



Stackable Instructionally- embedded Portable Science (SIPS) Assessments Project

Grade 8 Science

Unit 2 Sample Lesson “Analyze and Interpret Data on Gravitational Forces and Relative Mass of Objects”

Gravity and Motion of Objects in the Solar System

May 2023

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Science Grade 8

Unit 2: Gravity and Motion of Objects in the Solar System

Sample Lesson: Analyze and Interpret Data on Gravitational Forces and Relative Mass of Objects

Suggested Time to Complete: 150 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 make connections with Unit 1 by analyzing and interpreting data on the circular motion of an object and by connecting the patterns in the data with the motion of celestial objects in the solar system. Students obtain information about objects in the solar system and find similarities and/or differences in the orbits as a result of the different forces acting on those objects.

Connections to Prior Learning

DCIs

- **Prior Learning from 3-5:**

- The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in size and distance from Earth.
- 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.
- Some objects in the solar system can be seen with the naked eye. Planets in the night sky change positions and are not always visible from Earth as they orbit the sun. Stars appear in patterns called constellations, which can be used for navigation and appear to move together across the sky because of Earth's rotation.
- Each force acts on one particular object and has both strength and direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative addition of forces is used at this level.)
- The patterns of an object's motion in various situations can be observed and measured; when past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.)

CCC - Patterns

- **Prior learning from 3-5:**

- Patterns can be observed when the earth, which rotates on an axis, orbits the sun and the moon orbits the earth about an axis. These include day and night; daily and seasonal changes

Science Grade 8

Unit 2: Gravity and Motion of Objects in the Solar System

Sample Lesson: Analyze and Interpret Data on Gravitational Forces and Relative Mass of Objects

Suggested Time to Complete: 150 minutes

in the length and direction of shadows; phases of the moon; and different positions of the sun, moon, and stars at different times of the day, month, and year.

- **Prior learning from this grade band (e.g., Grades 6 & 7):** Students are expected to use graphs, charts, and images to identify patterns in data. They are also expected to use cause-and-effect relationships to identify patterns in data (Appendix G).
 - Multiple MS PEs use this CCC, so students will likely have some experience with the MS CCC elements prior to starting Grade 8 Unit 2.

CCC - Scale, Proportion, & Quantity

- **Prior learning from 3-5:** Students are expected to understand that events depend on phenomena that operate at very different scales, but also that fundamental interactions are present through these differences. They are also expected to understand the importance of units and their association with observable quantities.
 - In Grades 3-5, students learn to recognize that natural objects and observable phenomena exist from the very small to the immensely large. They will also learn to use standard units to measure and describe physical quantities such as weight, time, temperature, and volume (Appendix G).
- **Prior learning from this grade band (e.g., Grades 6 & 7):** Students are expected to become adept at working across different scales and how phenomena observed at one scale may not be observable at another scale. They use proportional relationships (e.g., speed) to gather information about the magnitude of properties and processes.
 - Multiple MS PEs use this CCC, so students will likely have some experience with the MS CCC elements prior to starting Grade 8 Unit 2.

CCC – Systems and System Models

- **Prior learning from 3-5:** Students are expected to understand that a system is composed of components that interact with one another and also that the system can do things that depend on the different components, which may each have a unique function, and that the components operating together can enable the system to carry out functions that individual parts cannot.
- **Prior learning from this grade band (e.g., Grades 6 & 7):** Students are expected to develop additional sophistication in identifying the way that components of a system interact with one another and with the environment (surroundings) of the system.
 - Multiple MS PEs use this CCC, so students will likely have some experience with the MS CCC elements prior to starting Grade 8 Unit 2.

SEP - Developing and Using Models

- **Prior learning from 3-5:** Students continue developing their modeling skills and abilities by developing and revising different types of models, along with beginning to consider that those models can have limitations (Appendix G).
 - PE 4-PS4-2 is an example of a 3-5 grade band PE that uses a Developing and Using Models SEP element that is very similar to the SEP element used by two unit 2 MS PEs (MS-ESS1-1 and MS-ESS1-2).
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Science Grade 8

Unit 2: Gravity and Motion of Objects in the Solar System

Sample Lesson: Analyze and Interpret Data on Gravitational Forces and Relative Mass of Objects

Suggested Time to Complete: 150 minutes

- **Prior learning from this grade band (e.g., Grades 6 & 7):** Students develop, use, and revise models to describe, test, and predict more abstract phenomena and to design systems.
 - Multiple MS PEs use this SEP, so students will likely have some experience with the MS SEP elements prior to starting Grade 8 Unit 2. MS-PS4-2 is an example MS PE that uses the same SEP element as two unit 2 MS PEs (MS-ESS1-1 and MS-ESS1-2).

