Title: Gravity Unit Based on STC's "Earth in Space"

Subject/Course: Astronomy Topic: Surface Gravity

Designer(s): Michelle DiBlasi Grade: 6

STAGE 1: DESIRED RESULTS

Content Standard(s):

- **MA-SC.ES.8:** Recognize that gravity is a force that pulls all things on and near the earth toward the center of the earth. Gravity plays a major role in the formation of the planets, stars, and solar system and in determining their motions.
- **MA-SC.ES.10:** Compare and contrast properties and conditions of objects in the solar system (i.e., sun, planets, and moons) to those on Earth (i.e., gravitational force, distance from the sun, speed, movement, temperature, and atmospheric conditions).
- **MA-SC-ES.1** Weight is the amount of gravitational pull on an object and is distinct from mass.

Understanding(s) *Students will understand that*:

Day 1:	Day 2:	Day 3:
• Gravity refers to a force that attracts objects to each other • Surface gravity holds us to Earth's surface. (STC)	• Mass is related to the amount of matter in an object, • Weight is the measure of the force of gravity on a body (STC)	• Surface gravity depends on the mass and radius of the planet

Driving Question(s)

- Why can't people fly?
- Why do the earth and the other planets in the solar system rotate around the sun?

***Students will know*:**	***Students will be able to*:**
• The difference between weight and mass and how they are related.	• Use a model to compare the weight of a can of soda on different planets. • Measure the weight of objects that have different masses. • Analyze the relationship between an object's weight on each planet and the planet's mass and diameter.

STAGE 2: ASSESSMENT EVIDENCE

Performance Task(s): Students will be able to make observations about a simulation of a can of soda on each of the different planets. Students will demonstrate their understanding of why a can of soda would have a different weight on different planets by analyzing their results and proposing their ideas for why the same soda can feels as though it has a different weight on different planets. Students will be able to synthesize their ideas into a coherent written definition of gravity.

Key Criteria:

- Characteristics about each planet that could explain why a soda can's weight would be different.
- Using their observations to support their ideas about different weights of a can on different planets.

Other Evidence:

- Written homework assignments
- Brainstorming in Journals
- Teacher observation of student's conversations and observations

STAGE 3: LEARNING PLAN

Key: vocabulary terms, *questions for students*, **words that will eventually become vocabulary terms/items that need revision**, **appendix material**

Materials: (per group of 4)

- ❑ 64 empty Pepsi cans
- ❑ 8 full Pepsi cans
- ❑ 9 sets of Planet Data Cards
- ❑ 1 Pair of scissors
- ❑ 11 kg of sand
- ❑ 1 triple beam balance
- ❑ 1 funnel
- ❑ Duct tape
- ❑ 1 black permanent marker
- ❑ Science journals
- ❑ 1 hole punch
- ❑ Projector and transparencies
- ❑ Each student should have 2 copy of worksheet on how much a Pepsi can weighs

Learning Activities:

TIME	PROCEDURE	CONCEPT
1 day before:	Group roles: The day before the lessons, 15 minutes will be spent on establishing group roles in their groups of 4 (a starter, recorder, reporter and getter). Teacher will also prepare the stations for the next day.	Cooperative learning
Day 1- 8:30am-8:35 am	Begin by having students brainstorm/writing down in their journals about what they already know about gravity and their ideas about gravity.	Activating students' prior knowledge of gravity
8:35 to 8:45	Have students share their ideas in the group and have the recorders record everyone's ideas into a large list.	Discussion within groups and compiling of ideas
8:50 to 9:10	Exploration: Stations should be previously set-up	Formative assessment

	1. Show students the eight stations that are set-up and that they will be observing how heavy a soda can would be on the different planets. Mention that the nine soda cans at each station would represent the same full can of soda on each planet. Instruct students to begin making observations at their station and record their responses on their data sheet. (Each can is filled with a different amount of sand so they have varied weights). 2. Teacher will be assessing students by asking them questions about their observations in order to assess their understanding of what they are observing and to provoke students to consider how they are supporting their observations with their conclusions. For example, on the teacher's formative assessment checklist, the teacher could prod students to consider why the same can of soda feels heavier on each planet considering each planets different characteristics and whether or not its' contents are changing each time?	questions Providing evidence and thinking critically Collaborating with one another to create a better understanding of their observations
9:10 to 9:15	Teacher should stop the groups where they are and have them clean-up their area. Students should also finish their written response to the question: What characteristic about each planet could explain why the weight of each can is different on each planet? For homework if they were not able to finish it during class.	Writing Communication Caring for materials
HW **DAY 2**	Students will read an article on the difference between Mass and Weight and in their journals will be writing about: 1. What 2 factors affect the gravity at a planet's surface? 2. If Mars has more mass than Mercury, then why is the force of gravity on each planet the same?	
8:30-8:40	Have students get into groups of four and discuss what their written responses were to the homework question. Share their ideas about what caused the cans to have different weights on different planets and have the recorder write down a collaborative answer to the question. The recorder should also write down questions that the group had that they felt as though would be helpful to know the answers to in order to solidify their response.	Collaboration of ideas
8:40-8:50	Have reporter from each group share the group's collaborative answer to the rest of the class for discussion and also share the questions that they may have. Teacher should record these questions and ideas on the whiteboard. Teacher should then pose questions. For example, if students say that the can was the heaviest on the bigger planets. The teacher could ask whether or not the can was heavier on mars than on mercury because mercury is smaller than mars?	Synthesis of data, collaboration
8:50-9:15	• Teacher should prompt students to consider when they are talking about when an object is heavier whether it has more weight or	Synthesis of data,

	more mass? And then prompt students to write in the journals individually about what they think the difference is between mass and weight. • Students should then share their ideas with their groups, create a collaborative definition for mass and weight and then discuss with the class (i.e. the reporter for each group shares their ideas and the teacher writes them down on the white board or poster board).	collaboration

Appendix A:

Groupings

Group	1	2	3	4	5
Members	Jack G.	Gavin	Nick F.	Sam F.	Natalie
	Cara	Sarah P.	Catherine	Henry	Jordan
	Ahamdi	Stephen B.	Nick S.	Patrick	Brian
	Sarah S.	Christina	Henrietta	Kristen	Anna

Group	6	7	8
Members	Marcus	Naomi	Brad
	Maria	Cam	Donna
	Foster	Trisha	James
	Jack S.	Chris	Louisa

Appendix B: Planets Worksheet

How Much Would a Can of Soda Weigh?

