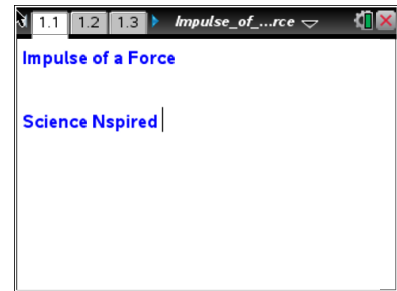




Science Objectives

- Students will determine the force exerted by a stationary object on the cart during a collision and the time of collision.
- Students will relate the effects of changes on mass and speed of motion on the magnitude of the impulse.
- Students will develop an understanding of the relationships between force, speed, time, and impulse.



Vocabulary

- force
- impulse
- mass
- speed
- time

TI-Nspire™ Technology Skills:

- Download a TI-Nspire document
- Open a document
- Move between pages
- Collect data with probes

About the Lesson

- This lesson allows students to observe the elastic collision of a moving cart with a stationary object.
- As a result, students will:
 - Measure the force exerted by the stationary object on the cart during the collision and the time of collision.
 - Add mass to the cart and change its speed and observe the effects of these changes on the magnitude of the impulse.
 - Collect experimental data and measure impulse while changing mass and speed.

Tech Tip:

Access free tutorials at <http://education.ti.com/calculator/spd/US/Online-Learning/Tutorials>

TI-Nspire™ Navigator™

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

Lesson Files:

Student Activity

- *Impulse_of_a_Force_Student.doc*
- *Impulse_of_a_Force_Student.pdf*

TI-Nspire document

- *Impulse_of_a_Force.tns*

Activity Materials

- *Impulse_of_a_Force.tns* document
- TI-Nspire™ Technology
- Vernier Dual-Range Force sensor
- Vernier EasyLink™ or Go!® Link interface
- cart (or Hall's carriage) and track
- right-angle clamp (optional)



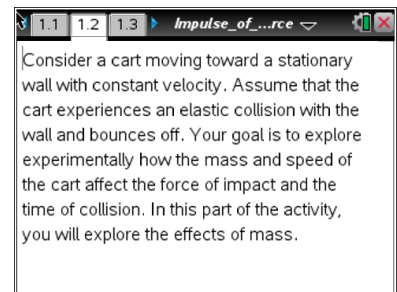
Discussion Points and Possible Answers

The purpose of this activity is to allow students to observe the elastic collision of a moving cart with a stationary object and to explore the impulse of the force acting on the cart during the collision. Students measure the force exerted by the stationary object on the cart during the collision and the time of collision. Students can add mass to the cart and change its speed and observe the effects of these changes on the magnitude of the impulse.

This activity consists of two parts. In the first part, students collect experimental data and measure impulse while adding the mass to the cart. In the second part, students collect experimental data and measure impulse while changing the speed of the cart.

Move to pages 1.2 and 1.3.

If you choose not to distribute the .tns file for this activity, students should open a new .tns file at this point



Exploring impulse for carts of different masses



1. Students will use a Vernier Dual-Range Force sensor to collect force data. Make sure the switch on the force sensor is in the ± 10 N position. Students should set up the track at a slight angle. They should mark a "starting point" for the cart, no more than 30 cm from the end of the track. Ideally, the angle of the track should be between 10° and 30° . (They can use tape, markers, or other means to mark the starting point. The most important thing is that the cart starts from the same point during each trial.) Students should mount the force sensor on this end of the track, with the hook directed up the track. For the most accurate results, the force sensor must remain stationary during the experiment. To prevent its movement during the collision, students should hold the force sensor down during the experiment. Alternatively, students can use a clamp to mount the force sensor to the tracks.

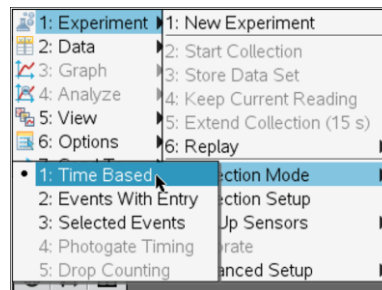
Move to page 1.4.

2. Students should connect the force sensor to the EasyLink interface (TI-Nspire handhelds) or to the Go! Link interface (TI-Nspire computer software). Students should not connect the EasyLink or Go! Link interface to their handheld or computer yet.
3. Next, they should connect the EasyLink interface to their handheld (or the Go! Link interface to their computer). The DataQuest application on page 1.4 should show that they are collecting data for force.





- Students should select the graph tab .
- Students should wait for the data collection display to stabilize, and then zero the force sensor (**Menu > Experiment > Set Up Sensors > Zero**).
- Next, students should set up the data collection for **Time Graph mode (Menu > Experiment > Collection Mode > Time Based)**. In the configuration window, they should select 0.01 sec for the time between the samples and 5 sec for the experiment length.
- Once students are ready to begin data collection, they should place the cart on the track so that its front wheels are aligned with the starting position.
- Students should start data collection by selecting **Start Data Collection**  in the DataQuest application. Immediately after data collection has started, students should release the cart so that it slides down the track and bounces off the force sensor. Students should stop the cart after the first bounce. They should make sure that the cart bounces off the force sensor before the data collection stops. If data collection stops before the cart bounces off the sensor, students can modify the experiment parameters to make the experiment longer; alternatively, they can start the cart closer to the sensor. A graph of force vs. time should be displayed on the screen.



After examining the graph, have students answer Questions 1–5 on the activity sheet.



