Unit 4: Space Systems: Stars and the Solar System

Module 11: *How Does Gravity Act on Objects?*

student pages 81–88

Learning Goals: Students gather evidence to support an argument that a gravitational force causes objects to move toward the center of Earth. To successfully develop these concepts, students should understand push/pull forces, identify Earth as spherical, be able to use evidence to support arguments, and recognize cause-and-effect relationships. As students form answers to the question "How does gravity act on objects?" they continue to refine their understanding of cause and effect.

Performance Expectation (PE): 5-PS2-1

- Support an argument that the gravitational force exerted by Earth on objects is directed down.
  [Clarification Statement: "Down" is a local description of the direction that points toward the center of the spherical Earth.] [Assessment Boundary: Assessment does not include mathematical representation of gravitational force.]

Additional Performance Expectations (PE): 5-ESS1-2, 3-5-ETS1-2

Science and Engineering Practices (SEP):	Disciplinary Core Ideas (DCI):	Crosscutting Concepts (CCC):
• Asking Questions and Defining Problems • Developing and Using Models • Planning and Carrying Out Investigations • Analyzing and Interpreting Data • Using Mathematics and Computational Thinking • Constructing Explanations and Designing Solutions • Engaging in Argument from Evidence • Obtaining, Evaluating, and Communicating Information	• PS2.B: Types of Interactions • ESS1.B: Earth and the Solar System • ETS1.B: Developing Possible Solutions	• Patterns • Cause and Effect • Scale, Proportion, and Quantity • Systems and System Models

Nature of Science (NOS): Scientific Investigations Use a Variety of Methods; Scientific Knowledge is Based on Empirical Evidence; Scientific Knowledge is Open to Revision in Light of New Evidence; Scientific Models, Laws, Mechanisms, and Theories Explain Natural Phenomena; Science is a Way of Knowing; Scientific Knowledge Assumes an Order and Consistency in Natural Systems; Science is a Human Endeavor; Science Addresses Questions About the Natural and Material World

Engineering Design (ED): Designing Solutions to Engineering Problems

Science, Technology, Society, and the Environment (STSE): Influence of Engineering, Technology, and Science on Society and the Natural World

State Standards Connections: ELA/Literacy: RI.5.1, RI.5.9, W.5.1

NGSS Lead States. 2013. *Next Generation Science Standards: For States, By States.* Washington, DC: The National Academies Press.

Learning Progression: In kindergarten, students designed and carried out investigations to compare the effects of different strengths and directions of pushes or pulls on the motion of an object. In grade 3, students designed and carried out investigations determining the effects of balanced and unbalanced forces on the motion of an object.

How Does Gravity Act on Objects?

Engage: Module 11

student page 81

Start Here 15–20 minutes

1 Pre-Assessment

Assign the Pre-Assessment as an online assignment. Then have students log into *Motivation Online* and complete the Pre-Assessment for Module 11.

After students complete the Pre-Assessment, access the Reports screen to view Standards Mastery and Item Analysis reports. Use the data to plan instruction.

2 Motivation Station

Read the Motivation Station: Scientific Fact. Discuss how the absence of gravity affects astronauts.

Observing Falling Objects 45–60 minutes

3 Materials: Prepare materials prior to the activity.

Per Group			*Per Student*	*Per Teacher*
• golf ball	• timing device/stopwatch	• coin	• safety goggles	• safety goggles
• tennis ball	• meter stick			
• index card	• plastic beaker			

4 Procedure

1. Place an index card on a beaker with a coin in the center of the card. Demonstrate how to thump the index card so the coin drops into the beaker.
2. Distribute beakers, index cards, and coins to each group. Allow time to practice thumping the card so the coin falls into the beaker.
3. Ask students if the coin could move without a force acting on it. Discuss the force that causes the coin to drop. Explain that the coin was at rest on top of the index card. When the card was thumped, the card moved, but the coin was still at rest. Gravity pulled the coin into the beaker with a downward force.
4. Show a tennis ball and a golf ball. Discuss how they are different. Explain the two balls will be dropped at the same time and height. Ask students to predict which ball will hit the ground first and record predictions in student editions.
5. Distribute a stopwatch, meter stick, and the balls to each group. As an option, this investigation can be conducted with the whole class, as it is somewhat difficult to release the objects at the same time. Conducting the test as a whole class may produce more accurate results.
6. Instruct groups to drop both objects at the same time from 1 meter. Have students repeat the investigation three times, recording findings after each trial.
7. Have students complete and discuss the questions.
8. Allow groups to share claims. Ask the class to determine if adequate and applicable evidence and reasoning was provided to support the claim. If not, ask the class to help the group add evidence to support their claim.
9. Extend the activity by asking *"What would happen if you repeated Activity 2 using different objects?"*

5 Answers

1. Drawings may vary.
   Observation: Students should observe that the coin stays in place in the center. The force of gravity causes the coin to fall into the cup.
2. The force of gravity caused the coin to drop downward into the beaker.
3. Predictions may vary.
4. No. The objects in the investigation are different masses, but in each trial they hit the ground at approximately the same time.
5. Claim statements may vary.

6 Formative Assessment

Ask students to think of a question to investigate gravity. Have students form a hypothesis and generate a list of equipment. Post the testable questions in the classroom. Provide additional instruction for students who have difficulty generating testable questions.

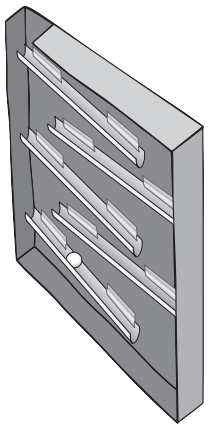
Explore: Module 11

Building Background 45–60 minutes

1 Materials: Prepare materials prior to the activity.

Per Group

- cardboard box
- tape
- toy car
- paper towel or wrapping paper rolls
- timing device/stopwatch
- ball
- marble



2 Procedure

1. Explain to students that they will create a timer to release an object that rolls (toy car, ball, marble) from an opening cut at the top of the box.
2. Instruct students to time the device so that the object reaches the bottom of the box in 10 seconds.
3. Have students revise the locations of the ramps and use different rolling objects until the object reaches the bottom in 10 seconds.
4. Allow each group to share their timer and determine who designed the most accurate timing device.
5. Discuss how the timer works and what causes the object to move through the timer.

