Bell Ringer: Perfectly Inelastic Collisions – ID: 13580

Time required
15 minutes

Topic: Momentum and Collisions

- *Calculate the total momentum of a system of objects.*
- *Explore the relationship between mass, velocity, and momentum in a perfectly inelastic collision.*

Activity Overview

In this activity, students use a simulation of a one-dimensional perfectly inelastic collision to explore the relationship between mass, velocity, and momentum. Students vary the initial masses and velocities of two objects prior to a collision. They observe how the final velocity and momentum of the system are affected by these variables.

Materials

To complete this activity, each student will require the following:

- *TI-Nspire™ technology*
- *pen or pencil*
- *blank sheet of paper*

TI-Nspire Applications

Graphs & Geometry, Notes

Teacher Preparation

Before carrying out this activity, review with students the law of conservation of momentum. Also, review the difference between elastic, inelastic, and perfectly inelastic collisions.

- *The screenshots on pages 2–5 demonstrate expected student results. Refer to the screenshots on page 6 for a preview of the student TI-Nspire document (.tns file). The solution .tns file contains sample responses to the questions posed in the student .tns file.*
- ***To download the student .tns file and solution .tns file, go to education.ti.com/exchange and enter "13580" in the search box.***
- *This activity is related to activity 8879: Collisions in One Dimension. If you wish, you may extend this bell-ringer activity with the longer activity. You can download the files for activity 8879 at education.ti.com/exchange.*

Classroom Management

- *This activity is designed to be **teacher-led**, with students following along on their handhelds. You may use the following pages to present the material to the class and encourage discussion. Note that the majority of the ideas and concepts are presented only in **this** document, so you should make sure to cover all the material necessary for students to comprehend the concepts.*
- *If you wish, you may modify this document for use as a student instruction sheet. You may also wish to use an overhead projector and TI-Nspire computer software to demonstrate the use of the TI-Nspire to students.*
- *If students do not have sufficient time to complete the main questions, they may also be completed as homework.*

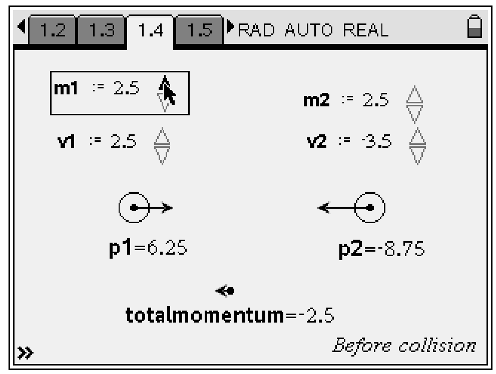
- *In some cases, these instructions are specific to those students using TI-Nspire handheld devices, but the activity can easily be done using TI-Nspire computer software.*

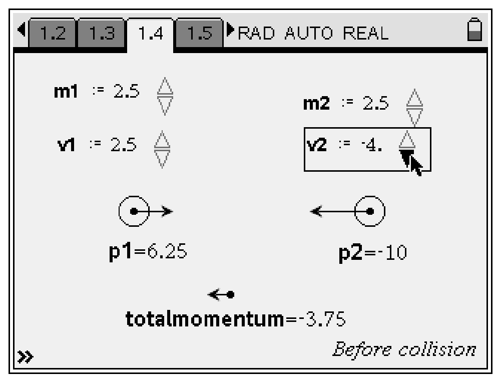
The following questions will guide student exploration during this activity:

- How can you represent momentum with a vector?
- How do you determine the total momentum of two moving objects?
- In a closed system, how does the total initial momentum of the system compare with the total final momentum of the system?
- What happens during a perfectly inelastic collision?

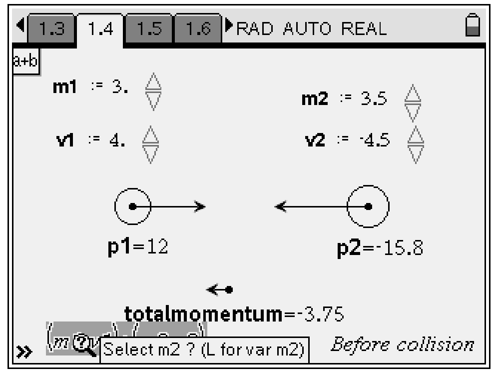
The purpose of this activity is for students to gain a visual understanding of momentum transfer during a perfectly inelastic collision. Students vary the initial conditions of a collision to explore how mass and initial velocity affect the final velocity of two objects after a perfectly inelastic collision.