Directions: Pick up each can of soda. On which planet does the soda weigh the least? On which planet does the soda weigh the most? Rank your finding in Table 1. Mark the lighter and increase the numbers until you get to the heaviest can. If some cans feel as if they are the same weight, then rank them with the same number.

Table 1 Weight of Soda on Each Planet's Surface

Planet	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Pluto
Rank in Weight								

Examine the information that is given to you on each of the planets. What characteristics about each planet could explain why the weight of each can is different on each planet? Write a paragraph below explaining your observations

Appendix C

Directions: Please answer these questions for homework thoughtfully and completely using your knowledge from your activities during class.

1. What 2 factors affect the gravity at a planet's surface?

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

2. If Mars has more mass than Mercury, then why is the force of gravity on each planet the same?

_____
_____
_____
_____
_____
_____
_____
_____
_____

Assessment

	Novice	Competent	Expert
Science Concepts	Cannot demonstrate that gravity is a force of attraction. Cannot differentiate between mass and weight. Cannot demonstrate their understanding that the gravity on planets differs due to the planets' mass and diameter.	Can verbalize the difference between weight and mass but does not have a full understanding of the concept that gravity is a force of attraction. Also, can make a connection that size of planets has something to due with gravity.	Can verbalize the difference between mass and weight and demonstrate that they understand that gravity is a force of attraction. Student clearly demonstrates the understanding that the gravity on planets differs due to the planets' mass and diameter.
Process Skills	Student does not make careful observations and struggle to make connections between the concepts of gravity, weight and mass.	Student makes some careful observations and is beginning to make connections between the concepts of gravity, mass and weight but still cannot make a connection to real world applications.	Student makes very detailed and careful observations and can also make strong connections between the concepts of gravity, weight and mass. Student can also apply their knowledge to interpreting new situations and real life applications.
Habits of Mind	Student needs to be reminded to contribute to group work. Students need	Student contributes to group work without prompting from the teacher and fulfills their group	Student demonstrates that he or she is a leader in their group and provides solid

	a lot of prompting to support their ideas.	role. Students are also beginning to provide evidence for their ideas.	evidence for all of their claims.

Title: Gravity Unit

Subject/Course: Astronomy Topic: Surface Gravity

Designer(s): Michelle DiBlasi Grade: 6

STAGE 1: DESIRED RESULTS

Content Standard(s):

- **MA-SC.ES.8:** Recognize that gravity is a force that pulls all things on and near the earth toward the center of the earth. Gravity plays a major role in the formation of the planets, stars, and solar system and in determining their motions.
- **MA-SC.ES.10:** Compare and contrast properties and conditions of objects in the solar system (i.e., sun, planets, and moons) to those on Earth (i.e., gravitational force, distance from the sun, speed, movement, temperature, and atmospheric conditions).
- **MA-SC-ES.1** Weight is the amount of gravitational pull on an object and is distinct from mass.

Understanding(s) *Students will understand that*:

Day 1:	Day 2:	Day 3:
• Gravity refers to a force that attracts objects to each other • Surface gravity holds us to Earth's surface.	• Mass is related to the amount of matter in an object, • Weight is the measure of the force of gravity on a body	• Surface gravity depends on the mass and radius of the planet

Driving Question(s)

- Why can't people fly?
- Why do the earth and the other planets in the solar system rotate around the sun?

***Students will know*:**	***Students will be able to*:**
• The difference between weight and mass and how they are related. • How Jupiter is similar and different to the other planets in the solar system.	• Measure the weight of objects that have different masses. • Analyze the relationship between an object's weight on each planet and the planet's mass and diameter.

STAGE 2: ASSESSMENT EVIDENCE

Performance Task(s): Students will be able to define the differences between mass and gravity based on an inquiry activity using a spring scale. Students will be able to synthesize their ideas into a coherent written definition of gravity. I would also use formal interviews to speak with each student using open-ended questions to prompt them to analyze their results and conclusions thus far to get a definitive assessment of each

student's understanding of gravity.
Key Criteria: o Characteristics about each planet that could explain why a soda can's weight would be different. o Using their observations to support their ideas about different weights of a can on different planets.
Other Evidence: • Written homework assignments • Brainstorming in Journals • Teacher observation of student's conversations and observations

STAGE 3: LEARNING PLAN

Key: vocabulary terms, *questions for students*, **words that will eventually become vocabulary terms/items that need revision**, **appendix material**

Materials: (per group of 4)

- ❑ 8 Spring Scales
- ❑ 8 Plastic Cylinders
- ❑ 200 Steel Washers
- ❑ Science journals
- ❑ 1 hole punch
- ❑

Learning Activities:

TIME	PROCEDURE	CONCEPT
1 Day Before (Prep Time)	• Teacher should set-up plastic cylinders with a hole punched in it 1 cm from the top, 2.5 N spring scales, and steel washers in plastic bags for group activities.	
Day 1		
8:30-8:55	• Teacher will introduce a spring scale and discuss with the class what it might be used for (Putting students ideas on a whiteboard) • Students will then use a spring scale in their groups with washers to try to determine what is being measured and how it works. While the teacher circulates and questions students in order to assess how they are thinking about this questions.	Collaboration Supporting predictions

