Science Objectives

- Students will investigate and discover relationships among distance, mass, and gravity.
- Students will explore how the distance of each planet from the Sun as well as the mass of each planet affects the gravitational force between the planet and the Sun.

Vocabulary

- law of universal gravitation
- inverse square law
- revolve
- astronomical unit

About the Lesson

- As a result of this lesson, students will:
  - Understand how the distance between two objects is related to the force of gravity between them.
  - Determine whether mass or distance has a greater effect on the gravity between two objects.

TI-Nspire™ Navigator™

- Send out the *Gravity_and_Objects.tns* file.
- Monitor student progress using Class Capture.
- Use Live Presenter to spotlight student answers.

Activity Materials

- Compatible TI Technologies: TI- Nspire™ CX Handhelds, TI-Nspire™ Apps for iPad®, TI-Nspire™ Software

Tech Tips:

- This activity includes screen captures taken from the TI-Nspire CX handheld. It is also appropriate for use with the TI-Nspire family of products including TI-Nspire software and TI-Nspire App. Slight variations to these directions may be required if using other technologies besides the handheld.
- Watch for additional Tech Tips throughout the activity for the specific technology you are using.
- Access free tutorials at http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials

Lesson Files:

Student Activity

- Gravity_and_Objects_Student.doc
- Gravity_and_Objects Student.pdf

TI-Nspire document

- Gravity_and_Objects.tns

Discussion Points and Possible Answers

Have students read the background information stated on their activity sheet or page 1.2 on the .tns file.

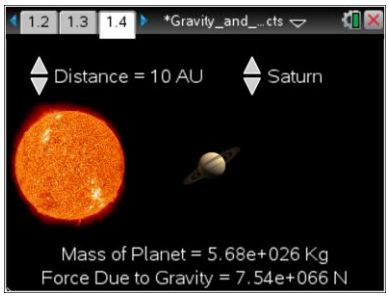
Move to page 1.3.

Have students answer question 1 in the .tns file, activity sheet, or both.

Q1. Which of the following best explains Newton's law of gravitation?

Answer: D. Every mass exerts an attractive force on every other mass.

Move to page 1.4.



1. Students will begin by observing how the gravitational force between two objects is related to mass of the objects. To do this, students will select the up and down arrows (▼ and ▲) next to the planet to change which planet they are measuring while **keeping distance constant at 10 AU** (astronomical units). Doing this will change the mass of an object without changing the distance. Students should then observe how the force of gravity between a planet and the Sun is related to the mass of the planet.

Note: Do not have students reset the simulation yet.

Tech Tip: To access the Directions again, select > **Gravitation**> **Directions**

Tech Tip: To access the Directions again, select menu or **Document Tools ( ) > Gravitation > Directions.**

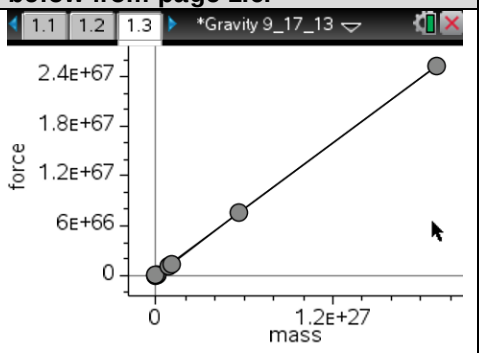
Move to pages 1.5 – 1.6

2. The planet mass versus force of gravity data will be captured on the spreadsheet on page 1.5. Students should plot the data in the graph on page 1.6. To do this, have students select the *x*-axis and then select the variable *mass* from the dropdown menu. Select the *y*-axis and then select the variable *force* from the dropdown menu.

Tech Tip: To scroll through data in the spreadsheet on screen 1.5, students can press their finger anywhere on the screen and drag it up or down.

Move to pages 1.7 – 1.9.

3. After examining the data in the spreadsheet on page 1.5 and the graphic representation on page 1.6, have the students record the data into the table on their activity page and answer questions 2 – 4.

Planet	Mass (kg)	Distance (AU)	Force (N)	Copy force versus mass graph below from page 1.6.
Mercury	3.3 e23	10	4.37 e63	
Venus	4.87 e24	10	6.46 e64	
Earth	5.97 e24	10	7.92 e64	
Mars	6.42 e23	10	8.51 e63	
Jupiter	1.9 e27	10	2.52 e67	
Saturn	5.68 e26	10	7.53 e66	
Uranus	8.68 e25	10	1.15 e66	
Neptune	1.02 e26	10	1.35 e66	

Q2. What happens to the force of gravity between a planet and the Sun as you select a planet with a greater mass?

Answer: A. The force of gravity goes up.

