Orbital Motion: Why the Moon Doesn't Yeet into Space

Unit	Utah SEEd Standard / NGSS Performance Expectation	Estimated Lesson Time:
Strand 6.1: STRUCTURE AND MOTION WITHIN THE SOLAR SYSTEM The solar system consists of the Sun, planets, and other objects within the Sun's gravitational influence. Gravity is the force of attraction between masses. The Sun-Earth-Moon system provides an opportunity to study interactions between objects in the solar system that influence phenomena observed from Earth. Scientists use data from many sources to determine the scale and properties of objects in our solar system.	**Standard 6.1.2** **Develop and use a model** to describe the role of gravity and inertia in orbital motions of objects in our solar system. (ESS1.B)	Two 45-minute lessons

Lesson Overview

Learning Objective(s)

I can develop and use a model to describe how gravity and inertia work together in the Earth-Moon system to keep the Moon in orbit.

Anchor Phenomenon

If gravity pulls the Moon toward Earth, why doesn't it crash into Earth or fly off into space?

Driving Question(s)

Why does the Moon stay in orbit instead of crashing into Earth or flying off into space?

Lesson Level Performance Expectations

Models show forward motion (inertia) in Earth's gravitational **system** keeps the moon in orbit.

Lesson Snapshot

Lesson Summary:

	Estimated Time	Section Overview	How are students answering the driving question or meeting the learning objectives? (Highlight SEPs, DCIs, and CCCs)
Experience the Phenomenon	**5 minutes**	- Students watch a short video about the Moon orbiting Earth. - They answer a few guiding questions (see worksheet p.1):	**SEP:** Students observe and analyze a real-world phenomenon, beginning the process of scientific inquiry. **DCI:** Introduces ESS1.B—Earth and the Solar System—by focusing on the Moon's motion and Earth's gravity.

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		○ "If gravity pulls the Moon toward Earth, why doesn't it just fall in?" ○ "What keeps the Moon from flying away into space?"	**CCC:** Helps students think about Earth-Moon as a system with interacting parts. **Teacher tips:** - Guide students to share ideas with partners ("turn and talk") and then discuss as a class. - For multilingual learners, make sure video captions are enabled.
Investigate the Phenomenon	**10 minutes**	- Students read about gravity and inertia (worksheet p.2–3). - They discuss how inertia works (e.g., car braking, Voyager spacecraft). - They compare what happens in a car and with Voyager in a Venn diagram. - Students roll a marble around a complete (uncut) hoop/plate, modeling inertia in circular motion. - Key vocabulary is clarified: inertia, gravity, velocity, mass.	**SEP:** Students construct explanations and develop a simple model (marble in plate). **DCI:** Deepens understanding of inertia as a property of matter and its role in space. **CCC:** Begins recognizing systems—Earth/Moon, marble/plate. **Teacher tips:** - Use analogies (car, Voyager) to make inertia relatable. - Facilitate group or paired reading for accessibility. - Use questions like "Why do objects in space keep moving in a straight line?" to prompt discussion. - Encourage students to use evidence from the reading in their responses. - Check for understanding: Ask students to explain Newton's First Law in their own words.
Model the Phenomenon	**30 minutes**	**What happens:** - Students move to hands-on modeling with marbles and plates/hoops, some with gaps ("gravity removed"). - Each group predicts the marble's path when it reaches the gap by drawing predictions on paper. - Students test the actual motion and record observations. - They analyze: ○ "While the marble was inside the track, what caused its direction to keep changing?"	**SEP:** Students develop and use models to test and explain phenomena, and identify limitations. **DCI:** Visualizes how gravity and inertia interact to create orbits, meeting ESS1.B. **CCC:** Explores system models and the effect of removing a system component (gravity). **Teacher tips:** - Circulate and ensure students are rolling the marble at a steady speed. - Ask guiding questions:

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		○ "Once the marble left the track, did its direction change?" ○ "Why does the marble keep moving in a straight line when gravity is gone?"	○ "What does the hoop represent?" (Gravity) ○ "What happens when the marble leaves the gap?" (Shows inertia) - Emphasize that straight-line marble motion after leaving the hoop represents how objects move when no force acts on them. - Encourage students to draw and label models, showing arrows for inertia and gravity. - Use analysis questions and prompt deeper thinking: ○ "How is the balance of gravity and inertia shown in the model?" ○ "What would happen if gravity were stronger or weaker?"

