



# Stackable Instructionally- embedded Portable Science (SIPS) Assessments Project

## Grade 5 Science Unit 4 Sample Lesson “Big, Small, it is all Relative” Earth and Its Gravitational Force and Motion September 2023

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## Science Grade 5

### Unit 4: Earth and Its Gravitational Force and Motion

#### Sample Lesson: Big, Small, it is all Relative

**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

In this lesson, students gather observational data to support an argument that stars range greatly in their distance from Earth and they emit light that can reach Earth. They represent data in graphical displays to reveal that the sun is closer than other stars and that the sun appears larger and brighter than others. Students utilize this data later in the unit when they construct an explanation of the observed relationship between distance and apparent size/brightness of the sun versus all other stars.

#### 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):

- 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]
  - 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]
  - 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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#### 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.

- Apparent size
- Apparent brightness

#### Targeted Stage 1 Learning Goals

##### Acquisition Goals (AG)

A2: Support an argument that stars range greatly in their distance from Earth and they emit light that can reach Earth, using evidence, data, or a model

A3: Represent data in graphical displays to reveal that the sun is closer than other stars and that the sun appears larger and brighter than other stars

A4\*: Construct an explanation of the observed relationship between distance and apparent size/brightness of the sun versus all other stars.

##### Common Core State Standards (CCSS):

MP.2      MP.4

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

EU2/EQ2      EU4/EQ4

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

### Formative Assessment Opportunities

Monitoring	Success Criteria	Possible Instructional Adjustments
<ul style="list-style-type: none"> <li>As students share their thinking about the video, listen to responses for examples of prior knowledge and opportunities to make connections to student thinking during the investigations.</li> <li>When students are developing definitions for key terms, monitor for students' abilities to use context clues and prior knowledge to define new words.</li> <li>As students analyze the data, monitor for logic and reasoning in the choices made to develop graphs and identify trends.</li> <li>Students writing explanations to answer the investigation questions provides the opportunity to observe students' ability to connect evidence to their claim using reasoning.</li> </ul>	<p>Students can:</p> <ul style="list-style-type: none"> <li>Accurately define key terms, <i>apparent size</i>, and <i>apparent brightness</i>.</li> <li>Explain how distance impacts the apparent size of objects.</li> <li>Explain how distance impacts the apparent brightness of objects.</li> <li>Describe how data shows that the sun is closer than other stars and/or that the sun appears larger and brighter than another star.</li> <li>Develop a graphical representation of data that supports the argument that the sun is closer than other stars and/or that the sun is larger and brighter than other stars.</li> <li>Identify what evidence or data supports an argument that stars range greatly in their distance from Earth</li> </ul>	<ul style="list-style-type: none"> <li>Provide wait time during the class discussion to allow students time to process the question and develop a response.</li> <li>Have students turn and talk before discussing the video as a group so that students can further develop their ideas before sharing.</li> <li>Modify the investigation instructions and expectations to encourage advanced students to use mathematical skills and analysis practice that are above grade level.</li> <li>Provide students who need language support dictionaries or other tools to support them in developing definitions.</li> <li>Share with students additional resources on apparent brightness,</li> </ul>

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and/or that stars emit light that can reach Earth.

- Use evidence and/or data to support an argument that stars range greatly in their distance from Earth and/or that stars emit light that can reach Earth.

apparent size, and the distances to stars if needed.

- Have advanced students create their own procedure plans and organizers for their data instead of using Appendix A or B.

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### Instructional Plan

#### Lesson Overview

In this lesson, students observe an instance where distance and perspective mislead individuals on the actual size and position of objects. Using commonly found resources, students gather data about the apparent size of objects at different distances, represent their data using charts, tables, or graphs, and analyze their data. Students use the evidence they gathered to support a multimodal explanation of the opening activity and misleading sizes. Next, students turn to apparent brightness and gather data on how the brightness of a source changes. Students create charts, tables, or graphs of their data and draw conclusions about the meaning of their data related to the brightness of objects. Students document their thinking and evidence in their notebooks to utilize later in the unit to support creating a model to explain the apparent brightness and relative sizes of the stars and sun in the sky.