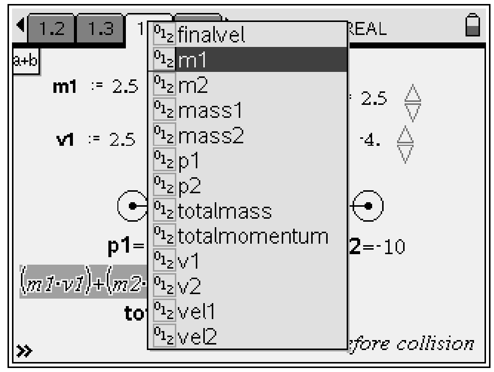
Step 1: Students should open the file **PhysBR_week15_1dcollision.tns** and read the first three pages. Page 1.4 shows a simulation of two circular objects traveling toward each other. The mass (**m**) and velocity (**v**) of each object are displayed above the objects. Students can vary the mass and velocity of either object using the NavPad to move the cursor to the up and down arrows located to the right of each variable. They can press ⓧ to change the values. The mass of each object ranges from 0.5 to 4, and the magnitude of the velocity of each object ranges from 0 to 5. Note that the velocity of object 1 (shown on the left) ranges from 0 to 5, and the velocity of object 2 (shown on the right) ranges from –5 to 0. This restricts the movement of the two objects so that they are traveling toward one another. Vectors labeled **p1** and **p2** represent the momentum of each object. The total momentum of the system (**totalmomentum**) is the sum of the momentums of the two objects (**totalmomentum** = **p1** + **p2**). Students should observe how the momentum of each object relates to its mass and velocity. They should also observe how the total momentum of the system relates to the momentum of each object.

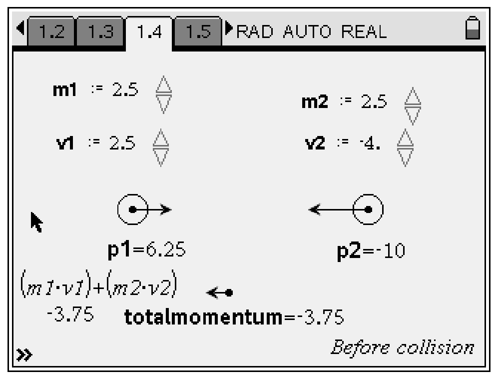




Step 2: Next, students should answer question 1 on page 1.5.







Q1. How is the total momentum calculated on page 1.4? Return to page 1.4 and verify that the total momentum quantity is correct by calculating the total momentum of the system.

A. *Students should recall that the total momentum of the system is the sum of the momentums of the two objects. Thus, the total momentum is given by:*
***totalmomentum* = (*m1* × *v1*) + (*m2* × *v2*)**
*To calculate the total momentum of the system using the handheld device, students should return to page 1.4 and select the **Text** tool (**Menu > Actions > Text**). They should then click once (press) on an empty area of page 1.4 to place a text box. After entering the expression in the text box, students should use the **Calculate** tool (**Menu > Actions > Calculate**) to determine the value of the expression. After they select the **Calculate** tool, they should click on the expression they entered for total momentum. They will be prompted to select values for m1, v1, m2, and v2. They should press to see a drop-down list of different variables. Students can use the NavPad to select the appropriate values for each variable. After students have selected the values for each variable, they should click on a blank spot on the page to place the calculated value of momentum in that location.*

Step 3: Next, students should read pages 1.6 and 1.7. Then, students should answer question 2 on page 1.7.

Q2. Predict the final velocity of the system for the following initial conditions:

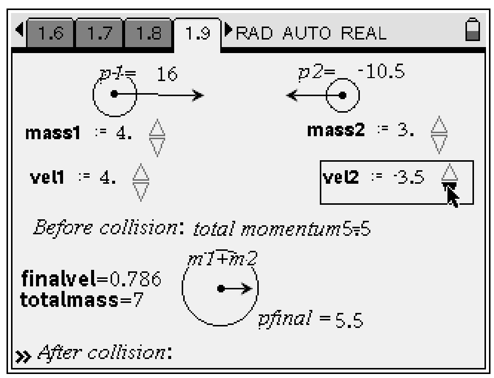
a. The masses and speeds of both objects are equal.

b. The masses of both objects are equal. Object 1 is traveling at full speed, but object 2 is at rest.

c. Object 2 is a very light object at rest. Object 1 is a heavy object traveling at full speed.