8:55-9:15	o Class will then return to a discussion and discuss/share how a spring scale works and what it is measuring.	
HW	For homework, students will be writing about what they think the differences are between mass and weight and how these two terms are related.	Science writing
Day 2		
8:30-9:10	• Have students get into their groups of four and instruct them that they will be using the spring scales that they experimented with yesterday to discover the relationship between mass and weight. • Students will have access to plastic cylinders with a hole punched in it 1 cm from the top, 2.5 N spring scales, and 25 steel washers in a plastic bag. • Have students use these materials in their groups of four to answer the questions: A. When you increase the mass of the cylinder, what happens to its weights? B. How are mass and weight related? C. What do you think the name of the force is that makes the cylinder have weight? D. What direction does this force pull on the cylinder? E. What force do you think holds us to Earth's surface? Teacher will be using formative assessment while observing student's conversations with one another and their responses to the prompts given for the activity. • **Formative assessment checklist** o What is gravity? o What is the difference between mass and weight? o How are mass and weight related? o How are we affected by gravity?	**Inquiry and Collaborative Learning** **Building a Community of Learners** **Making Connections and Reasoning**
9:10-9:15	Students are instructed to clean-up their areas.	**Caring for Materials**
Day 3		
8:30-9:15	Class will have a discussion about their inquiry activity and their responses to their homework questions. For example, teacher may ask class what gravity is? How it affects weight? What the difference is between mass and weight? Why different planets have different amounts of gravity? Etc…	

	If I had time, I would have I could used a probe to demonstrate that heavier and lighter objects fall at the same rate because gravity's acceleration is constant. By using the probe, the students would be able to visualize acceleration of objects due to gravity.	

Appendix A

Determining the Relationship between Mass and Weight

Directions: using a plastic cylinder, a 2.5 N spring scale, and 25 steel washers in a plastic determine the relationship how changing the mass of a cylinder, affects it's weight:

A. When you increase the mass of the cylinder by adding 5 weights, what happens to its weight?

B. How are mass and weight related?

C. What do you think the name of the force is that makes the cylinder have weight?

D. What direction does this force pull on the cylinder?

E. What force holds us to Earth's surface?

Assessment

	Novice	Competent	Expert
Science Concepts	Cannot demonstrate that gravity is a force of attraction. Cannot differentiate between mass and weight.	Can verbalize the difference between weight and mass but does not have a full understanding of the concept that gravity is a force of attraction.	Can verbalize the difference between mass and weight and demonstrate that they understand that gravity is a force of attraction.
Process Skills	Student does not make careful observations and struggle to make connections between the concepts of gravity, weight and mass.	Student makes some careful observations and is beginning to make connections between the concepts of gravity, mass and weight but still cannot make a connection to real world applications.	Student makes very detailed and careful observations and can also make strong connections between the concepts of gravity, weight and mass. Student can also apply their knowledge to interpreting new situations and real life applications.
Habits of Mind	Student needs to be reminded to contribute to group work. Students need a lot of prompting to support their ideas.	Student contributes to group work without prompting from the teacher and fulfills their group role. Students are also beginning to provide evidence for their ideas.	Student demonstrates that he or she is a leader in their group and provides solid evidence for all of their claims.

Title: Gravity Lesson Plan

Subject/Course: Astronomy Topic: Gravity and Orbital Motion

Designer(s): Michelle DiBlasi Grade: 6

STAGE 1: DESIRED RESULTS

Content Standard(s):

- **MA-SC.ES.8:** Recognize that gravity is a force that pulls all things on and near the earth toward the center of the earth. Gravity plays a major role in the formation of the planets, stars, and solar system and in determining their motions.
- **MA-SC.ES.10:** Compare and contrast properties and conditions of objects in the solar system (i.e., sun, planets, and moons) to those on Earth (i.e., gravitational force, distance from the sun, speed, movement, temperature, and atmospheric conditions).
- **MA-SC-ES.1** Weight is the amount of gravitational pull on an object and is distinct from mass.

Understanding(s) *Students will understand that*:

Day 1:	Day 2:	Day 3:
• All objects (from particles to large bodies in the universe) attract one another because of gravity • Gravity keeps the planets orbiting the sun	• Most objects in the solar system are in regular and predictable motion. • Unbalanced forces, including gravity, can change the speed and/or direction of an object's motion	• Most objects in the solar system are in regular and predictable motion. • Unbalanced forces, including gravity, can change the speed and/or direction of an object's motion

Driving Question(s)

- Why do planets orbit the sun?
- Why do we stay on the earth and not float into space?

***Students will know*:**

- That gravity keeps planets orbiting the sun
- Gravity is a force throughout our galaxy.
- Gravity can affect the speed or motion of objects.

***Students will be able to*:**

- Analyze patterns in planetary motion
- Observe the motion of a marble when acted on by different forces and relate that to planets
- Demonstrate their understanding of the effect of a pulling force on the orbital period of a sphere.

STAGE 2: ASSESSMENT EVIDENCE

Performance Task(s):

- Students will be involved in discussions with their group, recording observations, and answering thought-provoking questions about why their observations relate to the real world and support for their observations.

Key Criteria • Appropriate use of vocabulary • In-depth responses to questions • Clear and Coherent Observations recorded
Other Evidence: • Written homework assignments • Brainstorming in Journals • Teacher observation of student's conversations and observations

STAGE 3: LEARNING PLAN

Key: vocabulary terms, *questions for students*, **words that will eventually become vocabulary terms/items that need revision**, **appendix material**

Materials: (for groups of 4)

- ❑ 1 Pair of Goggles for each student
- ❑ 1 Copy per student of the four different worksheets for each station
- ❑ 1 plastic box filled with sand, flour and cocoa
- ❑ 1 large resealable plastic bag containing: 1 ruler, 1 marble, 1 measuring tape
- ❑ 1 empty plastic box
- ❑ 1 metal canning jar ring
- ❑ 1 marble
- ❑ 1 sheet of white paper
- ❑ 1 Planetary Motion model made of 1 quilting hoop and 1 latex sheet
- ❑ 4 plastic boxes or boxes of the same height
- ❑ 1 large, resealable plastic bag containing: 1 yellow balloon (filled with water), 1 ruler and 1 marble
- ❑ 1 plastic box containing: 1 Moon Orbiter containing 1 styrene sphere, 1 nylon fishing line, 1 screw eye, 1 piece of plastic tubing, 25 steel washers, and 1 stopwatch.

