The teacher asks students, "If we were observing the night sky, how should we be facing - towards or away from the sun?" Students turn away from the "sun" and face out, then place their hands around their eyes so their view is limited. Then, students draw a picture of what they see in front of them. Students turn slowly in a circle three times, then face away from the sun again. Students hold their hands around their eyes again and then draw a picture again of what they see. The teacher asks students, "Is what you see the same or different, and why do you think that is?"

Next, students walk around in the circle, about ¼ of the way around. Students turn away from the sun, cup their hands over their eyes, and observe what they see now. Then, students draw what they see. The teacher repeats these three more times so that the last observation is at the same place as the first.

The teacher provides students with time to look at their drawings and consider what they notice. Did the drawings change? Why did the drawings change? How do the first and last drawings compare?

The teacher returns to the classroom and facilitates a class discussion about the evidence

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collected during these investigations. Students observe that the night sky changes over a year and that the constellations return to the same location. Students also observe that as they revolve around the sun their view changes, and it was the same when they returned to the same spot. Students record this evidence as part of their scientific notebooks or journals.

Explain

☑ Explain understanding of concepts and processes

☑ Introduce new concepts and skills to seek conceptual clarity

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Closing

The teacher asks students to create an annotated drawing of what occurred when they walked around the circle. Students use labels, arrows, and other representations to create a visual of the investigation and add a caption that helps to explain what occurred and why.

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Differentiation Strategies and Resources

"Universal Design for Learning (UDL) is a framework to improve and optimize teaching and learning for all people based on scientific insights into how humans learn" (CAST, 2022). Taking time to reflect on prior instruction when planning for accessible, differentiated, and culturally responsive instruction for diverse learners and culturally diverse classrooms serves to identify ways to improve future instructional practices. The UDL Guidelines provide a framework for this reflection. The guidelines include three principles as ways to focus on variety and flexibility in instructional practices:

Multiple Means of Engagement

Multiple Means of Representation

Multiple Means of Action & Expression

By examining instruction and instructional materials through the lens of each of these principles, teachers can identify and thus reduce or remove barriers to diverse learners.

Learning Opportunities	UDL Principle	Example Differentiation Strategies & Resources
Explore		

Students look at a model tool and discuss how it is similar and different from real life.		• Provide different levels of support and scaffolds.
		  ○ Use focused questions to support students by drawing attention to types of similarities and differences between Stellarium and the real world.
		• Encourage collaborations with partners and in groups.
		  ○ Utilize peer discussion strategies to encourage students to talk with their group about the similarities and differences between the model and real life before sharing with the full class such as turn and talk.

Students gather, analyze, and interpret astronomical data on the position of a star in the sky over short, medium, and long time periods.		• Present clear and important goals and objectives.
		  ○ Make clear the purpose of the activities is to gather evidence to improve and support their sun-Earth model.
		  ○ Use question strategies to encourage student analysis as they gather astronomical data.

		• Explain how students should present their astronomical data and how to choose which structure best fits their data in the form of graphs, charts, diagrams, models, etc. ○ Model for students how to observe the position of an astronomical object and how to plot those observations in a sky chart over time. • Emphasize key information.

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		o After class discussion identify key takeaways from the data collected over short, medium, and long periods of time, and have students record them in their scientific notebooks.

Students model the motion of the earth around the sun and make observations to support the claim that the revolution of the earth around the sun causes the stars in the night sky to appear to move.		• Emphasize key information.
		  o Pose questions to students to scaffold them toward making connections between their changing observations and the changing observations of the night sky.
		• Provide models and scaffolds to aid in comprehension.
		  o Provide students with a model annotated drawing or a poster with information about what should be included in an annotated drawing.

Resources

- Stellarium

  [https://stellarium-web.org]

- MatchCard Science: Blank Sky Chart & Sextant

  [https://www.learn4yourlife.com/support-files/8astronomycskychartsextant.pdf]

- Wikimedia Commons: Polar Chart

  [https://upload.wikimedia.org/wikipedia/commons/1/14/Polar_chart-azimuthal_ortho_proj-blank.png]

Core Text Connections

- NASA Space Place: What Are Constellations?

