



Stackable Instructionally- embedded Portable Science (SIPS) Assessments Project

Grade 8 Science

Unit 2 Instructionally-embedded Assessment Task Specification Tool:

“Forces Modeling How Gravitational Forces Affect Motion”

Gravity and Motion of Objects in the Solar System

May 2023

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Grade 8	Unit 2	Instructional Segment 1	Task Title: Forces Modeling How Gravitational Forces Affect Motion
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Unit 2 Title: Gravity and Motion of Objects in the Solar System

Anchor Phenomenon	Problematization/Investigative Strategy for the Unit
In this unit, the anchor phenomenon is based on the shared experience that the class will have by viewing a video that introduces the James Webb Space Telescope (JWST). The teacher can problematize this for students by setting up the general questions of “What forces make it possible for the JWST to move as it did in the video?” and “Why can’t the JWST move in a straight-line path after launch?”	If we want to understand our solar system, we’ll need to research objects in our solar system and the Milky Way galaxy in the universe. We’ll need to understand the apparent motion and patterns of objects in the sky that can be observed. What are the connections between gravitational forces, masses of objects, and orbital motion of objects? What causes eclipses, the seasons, and lunar phases?

Segment 1 Overview

By engaging in the practices of analyzing and interpreting data, developing and using models, and constructing and presenting arguments using evidence, students learn that, regardless of mass, gravitational forces are always attractive. They also learn how gravity affects objects of varying masses and/or can be used as evidence for their arguments about the connections between gravitational forces and orbital motion. Students begin the unit by exploring an anchor phenomenon that is based on a shared class experience of viewing a video that introduces the James Webb Space Telescope (JWST) to explore the questions, “What forces make it possible for the JWST to move as it did in the video?” and “Why can’t the JWST move in a straight-line path after launch?” This leads to students researching and reviewing information from various sources to address these questions and to identify information to support a claim related to gravitational forces acting on JWST. Additional data related to the relative masses of objects and the magnitudes and interactions of gravitational forces is analyzed and interpreted to help students understand how changes in masses affect the size of the gravitational forces. Students then develop a “consensus” model and create short explanations of how the model shows the relationship between mass and gravitational force. Information about gravitational forces on a human scale is gathered and evaluated and then students conduct two virtual experiments to collect data related to gravitational forces on the human scale and planetary scale. The segment culminates with students researching how scientists use the relationships between masses of planetary objects and orbital motion, the bending of light by gravity, and other methods to discover the location of exoplanets throughout our galaxy.

Assessments for this segment focus on students' ability to use models and construct arguments from evidence, analyze and interpret data, and obtain, evaluate, and communicate information to show that regardless of mass, gravitational forces are always attractively connected to orbital motion. Students are formally assessed on their ability to obtain, communicate, and evaluate information, develop models, and construct arguments related to different aspects of how gravitational forces interact with objects in the solar system. Students are informally assessed on their ability to obtain information on gravitational forces and their ability to analyze, interpret and use data around gravitational forces and the mass of objects.

Lesson Title(s)	Lesson Description(s)
How Does JWST Stay in Orbit?	<p>In this lesson, students revisit the animation from the opening lesson, “The James Webb Space Telescope”, which shows JWST in its orbit. Students explore additional resources to understand why JWST is located where it is and why it can stay in its orbit. Students read additional information about gravity and interplanetary forces.</p> <p>After conducting their additional research, students revisit the driving question board to select a question to answer and explain. Students may need additional support in selecting an appropriate question to use as part of a scientific explanation. After selecting a question, students either individually or in small groups review the information from the opening activity, the data analysis, and the additional research and use that information to support the development of a CER which answers their question. The construction of a scientific argument should be done through the Claim-Evidence-Reasoning (CER) model. This is an opportunity to remediate, if needed, this skill taught in the previous unit.</p> <p><u>What Students Figure Out</u></p> <p>a. Gravitational force is always attractive (CCC: Patterns).</p> <p>b. Attractive forces, including the force of gravity, are responsible for regular orbital motions within a two-body system (CCC: Systems and System Models; Patterns).</p>
Modeling How Gravitational Forces Affect Motion	<p>In the lesson, "Forces Modeling How Gravitational Forces Affect Motion," students demonstrate how well they understand and can model the relationships between force, mass, and relative motion in two body systems. Students work in groups of 3-4 and use everyday objects to develop a model or two models of a two-body system to demonstrate their understanding of the relationships between gravitational forces, mass, and relative motion of objects.</p> <p><u>What Students Figure Out</u></p> <p>a. Gravitational force is always attractive (CCC: Patterns).</p> <p>b. Attractive forces, including the force of gravity, are responsible for regular orbital motions within a two-body system (CCC: Systems and System Models; Patterns).</p>
Formal Assessment Title	Assessment Description
Constructing Arguments about the Effects of Gravitational Forces	The teacher introduces the assessment by presenting two competing solar system models. One model will show Earth as the center of the solar system and the other model will show the sun as the center of the solar system. Students use data to support/refute an explanation about gravitational forces,

determine whether forces between objects are negligible/nonnegligible given data about the masses of the objects, and explain how an object's mass determines its relative motion.

At the end of the task, using the data provided about the mass of objects in our solar system and their acceleration due to gravity, students will support a claim related to the structure of the solar system.