SEP - Analyzing and Interpreting Data

- **Prior learning from 3-5:** Students will have experience with the collection of data using quantitative approaches to collecting data and conducting multiple trials of qualitative observations. They will be able to carry out the analysis and interpretation of the data using logical reasoning, mathematics, and/or computation.
 - In Grades 3-5, students will represent data in tables and/or various graphical displays to reveal patterns that indicate relationships. They will analyze data to refine a problem statement or the design of a proposed object, tool, or process.
- **Prior learning from this grade band (e.g., Grades 6 & 7):** Students will build understanding and skills with quantitative analysis of data. They will distinguish between correlation and causation and carry out basic statistical techniques of data and error analysis.
 - Multiple MS PEs use this SEP, so students will likely have some experience with the MS SEP elements prior to starting Grade 8 Unit 2.

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.

- Orbit
- Binary star
- Galaxy
- Radius
- Gravitational Force
- Rotation vs revolution
- Mass
- Solar System

Targeted Stage 1 Learning Goals

Acquisition Goals (AG)

A5. Analyze and interpret data on gravitational forces exerted by massive objects to show similarities and/or differences in the observed effects of those forces.

A14. Obtain, evaluate, and/or communicate information that our solar system includes multiple types of objects that orbit the Sun (and may also orbit one another).

Common Core State Standards (CCSS):

RST.6-8.1	MP.2
MP.4	6.RP.A.1
7.RP.A.2	

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

EU/EQ3	EU/EQ5
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Science Grade 8

Unit 2: Gravity and Motion of Objects in the Solar System

Sample Lesson: Analyze and Interpret Data on Gravitational Forces and Relative Mass of Objects

Suggested Time to Complete: 150 minutes

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 checked="" type="checkbox"/> Obtain, Evaluate, & Communicate Information <input type="checkbox"/> Plan & Carry Out Investigations	<input checked="" type="checkbox"/> ESS1.A: The Universe at Its Stars <input checked="" type="checkbox"/> ESS1. B: Earth and the Solar System <input checked="" type="checkbox"/> PS2.B Types of Interactions	<input type="checkbox"/> Cause & Effect <input type="checkbox"/> Energy & Matter <input checked="" type="checkbox"/> Patterns <input checked="" 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"> Teacher questioning. Student experimental data. Small group conferences and discussions. 	<p>Students can:</p> <ul style="list-style-type: none"> Gather data on the simulated orbit of small objects in class. Analyze the data to find patterns between multiple variables. Use data to answer questions related to orbital motions, including distances, to determine the relative masses of different objects in an orbital system. Use data to support an explanation of the relative masses of different objects in an orbital system based on orbital motions, including distances. 	<ul style="list-style-type: none"> Provide examples of data sets that show particular relationships for student reference. Ask in-the-moment questions as students are conducting the activity. Add or remove instructions and guidance from the student instructions to allow students an appropriate amount of space to create or support to find success.
<ul style="list-style-type: none"> Teacher questioning. 	<p>Students can:</p> <ul style="list-style-type: none"> Obtain and evaluate astronomical data to 	<ul style="list-style-type: none"> Ask in-the-moment questions to support

Science Grade 8

Unit 2: Gravity and Motion of Objects in the Solar System

Sample Lesson: Analyze and Interpret Data on Gravitational Forces and Relative Mass of Objects

Suggested Time to Complete: 150 minutes

<ul style="list-style-type: none">• Individual discussions on data and pattern recognition.• Student explanations.• Student feedback on peer explanations.	<p>determine if it is relevant to understanding the motion of celestial objects.</p> <ul style="list-style-type: none">• Analyze astronomical data to find patterns among celestial objects.• Compare the patterns between data sets to establish if their predictions were correct.• Explain using both data sets if their predictions were correct or not.• Provide feedback to peers for revising an explanation.• Identify information that supports the idea that our solar system includes multiple types of objects that orbit the sun.• Describe the relationships among objects in our solar system as a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.• Describe scientific evidence of Earth's relative position within our solar system.	<p>students with their data analysis.</p> <ul style="list-style-type: none">• Provide feedback as students draft their explanations.
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Science Grade 8

Unit 2: Gravity and Motion of Objects in the Solar System

Sample Lesson: Analyze and Interpret Data on Gravitational Forces and Relative Mass of Objects

Suggested Time to Complete: 150 minutes

Instructional Plan

Lesson Overview

In this lesson, students explore orbital motion using a simple circular motion device to identify possible relationships between different variables for orbiting objects. Students then analyze and interpret astronomical data to verify if their predictions match the natural world.