Learning Activities:

TIME	PROCEDURE	CONCEPT
Day 1 Prep	• Put together moon orbiter and planetary motion model, set up all stations and photocopy all four handouts for each student.	
8:30-8:40	• Show students a clip from the film, "Explore the Planets" and ask them to individually write down observations about the movements of the planets around the sun in their science journals.	Collaboration, synthesizing ideas

	(i.e. the planets are not always in line with one another when they orbit the sun or the earth orbits and spins on its axis counterclockwise) • Have students get into their assigned groups of four and discuss their observations and make a collaborative list of their observations while the recorder writes down the responses and questions they may have.	
8:40-8:50	• Have reporter report to the group what observations they made while the teacher writes down a collaborative list on a white poster board. • Teacher should prompt students to interpret their observations and answer their own questions by asking questions.	Analyzing observations Collaboration
8:50-8:55	• Teacher should then explain to students that they will doing a stations activity to discover the answers to many of their questions and to explain their observations. • Teacher should point out the stations tell them that they will be given 20 minutes to rotate through each station. • Students should also be prompted to make a notes section for each station in order to record their observations and data.	
8:55-9:10	• Students will begin their first station on Gravity's Effect on Objects in Motion where they will be: 1. Hold a marble 40 cm above a plastic box. With the marble in their hand, they will decide what two forces are acting on the marble. As a group, they will determine if the forces balanced (both pulling equally) or unbalanced (one pulling more than the other). 2. They will then let go of the marble and discuss their observations of the marble's motions with their group. They will then compare their observations with their predictions. 3. They will repeat these steps to see if the marble moves the same way each time and record their observations. 4. They will then use a ruler as a ramp to roll the marble into the plastic box and discuss and record their observations of how the marble moved. 5. They will experiment by rolling the marble down the ruler at different speeds and record how it leaves the ruler each time and the distance it travels each time. They will record this information in their science journals. They will also be prompted to answer questions like a. what pulling force act on the marble at all times? Etc… (See Appendix A)	Observation Collaboration Analyzing Observations
9:10-9:15	• Students will have time to clean up their area.	Caring for Materials
Day 2 8:30-8:35	• Students will continue their stations activity and finishing their observations and recording their answers on station 1.	Observation

		Collaboration Analyzing Observations
8:35-8:55	• Students will begin the inquiry activity at station 2 on Testing Balanced and Unbalanced forces in their groups. They will begin by: 1. Students will be told that they need to describe the motion of a marble. In order to do so, the teacher will ask them questions, like how could you record the motion of a marble? And how could you control which places the marble can roll? 2. Therefore, with prompting, the may place white paper in the bottom of a plastic box. Put the metal ring on top of the paper with the lid up. 3. Trace an outline of the ring onto the paper. Remove the metal ring from the paper. Mark four points at equal distances around the circle. Number the marks from 1 to 4 going clockwise. 4. Placing the metal ring on the circle again with the lip up. Place the marble inside the metal ring. Without moving the metal ring, they will describe the motion of the marble. They will record their observations in their science journals. 5. They will then use the ring to move the marble in circles. Keep the ring on the paper at all times. They will record their observations and discuss with their group how the ring creates a force that influences the marbles motion. They will also make a prediction about what will happen when they lift the ring. 6. They will then move the marble in circles again and lift the ring. They will record what happens in their science journal and describe the motion of the marble the unbalanced force of the ring. They will do this several times and record their observations in pictures and writing while using numbered markings to pinpoint the motion of the marble every time. 7. They will then answer questions in your notebook (like describing the motion of the marble when an unbalanced force (the metal ring) influences it. (See appendix B)	Observation Collaboration Analyzing Observations
8:55-9:00	• Students will have time to clean up their station	Caring for materials
9:00-9:15	• Students will begin Station 3 on Observing Planetary Motion given a Planetary Motion Model. They will: 1. Students will be prompted with questions about how they can demonstrate planetary motion with the marble and the ruler and	Observation Collaboration

	may potentially use their ruler as a ramp to roll the marble onto the latex sheet. Before they do so, they will make a prediction about the path the marble will take on the sheet and discuss their predictions in their group. 2. They will hold the ruler so that it faces the hoop and roll the marble onto the flat sheet while carefully observing. They will repeat this several times and discuss their observations with their group and record their results in their science journals. 3. They will then place the balloon in the center of the sheet and let go of it. They will discuss what the balloon does to the sheet and then roll the marble onto the sheet toward the edge of the hoop. They will then watch the balloon and marble carefully. They will carefully observe the behavior of the balloon and record their observations in their science notebook. They will also observe the behavior of the balloon and discuss their observations with their group and record everything. 4. They will then be prompted how they could increase the mass at the center of the sheet? They may then decide to push down on the balloon keeping a constant pressure. At this point, they will predict how the marble will move now that the center of the sheet has more mass. One of the students will roll the marble onto the sheet as they keep pressure on the balloon. They will discuss their observations in words and pictures in their notebook. 5. They will then turn the motion of the marble several times and observe its motion carefully. Everyone will take a turn doing this. They will record how the motion of the marble changes as it nears the balloon. 6. They will then be prompted with questions to determine how they could measure and unstable mass. They may then wobble the balloon slightly as the marble orbits it and observe what happens. They will try to use a gentle wobble on the balloon to keep the marble in motion. They will discuss and record all of their observations. They will then let go of the balloon and observe whether or not the balloon wobbles on its own as the marble orbits it. 7. They will answer questions in their notebook (Appendix C) They will then have 3 minutes to clean up their area	Analyzing Observations Caring for Materials
Day 3 8:30-8:35	• The students will have time to finish up station 3 and clean up their area when they are done.	
8:35-8:55	• Students will complete their final station, station 4, on investigating the effect of planetary Mass on a Moon's orbit given a Moon Orbiter. They will begin by: 1. Examining the moon orbiter and discussing with their group how they think the moon orbiter might work and recording	Observation Collaboration Analyzing

