Two Dimensional Collision Lab

Teacher's Guide

Topic:

Momentum and Collisions

The following information is provided to the student:

Question:
What is the evidence that momentum is conserved in a two-dimensional collision? In what manner does the evidence support the law of momentum conservation?

Purpose:
To conduct a vector analysis of a two dimensional collision in an effort to gather convincing evidence that the total system momentum is conserved AND to describe how the evidence supports the law of momentum conservation.

A complete lab write-up includes a Title, a Purpose, a Data section, and a Conclusion/Discussion of Results. The Data section should include a sketch of the experimental results as gathered by the carbon paper impressions (collision location, pre-collision landing location and striker and target sphere post-collision landing location). Actual measurements taken from the large paper should be recorded on your sketch and labeled using the usual conventions (p_1, p_1', p_2', Θ_1, Θ_2, etc.). A well-organized mathematical analysis should be conducted to show that momentum is conserved (or not conserved) in both the x- and the y-dimensions. Work should be labeled and follow-able. The Conclusion should explain how it is known that total system momentum is conserved; it should also include an error analysis.

Materials Required:

2-D collision apparatus; two identical metal spheres; carbon paper; paper; masking tape; meter stick.

Description of Procedure:

The 2-D collision apparatus (described below) is taped to the lab bench. The *striker* sphere is rolled from rest from the top of the ramp and off the apparatus onto the floor below. Once the approximate landing location is determined, paper is taped to the floor to form a continuous line of paper from the collision location to the landing location. Carbon paper is placed upon the paper and the *target* sphere is rolled down the ramp about ten times to form a sufficient number of impressions on the paper in order to locate the exact landing location. The exact landing location on the paper is marked and labeled as **Striker - before collision**. Now the adjustable arm upon which the *target* sphere rests is moved into position to be struck by the *striker* sphere. The *target* sphere is located just barely off the path of the *striker* sphere so that a glancing collision occurs. The *striker* sphere is then rolled down the ramp to collide with the *target* sphere. Once the approximate landing locations of the two spheres is determined, paper is placed at those locations and extended towards the original paper and taped together. Two pieces of carbon paper are placed on top of the paper; the collision is performed about ten times in order to form a sufficient number of impressions on the paper of the landing locations of the two spheres. The two landing locations are marked on the paper and labeled as **Striker - after collision** and **Target - after collision**. Finally, the plumb bob is extended downward from the collision location to the paper; the collision location is marked and labeled as **Collision Location**. Since the distance from the collision location to the three other marked locations are proportional to the velocity, they are also proportional to the momentum (since the spheres have identical mass). These vectors are drawn on the

paper and their magnitude and direction is measured and recorded. Component analysis is used to determine the total momentum before (or without) the collision and after the collision.

Alternative Materials and Procedure:

The 2-D collision apparatus is relatively simple. It consists of a small ramp with a groove which the sphere rolls down. The ramp gradually levels off at the bottom. The *striker* sphere rolls along the groove down the ramp to the end of the level section. At the end of the level section of the apparatus is a small resting platform for the *target* sphere. The resting platform can be rotated into and out of the line of motion of the *striker* sphere. The entire apparatus could likely be made using thermal pipe insulation purchased from a home store and a little creativity.

Safety Concern:

There is always a higher than usual level of risk associated with working in a science lab. Teachers should be aware of this and take the necessary precautions to insure that the working environment is as safe as possible. Student *horseplay* and off-task behaviors should not be tolerated.

Suggestions, Precautions, Notes:

1. This lab is a difficult lab and may be best suited for your most able classes. Regardless of what level of students perform this lab, it is a lab which deserves an extensive pre-lab and considerable guidance. In the end, results are impressively accurate.
2. It is important that the *striker* sphere and *the* target sphere are aligned at the same height at the moment of the collision. If so, all the momentum of the two spheres immediately after the collision lies in a horizontal plane. Thereafter, gravity acts upon the spheres to cause their fall to the floor. Since gravity doesn't alter the horizontal velocity of the spheres, and since each sphere falls to the ground in the same amount of time, the distance traveled by the spheres is proportional to the velocity and the momentum. If the collision occurs such that one of the spheres is projected slightly upward and the other downward, the time of fall will be different and the above reasoning no longer holds true.
3. The paper which is placed upon the floor must be all taped to each other; students should not use the tape sparingly. Inform students that momentum should be conserved in this lab, but masking tape should not.
4. It is helpful during the analysis to define east as the direction which the *target* sphere was moving before the collision. Thus, the pre-collision momentum was due east.
5. If the demands of the lab become to overwhelming, consider providing the following tables to assist students in the organization of their measurements and in their analysis:

Measurements:

	Before Collision Momentum		After Collision Momentum	
	Magnitude	Direction	Magnitude	Direction
Striker				
Target				

Analysis:

	Before Collision Momentum Components		After Collision Momentum Components	
	x-Dir'n	y-Dir'n	x-Dir'n	y-Dir'n

The Laboratory

Striker				
Target				
Total				

Auxiliary Materials:

None

Scoring Rubric:

M10. Two-Dimensional Collision Lab	**Score**
___ Included, labeled and organized all parts of the lab report. ___ Data section includes an informative sketch; the four strategic locations are shown. Measurements of p_1, p_1', p_2', Θ_1, Θ_2, are recorded and labeled on the sketch; units are included. Calculations of x- and y-momentum values for the individual objects and for the system are provided for before and after the collision; work is shown in an organized fashion; results are labeled and clearly discernible. Reveals both an understanding of momentum analysis and the ability to organize a complex solution. Results are accurate. ___ Conclusion/Discussion of Results describes how the evidence suggests that momentum is conserved (or not conserved); actual data values are referenced in an effort to establish *the proof*. An error analysis is conducted for the total x-momentum; work is shown.	____/____

Connections to The Physics Classroom Tutorial:

Pages on the topic of two dimensional collisions do not yet exist at The Physics Classroom.

Connections to Minds on Physics Internet Modules:

There are currently no sublevels on the topic of two dimensional collisions.