Science Objectives

* Students will explore how the mass and initial velocity of objects affect the outcome of an elastic collision.
* Students will apply Newton's second and third laws to a collision between two cars.

Vocabulary

* speed
* velocity
* force
* acceleration
* mass
* collision
* action-reaction forces

About the Lesson

* In this lesson, students will:
  * Manipulate the initial mass and velocity of objects and observe the final velocity of objects after a collision.
  * Calculation acceleration and force on objects during a collision.
 * Verify Newton's third law from data collected during the simulation.

TI-Nspire™ Navigator™

* Send out the *Newton and THE Law.tns* file. Tthe questions are Self-Check which you might want to change to Exam.
* Monitor student progress using Class Capture.
* Use Student Live Presenter to spotlight student answers and presentation of solutions.

Activity Materials

* Compatible TI Technologies: ▦ TI- Nspire™ CX Handhelds, 👆 TI-Nspire™ Apps for iPad®, 💻 TI-Nspire™ Software
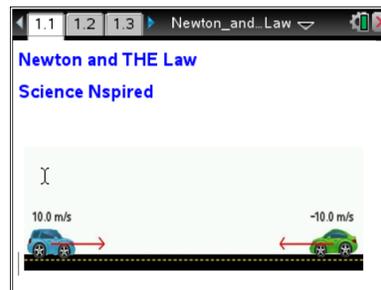
Tech Tips:

* 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

* Newton_and_THE_Law_Teacher.doc
* Newton_and_THE_Law_Student.doc

*TI-Nspire document*

* Newton_and_THE_Law.tns

Discussion Points and Possible Answers

Have students read the background information on the student activity sheet or on pages 1.2 & 1.3.

Move to page 1.4.

1. To begin, students will observe the final velocities of each car when the cars have the same initial mass and speed. Students should use the up and down arrows (▼ and ▲) to set the mass of the blue and green cars. They should set the masses of each car equal to 1.00 kg and observe the initial velocities of each car.

2. Then, they will select the play button to run the simulation. They should observe the final velocities of each car after the collision.

3. Have students repeat this process for different values of mass. In each trial, students should keep the mass of the cars equal to one another. Hae students select the [◄] button to reset the simulation after each trial.

4. Next, students will observe the final velocities of each car when the cars have the same initial mass but different initial velocities. They should set the mass of each car equal to 1.00 kg again.

5. Have students select and drag the arrow of the blue car to the left or right to change its velocity. Students should select the arrow again to lock it in place. They should repeat this process to change the velocity of the green car. The two speeds should not be equal to one another, but students should be sure to set the arrows so that they always point towards each other. (This will ensure that the cars will collide.)

6. Have students select the play button to run the simulation and observe the final velocities of each car after the collision.
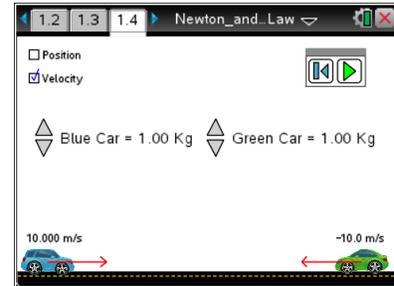
Tech Tip: To access the Directions again, students should select ✎ > **Newton and THE Law > Directions**.

Tech Tip: To access the Directions again, students should select menu or **Document Tools (⚒) > Newton and THE Law > Directions.**

Move to pages 1.5 - 1.8.

Have students answer questions 1 – 4 in the .tns file, the activity sheet, or both.

Q1. When the blue and green car have the same initial mass and speed, what happens to the velocity of each car after the collision?

Sample Answer: The speed of each car remains the same, but the cars begin traveling in the opposite direction.

Q2. When the blue and green car have the same initial mass but different initial speed, what happens to the velocity of each car after the collision?

Sample Answer: The cars seem to transfer their initial speed to one another. Each moves away from the collision in the opposite direction with a speed equal to the initial speed of the other car.

Q3. The blue car exerts a force F on the green car during the collision. Based on Newton's third law, what can you conclude?

Answer. C. The green car exerts a force $-F$ on the blue car.

Q4. What does a negative velocity value mean?

Sample Answer: The car is traveling to the left.

Move back to page 1.4.

7. Now, students will observe the final velocities of the cars when they have different initial masses and the same initial velocities. For the first trial, have students set the initial speed of each car to 10.0 m/s. They should set the mass of each car to any value. (Be sure that the masses are different.) Then, have students record the masses and initial velocities in the table on their activity sheet.
8. Have students run the simulation. They should observe and the record the final velocities of each car in the table on their activity sheet.
9. Have students reset the simulation and repeat these steps for three total trials. Students should be sure to keep the initial speed of each car at 10.0 m/s, but change the mass of the cars each trial. (Students should not worry about the three final columns yet.)

Trial	Car	Mass (kg)	Initial Velocity (m/s)	Final Velocity (m/s)	Change in Velocity (m/s)	Acceleration (m/s^2)	Force (N)
1	Blue	2.00	10.0	-16.6	-26.6	-53.2	-106.4
	Green	4.00	-10.0	3.3	13.3	26.6	106.4
2	Blue	3.00	10.0	-18.0	-28.0	-56.0	-168.0
	Green	7.00	-10.0	2.0	12.0	24.0	168.0
3	Blue	10.0	10.0	6.4	-3.6	-7.2	-72.0
	Green	1.00	-10.0	26.0	36.0	72.0	72.0

10. Next, students will calculate the quantities for the three final columns. To do this, students should use the following information:

   a. Change in Velocity = Final Velocity - Initial Velocity

   b. Acceleration = $\dfrac{\text{Change in Velocity}}{\text{Change in Time}}$

      This is the acceleration of the car during the collision. Assume that the cars are in contact for 0.5 s, so the change in time = 0.5 s.

   c. Force = mass x acceleration

      This is Newton's second law. This equation determines the force that a car experiences during the collision.

   d. Important: Be sure that students include the correct negative signs in all of your calculations!

   Tech Tip: To insert a calculator, have students select ⌷ctrl⌷ ⌷I⌷ > **Add Calculator**.

Move to pages 2.1 - 2.2.

Answer questions 5 and 6 below and/or in the .tns file.

Q5.   Do your calculations of force in the table support Newton's third law of motion? Why or why not?

   Sample Answer: Yes. The calculations show that each car experiences a force of equal magnitude but opposite direction during the collision. This supports Newton's third law, which states that the force that object 1 exerts on object 2 is equal and opposite to the force that object 2 exerts on object 1.

Q6.   Two cars have the same initial speeds. According to Newton's third law, they experience equal and opposite forces during a collision. Why is it that they may move away from one another at very different final velocities after the collision?

   Sample Answer: While both cars may have the same initial speed and experience equal magnitudes of force during the collision, the cars may have different masses. According to Newton's second law, this would cause each car to experience a different amount of acceleration during the collision. Because of this, they would move away at very different speeds.

TI-Nspire Navigator Opportunities

Make a student a Live Presenter to demonstrate what they discover along the way.

Use Quick Poll as Formative Assessment.

Wrap Up

Students should compose a lab report, which includes their data, analysis, and a discussion of the results of their test. Students may choose to use the TI-Nspire™ Student Edition software to convert their .tns files to PublishView Documents.

Assessment

- Use the questions in the Nspire document as Quick Polls during the lesson as needed.
- Have students check and confirm the calculations of their peers in the data table..