Tip: Log into *mentoringmindsonline.com* and select the *Whiteboard* button. Navigate to the Appendix: Image Bank to display the example picture of a timer on the screen.

Experimental Design 45–60 minutes

3 Materials: Prepare materials prior to the activity.

Per Group

- various materials, based on the experimental designs of the groups

Per Student

- safety goggles

Per Teacher

- safety goggles

4 Procedure

1. Ask each group to choose one of the testable questions generated in the Engage Formative Assessment activity.
2. Instruct groups to follow the directions in student editions to design an investigation testing gravity.
3. Make sure each group understands the following question in the context of their investigation "What effect does gravity have on _____?"

5 Answers

Experimental designs may vary.

Explain: Module 11

Check for Understanding

2–3 class periods

1 Materials: Prepare materials prior to the activity.

Per Student/Group

- Internet/library sources
- science notebooks

2 Procedure

Part A: Use evidence to support your viewpoint about heavier objects falling faster than lighter objects.

1. **Research:** Have students independently research Galileo's Leaning Tower of Pisa experiment. Ask students to gather evidence to support their viewpoint about the statement in the student edition. Using evidence, have students develop an argument statement. Any additional evidence gathered during research that was not previously used to support the argument statement should be recorded in student editions for possible use during the Socratic seminar.
2. **Socratic seminar:** Place students in two circles, inner and outer. Pair each student from the inner circle with a student from the outer circle. These student pairs will provide feedback after each discussion session. Review the rubric on page 83 in the student edition. Ask a volunteer from the inner circle to begin the discussion by reading his/her argument statement. Encourage the inner circle to engage in discussion about Galileo's Leaning Tower of Pisa experiment for 10 minutes, while the outer circle partners take notes and evaluate the inner circle partner arguments, evidence, participation, and engagement in the seminar. At the end of the inner circle discussion, the outer circle partner coaches the inner circle student concerning all aspects of the Socratic Seminar Scoring Rubric. Ask the inner and outer circles to change positions and repeat the discussion session.
3. Have students complete the reflection and revision of their original argument based on information learned during the seminar.

Part B: Use evidence to support your viewpoint of whether Earth is spherical.

4. **Research:** Have students independently research one of the following questions to support their viewpoint of whether Earth is spherical. Ask students to record all information and evidence in science notebooks.

   What patterns can be found in the appearance and position of constellations in the Northern and Southern Hemispheres during different times of year?
   Why do ships appear to sail beyond the horizon?
   What shape is Earth's shadow on the moon during an eclipse?
   How does the position of the North Star's height change above the horizon?

5. **Socratic Seminar:** Repeat the steps used for conducting a Socratic seminar. Have students use the evidence gathered to support their viewpoint of whether Earth is spherical.

   Note: Preview Internet websites for appropriate content to ensure that each website meets the instructional goals of the lesson and complies with district/school guidelines for acceptable use.

3 Answers

1. Arguments may vary.
2. Additional evidence for Socratic seminar may vary.
3. Personal goals for Socratic seminar may vary.
4. Answers may vary.
5. Revised argument statements may vary. Arguments should be scored with the Socratic Seminar Scoring Rubric on page 83 in student editions.

Elaborate: Module 11

Critical Thinking 35–40 minutes

1 Materials: Prepare materials prior to the activity.

Per Group			*Per Student*	*Per Teacher*
• timing device/stopwatch	• 10 washers	• straw	• safety goggles	• safety goggles
• empty spool	• scissors			
• meter stick	• string			

2 Procedure

1. **Instruct students to wear safety goggles during the entire investigation.**
2. Have students cut a piece of string one meter in length.
3. Direct students to thread 10 washers onto one end of the string and secure well with knots.
4. Have students cut a 12-centimeter section of straw and thread the other end of the string through the straw.
5. Ask students to add the empty spool after the straw and secure the spool to the end of the string.
6. Check each apparatus before students continue with the investigation.
7. Instruct students to measure 20 centimeters between the empty spool and the top of the straw.
8. Have students secure the string with their fingers. Direct students to hold the apparatus parallel to the floor and twirl the apparatus above their heads. Make sure students have sufficient room to perform the investigation safely.
9. Instruct group members to count the number of revolutions the spool makes in 15 seconds. Have students record all observations in student editions.
10. Repeat the investigation for five additional radius measurements.
11. Have students complete the discussion questions.
12. Discuss results with students. Compare results with other groups and discuss similarities and differences. Have students record additional information learned during the class discussion.

3 Answers

Answers in table may vary.

1. Observations may vary.
2. The sun's gravitational force acts upon each planet, pulling them into orbits that revolve around the sun.
3. The gravitational force does not act on objects farther away with as great a force.
4. Answers may vary.
5. Answers may vary.

4 Formative Assessment

Use the letters of the term "gravity" to create sentences and examples which describe gravitational forces. Review student responses to plan next steps for instruction.

Extend: Module 11

Vocabulary 20–30 minutes

1 Terms: Introduce these essential vocabulary terms during this module.

- argument
- beaker
- conclusion
- critique
- direction
- down
- Earth
- exert
- force
- gravitational force
- gravity
- hypothesis
- meter stick
- object
- question
- scientist
- stopwatch
- support

2 Procedure

1. Have students complete the graphic organizer with information that describes the term "gravitational force."
2. In each section of the circle, ask students to write the definition for each term as it relates to "gravitational force."