	their responses in their science journals. 2. They will then be prompted with questions on how they could use their materials to simulate the motion of the moon's orbit. They may then hold the narrow plastic tubing of the moon orbiter in their hands like a handle and hold the moon orbiter above their heads while moving their hand in circles to the get the sphere to orbit their hand, while using a steady and regular motion. 3. They will then increase the mass of the Moon orbiter by adding five washers to the cylinder. One student will move their hand in circles of their head to get the white sphere orbiting around their hand again. They will describe how fast the sphere has to move to stay in orbit around their hand with a mass of five washers pulling on it. They will also calculate its orbital period by taking the time it takes the sphere to orbit their hand by counting the number of seconds it takes the sphere to orbit their hand 10 times, for example. They will discuss and record all of their observations in their science journals. 4. They will also predict what will happen if they increase the mass of the moon orbiter's cylinder to 25 washers. They will then fill the cylinder of the moon orbiter with 25 washers and repeat the above procedure. They will also add 25 small washers to the moon orbiter's cylinder to determine the effects of different masses of an orbiting object on the orbital period. They will discuss all of their observations with their group and record them in their journals. They will also answer questions (see Appendix D).	Observations
8:55-9:00	• Clean up station 4	Caring for materials
9:00-9:15	• Once the stations activity is completed, the teacher will conduct a discussion with the class of the results, specifically what occurred and why things occurred in the activities and how they are related to the students everyday lives	
HW	• Students will finish up any questions that they could not finish and class and also read the article "Heavy Thoughts" (STC's Earth in Space) and answer the questions on the reading.	

Appendix A:

Station #1: Gravity's Effect on Objects in Motion

Answer the Following Questions in your Science Journal:

1. What pulling force acts on the marble at all times?

2. When you rolled the marble slowly, how did it move once it left the ruler?

3. How does the forward speed of the marble affect the motion of the marble once it leaves the ruler?

4. All planets that orbit the Sun are traveling forward due to inertia and falling toward the Sun due to gravity. Describe the path of something that has forward motion (like your marble) but is also being pulled down by gravity.

Appendix B:

Station #2: Testing Balanced and Unbalanced Forces

Answer the Following Questions in your Science Journal:

1. Describe the motion of the marble when an unbalanced force (the metal ring) influences it.

2. Describe the motion of the marble when the unbalanced force is removed.

3. Suppose you lifted the ring when the clockwise orbiting marble was at the "1". Draw the path the marble would take.

4. Suppose you lifted the ring when the clockwise orbiting marble was at the "4". Draw the path the marble would take.

5. Like the marble, the planets move forward due to inertia and inward due to an unbalanced force. Together, these forces cause the planets' path to curve. What is the unbalanced force that keeps the planets in orbit? What would happen to the planets without this unbalanced force?

Appendix C:

Station #3: Observing Planetary Motion

Answer the Following Questions in your Science Journal:

1. Describe how the marble moved when the mass in the center (the balloon) was not present.

2. Describe how the marble moved when the mass in the center was present.

3. As the distance between the balloon and the marble decreased, what happened to the marble's speed?

4. Based on your observations, which planet do you think would have the fastest orbital speed? What evidence do you have to support your answer?

5. What force keeps the planets in their orbital paths around the sun?

Appendix D:

Station #4: Investigating the Effect of Planetary Mass on a Moon's Orbit

Answer the Following Questions in your Science Journal:

Table 1 Planetary Mass Versus Moon's Orbital Period

Solar System Body	Approximate Mass (Kg)	Diameter (Km)	Distance from Planet (Km)	Orbital Speed (km/sec)	Orbital Period (days)
Jupiter	$189{,}900 \times 10^{22}$	142,984	X	X	X
Earth	597×10^{22}	12,756	X	X	X
Io	9×10^{22}	3643	421,600	17	~ 2 days
Moon	7×10^{22}	3475	384,400	1	~ 27 days

1. Examine table 1. Compare the mass of Jupiter with the mass of the Earth. Which planet has more mass?

2. Examine table 1. Compare Jupiter's moon Io with Earth's moon. How are they alike? How are they different?

3. Compare Io and the moon. Which planetary satellite travels faster (has a greater orbital speed)? Given your results from the inquiry, why do you think this is?

4. Orbital period is the time it takes a revolving object to orbit a central orbit. Which planetary satellite has a shorter orbital period? What is the relationship between the orbital speed and orbital period?

5. In lesson 1, you learned the approximate mass of each planet. How do you think scientists determine the mass of the planets?

Assessment

	Novice	**Competent**	**Expert**
Science Concepts	Student can relate the pull of gravity and the forces on a marble to the earth. However, student cannot demonstrate an understanding of the effect of a pulling force on the orbital period of a sphere.	Student can verbalize the understanding of the effect of a pulling force on the orbital period of a sphere but cannot necessarily relate that force to gravity and what occurs on earth.	Student fully understands that gravity is the force throughout the universe that creates a pulling force on the orbital period of a sphere and explains why the planets orbit the sun.
Process Skills	Student does not make careful observations and struggle to make connections between the actions of the marble and the planets as	Student makes some careful observations and is beginning to make connections between the concepts of gravity and how gravity influences planets to orbit the sun.	Student makes very detailed and careful observations and can also make strong connections between the concepts of gravity with the attraction that occurs between objects throughout our galaxy.

	determined by gravity.		
Habits of Mind	Student needs to be reminded to contribute to group work. Students need a lot of prompting to support their ideas.	Student contributes to group work without prompting from the teacher and fulfills their group role. Students are also beginning to provide evidence for their ideas.	Student demonstrates that he or she is a leader in their group and provides solid evidence for all of their claims.