#### Materials & Set-Up

- Balls of varying sizes. (e.g., basketball, baseball, soccer ball, softball)
- Meter stick or ruler and measuring tape.
- Light source
- Light brightness measuring device. (e.g., smartphone with light measuring app, brightness device, or probe)
- Handouts: *Big, Small, It's All Relative (Appendix A)*, and *How Bright is Bright? (Appendix B)*

If time is limited, the teacher may want to position the balls on a table in a hallway or open area of the classroom and pre-measure and mark the distances on the floor. Light probes are available from science supply companies and meters are available from major online retailers. The light meter does not need to be professional grade. Smart devices, such as phones or tablets, can provide a very reliable light meter using free apps.

#### Anchor or Investigative Phenomenon:

Students watch a video where a person appears to be interacting with a variety of objects only to find that the objects are actually all positioned in ways that are misleading about their size. Students conduct investigations to gather evidence and then explain how and why the objects' appearances are misleading.

**Driving Question:** How does the distance from an object impact its apparent size and brightness?




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	Teacher Does	Students Do
<b>Engage</b>		
	<ul style="list-style-type: none"><li>☑ Introduce object, event, phenomenon, problem, or question</li><li>☑ Build background knowledge</li><li>☑ Facilitate connections</li></ul>	
<b>Explore</b>		
	<ul style="list-style-type: none"><li>☑ Explore object, event, phenomenon, problem, or question</li><li>☑ Guided exploration with hands-on activities</li></ul>	
	<p>The teacher shows the class the <a href="#">video</a>, pausing the video at 7 seconds for students to rank objects from tallest to shortest: painting, man, ball, cup 1, cup 2, and a chair. Students turn and talk about why they ranked the objects how they did. The teacher shows students the remainder of the video to show that because of the relationship between apparent size and actual size of an object, things are not always as they appear. The teacher facilitates a class discussion about the video. Were students correct with their ranking? Why or why not? As a class, students develop a definition for the term, <i>apparent size</i>. The teacher asks students what they need to consider when thinking about the apparent size of objects.</p> <p>The teacher provides students with masking tape, a meter stick, ruler, and a series of similarly shaped objects, such as a basketball, a softball, and a baseball. Students arrange the objects in an open area where they have room - a field, a hallway, etc. The teacher directs students to gather data which they record in a table on the apparent size of each object at a variety of distances. Advanced</p>	<p> Students watch the video, <i>Forced Perspective</i>, and make predictions about the relative sizes of objects. After viewing the video and seeing the actual size of the objects, students discuss the video and their predictions. Using this as a starting point, students work together as a class to develop a class definition for the term apparent size.</p> <p>After developing the class definition, students explore how distance impacts the apparent size of objects by taking measurements of how large objects appear to be at different distances.</p> <p> Students graph their data and use their data to answer the investigation question, “How does distance change the apparent size of objects?” Students write a scientific explanation to answer the question, using evidence from their investigation. (See <i>Appendix C</i> for a potential organizer.)</p> <p> Next, students take the idea of apparent size and apply it to the related principle of apparent brightness. As a class and using what they already know about the word “apparent,” students develop a class</p>

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students should be encouraged to develop their own procedures and data organization. Students who require more guidance may be provided with supporting documents such as in *Appendix A*.

After gathering the data, students create a graph of their data and then consider what their data means about apparent size.

Students could decide to graph all of the measurement points, the averages, or both. Whichever students decide, the teacher encourages them to consider why they think that is appropriate and have them record their thinking.

As students work on their analysis, the teacher walks around the room and checks in with students, asking scaffolding questions for students who need guidance and probing questions that encourage students to think about what their data means.

After students gather their data and write a short conclusion about what it means, the teacher challenges students to arrange the two objects to appear to be the same size. Students draw a picture of their setup with labels that include which object is which, measurements of their actual size, and measurements of their distance from the observer.

Next, students explore apparent brightness. Now that students have explored apparent size, the teacher asks them what they think *apparent brightness* means.

As a class, discuss the term and develop a class definition.

definition for what they think apparent brightness is. Students gather data about the brightness of objects and how the measured brightness changes as the distance changes.



Students graph the measured brightness at different distances and use their graphs to write a scientific explanation for the question, “How does distance change the apparent brightness of objects?” (Note: Inverse Square Law and the Inverse Square relationship are above grade level. The focus is for students to see that brightness decreases rapidly as you move away, but then slows down. For students above grade level, the teacher may want to encourage them to find the inverse square relationship.)

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To understand how brightness is impacted by distance, students collect data using a light meter and measure the change in brightness at different distances from a light source, similar to the science project [Star light, Star bright: How Does Light Intensity Change with Distance?](#) (Note: The inverse square law is above grade level, use this page only as teacher information.) Students use a light meter or light meter app on a smartphone/tablet to measure how bright a light source is at different distances. Advanced students should be encouraged to develop their own procedures and data organization. Students who need more support may want to utilize the activity in *Appendix B*.