NGSS PE(s) Code(s) & Description(s)

MS-ESS1-2. Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. [Clarification Statement: Emphasis for the model is on gravity as the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. Examples of models can be physical (such as the analogy of distance along a football field or computer visualizations of elliptical orbits) or conceptual (such as mathematical proportions relative to the size of familiar objects such as students' school or state).] [Assessment Boundary: Assessment does not include Kepler's Laws of orbital motion or the apparent retrograde motion of the planets as viewed from Earth.]

MS-PS2-4. Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. [Clarification Statement: Examples of evidence for arguments could include data generated from simulations or digital tools; and charts displaying mass, strength of interaction, distance from the Sun, and orbital periods of objects within the solar system.] [Assessment Boundary: Assessment does not include Newton's Law of Gravitation or Kepler's Laws.]

AG(s) Code(s) & Description(s)

A4. Construct and present an argument to support an explanation that gravitational forces are always attractive (or refute an explanation that gravitational forces can be repulsive).

A19. Construct and present an argument about how gravitational forces lead to a regular orbital motion of a moving object.

Evidence Statement(s)

- Communicate information from science and technical texts to support the claim that gravitational interactions are attractive.
 - Use data on mass and gravitational force to determine similarities and differences in forces exhibited with objects of varying masses.
 - Identify evidence or data that supports an explanation that gravitational forces are always attractive.
 - Use reasoning to connect appropriate evidence about the forces on objects and construct the argument that gravitational forces are attractive.
 - Identify evidence, data, or models that support an argument that gravity causes a pattern of smaller/less massive objects orbiting around larger/more massive objects at all system scales in the universe.
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Phenomenon or Phenomenon-rooted Design Problem

- Images describing how our understanding of the universe has changed over time. Early peoples' first idea of the universe had Earth at the center. Later, as human understanding grew, the sun was thought to be the center of the universe. As our ways of investigating the universe become more sophisticated, we have a new understanding of the universe's structure.
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General Scenario Description

- As scientists have obtained additional data, models of Earth have changed over time. Two models will be presented to students. Students will have to use the data presented and their knowledge of gravitational forces to determine which model better supports our current understanding of how planets orbit in the solar system.

Chain of Sensemaking

- Students are introduced to different historical depictions of the universe (Geocentric, Heliocentric).
- Students analyze gravitational forces using data from various objects in the solar system.
- Students explain which objects in the solar system have the greatest mass and gravitational pull and the least.
- Students analyze gravitational forces using data from various objects in the solar system.
- Students explain the role of distance in determining gravitation pull.
- Students compare and contrast geocentric and heliocentric depictions of the universe using a Venn diagram.
- Students complete a C-E-R about which of the two models is most accurate based on the data.

Work Products

- Completed Venn diagram and explanation
- Constructed-response

Application of Universal Design for Learning-based Guidelines to Promote Accessibility (<https://udlguidelines.cast.org/>)

Multiple Means of Engagement	Multiple Means of Representation	Multiple Means of Action & Expression
<input type="checkbox"/> Context or content	<input checked="" type="checkbox"/> Provide visual diagrams and charts	<input checked="" type="checkbox"/> Solve problems using a variety of strategies
<input checked="" type="checkbox"/> Age appropriate	<input checked="" type="checkbox"/> Make explicit links between information provided in texts and any accompanying representation of that information in illustrations, equations, charts, or diagrams	<input type="checkbox"/> Sentence starters
<input checked="" type="checkbox"/> Appropriate for different groups	<input checked="" type="checkbox"/> Activate relevant prior knowledge	<input checked="" type="checkbox"/> Embed prompts to “show and explain your work”
<input checked="" type="checkbox"/> Makes sense of complex ideas in creative ways	<input type="checkbox"/> Bridge concepts with relevant and simple analogies and limited use of metaphors	
<input checked="" type="checkbox"/> Vary the degree of challenge or complexity within prompts	<input checked="" type="checkbox"/> Highlight or emphasize key elements in text, graphics, diagrams, formulas	
	<input type="checkbox"/> Use outlines, graphic organizers, unit organizer routines, concept organizer routines, and concept mastery routines to	

emphasize key ideas and relationships

- Give explicit prompts for each step in a sequential process

Targeted PE(s) Code(s) and Alternate Conception(s)

- **NGSS PE: MS-ESS1-2** Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.
 - **Common Alternate Conceptions**
 - The Milky Way galaxy is at the center of the universe.
 - Earth and the solar system are at the center of the Milky Way.
 - The relative proximity of Earth to the Sun causes seasons.
 - Celestial bodies are discrete bodies without pattern or without hierarchy.
 - The solar system always existed in its current form.
 - Some, but not all, celestial objects have gravity.
- **NGSS PE: MS-PS2-4** Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.
 - **Common Alternate Conceptions**
 - The magnitudes of the gravitational forces exerted on interacting objects are not equal, with the smaller mass receiving a larger force and the larger mass receiving a smaller force.
 - Gravitational force only applies to large objects such as planets and stars.
 - There is no gravity in space.

Unit 2 Vocabulary

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| ● Orbit | ● Scale (and possible 'scale model') |
| ● Gravitational force of attraction | ● Mass |
| ● Asteroids | ● Moons |
| ● Planets | ● Sun |
| ● Geocentric | ● Heliocentric |
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