Title: Gravity Inquiry Science Lesson Plan

Subject/Course: Astronomy Topic: Gravity and Tides

Designer(s): Michelle DiBlasi Grade: 6

STAGE 1: DESIRED RESULTS

Content Standard(s):

- **MA-SC.ES.8:** Recognize that gravity is a force that pulls all things on and near the earth toward the center of the earth. Gravity plays a major role in the formation of the planets, stars, and solar system and in determining their motions.
- **MA-SC.ES.9:** Describe lunar and solar eclipses, the observed moon phases, and tides. Relate them to the relative positions of the earth, moon, and sun.
- **MA-SC-8.I.4** Present and explain data and findings using multiple representations, including tables, graphs, mathematical and physical models, and demonstrations

Understanding(s) *Students will understand that*:

- Tides are the periodic rise and fall of the sea level and other bodies of water (STC)
- The gravitational attraction between the Earth and the Moon and the Sun and the Earth contributes to the formation of the tides.

Driving Question(s)

- Why does the water go down when we are at the beach?
- Why can we only go wakeboarding at certain points during the day at the beach?

***Students will know*:**	***Students will be able to*:**
• That gravity is a force of attraction between objects in our galaxy • That the moon orbits the earth	• Discover that the moon's orbit around the earth contributes to the formation of the tides

STAGE 2: ASSESSMENT EVIDENCE

Performance Task(s): Students will be able to graph and analyze patterns in the times and the heights of tides, and phases of the moon. The students will draw conclusions about the cause and occurrence of tides.
Key Criteria: • Tide changes are caused by the gravitational attraction between the Moon and the Earth • Tides are the rise and fall of the sea level throughout everyday.
Other Evidence: • Homework questions/ Worksheets • Teacher observations

STAGE 3: LEARNING PLAN

Key: vocabulary terms, *questions for students*, **words that will eventually become vocabulary terms/items that need revision**, **appendix material**

Materials: (per group of 4)

- ❑ 1 Blue water-filled balloon, 11" round
- ❑ For each group of four students, 1 copy of Earth's Tidal Bulge (copied onto blue cardstock)
- ❑ For each group of four students, Sun-Earth-Moon Board
- ❑ For each group of four students, 1 rod labeled E
- ❑ For each group of four students, 1 Globe of earth, 12 cm
- ❑ For each group of four students, 1 Mini Maglite
- ❑ For each group of four students, 2 AA batteries
- ❑ For each group of four students, 1 Styrene sphere, 3.5 cm
- ❑ For each group of four students, 1 pair of scissors

Learning Activities:

TIME	PROCEDURE	CONCEPT
Prep	Make photocopies of worksheets, and set up the video equipment. Fill one 11 inch blue balloon with water and tie tightly. Have students read the story "Marching to the Beat of the Tides".	
Day 1	Begin by discussing their reading assignment, Marching to the Beat of the	Activating Prior

8:30-8:40	Tides". Ask students, why does the story say that the tides are like clockwork? Also, ask them to give examples of organisms that they may know that are affected by tides.	Knowledge
8:40-8:45	• Have students write down in their science journals things that they may already know about tides for 5 minutes	Activating Prior Knowledge
8:45-8:50	• Have students discuss their results with their group and have the recorder create a collaborative list.	Collaboration Synthesizing
8:50-9:00	• Reporters share with the class what they already know about tides while the teacher writes everything down on the whiteboard and asking students questions on what their ideas and how they are supporting them.	Activating Prior Knowledge Collaboration
9:00-9:15	• Show students the water-filled balloon and ask them how we could show the effect of gravity on the balloon. Students, with prompting, may come up with projecting the image of the balloon on the whiteboard with the projector first with a hand underneath it and tracing it. Then, holding the balloon, by the neck, tracing the new shape it makes. • Teacher will prompt students to discuss the differences between the shape of the balloon depending on the forces acting on it. Teacher should ask students why there is a bulge in the balloon.	Analyzing forces
H.W.	• Students should write about how the forces on the balloon could be related to oceans. And, knowing that the moon (like other objects) has a gravitational pull on the earth, how this could affect the shapes of the oceans?	Comparison and analyzing a simulation
Day 2		
8:30-8:45	• Students will begin by cutting out copies of the two different pictures of the shapes of the balloon in their groups. Each group will also be given a 12 cm earth globe. A Sun-Earth-Moon Board and asked to predict how the Earth's high and low tides are caused based on the gravitational pull of the moon and the earth. Students will be asked to predict what tides would occur near them depending on the rotation of the earth on its' axis	Predicting Collaboration
8:45-9:00	o Ask students to predict whether tides would occur on other planets and moons and support their predictions by writing in their journals individually o Students should then collaborate with their groups and discuss their answers o The recorder should write down the synthesized responses and then the reporter should share with the class what they predicted and why? o The teacher should create a list of the ideas on the whiteboard and ask prompting questions to make sure that students are fully supporting their ideas. If there is time I would definitely want to use the website:	Science writing

	http://www.geocities.com/Paris/6502/impact.html. This website provides a simulation for students on the effects of gravity on planets' orbits and in space. In the simulator students can actually create planets and based on their mass, size and distance from the sun, the students can visualize how this "planet" would orbit the sun. This simulator would be especially useful for this unit because when the students explore the effect of gravity on planets' orbits it is impossible for them to actually see things in space so a simulation would definitely allow them to visualize the effects of gravity in space.	
HW	Students will read "Can Water Fall Up" and answer the questions that are at the bottom of the article on tides on other planets.	Science Writing

Assessment

	Novice	**Competent**	**Expert**
Science Concepts	Student does demonstrate that they understand that the moon has an effect on the tides but cannot explain why.	Student can verbalize the understanding that the moon's gravitational pull affects the tides but does not know what happens to the tides when the earth and the moon are in different positions.	Student can verbalize the understanding that the moon's gravitational pull effects the tides and does know what happens to the tides when the earth and the moon are in different positions based on earth's spinning on its' axis.
Process Skills	Student does not make careful observations and struggle to make connections between the actions of the marble and the planets as determined by gravity.	Student makes some careful observations and is beginning to make connections between the concepts of gravity and how gravity influences planets to orbit the sun.	Student makes very detailed and careful observations and can also make strong connections between the concepts of gravity with the attraction that occurs between objects throughout our galaxy.