3 Answers

Related words may vary.
Sentences may vary.
Force: a gravitational force is a pull that causes an object to move, stop, or change to a downward direction
Motion: movement due to gravitational force causes an object to move down toward the center of Earth
Direction: a gravitational force causes an object's path to move downward

4 Formative Vocabulary Assessment

Present students with an analogy prompt:

A gravitational force is like _____ *because* _____.

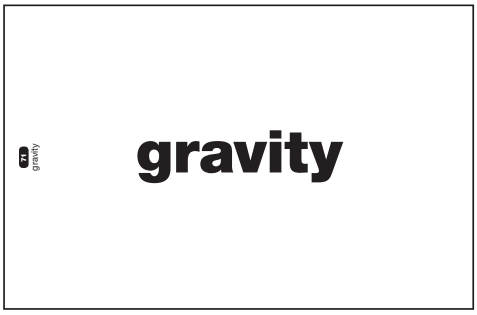
Review student responses and plan additional instruction as needed.

Optional Vocabulary Activity 5–10 minutes

After all the vocabulary terms have been introduced for the module, have students bring pictures or example items from home that represent the vocabulary terms. Make a display of the items after each student describes his/her example and how it relates to the vocabulary terms.

Vocabulary Cards 10–30 minutes

Consult the *Motivation Science™ Word Play Activities with Teacher Guide* that accompanies the *Motivation Science™ Vocabulary Card Set* for additional activities to use with terms that have not yet been mastered.



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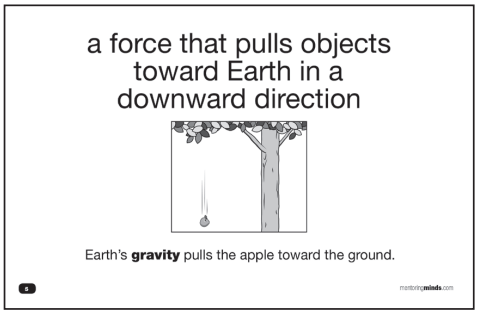


back

Module 11

Extend: Module 11

Homework 1 evening

1 Procedure

1. Review the activity directions with students before assigning to complete at home.
2. **Remind students to obtain parent permission before conducting the investigation.**
3. Explain that students will design and illustrate an investigation to test gravity with toys or objects found at home. Explain that students will write a summary of the investigation and a claim that describes gravitational forces. Remind students to use evidence and reasoning to support their claim.
4. Have students share their results with the class.

2 Parent Activities

Review Parent Activities and encourage students to complete these with a parent or guardian.

3 Answers

Investigation questions, illustrations, and summaries may vary.
Claims may vary but should provide evidence that gravitational forces pull objects down toward the center of Earth.

Reflection/Journal Prompt 20–30 minutes

In science notebooks, have students respond to the following reflection/journal prompt:

Write a story telling what it would be like to spend a day on Earth without gravitational forces.

Extending Student Thinking 45–60 minutes

Have students research famous scientists that contributed to the understanding of gravitational forces. Then have students write a biography about a scientist such as Aristotle, Galileo, Sir Isaac Newton, and Albert Einstein.

Note: Preview Internet websites for appropriate content to ensure that each website meets the instructional goals of the lesson and complies with district/school guidelines for acceptable use.

Cross-Curricular Connection 30–45 minutes

Physical Education

Explore the forces of gravity through the physics of sports. Research the physics of baseball, basketball, volleyball, soccer, skateboarding, ice hockey, cheerleading, ice skating, and other sports.

Note: Preview Internet websites for appropriate content to ensure that each website meets the instructional goals of the lesson and complies with district/school guidelines for acceptable use.

Children's Literature Connections 10–30 minutes

Awesome Experiments in Force & Motion – Michael A. DiSpezio
Experiments with Force and Motion – Colin Uttley
Forces – Peter Riley
Galileo's Leaning Tower Experiment – Wendy Macdonald
I Fall Down – Vicki Cobb
Isaac Newton: The Scientist Who Changed Everything – Philip Steele
Newton and Me – Lynne Mayer
Super Science: Feel the Force!: Full of Pop-Up Physics Fun! – Tom Adams

Evaluate: Module 11

student page 87

Post-Assessment 45–60 minutes

1 Procedure

Have students log into *Motivation Online* to take the Post-Assessment to benefit from progress monitoring.

1. Review the Module 11 Learning Goals and standards information at the beginning of Unit 4 to provide a purpose for the assessment.
2. Complete the *Module 11 Notes* section with Assessment Learning Goals and Accomodations.
3. Have students complete the Evaluate/Post-Assessment section on pages 87–88 of the student edition if Internet or computer access is limited.
4. Following the assessment, have students record how many questions they got correct on Chart Your Success page 140 in the student edition.
5. Ask students to participate in self-reflection by collecting information about their own learning, analyzing what it reveals about their progress toward the intended learning goal, and planning the next steps in their learning.

2 Materials: This assessment includes a hands-on performance task requiring materials. Prepare materials prior to administering the assessment. Determine whether students will complete the performance task individually or in groups.

Per Group or Student

- various-shaped balloons
- meter stick (optional)
- timing device/stopwatch (optional)
- rubber band
- iron nail
- toy car
- marble
- ball

Per Student

- safety goggles

Per Teacher

- safety goggles

3 Module 11 Notes

Assessment Learning Goals

Accommodations

English Language Learners	Below-Level Readers
Visually Impaired Students	Hearing Impaired Students

4 Answers, page 87

1. Yes, no, yes, no, yes
2. D
3. Arrows at all locations should point toward the center of Earth. See the Appendix: Image Bank for an example image.
4. Statements 2 and 3 are false statements. Statement rewrites may vary but should be factual statements about gravitational force. Some examples are shown.
   (2) Gravitational forces exist beyond Earth, such as planets orbiting the sun.
   (3) Earth's spherical shape allows all objects to fall downward, no matter their location on Earth's surface. Proof that Earth is spherical includes a ship sailing beyond the horizon, the shape of Earth's shadow on the face of the moon during an eclipse, cyclical cycle of constellation movement during the seasons, and/or the change in position of the North Star's height above the horizon as you travel north and south.
5. A reasonable prediction is approximately 0.45 seconds. The apple, regardless of size or shape, will fall to the ground from 1 meter in the same amount of time.
6. Gravitational force causes an object that is released from a height of 1 meter to fall downward to the ground.