As students create graphs of their data, the teacher uses questioning to support students in recognizing that brightness drops off significantly as they move away from the source (Note: the mathematical relationship (Inverse Square) is above grade level but could be an opportunity for advanced students.). After students have created their graphs, the class discusses what the graph means for brightness. Students write a scientific explanation to answer the question, “How does the apparent brightness of an object change as distance grows?”

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#### Explain

- Explain understanding of concepts and processes
- Introduce new concepts and skills to seek conceptual clarity

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#### Closing



To close the lesson, the teacher reshows the initial video to students, pausing at 7 seconds again.

The teacher asks students to create an annotated drawing that uses evidence, logic, and reasoning to explain the apparent sizes of the different objects which includes drawings, labels, explanatory text, and other representations that they feel are appropriate.

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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		
		<ul style="list-style-type: none"><li>Make work authentic and relevant.</li></ul>

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<p><i>Students watch a video where objects appear larger relative to each other than they actually are.</i></p>		<ul style="list-style-type: none"> <li>○ Use the opening video to peak interest and encourage students to consider how observations are influenced by the observer.</li> </ul>
		<ul style="list-style-type: none"> <li>● Supply or activate background knowledge.                             <ul style="list-style-type: none"> <li>○ Use the opening video to support students in recalling past experiences with observation, the importance of accurate measurements, and how appearances can be misleading.</li> </ul> </li> </ul>
<p><i>Students develop class definitions for key vocabulary terms.</i></p>		<ul style="list-style-type: none"> <li>● Allow ownership of parts of instructional tasks.                             <ul style="list-style-type: none"> <li>○ As a class develop the definitions for key terms, ‘Apparent size’ and ‘Apparent Brightness’ encouraging students to write them using words familiar to them.</li> </ul> </li> <li>● Encourage collaboration with partners and groups.                             <ul style="list-style-type: none"> <li>○ Use open-ended questions and statements such as “What can we add?” to encourage students to build on each others’ ideas.</li> </ul> </li> </ul>
<p><i>Students conduct an investigation to measure the apparent size of objects at different distances and find that the apparent size becomes smaller the farther away the observer is from the object.</i></p>		<ul style="list-style-type: none"> <li>● Provide different levels of support and scaffolds.                             <ul style="list-style-type: none"> <li>○ Utilize scaffolding resources such as <i>Big, Small, It’s All Relative (Appendix A)</i>, and <i>How Bright is Bright? (Appendix B)</i> to support students who need additional guidance.</li> <li>○ Encourage advanced students to work without scaffolding documents or to deepen their analysis.</li> </ul> </li> <li>● Encourage collaboration with partners and in groups.                             <ul style="list-style-type: none"> <li>○ As students are working in small groups, provide guidance and feedback to ensure that all students are able to participate and that all students are participating at levels appropriate for them.</li> </ul> </li> </ul>
<p><i>Students conduct an investigation to measure the apparent brightness of objects at different distances and find that the apparent brightness becomes smaller the farther away the observer is from the object.</i></p>		<ul style="list-style-type: none"> <li>● Emphasize key information.                             <ul style="list-style-type: none"> <li>○ Use questioning strategies to support students in identifying similarities and differences within their data with increasing distance between the objects.</li> </ul> </li> <li>● Provide models and scaffolds to aid in comprehension.                             <ul style="list-style-type: none"> <li>○ Provide sample data of different relationships to help students see how the shape of the data can help us understand how the two variables, shape and distance, are related.</li> </ul> </li> <li>● Explain the structure of graphs, charts, diagrams, models, etc.                             <ul style="list-style-type: none"> <li>○ Use questions and provide guidance to support students who need assistance in setting up their graph, graphing data, and</li> </ul> </li> </ul>

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		deciding on the appropriate type of graph to utilize in finding a relationship between size and distance.
		<ul style="list-style-type: none"><li>• Vary the ways for students to respond to questions or a task.<ul style="list-style-type: none"><li>○ Provide students with options for responding to the questions in the handouts <i>Big, Small, It's All Relative (Appendix A)</i>, and <i>How Bright is Bright? (Appendix B)</i> such as typing answers into an online submission, oral presentation, using drawings/pictures, or other options as appropriate.</li></ul></li><li>• Provide varied levels of support and practice.<ul style="list-style-type: none"><li>○ Encourage advanced students to draw trend lines and identify more complicated relationships, make predictions about the brightness or size at particular distances, and then verify if their predictions were correct.</li><li>○ Support students who need guidance through modeling using example data from a different situation to recall past experiences of data analysis, and encourage them to refer to scientific notebooks for past work.</li></ul></li></ul>