Q3. What evidence leads you to your conclusion in the previous question?

Answer: Student responses will vary. Sample answer: From the graph on page 1.5, as the mass of the planet increases the force of gravity between the planet and the Sun increases. It is a linear relationship.

Q4. Before you manipulate the distance, predict what will happen to the force of gravity between a planet and the Sun when you change the distance between them.

Answer: Students will have varying responses here.

Move on to page 2.1 and then move back to page 1.4.

4. Students will observe how the force of gravity between two objects is related to the distance between them. Before collecting data, students must reset the simulation on page 1.4. To do this, go to page 1.4. Have students select **Menu > Gravitation > Erase Data**. This will remove all of the data you previously collected. Note: Be sure that students have recorded all of your data onto their student worksheet before doing this.

Tech Tip: To erase the data, select > **Gravitation> Erase Data.**

Tech Tip: Select menu or **Document Tools ( ) > Gravitation > Erase Data.**

5. In the next part of the simulation, students will keep the planet constant and **change the distance** from 0.5 AU to 30 AU. Students should pay attention to what happens to the gravitational force between the planet and the Sun as they change the distance between them

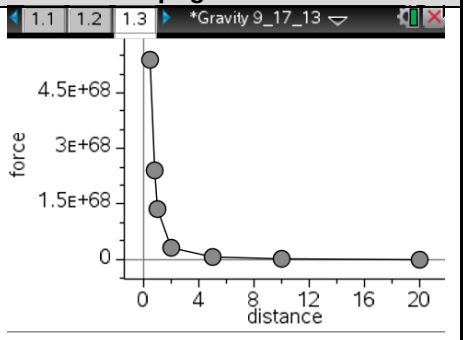
Move to pages 2.2 - 2.8

Q5. As you move your planet closer to the Sun, what happens to the force?

Answer: A. The force of gravity increases.

Q6. Set your planet to Neptune and your distance to 30 AU. Then, erase the data in your simulation by following the same process as before. Move the distance from 30 AU down to .5 AU. Return to the graph on page 1.6. This time, set the *y*-axis to force and the *x*-axis to distance. Does the slope/curve of the current graph match the mass versus force graph you copied earlier? *Copy the data from the spreadsheet on page 1.5 and graph from page 1.6 below.*

Answer: No.

Planet selected	Distance (AU)	Force (N)	Copy distance versus force graph below from page 1.6.
Neptune	0.5	5.41 e68	
	0.75	2.40 e68	
	1	1.35 e68	
	2	3.38 e67	
	5	5.41 e66	
	10	1.35 e66	
	20	3.38 e65	
	30	1.50 e65	

Q7. What similarities or differences do you notice between the mass versus force graph and the force versus distance graph?

Sample Answer: The mass versus force graph is a straight, linear line while the distance versus force graph is an exponential curve.

Q8. The relationship between the force of gravity and distance between two objects is described by the inverse square law. This means that the force of gravity between two objects is inversely related to the square of the distance between them. Return to page 1.6. Set the *x*-axis to inverse square. Keep the *y*-axis set to force. How does the graph compare to the mass versus force graph you copied earlier?

Sample Answer: They are both linear graphs. Just as the mass of a planet is linearly proportional to the force of gravity, the inverse square of the distance between the planet and the Sun is linearly proportional to the force of gravity.

Q9. If Earth were a more massive planet, what would happen to the gravitational attraction be between the Sun and the Earth?

Sample Answer: A. There would be greater gravitational attraction.

Q10. Which has a larger effect on the gravitational attraction between two objects?

Sample Answer: B. distance

Q11. Defend your answer to question 10 with evidence collected during the simulation.

Sample Answer: As shown in the graph on page 1.4, the mass of an object is linearly proportional to the gravitational force. However, the distance between two objects has an inverse square relationship to the gravitational force. Thus, a small change in the distance between two objects will lead to a more significant change in the gravitational force between them.

TI-Nspire Navigator Opportunities

Make a student a Live Presenter to illustrate show how to manipulate the planet while keeping distance constant as well as how to manipulate the distance will keeping the planet constant. Throughout the activity, monitor student progress. At the end of the activity, collect the .tns file and save to Portfolio.

Wrap Up

When students are finished with the activity, retrieve the .tns file using TI-Nspire Navigator. Save grades to Portfolio. Discuss activity questions using Slide Show.

Assessment

- Formative assessment will consist of questions embedded in the .tns file. The questions will be graded when the .tns file is retrieved. The Slide Show will be utilized to give students immediate feedback on their assessment.
- Summative assessment could consist of questions/problems on the chapter test or for students to create a model of the solar system based on data in the simulation.