Evaluate: Module 11

Post-Assessment, continued

45–60 minutes

5 Answers, page 88

7. Drawings may vary but should include all materials required to carry out the investigation.
8. Investigation procedures may vary but should only include one variable tested during the investigation.
9. Problems may vary, but students should be able to explain the problem and how they redesigned the investigation to overcome the problem.
10. Observations may vary but should include how gravitational forces caused the object to move downward.
11. Gravitational forces affect objects by causing them to move downward toward the center of Earth.

Interventions

10–15 minutes each

Use the following activities to provide remediation.

1. Set a timer for three minutes. Have students write as many characteristics as they can about gravitational forces. Collect and share some of the ideas with the class. Allow students to agree or disagree with each statement, citing evidence and reasoning to support their claims.
2. Ask a student to take one sheet of aluminum foil and crumple it into a tight ball. Ask another student to take five sheets of aluminum foil and crumple them into a tight ball. Show the class each ball. Have students record predictions about when each ball will hit the ground. Remind students about gravitational forces. Ask a student to hold both foil balls above the table at 50 cm. Instruct the student to drop the balls at the same time. Direct all students to observe the balls as they fall and record observations. Repeat the process four more times. Discuss how students' predictions and the investigation outcomes are alike and different. Be sure students are able to understand the cause of the motion, direction of the force acting on each ball, and how the different-sized balls impacted the results.
3. Show students video clips of a ship sailing past the horizon and a lunar eclipse. Discuss how each provides evidence that Earth is spherical in shape.

6 Formative Assessment

Ask students to write a summary sentence that answers *who*, *what*, *when*, *where*, *why*, and *how* questions about gravitational force. Review summary sentences to determine whether additional instruction is needed.

Key for Recommended Grouping

Individual Partners Groups Whole Class

CCC: Cause and Effect
ED: Designing Solutions to Engineering Problems
DOK: 2
Bloom's Level: Comprehension/Understand

Formative Assessment

PEs: 5-ESS3-1; 3-5-ETS1-2
SEP: Constructing Explanations and Designing Solutions
DCIs: ESS3.C; ETS1.B
CCC: Cause and Effect
ED: Designing Solutions to Engineering Problems
DOK: 2
Bloom's Level: Comprehension/Understand

Module 11

Engage page 81

Pre-Assessment

PE: 5-PS2-1
SEP: Analyzing and Interpreting Data
DCI: PS2.B
CCC: Cause and Effect
DOK: 2
Bloom's Level: Analysis/Analyze

Observing Falling Objects

PE: 5-PS2-1
SEPs: Planning and Carrying Out Investigations; Analyzing and Interpreting Data; Constructing Explanations and Designing Solutions
DCI: PS2.B
CCCs: Cause and Effect; Scale, Proportion, and Quantity
NOS: Scientific Investigations Use a Variety of Methods; Scientific Knowledge is Based on Empirical Evidence; Scientific Knowledge is Open to Revision in Light of New Evidence
DOK: 3
Bloom's Level: Application/Apply

Formative Assessment

PE: 5-PS2-1
SEPs: Asking Questions and Defining Problems; Planning and Carrying Out Investigations
DCI: PS2.B
CCCs: Cause and Effect; Scale, Proportion, and Quantity
NOS: Scientific Investigations Use a Variety of Methods
DOK: 3
Bloom's Level: Application/Apply

Explore page 82

Building Background

PEs: 5-PS2-1; 3-5-ETS1-2
SEPs: Developing and Using Models; Planning and Carrying Out Investigations; Analyzing and Interpreting Data; Using Mathematics and Computational Thinking; Constructing Explanations and Designing Solutions
DCIs: PS2.B; ETS1.B
CCCs: Cause and Effect; Scale, Proportion, and Quantity; System and System Models
ED: Designing Solutions to Engineering Problems
STSE: Influence of Engineering, Technology, and Science on Society and the Natural World
DOK: 3
Bloom's Level: Application Apply

Experimental Design

PE: 5-PS2-1
SEPs: Asking Questions and Defining Problems; Planning and Carrying Out Investigations; Analyzing and Interpreting Data; Using Mathematics and Computational Thinking; Constructing Explanations and Designing Solutions
DCI: PS2.B
CCCs: Cause and Effect; Scale, Proportion, and Quantity
NOS: Scientific Investigations Use a Variety of Methods; Scientific Knowledge is Based on Empirical Evidence
DOK: 4
Bloom's Levels: Application/Apply; Analysis/Analyze

Explain page 83

Check for Understanding

PEs: 5-PS2-1; 5-ESS1-2
SEPs: Asking Questions and Defining Problems; Analyzing and Interpreting Data; Constructing Explanations and Designing Solutions; Engaging in Argument from Evidence; Obtaining, Evaluating, and Communicating Information
DCI: PS2.B
CCCs: Patterns; Cause and Effect
NOS: Scientific Knowledge is Open to Revision in Light of New Evidence; Science is a Way of Knowing; Scientific Knowledge Assumes an Order and Consistency in Natural Systems
ELA: RI.5.1; RI.5.9
DOK: 3
Bloom's Level: Evaluation/Evaluate