Materials & Set-Up

- Handouts
 - [Uniform Circular Motion](https://learning.hccs.edu/faculty/kam.chu/p/hys1401/lab-handout/lab-7-circular-motion)
[chrome-extension://efaidnbmninnbpcajpcgclclefindmkaj/https://learning.hccs.edu/faculty/kam.chu/p/hys1401/lab-handout/lab-7-circular-motion]
- Activity Materials, one for each group:
 - String
 - Plastic tube
 - Rubber stoppers of varying sizes
 - Masking Tape
 - Paper clips
 - Spring scale or force meter.
 - Table clamp
- Device with internet access for each student

Anchor or Investigative Phenomenon: The James Webb Space Telescope (JWST)

The James Webb Space Telescope (JWST) is an infrared space observatory that launched from Earth on December 25, 2021. Webb is the successor of the Hubble Space Telescope. It will explore the cosmos to reveal the history of the universe from the Big Bang to alien planet information and more and is now in orbit in our solar system. The formation of galaxies, planets outside of our Solar System, and newborn stars will be studied by Webb. Webb is a massive telescope that looms three stories high and covers the size of a tennis court.

- Resources:
 - [Details on the orbit of the JWST](https://jwst.nasa.gov/content/about/orbit.html)
[https://jwst.nasa.gov/content/about/orbit.html]
 - [Educational resources on JWST – formal learning environments](https://jwst.nasa.gov/content/forEducators/formal.html)
[https://jwst.nasa.gov/content/forEducators/formal.html]
 - [Educational resources on JWST – informal learning environments](https://jwst.nasa.gov/content/forEducators/informal.html)
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Science Grade 8

Unit 2: Gravity and Motion of Objects in the Solar System

Sample Lesson: Analyze and Interpret Data on Gravitational Forces and Relative Mass of Objects

Suggested Time to Complete: 150 minutes

	Teacher Does	Students Do
Engage		
<input checked="" type="checkbox"/> Introduce object, event, phenomenon, problem, or question		
<input checked="" type="checkbox"/> Build background knowledge		
<input checked="" type="checkbox"/> Facilitate connections		
Explore		
<input checked="" type="checkbox"/> Explore object, event, phenomenon, problem, or question		
<input checked="" type="checkbox"/> Guided exploration with hands-on activities		
	<p>The teacher begins by reminding students of the previous activity from Unit 1, <i>Changing Motion</i>, where they explored the changing motion of an object moving in a circle. As students work on the activity, the teacher provides appropriate scaffolds and supports. The instructions in Appendix A should be modified by the teacher to allow students the most freedom possible in their experimentation while also providing necessary support.</p> <p>Following the opening activity, the teacher facilitates a class discussion asking students to connect this activity with the James Webb Space Telescope (JWST) or any orbiting object.</p> <p>The teacher provides students with scaffolds and supports as they develop a hypothesis about the motion of stellar objects and then gather data on those objects. The teacher may opt to have students conduct their own research to gather data or provide resources. A list of potential data sources is included in the resources section.</p> <p>Students draw from their data that there is the presence of a</p>	<p>Students revisit the Unit 1 activity, <i>Changing Motion</i>, to gather data, with the goal this time of connecting the orbital motion of objects. Students gather data on the motion of the object when changing several variables. The handout in Appendix A could be used by the teacher as a scaffold to support students in the activity. Appendix A is written in the style of a structured learning activity. Students should conduct the activity with the least amount of instruction possible in order to support them in developing their Science and Engineering Practices.</p> <p>Students discuss the activity and how it connects to the JWST.</p> <p>After the discussion, students make predictions on how the motion of stellar objects will vary in their circular orbits (change in an object's motion depends on the sum of the forces on the object and the mass of the object). Students write a testable hypothesis and then gather stellar data from digital resources to gather data in support of or against their hypothesis. (There is no "control" in this experiment,</p>