#### Resources

- [Forced Perspective](https://thewonderofscience.com/phenomenon/2018/7/5/forced-perspective)  
[https://thewonderofscience.com/phenomenon/2018/7/5/forced-perspective]
- [Star light, Star bright: How Does Light Intensity Change with Distance?](https://www.sciencebuddies.org/science-fair-projects/project-ideas/Astro_p034/astronomy/how-does-light-intensity-change-with-distance)  
[https://www.sciencebuddies.org/science-fair-projects/project-ideas/Astro\_p034/astronomy/how-does-light-intensity-change-with-distance]

#### Core Text Connections

- [Crash Course Kids: Seeing Stars](https://www.youtube.com/watch?v=M41yLjQ2ot0)  
[https://www.youtube.com/watch?v=M41yLjQ2ot0]
- [MightyOwl: A Star's Distance from Earth Affects its Brightness.](https://youtu.be/nwAS0HhRk5M)  
[https://youtu.be/nwAS0HhRk5M]
- [Crash Course Kids: Glow On](https://youtu.be/Zo-sKzMWYFA)  
[https://youtu.be/Zo-sKzMWYFA]

## Appendix A: Sample Handout Materials

### Big, Small, It's All Relative

#### *Materials:*

- Basketball
- Softball
- Baseball
- Meter stick
- Ruler
- Masking tape

Investigation question: How does distance change the apparent size of objects?

#### *Data Collection:*

1. Line up the basketball, softball, and baseball in a line.
2. Use the meter stick to measure 1 meter away from the line of balls. Mark the spot with a piece of tape.
3. Use the meter stick to measure 2 meters away from the line of balls. Mark the spot with a piece of tape.
4. Repeat for 3, 4, 5, 6, 7, 8, 9, and 10 meters away from the line of balls.
5. Using the ruler have each person in your group stand at 10 meters and have them hold up the ruler to measure how big each ball appears to be in centimeters.
6. Record each person's measurement under apparent size in the data table.
7. Repeat for 9, 8, 7, 6, 5, 4, 3, 2, and 1 meter away from the ball.
8. Answer the Data Collection questions before moving on.

#### *Data Analysis:*

1. For each distance and object, find the average apparent size for the group.
  - a.  $AVERAGE = (SUM \text{ of Measurements}) / (\text{Number of Measurements})$
2. Record the average in the table.
3. Using graph paper create a graph to show how the distance away from the balls impacts their apparent size.
4. Answer the Data Analysis questions before moving on.

***Conclusion:***

1. Use your data as evidence to support your answer to the investigation question, “How does distance change the apparent size of objects?” Record your claim, evidence, and reasoning.

## Student Worksheet

Basketball			Softball			Baseball		
<u>Distance</u>	<u>Apparent Sizes</u>	<u>Average</u>	<u>Distance</u>	<u>Apparent Sizes</u>	<u>Average</u>	<u>Distance</u>	<u>Apparent Sizes</u>	<u>Average</u>
1.0 m			1.0 m			1.0 m		
2.0 m			2.0 m			2.0 m		
3.0 m			3.0 m			3.0 m		
4.0 m			4.0 m			4.0 m		
5.0 m			5.0 m			5.0 m		
6.0 m			6.0 m			6.0 m		
7.0 m			7.0 m			7.0 m		
8.0 m			8.0 m			8.0 m		
9.0 m			9.0 m			9.0 m		
10.0 m			10.0 m			10.0 m		

**Data Collection Questions:**

- How did you hold the ruler when you measured the apparent size? Why did you hold it that way?

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- Find someone who held the ruler differently than you did. Why did they do it that way? If you can't find someone who did it differently, write down another way hold the ruler when measuring the apparent size and write down why it is better or worse than what you did.