- Q1. Use the graph to determine the time of collision and the magnitude of the force acting on the cart during the collision.

Answer: The jump in the graph of the force represents the moment of collision. Using the cursor and the **Graph Trace** function (**Menu > Trace > Graph Trace**), students can identify the initial and final points of this part of the graph. (Students should change the graph from separate points to connected points using the **Attributes** tool (**Menu > Actions > Attributes**) before carrying out the graph trace.) The difference between the x-coordinates on the graph is equal to the time of collision. The average force of impact during the collision can be found as the area under the

curve divided by the time interval: $F_{av} = \frac{1}{\Delta t} \int_{t_1}^{t_2} F(t) dt$. For these data, the graph of F vs. t should

appear to be a triangle. The area of a triangle is $\frac{1}{2}(\text{base})(\text{height})$. Therefore, the average force is equal to $\frac{1}{2}(\Delta t)(F_{max})$. Students can use the **Graph Trace** tool to identify the y-coordinates (force) of the maximum and minimum points. The negative sign on the force coordinates represents the direction of the force toward the sensor at the impact.

- Q2. Calculate the impulse produced during this collision.

Answer: The impulse can be calculated as the product of the average force of impact and the time of collision ($impulse = F_{av} \cdot \Delta t$). The impulse is also equal to the area under the curve

during the collision ($impulse = \int_{t_1}^{t_2} F(t) dt$). Students can use their calculated forces and times

to calculate impulse.

- Q3. What do you think will happen to the time of collision if you add weight to the cart but keep its speed the same?

Answer: Student answers will vary. Encourage students to discuss their answers and defend their predictions.


- Q4. What do you think will happen to the force of impact if you add weight to the cart but keep its speed the same?

Answer: Student answers will vary, but students should be able to reason that if the cart is heavier, the force of impact should be larger.



- Q5. What do you think will happen to the impulse of the collision if you add weight to the cart but keep its speed the same?

Answer: Student answers will vary, but students should be able to reason that if the cart is heavier, the impulse should be larger.

9. Students should test their predictions by adding weight to the cart and repeating the experiment. If they closed the DataQuest application in step 9, they should insert a new DataQuest Application (**Doc > Insert > Vernier DataQuest**). They should again place the cart on the starting point and select . Students should select **Store latest Data Set**. This will save the data collected during the first run. The data for the new run (with the heavier cart) will be stored in a new variable. They should examine the resulting graph, calculate time, force, and impulse for the collision, and then answer Question 6.

Have students answer the question on the activity sheet.

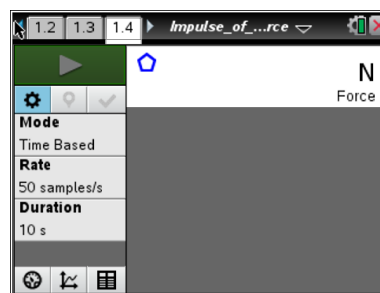
- Q6. What do you think will happen to the impulse of the collision if you add weight to the cart but keep its speed the same?

Answer: Student answers will vary. Encourage students to discuss their answers and to use metacognitive thinking to analyze any errors in their reasoning. If time allows, you may have students repeat the experiment several times with several different masses and attempt to find a quantitative relationship between mass and impulse. They should confirm that impulse is directly proportional to mass.

Exploring impulse for a cart moving with different speeds

Return to page 1.4.

10. Students should return to page 1.4 and answer Questions 7 – 9.



Have students answer Questions 7 – 9 on the activity sheet.



Q7. What do you think will happen to the time of collision if you increase the speed of the cart but keep its weight constant?

Answer: Student answers will vary. Encourage students to discuss their answers and defend their predictions.

Q8. What will happen to the force of impact if you increase the speed of the cart but keep its weight constant?

Answer: Student answers will vary, but most students should be able to reason that if the speed of the cart is larger, the force of impact will be larger.

Q9. What do you think will happen to the impulse of the collision if you increase the speed of the cart but keep its weight constant?

Answer: Student answers will vary. Some students may correctly infer that impulse will increase as speed increases. Encourage students to discuss their answers and defend their predictions.

Return to page 1.4.

11. Next, students should increase the incline of the track. They should again store their previous data runs before collecting new data. They should then answer Questions 10 – 12.



Have students answer Questions 10 – 12 on the activity sheet.

Q10. Were your predictions about force, time, and impulse correct? If not, describe any errors in your reasoning.

Answer: Student answers will vary. Encourage students to use metacognitive thinking to identify errors in reasoning. If time allows, you may have students repeat the experiment several times with several different speeds and attempt to find a quantitative relationship between speed and impulse.



Q11. What factors affect impulse?

Answer: Impulse of force depends on the mass and change in velocity of the cart, so it depends on the change of momentum.

Q12. If a scientist wants to minimize the impulse produced during a collision between two objects, what should the scientist do?

Answer: The scientist should minimize the masses of the objects and their speeds at the time of collision.

TI-Nspire Navigator Opportunities

Use Navigator to capture screen shots of student progress and to retrieve the file from each student at the end of the class period. The student questions can be electronically graded and added to the student portfolio.

Wrap Up

When students are finished with the activity, pull back the .tns file using TI-Nspire Navigator. Save grades to Portfolio. Discuss activity questions using Slide Show. Make sure the concept of balancing torques is firm in their understanding and not balancing forces.

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 will consist of questions/problems on the chapter test.