Habits of Mind	Student needs to be reminded to contribute to group work. Students need a lot of prompting to support their ideas.	Students contribute to group work without prompting from the teacher and fulfill their group role. Students are also beginning to provide evidence for their ideas.	Student demonstrates that he or she is a leader in their group and provides solid evidence for all of their claims.

Title: Gravity Inquiry Science Lesson Plan

Subject/Course: Astronomy Science Topic: Gravity and Tides

Designer(s): Michelle DiBlasi Grade: 6

STAGE 1: DESIRED RESULTS

Content Standard(s):

- **MA-SC.ES.8:** Recognize that gravity is a force that pulls all things on and near the earth toward the center of the earth. Gravity plays a major role in the formation of the planets, stars, and solar system and in determining their motions.
- **MA-SC.ES.9:** Describe lunar and solar eclipses, the observed moon phases, and tides. Relate them to the relative positions of the earth, moon, and sun.
- **MA-SC-8.I.4** Present and explain data and findings using multiple representations, including tables, graphs, mathematical and physical models, and demonstrations

Understanding(s) *Students will understand that*:

- Tides are the periodic rise and fall of the sea level and other bodies of water (STC)
- The gravitational attraction between the Earth and the Moon and the Sun and the Earth contributes to the formation of the tides.
- Usually two high tides and two low tides occur every day
- The time at which high and low tides occur changes every day by about 50 minutes due to the Moon's orbit around the earth.

Driving Question(s)

- Why does the water go down when we are at the beach?
- Why can we only go wakeboarding at certain points during the day at the beach?

***Students will know*:**

- That gravity is a force of attraction between objects in our galaxy
- That the moon orbits the earth

***Students will be able to*:**

- Graph data on tides and the phases of the moon.

STAGE 2: ASSESSMENT EVIDENCE

Performance Task(s): Students will be able to graph and analyze patterns in the times and the heights of tides, and phases of the moon. The students will draw conclusions about the cause and occurrence of tides. I would also use videos as a final form of assessment and have students give a report about they have discovered about planets' orbits, mass vs. weight, and tides and how these concepts all relate to gravity. Having students create a report on video would not only be fun for the students but also help them to focus on the important things they learned based on focused ideas and questions

that I have provided.
Key Criteria: • Tide changes are caused by the gravitational attraction between the Moon and the Earth • Tides are the rise and fall of the sea level throughout everyday.
Other Evidence: • Homework questions/ Worksheets • Teacher observations • Student Graphing of tides and moon phases • Questions analyzing explorations.

STAGE 3: LEARNING PLAN

Key: vocabulary terms, *questions for students*, **words that will eventually become vocabulary terms/items that need revision**, **appendix material**

Materials: (per group of 4)

- ❑ Poster paper.
- ❑ National Geographic Video on Sun, Earth, Moon
- ❑ 8 Sheets of blue cardstock (21.5 cm x 28 cm)
- ❑ For each student, 1 copy of Bode's law sheet
- ❑ For each student, 1 sheet of graph paper
- ❑ For each student, Planetary chart

Learning Activities:

TIME	PROCEDURE	CONCEPT
Prep	Set up video equipment and make photocopies of data that we collected at the beach and graphed	
Day 1 8:30-8:40	• Have students watch the "Sun, Earth, Moon" video and then ask students questions about whether or not the earth and the moon both pull on each other? And how would this relate to tides? Why it doesn't appear as if there are "land" changes?	
8:40-9:15	• Get tidal information for the tides and the moon phases at the beach nearest the school. (This could definitely be a field trip to collect data) and graph this information based on times and when and how high the tides are and what the moon looks like. • Students will analyze a month of tides at this beach. They will work in their groups to figure out how to read the table and put	Collaborative learning, ensuring comfort with answers. Collecting and

	into their science notebooks the answers to questions like : o At what time did the high tides occur on April 5th, 2009 o How high were the high tides on April 5th? o At what time did the moon rise on Aril 9th? o At what time did the second high tide occur on April 9th? o How much of the moon was visible on April 8th? Given this percentage, what phase was the Moon in on April 8th? o How much of the Moon was visible on April 16th? Given this percentage, what phase was the moon in on April 16th?	graphing data
Day 2		
8:30-9:00	• Students will continue to analyze their data and work in their groups to answer questions in their science journals like: o Examining the height of the tides each day, how does the height change over 24 hours? o A high tide occurs when the tide reaches its maximum height on each rise. How many high tides normally occur along this beach in 24 hours? o Why do you think this pattern of high and low tides exist? o Compare the times that high and low tides occur each day over a two-week period. What do you observe? o Examine the data showing moonrise and moonset times. Compare these times to the times of high and low tides. What patterns do you observe? What explanations can you give for these patterns? o Examine the data showing phases and compare the phases of the Moon to the times of high and low tides. During what phases do highest high tides occur? What explanation can you give for these patterns?	Analyzing gravitational effects Collecting data Science writing Group Collaboration and Communication Analyzing graph data Inferring
9:00-9:15	o Class will have a discussion about the results and compare what phases of the moons were associated with which tides and why.	

