PHYSICS 4AL

EXPERIMENT 4: MOMENTUM AND IMPULSE

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Date of Lab: May 9th, 2017
Lab Section: Tuesday, 5 P.M.
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Contents

DISCUSSION

Measured Values

The mass of the glider used in the experiment was 203 ± 0.5 g. The length of the flag 38 ± 0.5 mm.

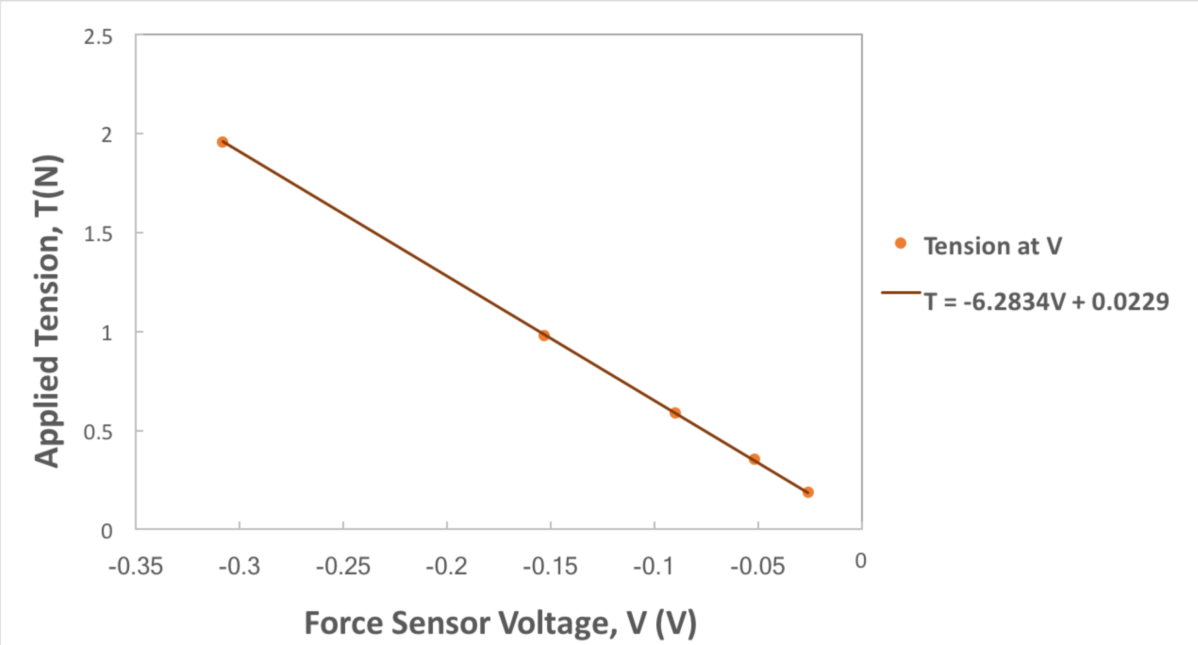

Figure 4.1 Voltage due to applied Tension. The best fit line has the equation $T = (-6.283 \pm 0.004)V + (0.023 \pm 0.002)$. The slope of the best fit line is the calibration constant: -6.283 ± 0.004 N/V.

Trial	Initial Velocity (m/s)	Final Velocity (m/s)
1	-0.1779 ± 0.0005	0.0821 ± 0.0005
2	-0.1415 ± 0.0005	0.0774 ± 0.0005

Table 4.1 Initial and final velocities recorded by the photogate for two trials. Velocity heading towards the force sensor was considered negative, and velocity directed away was positive.

Impulse Calculation - Method 1

Momentum, given by P, is the product of mass m and velocity v, or $P = mv$. The change in momentum is known as impulse, or $\Delta P = P_f - P_i = m(v_f - v_i)$. Using this formula, the velocities given in **Table 4.1**, and the mass of the glider, for Trial one, the impulse $\Delta P_1 = 0.0528 \pm 0.0005$ kg·m/s. For Trial two, the impulse $\Delta P_2 = 0.0408 \pm 0.0005$ kg·m/s.