Elaborate page 84

Critical Thinking

PEs: 5-PS2-1; 5-ESS1-2
SEPs: Developing and Using Models; Planning and Carrying Out Investigations; Analyzing and Interpreting Data; Using Mathematics and Computational Thinking; Constructing Explanations and Designing Solutions
DCIs: PS2.B; ESS1.B
CCCs: Patterns; Cause and Effect
NOS: Scientific Investigations Use a Variety of Methods; Scientific Knowledge is Based on Empirical Evidence; Scientific Models, Laws, Mechanisms, and Theories Explain Natural Phenomena
DOK: 3
Bloom's Level: Application/Apply

Formative Assessment

PE: 5-PS2-1
DCI: PS2.B
DOK: 2
Bloom's Level: Comprehension/Understand

Extend pages 85–86

Vocabulary

PE: 5-PS2-1
DCI: PS2.B
DOK: 2
Bloom's Level: Comprehension/Understand

Formative Vocabulary Assessment

PEs: 5-PS2-1; 5-ESS1-2
DCIs: PS2.B; ESS1.B
DOK: 2
Bloom's Level: Comprehension/Understand

Optional Vocabulary Activity

PE: 5-PS2-1
DCI: PS2.B
DOK: 2
Bloom's Level: Application/Apply

Homework

PE: 5-PS2-1
SEPs: Asking Questions and Defining Problems; Planning and Carrying Out Investigations; Analyzing and Interpreting Data; Using Mathematics and Computational Thinking; Constructing Explanations and Designing Solutions
DCI: PS2.B
CCCs: Cause and Effect; Scale, Proportion, and Quantity
NOS: Scientific Investigations Use a Variety of Methods; Scientific Knowledge is Based on Empirical Evidence
DOK: 4
Bloom's Level: Application/Apply

Reflection/Journal Prompt

PE: 5-PS2-1
SEP: Constructing Explanations and Designing Solutions
DCI: PS2.B
CCC: Cause and Effect
ELA: W.5.1
DOK: 2
Bloom's Level: Application/Apply

Extending Student Thinking

PE: 5-PS2-1
SEP: Obtaining, Evaluating, and Communicating Information
DCI: PS2.B
CCC: Cause and Effect
NOS: Science is a Human Endeavor
ELA: RI.5.9
DOK: 2
Bloom's Level: Comprehension/Understand

Cross-Curricular Connection

Physical Education
PE: 5-PS2-1
SEPs: Constructing Explanations and Designing Solutions; Obtaining, Evaluating, and Communicating Information
DCI: PS2.B
CCC: Cause and Effect
NOS: Science Addresses Questions About the Natural and Material World
ELA: RI.5.1; RI.5.9
DOK: 2
Bloom's Level: Analysis/Analyze

Evaluate pages 87–88

Post-Assessment

1. PE: 5-PS2-1
   SEPs: Developing and Using Models; Constructing Explanations and Designing Solutions
   DCI: PS2.B
   CCC: Cause and Effect
   DOK: 2
   Bloom's Level: Analysis/Analyze
2. PE: 5-PS2-1
   SEP: Constructing Explanations and Designing Solutions
   DCI: PS2.B
   CCC: Cause and Effect
   DOK: 2
   Bloom's Level: Comprehension/Understand

3. PE: 5-PS2-1
   SEP: Developing and Using Models
   DCI: PS2.B
   CCCs: Patterns; Cause and Effect
   DOK: 2
   Bloom's Level: Application/Apply
4. PE: 5-PS2-1
   SEPs: Analyzing and Interpreting Data; Constructing Explanations and Designing Solutions; Engaging in Argument from Evidence
   DCI: PS2.B
   CCC: Cause and Effect
   DOK: 3
   Bloom's Level: Evaluation/Evaluate
5. PE: 5-PS2-1
   SEPs: Analyzing and Interpreting Data; Using Mathematics and Computational Thinking; Constructing Explanations and Designing Solutions
   DCI: PS2.B
   DOK: 2
   Bloom's Level: Application/Apply
6. PE: 5-PS2-1
   SEP: Constructing Explanations and Designing Solutions
   DCI: PS2.B
   CCC: Cause and Effect
   DOK: 2
   Bloom's Level: Comprehension/Understand
7. PE: 5-PS2-1
   SEP: Planning and Carrying Out Investigations
   DCI: PS2.B
   CCCs: Cause and Effect; Scale, Proportion, and Quantity
   DOK: 3
   Bloom's Level: Application/Apply
8. PE: 5-PS2-1
   SEPs: Planning and Carrying Out Investigations; Analyzing and Interpreting Data; Constructing Explanations and Designing Solutions
   DCI: PS2.B
   CCCs: Cause and Effect; Scale, Proportion, and Quantity
   DOK: 3
   Bloom's Level: Application/Apply
9. PE: 5-PS2-1
   SEP: Planning and Carrying Out Investigations
   DCI: PS2.B
   CCC: Cause and Effect
   DOK: 3
   Bloom's Level: Evaluation/Evaulate
10. PE: 5-PS2-1
    SEPs: Analyzing and Interpreting Data; Constructing Explanations and Designing Solutions
    DCI: PS2.B
    CCCs: Cause and Effect; Scale, Proportion, and Quantity
    DOK: 2
    Bloom's Level: Comprehension/Understand
11. PE: 5-PS2-1
    SEP: Constructing Explanations and Designing Solutions
    DCI: PS2.B
    CCC: Cause and Effect
    DOK: 3
    Bloom's Level: Evaluation/Evaluate