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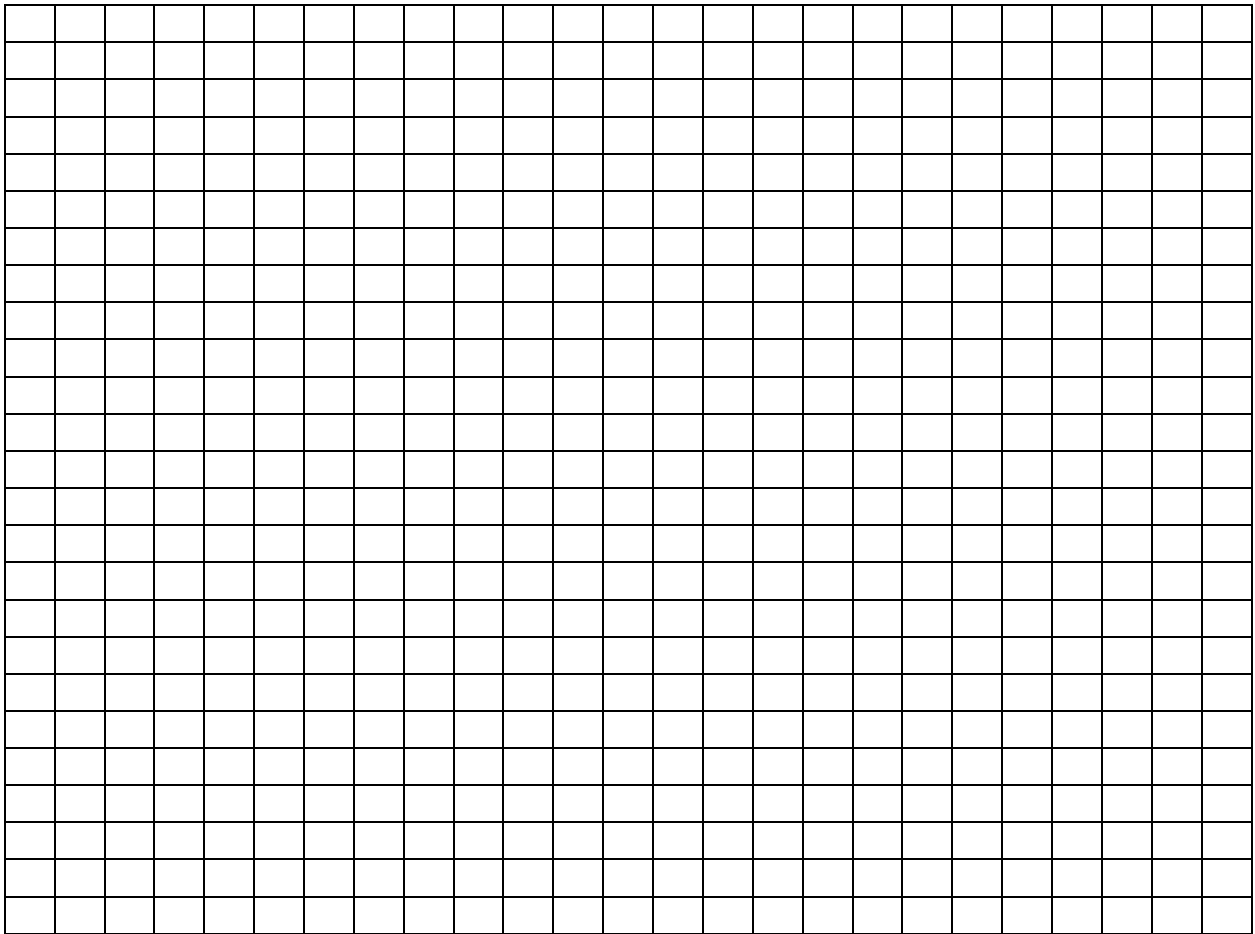
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## Graph of Data

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### *Data Analysis Questions:*

1. Did you graph only the measurements, only the averages, or both? Why?

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**Challenge:**

Arrange the three balls so that a person standing in at 10 m would think they are all the same size. Draw a picture of your setup and label the distance between objects below.

**Conclusion:**

Write your answer to the question “How does distance change the apparent size of objects?” below. Support your claim using evidence and reasoning.

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## Appendix B

### How Bright is Bright?

#### *Materials*

- Light source
- Meter stick
- Light meter/brightness probe/smart device with light meter app

Investigation question: How does distance change the apparent brightness of objects?

#### *Data Collection:*

1. Place the meter stick so that zero is at the light source.
2. Use the light meter to measure the brightness at 50 cm.
3. Record the brightness in the data table.
4. Move 5 cm closer and repeat.
5. Continue gathering data until you are at 0 cm.