Science Grade 8

Unit 2: Gravity and Motion of Objects in the Solar System

Sample Lesson: Analyze and Interpret Data on Gravitational Forces and Relative Mass of Objects

Suggested Time to Complete: 150 minutes

net force between massive objects and all other objects and that this force depends on the mass of the objects and their distance apart. (Note: the distance will be a larger factor; the teacher can support students in finding objects of similar distance but different masses.) The teacher should encourage students to gather data from several different sources about objects that orbit celestial objects and then plot and graph this data using data analysis software such as [CODAP](https://codap.concord.org) [<https://codap.concord.org>] as they engage in [computational thinking](https://stemteachingtools.org/brief/56) [<https://stemteachingtools.org/brief/56>]. This may be easiest to accomplish by looking at objects in orbiting belts or comparing moons around individual gas giants ([Saturn](#) or [Jupiter](#) would be good examples). Students should find that speeds are close to the same for objects at the same distance (If they recall from the previous unit, they may make the connection that a larger mass means that the force must be bigger if the change in motion is the same). The teacher provides support and guidance as students analyze their data through scaffolding questions. The teacher should not provide data analysis. If students struggle in

instead, much like astronomers do, students look at data to determine if their idea matches what occurs in the natural world.)



Students study data/evidence related to the relative masses of objects, their radii of orbit, and other data that they deem relevant. This information could include a look at Earth-sun-moon, binary stars, moons around planets in our solar system, or other examples. Students gather and analyze data to find patterns and see if their takeaways from the circular motion activity are reflected in the astronomical data.

Science Grade 8

Unit 2: Gravity and Motion of Objects in the Solar System

Sample Lesson: Analyze and Interpret Data on Gravitational Forces and Relative Mass of Objects

Suggested Time to Complete: 150 minutes

recognizing patterns, the teacher can provide students with examples of relationships/patterns in data and encourage students to create different scatterplots of the variables, including shifting the independent and dependent variable axis.

Explain

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

The teacher cycles around the classroom providing feedback and asking probing questions as students write an explanation about the results of their data analysis.



Students write an explanation of the validity of their hypothesis using data from the experiment. This could, but does not necessarily need to, follow a CER format.

Elaborate

- Build on or extend understanding and skill
- Apply concepts in new or related contexts

Evaluate

- Self-assess knowledge, skills, and abilities
- Evaluate student development and lesson effectiveness

Closing

Students share their explanation of their hypothesis with a partner who evaluates the explanation and gives feedback. For homework, students revise the explanation to be returned the next class period.

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

Science Grade 8

Unit 2: Gravity and Motion of Objects in the Solar System

Sample Lesson: Analyze and Interpret Data on Gravitational Forces and Relative Mass of Objects

Suggested Time to Complete: 150 minutes



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		
<p><i>Students conduct the investigation and gather data on the motion of objects in a simulated orbit.</i></p>		<p>Allow ownership of parts of instructional tasks.</p> <ul style="list-style-type: none"> Students are tasked with determining what variables to test.
		<p>Provide different levels of support and scaffolds.</p> <ul style="list-style-type: none"> Lab instructions can be modified to meet the needs of different learners.
		<p>Encourage collaboration with partners and in groups.</p> <ul style="list-style-type: none"> Groups are assigned with purpose to encourage heterogeneity with agreed-upon roles to encourage participation.
		<p>Support self-reflection and evaluation.</p> <ul style="list-style-type: none"> Provide visual tools to foster independence, prepare students for the next activity, break tasks into smaller steps, and aid transition.
		<p>Provide safety and reduce distractions</p> <ul style="list-style-type: none"> Provide a variety of ways in which students can ask a question or seek help (e.g., individually, small group, asking a peer, etc.). Offer opportunities for students to share in a way that is comfortable given their culture and family dynamics (e.g., Some cultures find talking over each other as normal while others wait for complete silence before contributing; some are comfortable with directness or do not have the language level to be polite. Some respond respectfully using facial movements. (Eye contact varies by culture.)
		<p>Explain structure of graphs, charts, diagrams, models, etc.</p> <ul style="list-style-type: none"> Supports on data analysis such as sample data with matching equations may be provided for students who need additional support finding patterns in the data.
		<p>Supply or activate background knowledge.</p> <ul style="list-style-type: none"> The activity is a repeat of an activity from the prior unit with a different focus.