Interventions

1. PE: 5-PS2-1
   SEPs: Analyzing and Interpreting Data; Engaging in Argument from Evidence
   DCI: PS2.B
   CCC: Cause and Effect
   NOS: Scientific Knowledge Assumes an Order and Consistency in Natural Systems
   DOK: 3
   Bloom's Level: Evaluation/ Evaluate
2. PE: 5-PS2-1
   SEPs: Planning and Carrying Out Investigations; Analyzing and Interpreting Data; Using Mathematics and Computational Thinking; Constructing Explanations and Designing Solutions
   DCI: PS2.B
   CCC: Cause and Effect
   NOS: Scientific Knowledge Assumes an Order and Consistency in Natural Systems
   DOK: 2
   Bloom's Level: Analysis/Analyze
3. PE: 5-PS2-1
   SEPs: Developing and Using Models; Constructing Explanations and Designing Solutions
   DCI: PS2.B
   CCC: Cause and Effect
   NOS: Scientific Knowledge is Open to Revision in Light of New Evidence; Scientific Models, Laws, Mechanisms, and Theories Explain Natural Phenomena
   DOK: 2
   Bloom's Level: Comprehension/Understand

Formative Assessment

PE: 5-PS2-1
SEP: Constructing Explanations and Designing Solutions
DCI: PS2.B
CCC: Cause and Effect
NOS: Scientific Knowledge Assumes an Order and Consistency in Natural Systems
DOK: 2
Bloom's Level: Comprehension/Understand

Module 12

Engage page 89

Pre-Assessment

PEs: 5-ESS1-1; 1-ESS1-1
DCI: ESS1.A
DOK: 1
Bloom's Level: Knowledge/Remember

Perception

PE: 5-ESS1-1
SEPs: Planning and Carrying Out Investigations; Analyzing and Interpreting Data; Using Mathematics and Computational Thinking
DCI: ESS1.A
CCC: Scale, Proportion, and Quantity
NOS: Scientific Investigations Use a Variety of Methods
Math: MP.2; MP.4
DOK: 2
Bloom's Levels: Comprehension/Understand; Application/Apply

Formative Assessment

PEs: 5-ESS1-1; 4-PS4-2
DCI: ESS1.A
CCC: Scale, Proportion, and Quantity
DOK: 2
Bloom's Level: Comprehension/Understand

Explore page 90

Brightness of Stars

PE: 5-ESS1-1
SEPs: Developing and Using Models; Analyzing and Interpreting Data; Using Mathematics and Computational Thinking; Constructing Explanations and Designing Solutions
DCI: ESS1.A
CCCs: Cause and Effect; Scale, Proportion, and Quantity; Systems and System Models
NOS: Scientific Knowledge is Based on Empirical Evidence
Math: MP.2; MP.4
DOK: 3
Bloom's Level: Analysis/Analyze

Comparing Stars

PE: 5-ESS1-1
SEPs: Developing and Using Models; Analyzing and Interpreting Data; Using Mathematics and Computational Thinking; Constructing Explanations and Designing Solutions
DCI: ESS1.A
CCCs: Cause and Effect; Scale, Proportion, and Quantity; Systems and System Models
NOS: Scientific Knowledge is Based on Empirical Evidence
Math: MP.2; MP.4
DOK: 3
Bloom's Level: Analysis/Analyze

Explain page 91

Check for Understanding

PE: 5-ESS1-1
SEPs: Analyzing and Interpreting Data; Using Mathematics and Computational Thinking; Engaging in Argument from Evidence; Constructing Explanations and Designing Solutions; Obtaining, Evaluating, and Communicating Information
DCI: ESS1.A
CCCs: Cause and Effect; Scale, Proportion, and Quantity
NOS: Scientific Knowledge is Based on Empirical Evidence
ELA: RI.5.1; RI.5.7; RI.5.8; RI.5.9; W.5.1
Math: MP.2; MP.4
DOK: 3
Bloom's Level: Evaluation/Evaluate

Elaborate page 92

Critical Thinking

PE: 5-ESS1-1
SEPs: Developing and Using Models; Analyzing and Interpreting Data; Using Mathematics and Computational Thinking
DCI: ESS1.A
CCCs: Scale, Proportion, and Quantity; Systems and System Models
Math: MP.2; MP.4
DOK: 3
Bloom's Level: Application/Apply

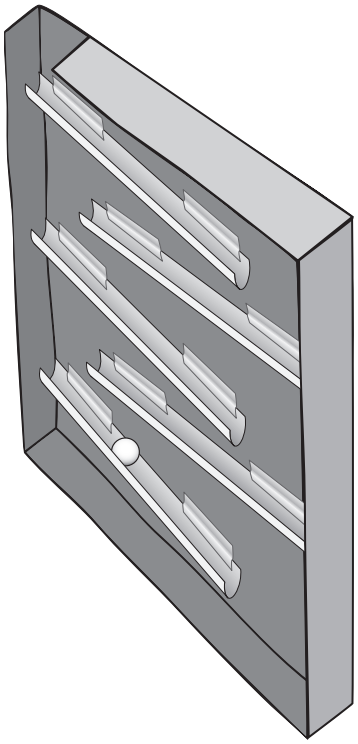
Formative Assessment

PE: 5-ESS1-1
SEP: Developing and Using Models
DCI: ESS1.A
CCCs: Scale, Proportion, and Quantity; Systems and System Models
DOK: 3
Bloom's Level: Comprehension/Understand

Module 11 pages 81–88

Explore

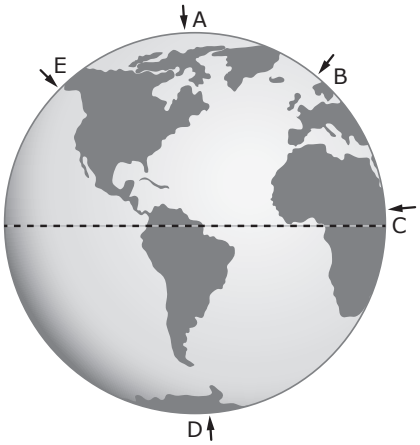
Building Background, page 82



Evaluate

Post-Assessment Question 3 Answer, page 87

Appendix: Image Bank



Name _____

Unit 4: Space Systems: Stars and the Solar System

Module 11 How Does Gravity Act on Objects?

Module 12 Why Do Some Stars Look Brighter Than Others?