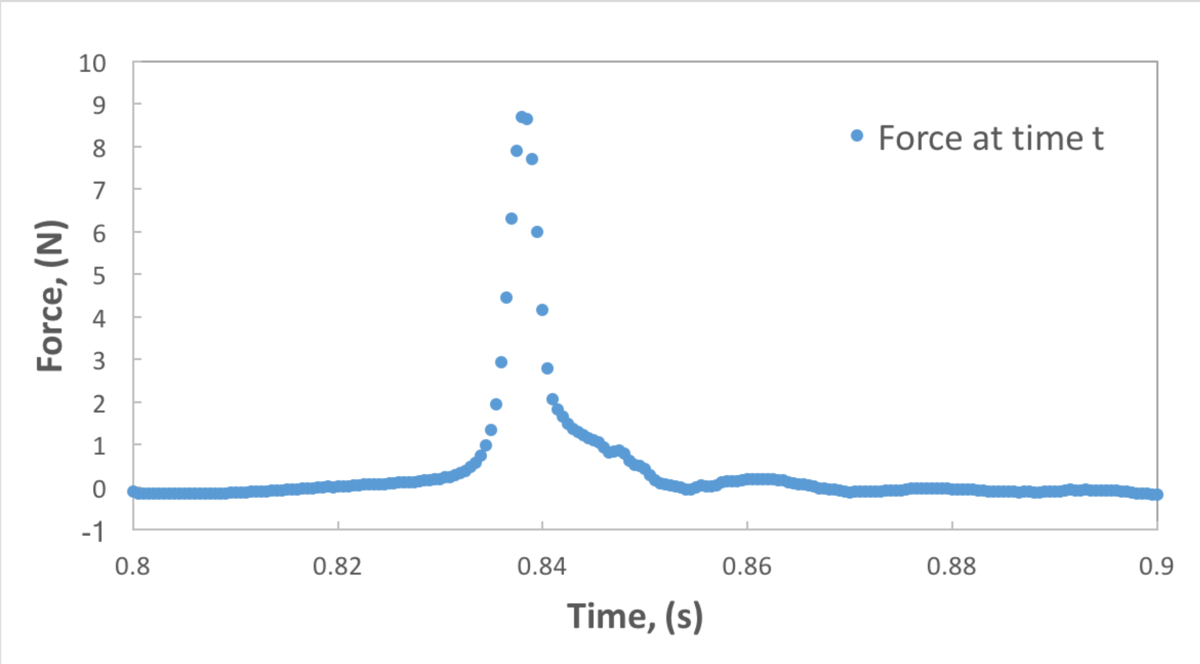

Figure 4.2 Trial 1 of force of moving glider against time. This glider moved at a faster velocity than Trial 2. The data points represent the force sensor readings in Newtons at a specific time interval, before and after the collision with the force sensor represented by the peak in data. The area under the curve of the peak represents the impulse of the collision.

Impulse Calculation - Method 2

Impulse can also be known as the force F over time interval t. This can be put into the form $\Delta P = \int_{t_i}^{t_f} F(t)dt$. We can approximate this impulse using Riemann sums, or $\Delta P \approx \Delta t \sum_{i=1}^{n} \bar{F}(t_i)$, where Δt is the time interval between each data point, and $\bar{F}(t_i)$ is the average force between t_i and t_{i+1}. For our numerical integration, Δt was 0.0005 s, and $\bar{F}(t_i) = \frac{F(t_i)+F(t_{i+1})}{2}$.

To obtain our impulse calculations, we multipled the voltage read by the force sensor by our calibration coefficient found previously in **Figure 4.1**, then subtracted the average background noise of the force sensor. To calculate our numerical integration, we needed to Find the range where the force detected went above zero on both **Figures 4.2** and **4.3** (to signify the cart hitting the force sensor). We the calculated the area under the curve with the formula involving Riemann sums derived previously. For Trial 1, $\Delta P_1 = 0.04509 \pm 0.00003$ kg·m/s, and for Trial 2, $\Delta P_2 = 0.03701 \pm 0.00002$ kg·m/s. The fractional uncertainty for the impulse is the same as the fractional uncertainty of the coefficient calibration.