Science Grade 8

Unit 2: Gravity and Motion of Objects in the Solar System

Sample Lesson: Analyze and Interpret Data on Gravitational Forces and Relative Mass of Objects

Suggested Time to Complete: 150 minutes




		<p>Provide varied levels of support and practice.</p> <ul style="list-style-type: none"> As students engage with the topic the teacher can provide customized support through in-the-moment questions and feedback. Allow students to share and make connections with their personal and cultural experiences with the night sky, solar eclipses, seasonal changes, etc. <p>Provide options for accessing instructional activities and material.</p> <ul style="list-style-type: none"> Ensure that all students can physically access and interact with all activities and materials (e.g., table high enough to allow wheelchair access, an adaptation that allows access to print material, space to move to all areas in a classroom or lab, book holder, adapted keyboard, single switch, etc.). Ensure access is available for students who have a hearing impairment or visual impairment, who are blind, deaf, or deaf/blind (e.g., include an audio description for video content, closed captions for video content, alternative text for graphics, preferential seating, an American Sign Language (ASL) interpreter, screen reader, enlarged text, etc.). Place activities on bulletin boards or wall charts to allow students to more easily see, manipulate materials, write, and access using assistive technology. Allow for differences in rate, timing, speed, and range of motion (e.g., Allow enough time for all students to process the question and formulate their responses; Allow enough time for all students to move from one activity to the next, or to perform a task.).
<p><i>Students gather astronomical orbital data for a variety of celestial objects and analyze that data for patterns to determine if the patterns seen in the simulated orbit match the natural world.</i></p>		<p>Provide choices.</p> <ul style="list-style-type: none"> Students select the celestial objects for analysis and the sources of data. <p>Allow ownership of parts of instructional tasks.</p> <ul style="list-style-type: none"> Students determine what sources to use, what celestial objects to consider, and how best to analyze the data.
		<p>Explain structure of graphs, charts, diagrams, models, etc.</p> <ul style="list-style-type: none"> Scaffolds on data analysis may be provided to students who need them, such as sample data with relevant equations.
		<p>Support transfer and generalization of skills and knowledge.</p>

Science Grade 8

Unit 2: Gravity and Motion of Objects in the Solar System

Sample Lesson: Analyze and Interpret Data on Gravitational Forces and Relative Mass of Objects

Suggested Time to Complete: 150 minutes

		<ul style="list-style-type: none"> Both activities ask students to engage in data analysis to find patterns, both from gathered data and from astronomical data. Data analysis is a complex skill that has extensive applications beyond the science classroom. Use a variety of materials and activities to investigate gravitational forces on the human scale and the planetary scale. Make explicit connections between concepts of mass, orbital radii, and orbital periods of objects in various solar systems.
Explain		
<p><i>Students review their analysis and write an explanation in which they explain if their predictions were correct using astronomical data to support their thinking.</i></p>		<p>Support self-reflection and evaluation.</p> <ul style="list-style-type: none"> Students evaluate peers on the quality of their scientific explanation. After reflecting on the feedback students then revise their own explanation.
		<p>Provide supports to help with managing information and resources.</p> <ul style="list-style-type: none"> Students may use graphic organizers and note-taking structures to support the organization of their information.
		<p>Support planning and strategy skills.</p> <ul style="list-style-type: none"> The teacher may provide scaffolding documents to support the development of the explanation such as graphic organizers. <p>Use technology or assistive technology (AT) to broaden access to instructional materials.</p> <ul style="list-style-type: none"> Make use of technology such as spellcheckers, word prediction software, and text-to-speech software. Provide a screen reader and web-based reader. Ensure that key terms to search the internet (e.g., science terminology) are included on a student’s AAC device and that the student has a way to independently or with minimal support access the computer (e.g., adapted mouse, adapted keyboard, enlarge the screen, text to speech, etc.). Provide low-tech tools such as pencil grips, page-turners, reading guides/strips, slant boards, tactile rulers, manipulatives, etc.
		<p>Connect dominant language (e.g., English) with first languages (e.g., Spanish).</p>

Science Grade 8

Unit 2: Gravity and Motion of Objects in the Solar System

Sample Lesson: Analyze and Interpret Data on Gravitational Forces and Relative Mass of Objects

