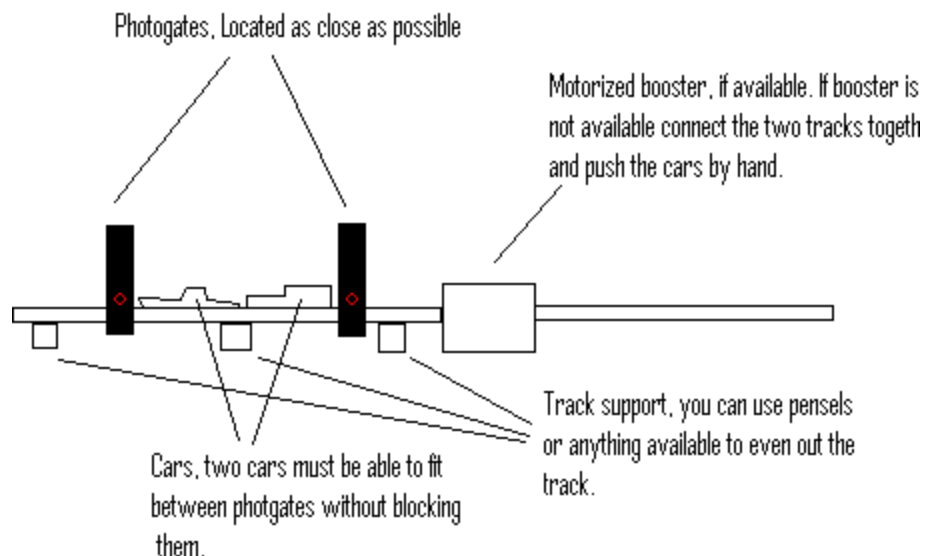# Momentum and Impulse

By

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1. Introduction

Impulse and Momentum are very important physical concepts. They represent a subcategory of inertia called "inertia in motion". Applications of this concept can be seen in everyday examples. For instance, the game of billiard is largely based on the concepts of transfer of momentum and impulse. A basketball bouncing on the court is driven by concept of impulse. We will study the affects of impulse and momentum in the collision between two objects within a controlled environment.

Below is a picture of the experimental setup:

2. Background

2.1 Momentum

Momentum is inertia in motion. Inertia is the tendency of the body to remain in its current state.

$$momentum = mass * velocity = m * v$$

2.2 Impulse

Impulse is the time interval during which the force is acting on the body. Fore example playing tennis you apply a big force on the ball for a short period of time this is called impulse.

$$impulse = F(\Delta t) = F(t_2 - t_1)$$

Δ means a change in the variable, in our case the variable is t. In other words Δt= $(t_2 - t_1)$ where t_1 is the beginning of the time interval and t_2 is the end of the interval

By applying an impulse to the body you are changing its inertia. Therefore, it should also be noted that impulse is equal change in momentum.

Impulse = change in momentum

Ft = Δ(mv) t - total time interval

2.3 Law of Conservation of Momentum

In the absence of an external force, the momentum of a system remains unchanged.

Because of the law of conservation of momentum we are able to analyze the outcome of a collision between two rigid bodies. There are two types of collisions: Elastic and Inelastic. In an elastic collision two or more bodies collide without damage or heat generation. In an inelastic collision the bodies collide and become attached together.

We can analyze the collision in two stages: before and after the collision. According to the law of conservation of momentum we get:

Net momentum before collision = Net momentum after collision

3. Objective:

· To familiarize student with different types of collision and their outcome.
· To find the speed of objects before and after the collision.
· To learn how to use modern instrumentation to acquire data for the experiment

4. Equipment List

-Two toy HotWheels cars
-PC
-Ruler or caliper
-HotWheels motorized booster

-2 Vernier Photo Gates
-Vernier Data Logger Pro
-Scale
-2 right angle clamps

-2 ring stands   -2 HotWheels tracks
-momentum.xls file

5. Experimental Procedure:
Part 1, acquiring data

1. Measure the mass of each car and record it in the data table (required for calculation of momentum).

2. Measure the length of each car and record it in the data table (required to calculate speed of the car as it passes through the photogate).

	Car1	Car2
Mass g		
Length m		

3. Assemble the racing track. Car booster should be in between the two straight track pieces. Place the photogates upstream of the arrow drawn on the booster, in the middle of the racing track.

4. Plug in lab pro interface. Connect the two photogates to dig1 and dig2 connections.

5. Photogates should be apart from each other so that the distance is enough to put two cars in between the photogate without covering the light beam.

6. After this, place the cars as shown in the picture make sure that the cars are facing each other with the side that doesn't have Velcro on it. Turn on the Motorized Booster, practice launching the car so that it doesn't hit the photogate but does hit the other car with enough force for it to go in a straight line through the second photogate. If the cars are being launched too fast adjust the speed of the booster by turning the knob on the side of the booster. Note that cars should be launched fast enough to hit each other and after the impact they both should pass through second photogate!

7. Load Logger Pro 3 and then open file momentum.cmbl. On the screen you will see graph representing the state of photogates and under it you will see table in which photogate parameters will be stored during the experiment

8. Click on the Data Collection icon on the menu, it's the one that looks like a clock. The default values for length of time and samples per second are 20 and 100 respectively. You may change those values but be aware that they may affect you results.

9. Click on the green collect button to begin collecting data. Launch the first car. Photo gates will record the time of their respective on/off state which will be used to calculate the speed of the cars.

10. Click on red stop button. Check your data there should be one time interval for Gate1 and two time intervals for Gate2. If this is not the case or if you are not satisfied with your data you will have to rerun the experiment again from Step 6.

11. Open Microsoft Excel and than open the momentum.xls file. Enter the data for the cars, lengths and mass. Go back to Logger Pro copy the first 3 columns of data and paste them in highlighted cells in Excel. Make sure that you paste your data in to the respective data fields of the Excel sheet depending on which car was launched first.

12. Switch the cars around now the car that was launched before should be at rest and the car that was stationary before should be launched. Go to step 6 and than repeat the procedure

13. Print out your Excel sheet.

14. Now we have to repeat the experiment for inelastic collision. Go to Step 6 and place each car with the velcroed side facing each other. Repeat the experiment.

6. Analysis/Questions:

1. By looking at the momentum before and after the impact write a paragraph describing any possible reasons for an error. Hint: Are there any external forces not accounted for in the experiment? Are the impacts perfect?

2. How can you improve the accuracy of the experiment?

References:

[1] Paule G. Hewitt, Conceptual Physics. Prentice Hall, Upper Saddle River, NJ, (2002).
[2] K. Appel, J. Gastineau, C. Bakken, D. Vernier, Physics with Computers. Vernier Software & Technology, Beaverton, Oregon, 3rd Ed., (2003).