DISCIPLINARY CORE IDEAS	SCIENCE & ENGINEERING PRACTICES	CROSSCUTTING CONCEPTS
(ESS1.B): Earth and the Solar System **Students know and apply the Disciplinary Core Idea (DCI) of (ESS1.B) Earth and the Solar System in their thinking and reasoning to communicate that:** - The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. - This model of the solar system can explain tides, eclipses of the sun and the moon, and the motion of the planets in the sky relative to the stars. Earth's spin axis is fixed in direction over the short term but tilted relative to its orbit around the sun. - The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.	**Developing and Using Models:** Students will develop, use, and revise a model to show orbital motion of objects in our solar system. **Students do and use this Science and Engineering Practice (SEP) by:** - Evaluating limitations of a model for a proposed object or tool. - Developing or modifying a model—based on evidence – to match what happens if a variable or component of a system is changed. - Using and/or developing a model of simple systems with uncertain and less predictable factors. - Developing and/or revising a model to show the relationships among variables, including those that are not observable but predict observable phenomena. - Developing and/or using a model to predict and/or describe phenomena. - Developing a model to describe unobservable mechanisms. - Developing and/or using a model to generate data to test ideas about phenomena in natural or designed	Systems and System Models: Models can be used to explain the parameters and relationships that describe complex systems. **Students think and connect through this Crosscutting Concept (CCC) to reason that:** - Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. - Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. - Models are limited in that they only represent certain aspects of the system under study.

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	systems, including those representing inputs and outputs, and those at unobservable scales.	

Related knowledge and skills from prior grades

Disciplinary Core Idea: 3-5	Science and Engineering Practices: 3-5	Cross-Cutting Concepts: 3-5
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.	- Identify limitations of models. - Collaboratively develop and/or revise a model based on evidence that shows the relationships among variables for frequent and regular occurring events. - Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution. - Develop and/or use models to describe and/or predict phenomena. - Develop a diagram or simple physical prototype to convey a proposed object, tool, or process. - Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system.	- A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. - A system can be described in terms of its components and their interactions.

Materials

Link to all materials on the 3DRST website (3drst.byu.edu): https://3drst.byu.edu/6th-6-1-2-orbital-motion
Link to all materials on Canvas Commons: https://tinyurl.com/3DRSTsixth

Student Materials	Teacher Materials	Lab Materials/Other Resources
Student worksheet Student Reading: Inertia and Gravity	Teacher Slides Moon orbits Earth video	Glass marbles Plastic marbles Metal marbles Embroidery hoop or Paper plates Traffic Cones Construction Paper Large sheets of paper

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LESSON PREPARATION

Material Preparation:

The teacher will need to cut the paper plates to the openings shown in the student workbook

Marble and Plate Activity Instructions

Materials (per group)

- 1 glass marble
- 1 uncut embroidery hoop or plastic plate (represents a full orbit)
- 1–3 plates/hoops with sections cut out (to simulate "removing gravity")
- Large sheet of paper for drawing paths
- Colored pencils (one per student)

Setup

1. **Practice Orbit Motion:**
   a. Place the marble inside the uncut (complete) plate.
   b. Gently roll the marble around the inside edge, practicing steady speed.
2. **Discussion Prompt:**
   a. Ask: "In this model, what does the marble represent? What does the wall of the plate represent?"
   b. Guide students to see the marble's motion as inertia, and the plate wall as gravity.
3. **Predict the Path:**
   a. Place a cut plate (with a section removed) on the paper.
   b. Each student predicts the marble's path when it reaches the gap by drawing on the paper in their own color.
4. **Test and Observe:**
   a. Roll the marble around the plate and let it exit through the gap.
   b. Students observe and record the actual path (repeat with marbles of different masses if available).
5. **Record Results:**
   a. Complete the observation table (marble mass, prediction, and outcomes).
6. **Analysis Questions:**
   a. What caused the marble's direction to change inside the track?
   b. What happened after it left the track?
   c. How does this model represent how gravity and inertia work together?