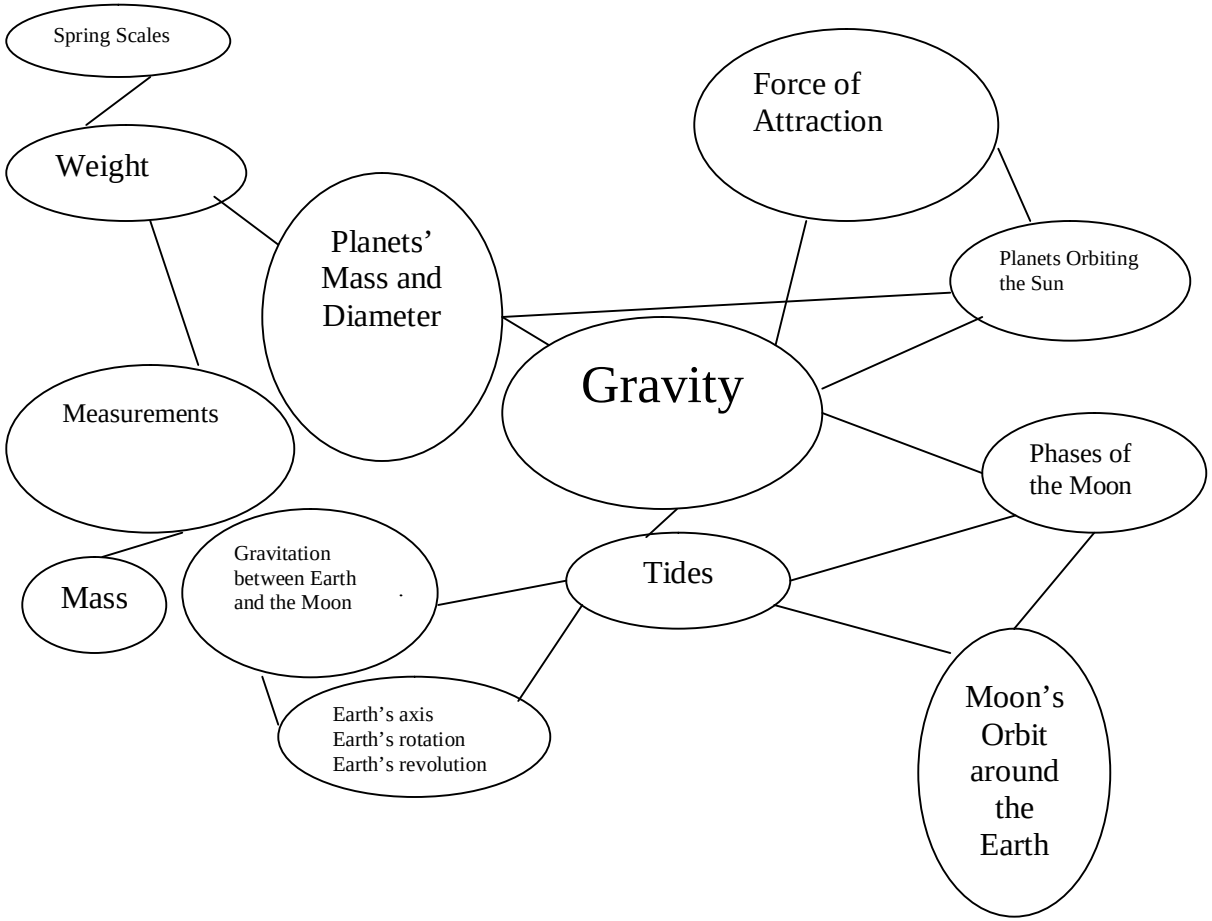
Appendix A

Graph your data, using appropriate labels, title, and scale.

Assessment

	Novice	Competent	Expert
Science Concepts	Students cannot demonstrate an understanding of the effect of a pulling force on the orbital period of a sphere.	Student can verbalize the understanding of the effect of a pulling force on the orbital period of a sphere but cannot necessarily relate that force to gravity and what occurs on earth.	Student fully understands that gravity is the force throughout the universe that creates a pulling force on the orbital period of a sphere and explains why the planets orbit the sun.
Process Skills	Student does not make careful observations and struggle to make connections between the actions of the marble and the planets as determined by gravity.	Student makes some careful observations and is beginning to make connections between the concepts of gravity and how gravity influences planets to orbit the sun.	Student makes very detailed and careful observations and can also make strong connections between the concepts of gravity with the attraction that occurs between objects throughout our galaxy.
Habits of Mind	Student needs to be reminded	Students contribute to group work	Student demonstrates that he

	to contribute to group work. Students need a lot of prompting to support their ideas.	without prompting from the teacher and fulfill their group role. Students are also beginning to provide evidence for their ideas.	or she is a leader in their group and provides solid evidence for all of their claims.


Spring Scales
Weight
Planets' Mass and Diameter
Force of Attraction
Planets Orbiting the Sun
Gravity
Measurements
Phases of the Moon
Mass
Gravitation between Earth and the Moon
Tides
Earth's axis
Earth's rotation
Earth's revolution
Moon's Orbit around the Earth

Personal Reflection

After teaching the first two days of my unit in my four classes of 16 sixth grade students, I thought that overall it went very well. The students were very engaged in the inquiry activities and through my observation and formative assessment the majority of the students were able to get to the understandings that I was hoping they would discover and worked well in their groups to expand upon one another's thought processes. I think that it was very helpful to me that I have been co-teaching these sixth grade students since the beginning of February, so I know them very well and they are already used to inquiry learning because I also teach through inquiry activities.

Overall, during the lessons, the students appeared to be on task and were definitely very cooperative with one another. They were also already used to their group roles of the starter, recorder, reporter and getter, so that was not an issue during the lessons. After the first day, one of my students told me during class that this activity was "really fun" and the following day I had a student come up to me in the hall way and asking me if it were possible that they could have a "double science class today" because they really enjoyed the inquiry activities.

Some things that I learned during the lessons were that it was difficult for me to get around to all the students and assess every single student in depth during the 45 minute class period (even though I only had 16 students in each class). I also had to be really careful about always bringing my class roster with me when I was talking to students so I could record where they were at in their process skills and habits of mind etc… I really underestimated the amount of time things were going to take and found that I did not get as far as I would have liked in the two days. Even though I am used to teaching in an inquiry way, it is still a challenge for me to not "give away answers" to the students, so that was also a constant struggle during my classes. However, the students did have a very strong background on the planets, so the transition to learning about gravity by relating it to the planets was very successful and the students were able to make some great connections between planet size and the amount of gravity. I thought that overall the lessons were both very successful but I wished that I could have spent some more time on the unit in order to really see the results of what the students were really able to figure out about gravity!