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		<ul style="list-style-type: none">• Have a student respond using the first language and then translate it into English.• Check understanding of content and not on sentence structure and grammar.
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Resources

- [Binary Star Animation](https://youtu.be/iZ0RqO4VCAk)
[https://youtu.be/iZ0RqO4VCAk]
- [Solar System Data](https://ssd.jpl.nasa.gov/planets/phys_par.html)
[https://ssd.jpl.nasa.gov/planets/phys_par.html]
- [Moons of Saturn:](https://www.britannica.com/place/Saturn-planet/Moons)
[https://www.britannica.com/place/Saturn-planet/Moons]
- [Moons of Saturn \(NASA\):](https://solarsystem.nasa.gov/moons/Saturnmoons/overview/?page=0&per_page=40&order=name+asc&search=&placeholder=Enter+moon+name&condition_1=38%3Aparent_id&condition_2=moon%3Abody_type%3Ailike)
[https://solarsystem.nasa.gov/moons/Saturnmoons/overview/?page=0&per_page=40&order=name+asc&search=&placeholder=Enter+moon+name&condition_1=38%3Aparent_id&condition_2=moon%3Abody_type%3Ailike]
- [Moons of Jupiter:](https://airandspace.si.edu/exhibitions/exploring-the-planets/online/solar-system/jupiter/moons.cfm)
[https://airandspace.si.edu/exhibitions/exploring-the-planets/online/solar-system/jupiter/moons.cfm]
- [Moons of Jupiter \(NASA\):](https://solarsystem.nasa.gov/moons/jupiter-moons/overview/?page=0&per_page=40&order=name+asc&search=&placeholder=Enter+moon+name&condition_1=9%3Aparent_id&condition_2=moon%3Abody_type%3Ailike&condition_3=moon%3Abody_type)
[https://solarsystem.nasa.gov/moons/jupiter-moons/overview/?page=0&per_page=40&order=name+asc&search=&placeholder=Enter+moon+name&condition_1=9%3Aparent_id&condition_2=moon%3Abody_type%3Ailike&condition_3=moon%3Abody_type]
- [Reference Lab](https://www.madison-schools.com/cms/lib/MS01001041/Centricity/Domain/3318/what%20keeps%20the%20stopper%20moving%20in%20a%20circle%20lab.pdf)
[https://www.madison-schools.com/cms/lib/MS01001041/Centricity/Domain/3318/what%20keeps%20the%20stopper%20moving%20in%20a%20circle%20lab.pdf]
- [NASA Open Data](https://data.nasa.gov)
[https://data.nasa.gov]
- [NASA Jet Propulsion Laboratory Solar System Dynamics](https://ssd.jpl.nasa.gov) (Database of solar system objects).
[https://ssd.jpl.nasa.gov]
- [How Place-Based Science Education Strategies Can Support Equity for Students, Teachers, and Communities](https://stemteachingtools.org/brief/57)
[https://stemteachingtools.org/brief/57]
- [Supporting observations, wonderings, systems thinking & “Should We” deliberations through Learning in Places](#)

Science Grade 8

Unit 2: Gravity and Motion of Objects in the Solar System

Sample Lesson: Analyze and Interpret Data on Gravitational Forces and Relative Mass of Objects

Suggested Time to Complete: 150 minutes

[<https://stemteachingtools.org/brief/82>]

- [Place-based Science Education in Urban Contexts](https://stemteachingtools.org/sp/place-based-science-education-in-urban-contexts)
[<https://stemteachingtools.org/sp/place-based-science-education-in-urban-contexts>]
- [How Can You Advance Equity and Justice Through Science Teaching?](https://stemteachingtools.org/brief/71)
[<https://stemteachingtools.org/brief/71>]
- [Beyond the Written C-E-R: Supporting Classroom Argumentative Talk about Investigations](https://stemteachingtools.org/brief/17)
[<https://stemteachingtools.org/brief/17>]
- [Common Online Data Analysis Platform](https://codap.concord.org)
[<https://codap.concord.org>]