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Required Previous Knowledge:

This lesson builds on students' prior understanding of the following DCIs developed in previous units, specifically gravity.

Vocabulary Definitions:

Inertia: the idea that an object will continue its current motion until some force causes its speed or direction to change
Velocity: the rate at which an object changes its position
Gravity: the force by which a planet or other body draws objects towards its center
Gravitational Pull: the invisible, attractive force that any two objects with mass exert on each other, drawing them together
Mass: amount of matter in a substance or object
Solar System: a star and the celestial bodies, like planets, moons, asteroids, and comets, that orbit it due to gravity

EXPERIENCE THE PHENOMENON/PROBLEM (ENGAGE)

What Students Are Doing	Teacher Tips
Slide 3: Students watch a simulation video of the moon orbiting the Earth. Students answer the first two questions on the worksheet (**Slide 5)**: • What keeps the Moon from falling onto Earth? • What keeps the Moon from flying away into space?	- Start with a dramatic, real-world scenario: "Imagine you woke up and the Moon suddenly flew off into space—what would happen on Earth?" Invite predictions to boost curiosity and link to real consequences. - Begin with a quick formative assessment (e.g., a "What do you already know?" sticky note or digital poll) about gravity, inertia, and orbits to activate schema and address misconceptions early.
What Teachers Are Doing	**Teacher Tips**
After students watch the video (**Slide 3**) and answer the worksheet questions (**Slide 5)**, the teacher guides the discussion to examine students' thinking and solidify background knowledge. For each question, have the students turn and talk. Then discuss the questions as a class. If your LEA requires it, the teacher reviews the vocabulary with the students (**Slide 4)**.	

INVESTIGATE THE PHENOMENON (EXPLORE)

What Students Are Doing	Teacher Tips

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- **Slide 6**: Students compare and contrast Voyager 1 with someone riding in a car and the driver slams on the brakes, using a Venn diagram on their worksheets to learn about inertia. - Students will begin to discuss inertia. - Students begin discussing the Earth's orbit. - Students roll the marble around the complete hoop. - They read a passage about gravity and Inertia. - Students answer questions about the passage and then discuss them with the class.	Allow read-together or group reading. The reading is provided in both the student worksheet and as a stand-alone document in the lesson materials.
What Teachers Are Doing	**Teacher Tips**

- **Slide 6**: The teacher discusses the difference between a car slamming on its brakes and the passenger moving forward due to inertia, and how Voyager continues to move in space for decades because of inertia.
- **Slide 7:** The teacher facilitates the marble-and-plate activity.
- The teacher facilitates a discussion using the questions on slide 7 to make sure students understand the paper plate model.
- The teacher has students read the passage on gravity and inertia (page 3 of the student worksheet and **Slides 8-10**) and answer the worksheet questions. The teacher then leads a discussion about the questions the students answered on the worksheet. **(Slide 11)**
  - What is inertia?
  - How does it affect objects not moving?
  - Why do objects in space keep moving in a straight line?
  - What is gravity, and how does it affect us?
	- Facilitate a group reading of the passage about inertia; encourage paired or group reading for improved understanding.
	- Encourage students to use evidence from the reading in their responses.
	- Clarify key vocabulary (inertia, gravity, orbit) using diagrams or real-life examples.
	- Check for understanding by asking students to explain Newton's first law of motion in their own words.
	- Support multilingual learners by providing sentence stems and visuals.
	- After the marble model, prompt students to identify and discuss the limitations of the model (e.g., "How is our marble activity similar to and different from a real planetary orbit?"). This aligns with NGSS's emphasis on developing and critiquing models.
	- Use sentence stems and graphic organizers for explanations:
	  - "Gravity is like _____ because _____."
	  - "Inertia affects the marble by _____."
	- For multilingual learners, provide vocabulary cards with visuals and interactive word walls.
	- Include structured peer discussion opportunities (e.g., "turn and talk" or small group debates) after each key step, not just after worksheet questions. This increases engagement and peer-supported learning (PLC at Work).