  [https://spaceplace.nasa.gov/constellations/en/]

- Lunar and Planetary Institute: About Constellations

  [https://www.lpi.usra.edu/education/skytellers/constellations/]

Appendix A:

Tracking Our Stars Across the Sky

Tracking the Moon

Use the chart below to track the movement of the moon, following along with your teacher as they model how to use Stellarium and how to plot points on a sky chart.
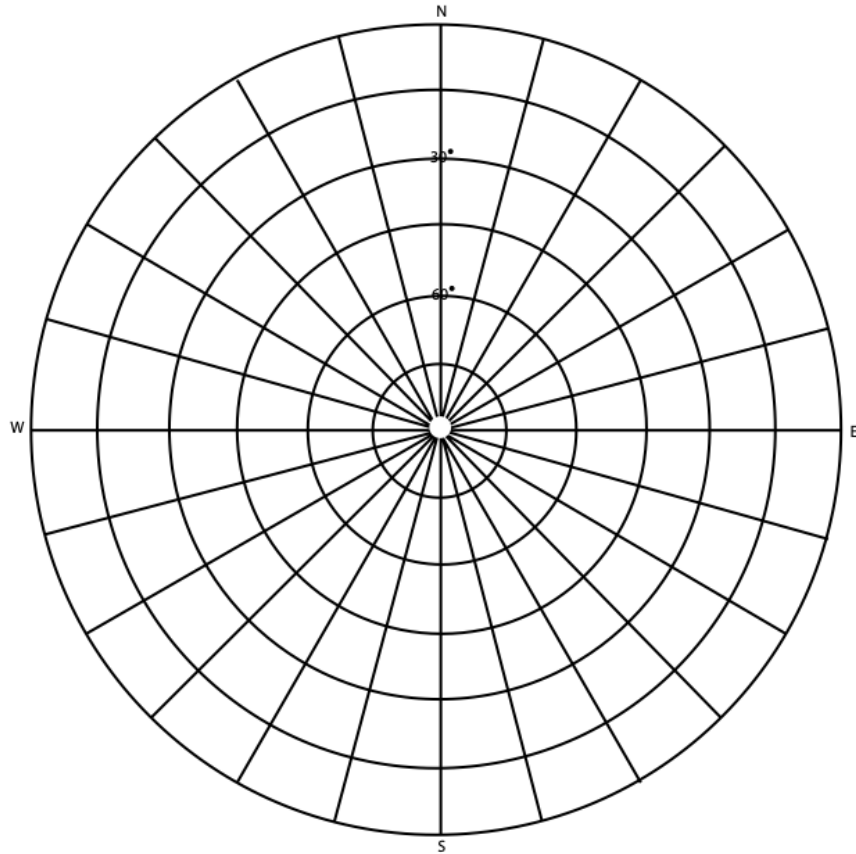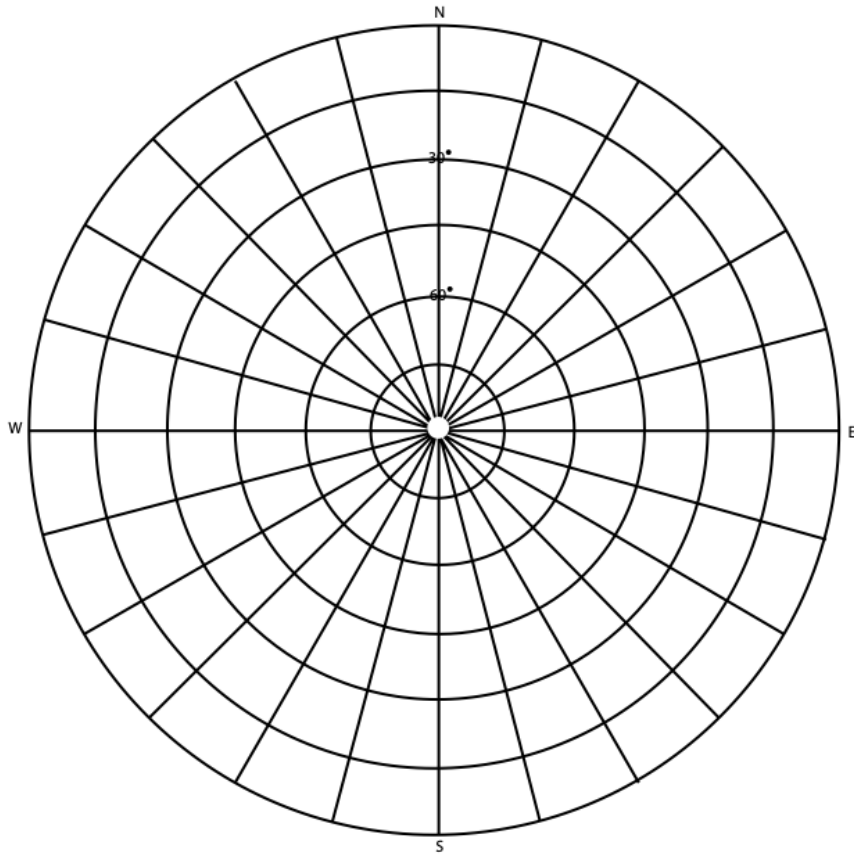