Module 13 How Do Patterns Help Us Understand Phenomena?

In the three modules in Unit 4, you will explore phenomena related to stars and the solar system.

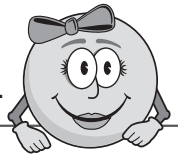
Think about objects that can be seen in the daytime and nighttime skies. Draw pictures of objects in the sky.

Daytime
Nighttime

Name _____

Motivation Station: Scientific Fact

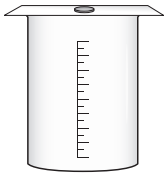
Astronauts must exercise while in space because living in microgravity conditions can have harmful effects on the body. Without the force of gravity acting on the muscles, loss of muscle mass occurs at a rapid rate.



How Does Gravity Act on Objects?

Observing Falling Objects

1. Stack a coin, index card, and a beaker, as shown in the picture. Thump the index card to quickly knock it off the beaker. Record your observations.

Investigation Setup	Drawing	Observation
		

2. Explain the force that caused the coin to drop into the beaker.

_____

_____

Using a tennis ball and a golf ball dropped from the same height, predict which object will hit the ground first, perform the test, and record the results.

3. Prediction _____

_____

Trial	Results
1	
2	
3	

4. Does the mass of an object affect the amount of time it takes for the object to hit the ground when dropped from the same height? Use evidence from the investigation to support your answer.

_____

_____

5. Write a claim discussing the force acting on the two balls. Cite evidence to support your claim.

_____

_____

Module 11 Explore
Inquiry

Name _____

Experimental Design

1. Select one question from the list of testable questions to investigate. Record the question.
2. Think about the materials needed to investigate the question and create a materials list.
3. Decide the procedure for testing the question and record the steps.
4. Perform the experiment. Repeat the investigation to make sure the results are valid. Record the results from all trials.
5. Use the results gathered by the group to form a conclusion. Record the conclusion and any other information learned from the experiment. Share the results with the class.

Question

_____

Materials

Procedure

_____

_____

_____

_____

_____

Results

Conclusion

_____

_____

_____

Name _____

Module 11 Explain
Check for Understanding

Use Internet and library sources to research Galileo's Leaning Tower of Pisa experiment. Use evidence gathered in research to support your viewpoint.

Heavier objects fall faster than lighter objects.

1. Develop an argument to support your viewpoint. Cite evidence to defend your position.

_____

_____

_____

2. Record additional evidence for the Socratic seminar.

_____

_____

_____

Participate in a Socratic seminar to discuss Galileo's Leaning Tower of Pisa gravitational force experiment.

3. Write a personal goal for participation in the Socratic seminar. _____

_____

4. Do all students in your class agree with your viewpoint? Why or why not?

_____

_____

5. Revise your argument based on information learned during the Socratic seminar.

_____

_____

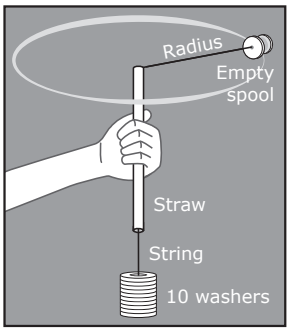
Socratic Seminar Scoring Rubric

	Advanced (5)	Proficient (3)	Basic (1)
Argument	States an argument with several sources of supporting evidence.	States an argument with one source of supporting evidence.	States an argument but lacks sources of supporting evidence.
Evidence	Provides multiple sources of supporting evidence with discussion points.	Provides some supporting evidence with discussion points.	Does not provide supporting evidence with discussion points.
Participation	Actively participates in the discussion by asking questions and making comments.	Participates in the discussion.	Rarely participates in the discussion.
Engagement	Actively includes others in the discussion by asking questions and soliciting comments.	Includes others in the discussion by asking questions or soliciting comments.	Does not include others in the discussion.
		Total	_____ / 20 points

Module 11 Elaborate
Critical Thinking

Name _____

An orbit is a curved path created by gravitational forces between two objects in space. Complete the investigation by simulating gravity in orbitals.



Procedure

- Cut a piece of string one meter in length.
- Thread 10 washers onto one end of the string and secure.
- Cut a 12-centimeter section of a straw.
- Thread the other end of the string through the straw, followed by an empty spool. Secure the empty spool to the end of the string.
- Use a metric ruler to measure 20 centimeters from the empty spool to the top of the straw. Secure this length with your fingers.
- Hold the spool parallel to the floor and begin twirling the straw at the 20-centimeter length.
- Continue twirling until the orbit is parallel to the floor. Count the number of revolutions of the spool in 15 seconds. Record the number of revolutions in the table provided.
- Repeat the procedure for five additional radius measurements and record observations.

Trial	1	2	3	4	5	6
Radius (cm)	20	30	40	50	60	70
Revolutions (15 seconds)						