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MODEL THE PHENOMENON (EXPLAIN)

What Students Are Doing	Teacher Tips

- **Slide 12:** Students predict the path of each marble after it leaves the cut paper plate.
Prediction Instructions for Students
Set Up
- Place the cut plate (with a section removed) on a large sheet of construction paper.
Make Your Prediction
- Before rolling the marble, each group member uses a different color pencil to draw the path they think the marble will follow when it reaches the gap (where the plate wall is missing).
- Draw your predicted path directly on the construction paper, starting from the spot where the marble will exit the plate.
- Think: What do you expect the marble to do when the "inward pull" (gravity) is suddenly gone?
Repeat
- Repeat this step for each marble if you are using different marbles (e.g., different masses).
Test and Compare
- After making predictions, roll the marble and observe what actually happens. Compare the real path to your drawn predictions.
- **Slide 13-14:** Students spin three different marbles with different masses around incomplete plates to see what happens when gravity is removed.
- **Slides 15-16:** Students answer questions on the worksheet.
- **Slide 17:** Students draw a model to show understanding of how gravity and inertia work together.
- **Slide 18:** Students complete an exit ticket.
	- Circulate and observe as students roll marbles in the plate, ensuring they keep a steady speed.
	- Ask guiding questions:
	  - What does the plate represent? (Gravity)
	  - What happens when the marble leaves the gap? (It moves in a straight line—shows inertia)
	  - How does the marble's path change with different gap positions?
	- Encourage students to explain their reasoning aloud as they draw their predictions.
	- Use prompts:
	- "What force is acting on the marble before it reaches the gap?"
	- "What will happen when that force is gone?"
	- For multilingual learners or students needing support, provide sentence frames:
	- "I think the marble will _____ because _____."
	  - Remind students that there are no "wrong" predictions—this is about thinking like a scientist!
	- Emphasize that the marble's straight-line motion after leaving the hoop models how objects move when no force acts on them (Newton's first law).
	- Use analysis questions to prompt deeper thinking:
	  - How is the balance of gravity and inertia shown in the model?
	  - What would happen if gravity were stronger or weaker?
	- Support all students by prompting them to draw or explain their predictions and observations.
	- For multilingual learners, reinforce key vocabulary with visuals and sentence frames.

What Teachers Are Doing	**Teacher Tips**
- The teacher gives instructions on how to make predictions and test the marbles. - The teacher walks around and makes sure students are doing it correctly. - The teacher gives directions on making the model. - The teacher gives the exit ticket.	What makes a strong model + explanation? Students should show: - Forward motion (inertia) - Inward pull (gravity)

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	Students should explain: - Why the moon doesn't fall - Why doesn't it fly away Students should use: - Evidence from the marble model.

POSSIBLE EXTENSIONS/ALTERNATIVE ADAPTATIONS

- Have students research and present on real-world examples of gravity and inertia in our solar system (e.g., why some moons have irregular orbits).
- Challenge advanced students to predict and test the effect of changing the mass (using different marbles) on the observed motion.

For multilingual learners: Provide key vocabulary with visuals and sentence stems for discussion (e.g., "Inertia means...").
For students with reading difficulties: Use paired or group reading for the passage about inertia; provide audio support if possible.
For students with motor difficulties: Allow them to direct a partner in performing the marble activity, or use a digital simulation.
For visual learners: Use color-coded diagrams showing the marble's path as gravity is "removed."
For students who need more structure: Offer a step-by-step checklist for the hands-on activity and clear graphic organizers for predictions and observations.
For all students: Encourage drawing and labeling models to show their understanding.

Extend and Differentiate

For advanced students: Challenge them to research real moons with irregular orbits or run the marble with different masses and graph results.

For students needing more structure: Provide step-by-step checklists and/or a digital simulation option for those with motor difficulties.

Connect to the Real World and Student Interests

Have students find or bring in news stories or social media posts about space missions (e.g., Artemis, Voyager) and relate them to the lesson concepts.

This lesson was created by Westen Miller, Megan Sitterud, Kris Ericksen, and Maggie Grindstaff

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