Trial	Impulse (Method 1 Change in Momentum) (kg·m/s)	Impulse (Riemann Sums) (kg·m/s)
1	0.0528 ± 0.0005	0.04509 ± 0.00003
2	0.0408 ± 0.0005	0.03701 ± 0.00002

Table 4.2 Results for both trials and methods of impulse calculation.

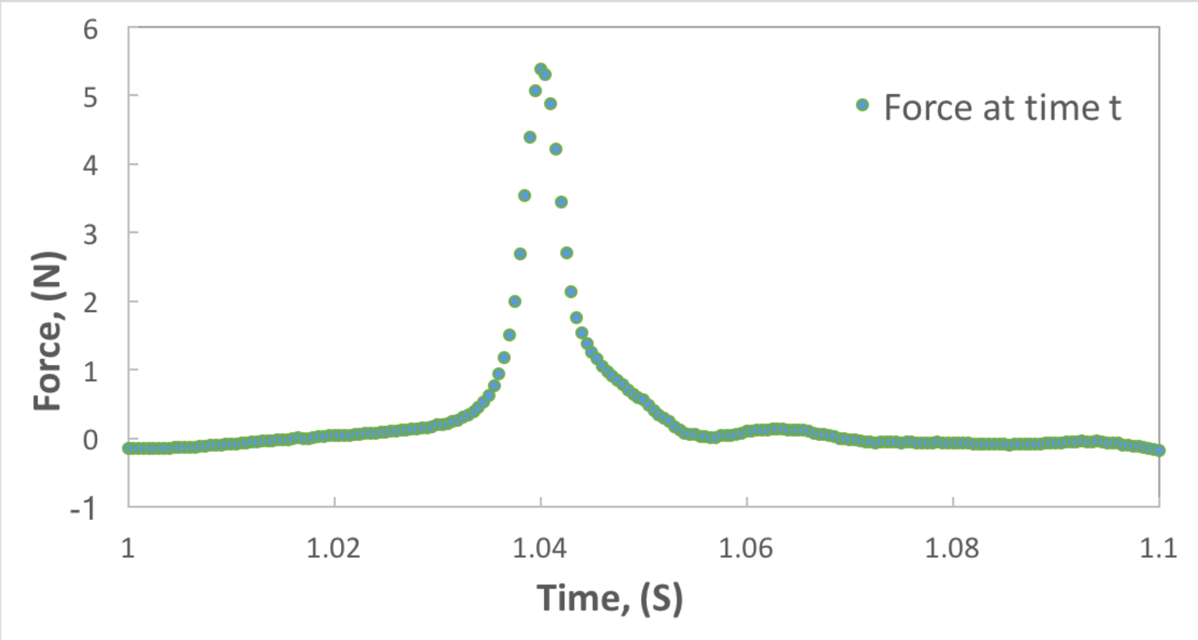

Figure 4.3 Trial 2 of force of moving glider against time. This glider moved at a slower velocity compared to Trial 1. The data points represent the force sensor readings in Newtons at a specific time interval, before and after the collision with the force sensor represented by the peak in data. The area under the curve of the peak represeents the impulse of the collision.

We can see that calculating the impulse in different ways yields slightly different results. We can attribute this error to the "ringing" of the force sensor after it was struck by the cart, which would cause error in the Reimann sum calculation since impulse is still being exerted after it dipped back down to zero.

Extra Credit

Presentation

Introduction

Our experiment sought to prove that while energy is lost in collisions due to friction, change in momentum, or impulse, is constant. Impulse is defined to be the amount of force acting over a certain time period. Because impulse is also the change in an object's momentum, we can also measure it that way. If both these ways of calculating impulse were equal, then we would have proved that impulse is constant during a collision. A glider with a flag on top was set up on an air track with a force sensor at the end of a track and a photogate to track the flag's movement. The collision with the force sensor was monitored with the photogate, and the velocities obtained by the photogate allowed us to calculate impulse by change in momentum. Force over time was measured with the force sensor, and impulse was calculated by summing the force in the time interval of the collision. The two values obtained were compared to verify that the results were close but outside the margin of error.

Methods