1. Record observations.

_____

_____

2. How does the investigation simulate planets orbiting the sun?

_____

_____

3. How does the gravitational force change as distance increases between the two objects?

_____

_____

4. What is a limitation of this model?

_____

_____

5. What is an advantage of this model?

_____

_____

Name _____

Module 11 Extend
Vocabulary Activity

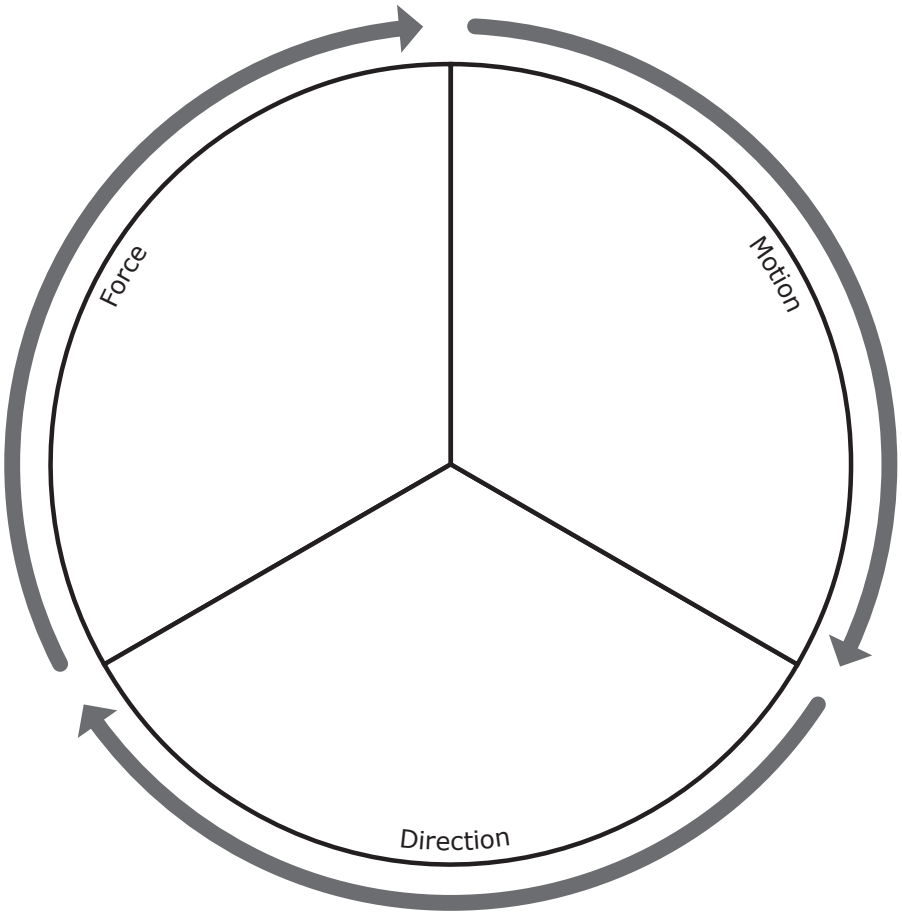
Complete the graphic organizer with information that describes "gravitational force."

Gravitational Force

Related Words

Sentence

In the sections, write the definition for each term as each relates to gravitational force.



Module 11 Extend
Homework

Name _____

Obtain parent permission before conducting this investigation.

Design an investigation to test gravity with toys or objects found in your home. Illustrate the investigation. Write a brief summary of the investigation. Generate a claim that describes gravitational force. Use evidence and reasoning to support the claim. Share your investigation and results with the class.

What question will you test?

_____

Illustration of Investigation

Summary

_____

_____

_____

_____

Gravitational Force Claim

_____

_____

_____

_____

Parent Activities

1. Help your child complete the home investigation to test gravity.
2. Take a trip or watch a sporting event and discuss how gravitational forces impact the game.

Name _____

Module 11 Evaluate
Post-Assessment

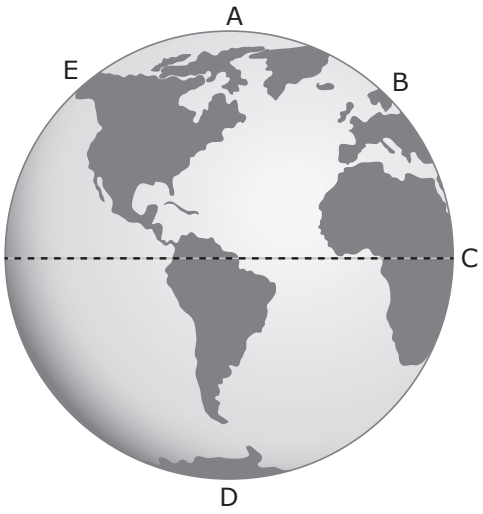
1. Select Yes or No for each scenario in which movement is caused by gravitational force.

Scenarios	Yes	No
A ball rolls off a table and moves towards the floor.	☐	☐
An iron nail moves toward a magnet located 10 cm away.	☐	☐
A liquid is poured into a glass and settles on the bottom.	☐	☐
A toy car rolls across the floor slowly coming to a stop.	☐	☐
An acorn detaches from a tree and falls to the ground.	☐	☐

2. Which statement supports the claim that a gravitational force pulls objects down toward the center of Earth?

Ⓐ Earth's surface seems to disappear as objects move beyond the horizon.
Ⓑ Earth's shadow appears spherical as it moves over the face of the moon.
Ⓒ The North Star changes height above the horizon when traveling north and south along Earth's surface.
Ⓓ All of the above

3. Use arrows to indicate the direction in which the force of gravity acts at each location on Earth.



4. Read each statement written by a student after learning about gravitational force.

(1.) Gravitational force is a force that pulls objects down towards the center of Earth.
(2.) This force only exists on Earth.
(3.) Earth's shape allows only heavy objects to fall downward, no matter their location on Earth.

Identify all false statements. Use evidence to rewrite each false statement.

_____

_____

Use the scenario to answer questions 5 and 6.

Students drop a whole apple from 1 meter and record the fall time in the table. The investigation is repeated three times.

Trial	Whole Apple	Half of an Apple
1	0.45 second	
2	0.44 second	
3	0.46 second	

5. What is a reasonable prediction for the time it takes half an apple to fall 1 meter? Use evidence to support your answer.

_____

_____

6. What causes the apples to fall when released from a height of 1 meter?

_____

_____

Module 11 Evaluate
Post-Assessment

Name _____

Hands-on Performance Task

There are many ways to test gravitational force on objects. Devise a plan to test gravitational force on the chosen object.

Circle the object to test with gravitational force.

balloon marble rubber band car ball iron nail

7. Create a drawing of your investigation.

8. Describe the investigation performed. Identify your independent variable.

9. What problems were encountered during the investigation? Explain how the issues were resolved.

10. What did you observe during the investigation?

11. What can you conclude about the effect gravitational force had on the object? Cite evidence from the investigation in your answer.