[1]

1. How can you show the movement of the moon using a sky chart?

[1] Image Source: Learn For Your Life: MatchCard Science at https://www.learn4yourlife.com

Tracking Your Constellation Over a Day:

1. Open Stellarium [https://stellarium-web.org] and click on a star in your constellation, then click on the target icon to keep Stellarium focused on your star. Write its name below. (Turn off the atmosphere if you cannot see stars because of the daylight.)

    a. Name of your star: _____

2. Use the date/time tool to set the time to today at 18:00 (6:00 PM). Plot the location of your star on the map below. If it is below the horizon, record that below the map.

3. Plot the star's position each hour for the next 12 hours.

**Star Tracking Over ½ Day**

Below the horizon times:

What do you notice about the movement of the star? What patterns do you see in the movement of the star over ½ of a day?

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[2] Image Source: Learn For Your Life: MatchCard Science at https://www.learn4yourlife.com

Tracking Your Constellation Over a Month:

1. Using the same star, set the date/time to August 1st at 0:00 (12:00 AM). Plot the location of the star on the sky chart below. Label the point with the day of the month, 1. If it is below the horizon record the date below the chart.

2. Advance the time by 1 day to August 2nd. Plot the location of your star on the map and label it 2. If it is below the horizon record the date below the chart.

3. Repeat for all 31 days in August.

Star Tracking Over August
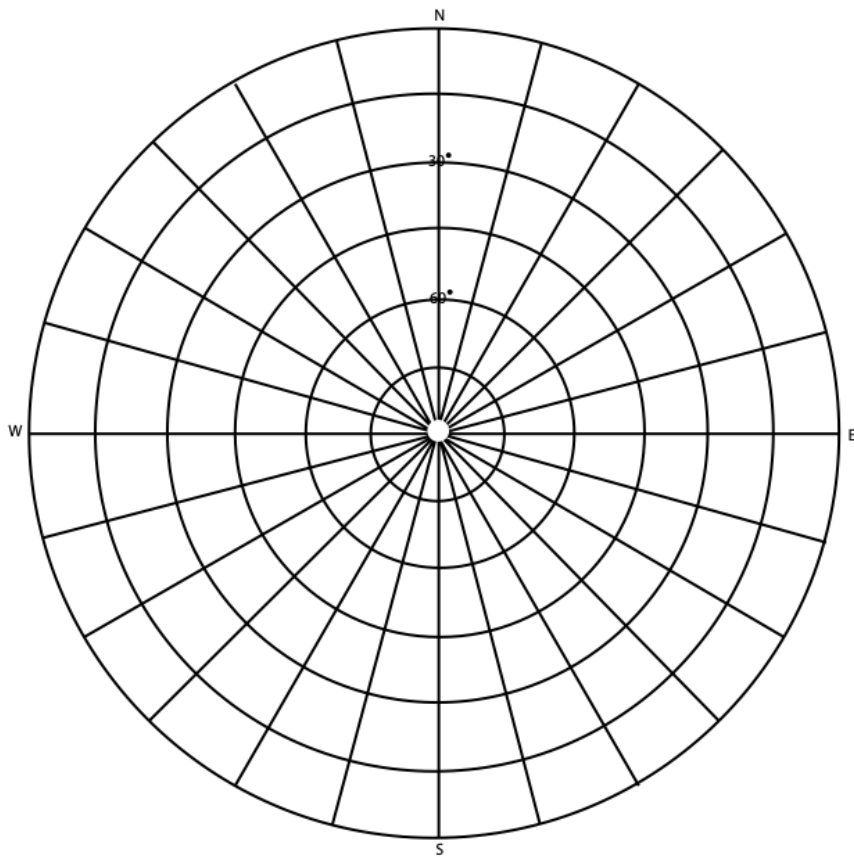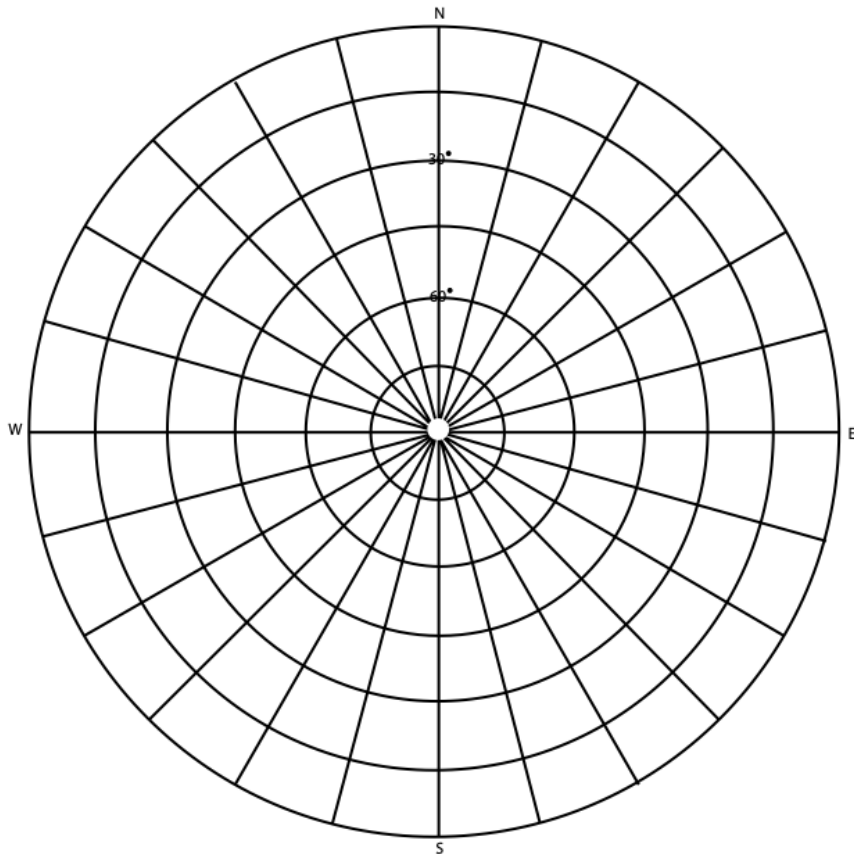

3

Below the horizon dates:

What do you notice about the star? What patterns do you see in its movement over one month?

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3 Image Source: Learn For Your Life: MatchCard Science at https://www.learn4yourlife.com

Tracking Your Constellation Over Five Years:

1. Using the same star, again set the date/time to August 1st at 0:00 (12:00 AM). Plot the location of the star on the sky chart below. Label the point with the month and year, August 2024 for example.

2. Advance the time by 1 month to September 1st. Plot the location of your star on the map and label it. If it is below the horizon record the date below the chart.

3. Repeat for each month over a five-year period. Always use the first day at 0:00.

Star Tracking Over Five Years

Below the horizon dates:

What do you notice about the star? What patterns do you see in its movement over several years?

Appendix B

Observations, Data Tables, Graphs

Patterns In Data

Claim Based on Data and Patterns

Reasons Data Supports Claim

Explanation
Connect the Claim to the Evidence and Patterns Using Reasoning