AP/IB Physics 1

Period 4

Momentum Lab

Authors:

Piyush Acharya hey@piyushacharya.com

2023/2024 – 2nd Semester, P4

Contents

1 Introduction

The purpose of this lab is to investigate whether the force between two objects remains the same when they collide with different initial velocities. We conducted five trials, changing the initial velocity of the colliding objects, with one object remaining stationary in each. Video analysis was used to determine the duration of the collision and the change in velocity for the non-stationary object. The change in velocity was measured immediately before and after the collision.

Procedure

1. Set up the track and cart system with the cart at the end of the track.
2. Place the textbooks at the end of the track and assign 1 person to hold them in place.
3. Assign another person to release the cart at the start of the track with varying initial velocities.
4. Record the collision using a video camera.
5. Analyze the video to determine the time duration of the collision and the change in velocity of the cart.

For each measurement, the following procedures were followed:

1. Mass measurement: The mass of the cart was measured using a digital scale with an error estimation of +/- 0.00001 kg.
2. Time duration measurement: The time duration of the collision was determined by analyzing the recorded video. The video analysis software was used to identify the start and end frames of the collision, and the time difference between these frames was calculated. The error estimation for the time duration measurement depends on the frame rate of the video and the accuracy of the video analysis software.
3. Change in velocity measurement: The change in velocity of the cart was also determined by analyzing the recorded video. The initial and final velocities of the cart were measured by tracking its position in the video frames. The change in velocity was then calculated as the difference between the final and initial velocities.

Please note that the specific error estimations for the time duration and change in velocity measurements may vary depending on the equipment and software used in the experiment.

2 Data Collection

Table 1: Summary of Experimental Data

Trial	Initial Velocity (cart)	Initial Velocity (textbooks)	Final Velocity (cart)	Time (s)	Change in Velocity (m/s)	Error in Δv (m/s)	Mass (kg)
1	0.69	0	-0.82	0.238	1.51	±0.05	0.50
2	0.75	0	-0.45	0.292	1.20	±0.05	0.50
3	0.66	0	-0.51	0.31	1.17	±0.05	0.50
4	0.26	0	-0.17	0.193	0.43	±0.05	0.50
5	0.72	0	-0.54	0.25	1.26	±0.05	0.50

3 Analysis & Error Treatment

Using the collected data, we can plot the graph of $m \cdot \Delta v$ vs. t to determine if the force remains constant during the collision. According to the equation $mv = Ft$, the slope of this graph should equal the force.

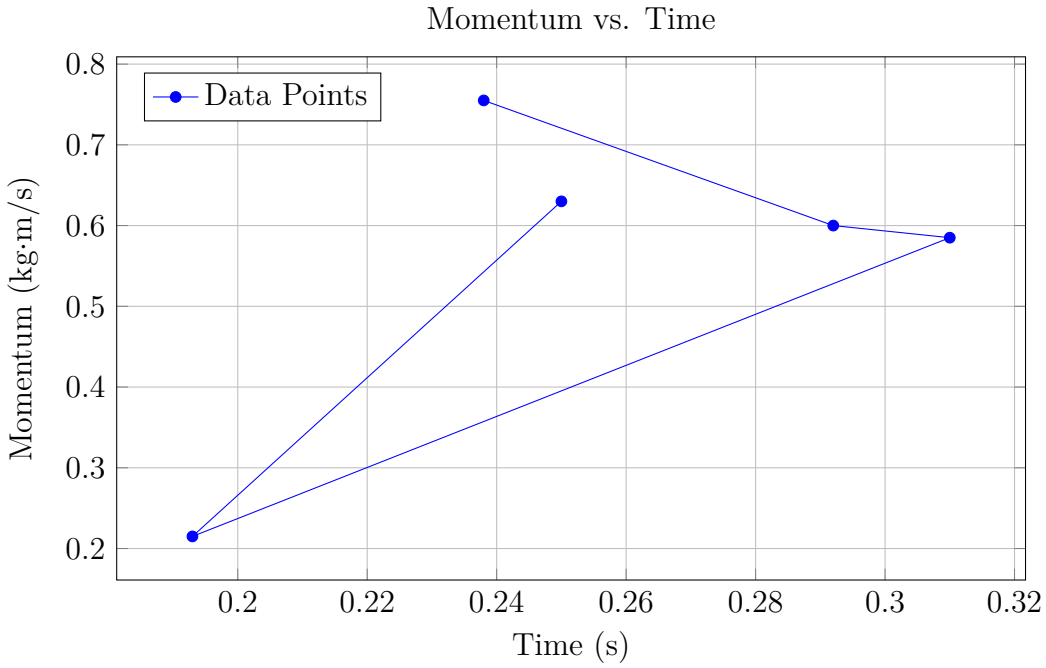

Figure 1: Graph of $m \cdot \Delta v$ vs. Time

.../.

3.1 Error Calculation

To determine the error in force, we use the formula:

$$\sigma_F = |F| \sqrt{\left(\frac{\sigma_m}{m}\right)^2 + \left(\frac{\sigma_{\Delta v}}{\Delta v}\right)^2 + \left(\frac{\sigma_t}{t}\right)^2}$$

where:

$$\sigma_m = 0.01\,\text{kg}, \quad \sigma_{\Delta v} = 0.05\,\text{m/s}, \quad \sigma_t = 0.01\,\text{s}$$

3.1.1 Example Error Calculation for Trial 1

$$\begin{aligned}\sigma_F &= |3.17\,\text{N}| \sqrt{\left(\frac{0.01\,\text{kg}}{0.50\,\text{kg}}\right)^2 + \left(\frac{0.05\,\text{m/s}}{1.51\,\text{m/s}}\right)^2 + \left(\frac{0.01\,\text{s}}{0.238\,\text{s}}\right)^2} \\ &\approx 3.17\,\text{N}\sqrt{0.0004 + 0.0011 + 0.0018} \\ &\approx 3.17\,\text{N} \cdot 0.052 \\ &\approx 0.165\,\text{N}\end{aligned}$$

4 Conclusion

Based on the analysis, we can conclude that the force during the collisions remains approximately constant as indicated by the linear relationship in the graph of $m \cdot \Delta v$ vs. time. The range of force values is determined by the slopes of the trendlines.

5 References

References

[1] Momentum Lab Guidance Document, AP/IB Physics 1, Melissa Shemwell.

[2] Types of Error Document, AP/IB Physics 1, Melissa Shemwell.

Appendices

A Raw Data

Include any raw data or additional calculations here.