Core Text Connections

- [Solar System Exploration](https://solarsystem.nasa.gov/solar-system/our-solar-system/overview/)
[<https://solarsystem.nasa.gov/solar-system/our-solar-system/overview/>]
 - [The “Nine” Planets](https://nineplanets.org)
[<https://nineplanets.org>]
 - [Earth Observatory, Earth Satellite Orbits \(NASA, from 2009, no longer being updated\)](https://earthobservatory.nasa.gov/features/OrbitsCatalog)
[<https://earthobservatory.nasa.gov/features/OrbitsCatalog>]
 - [NASA JPL Orbit Viewer](https://ssd.jpl.nasa.gov/tools/orbit_viewer.html)
[https://ssd.jpl.nasa.gov/tools/orbit_viewer.html]
 - [Types of Orbits](https://ssd.jpl.nasa.gov/tools/orbit_viewer.html) (European Space Agency, ESA)
[https://ssd.jpl.nasa.gov/tools/orbit_viewer.html]
 - [Solar System](https://www.britannica.com/science/solar-system) (Britannica)
[<https://www.britannica.com/science/solar-system>]
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Science Grade 8

Unit 2: Gravity and Motion of Objects in the Solar System

Sample Lesson: Analyze and Interpret Data on Gravitational Forces and Relative Mass of Objects

Suggested Time to Complete: 150 minutes

Appendix A

Instructions: In this activity, you will revisit an activity from the previous unit. This time we will collect numerical data and then look for patterns in that data that can help us better understand how and why the James Webb Space Telescope moves as it does.

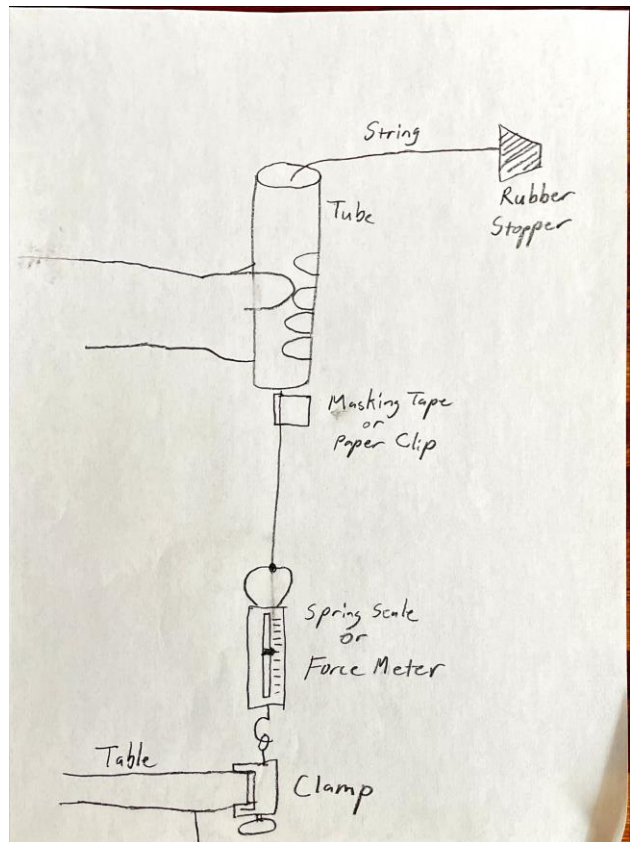
Introduction

As a refresher, here is the setup for the apparatus:

1. What are some of the potential variables you can measure?
2. Which variables can you control?
3. For each variable you can control, predict how changing it will impact the other variables you can measure.

Example:

As _____ goes up/down _____ will go up/down.



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Introductory Experiment: Changing the Radius

In this example, you will change the radius of the circular motion and see the impact on the force and the speed. You can find the speed by using $s = d \div t$. Remember it is a circle, and the circumference of a circle is $C = 2\pi r$. For the first set of trials, keep the size of the force constant. For the second set of trials, keep the speed constant.

Test One:

Mass of stopper: _____

Trial	Radius	Time for 10 revolutions	Calculated Speed	Force

Repeat this experiment with a changing radius and a constant force.

Trial	Radius	Time for 10 revolutions	Calculated Speed	Force

Using this run through as an example, gather additional data on the impact of changing other variables that you identified in the introduction.

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Analysis Questions

1. In the introduction, you predicted how changing certain variables would impact others. Which of your predictions were supported by the data? Explain how your data support your predictions.
2. Which of your predictions were not supported by the data? Explain how your data does not support your predictions.
3. Thinking about objects orbiting in space, do you think that you will find similar patterns in space? Why or why not?