A. *Students should answer this question without using the simulation on page 1.9. Encourage students to use conservation of momentum to reason out the result of each collision. Have students visualize the collision for each scenario, imagining real-world instances of inelastic collisions. Also, encourage students to consider how the initial mass, velocity, and momentum of each object will change when the objects collide.*

Step 4: Next, students should read page 1.8 and then proceed to the simulation on page 1.9. The simulation shows the objects and information displayed on screen 1.4. It also shows values for mass, velocity, and momentum after the collision. After the objects collide, they stick together and move as one mass with velocity **v**. Students should vary the initial mass and velocity of the objects as they did in Step 1. Students should observe how the final mass, velocity, and momentum are affected by the different initial conditions. Then, students should answer questions 3 and 4.



Q3. Describe how the final velocity was affected for each of the initial conditions described on page 1.7.

A. *a. The final velocity was zero. Because both objects had the same mass and were traveling toward one another at the same initial speed, the momentum of each object was equal in magnitude and opposite in direction to the other. Thus, the total initial momentum of the system was zero. Because the system moved at one velocity after the collision, the velocity must be zero after the collision to ensure that the total momentum of the system was conserved.*

b. The final velocity was half the initial velocity of object 1. This is because the total initial momentum of the system was determined entirely by object 1. When object 1 collided with object 2, the total mass of the moving system doubled, so its velocity must have been halved for momentum to be conserved.

c. The final velocity was almost equivalent to the initial velocity of object 1. This is because the mass of object 2 was very small compared with object 1. When the objects collided, the total mass of the moving system did not change considerably, so its velocity did not need to change considerably to ensure that momentum was conserved.

Q4. How did the total momentum of the system before the collision compare with the final momentum of the system? Why is this the case?

A. *The total momentum of the system was the same before and after the collision. This is because momentum was conserved.*

Suggestions for Extension Activities: If you wish, you may have students derive a general formula relating the final velocity of the objects with the initial velocities and masses of the objects: $v = \frac{(m1 \times v1) + (m2 \times v2)}{(m1 + m2)}$. Then, students can enter the expression into the handheld device to verify the formula.

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(Student)TI-Nspire File: *PhysBR_week15_1dcollision.tns*

1.1

PERFECTLY INELASTIC COLLISIONS

Physics

Momentum and Collisions

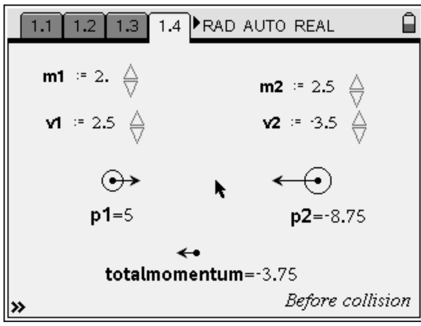
1.2

Recall that the momentum of an object is the product of the object's velocity and mass. Momentum can be represented with a vector. If there are multiple objects in a system, you can add the momentums of the objects to determine the total momentum of the system.

1.3

On page 1.4, two objects (m_1 and m_2) are traveling toward each other with velocities v_1 and v_2, respectively. The momentum, p, of each object is represented with a vector. Change the velocity and mass of each object to observe how the total momentum of the system changes.

1.4



1.5

1. How is the total momentum calculated on page 1.4? Return to page 1.4 and verify that the total momentum quantity is correct by calculating the total momentum of the system.

1.6

During a perfectly inelastic collision, two objects collide and stick together. After the collision, the two objects move as one mass, M. The final velocity of the objects after an inelastic collision is determined by the initial conditions.

1.7

2. Predict the final velocity of the system for the following initial conditions:

a. The masses and speeds of both objects are equal.

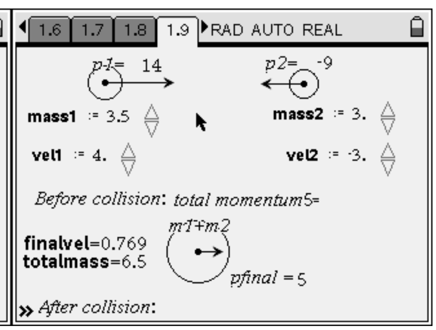
b. The masses of both objects are equal. Object 1 is traveling at full speed, but object 2 is at rest.

c. Object 2 is a very light object at rest. Object 1 is a heavy object traveling at full

1.8

On page 1.9, change the initial conditions to observe how the final velocity of the system changes. Check your observations against your predictions on page 1.7.

1.9



1.10

3. Describe how the final velocity was affected for each of the initial conditions described on page 1.7.

1.11

4. How did the total momentum of the system before the collision compare with the final momentum of the system? Why is this the case?