#### *Data Analysis:*

1. Using graph paper create a graph to show how the distance away from the light impacts the apparent brightness.

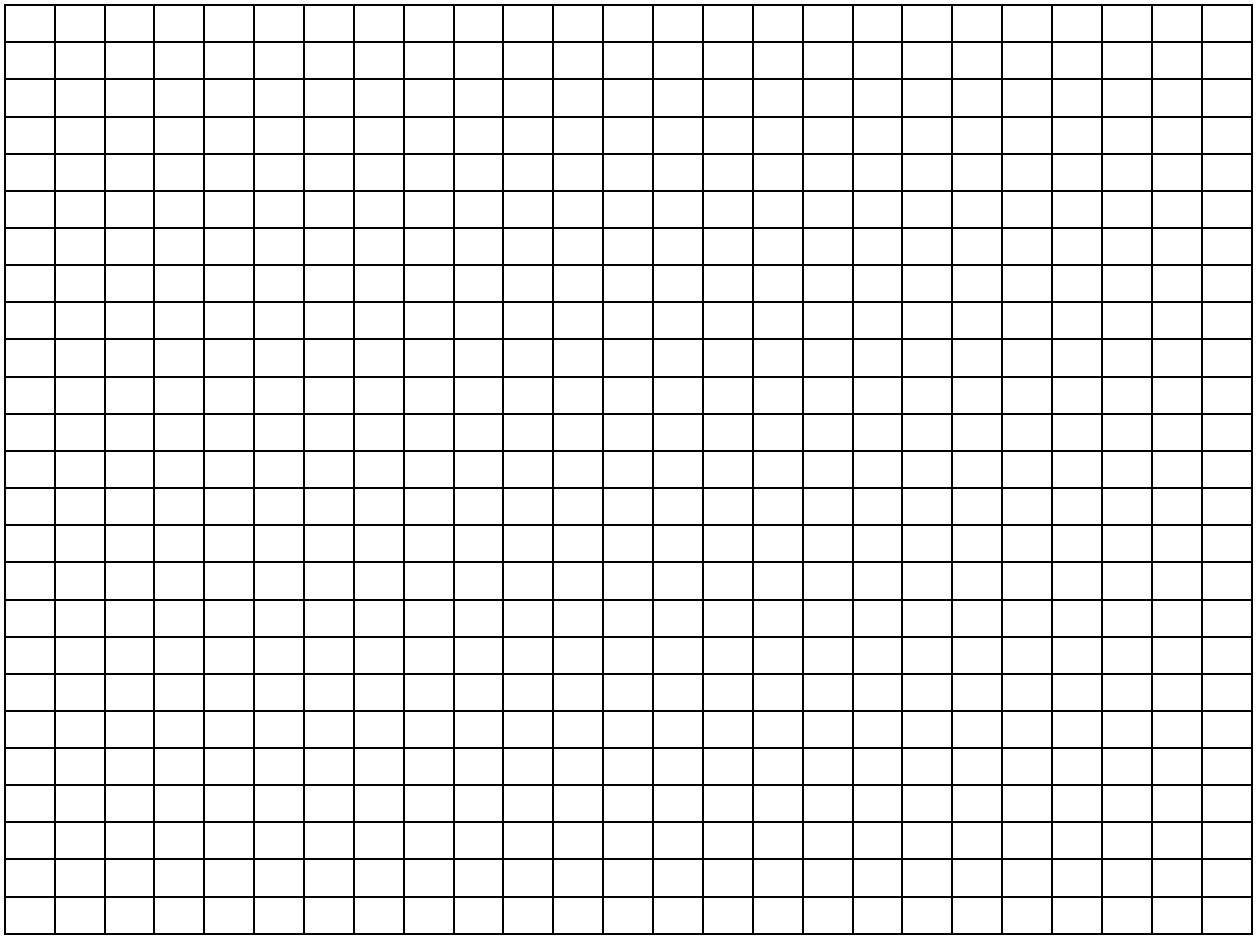
#### *Conclusion:*

Use your data as evidence to support your answer to the investigation question, “How does distance change the apparent brightness of objects?” Record your claim, evidence, and reasoning.

**Brightness Data Table**

Distance	Brightness
50 cm	
45 cm	
40 cm	
35 cm	
30 cm	
25 cm	
20 cm	
15 cm	
10 cm	
5 cm	
0 cm	

# Graph of Data



**Conclusion:**

Write your answer to the question “How does distance change the apparent brightness of objects?” below. Support your claim using evidence and reasoning.

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## **Appendix C**

**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**