Constantine Theocharis

Physics DP1

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IA: How Different Starting Heights Affect a Ping Pong Ball's Time Taken to Roll Down a Ramp

Research question: How do different starting heights affect a ping pong ball's time taken to roll down a ramp?

This IA aims to compare how different starting heights affect a ping pong ball's time taken to roll down a ramp. The purpose is to derrive the average velocity of the ball from all the trials and come to a conclusion as to whether the velocity between starting heights remains the same. The independent variable of this investigation is the starting height of the ping pong ball and the dependent variable is the time taken to roll down the ramp.

One of the controlled variables in the experiment was the location of release of the ping pong ball relative to distance markings. This was to ensure that the distance travelled didn't vary beyond the set distance increments. Also, the angle between ramp and the table was kept the same in order to ensure that gravity has the same effect on the ping pong balls between trials.

Apparatus

- Metal ramp: 1.47 m long, 3.75 cm wide, 14° to the table.
- Light-gates & data-logging software.
- 3 retort stands
- 3 boss clamps
- Meter ruler
- Pencil
- Ping pong ball

Method

1. All the apparatus was collected.
2. The retort stands, boss clamps, light-gates and metal ramp were set up as shown in figure 1
3. A mark was drawn on the side of the ramp every 10 cm.
4. The first light-gate was moved to the bottom of the ramp and the second to the top.
5. The ball was rolled from the top to test that the light-gates were functional.
6. The data-logging software was initiated.
7. The first light-gate was moved to the 10 cm mark.
8. The ball was rolled from the top five times.
9. The first light-gate was moved down 10 cm.
10. Steps 8-9 were repeated eight more times until the first light-gate reached the 90 cm mark.
11. The data was recorded in a table

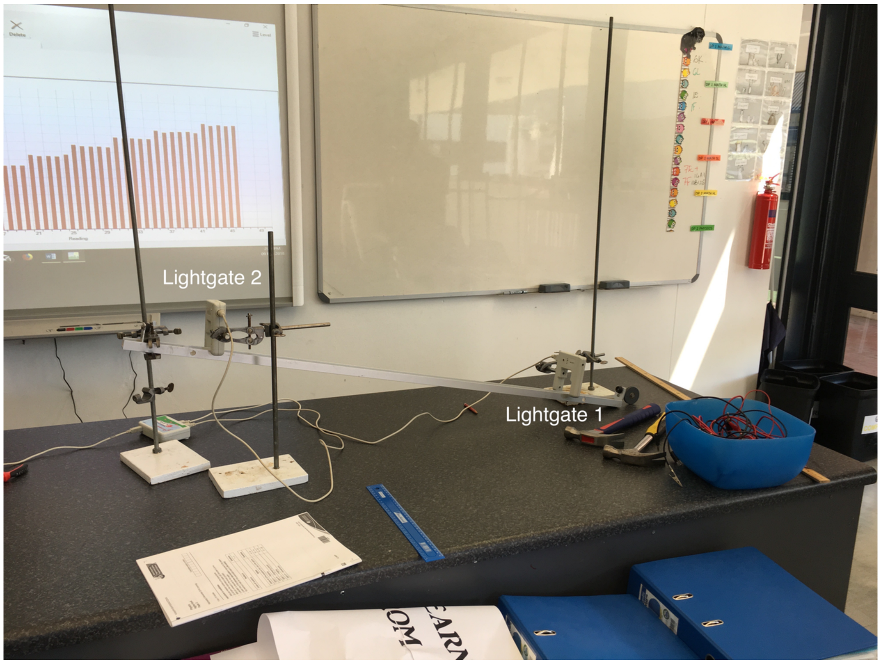

Figure 1: The setup of the experiment. (Lightgates, retort stands and ramp shown)

Results & Analysis

Table 1 displays the raw data collected from the experiment.

Distance (m) [±0.001]	**Time reading 1 (s) [±0.001]**	**Time reading 2 (s) [±0.001]**	**Time reading 3 (s) [±0.001]**	**Time reading 4 (s) [±0.001]**	**Time reading 5 (s) [±0.001]**
0.100	0.250	0.250	0.256	0.252	0.254
0.200	0.437	0.435	0.437	0.440	0.434
0.300	0.596	0.587	0.583	0.588	0.587
0.400	0.731	0.731	0.725	0.726	0.729
0.500	0.849	0.839	0.843	0.837	0.861
0.600	0.973	0.964	0.960	0.963	0.955
0.700	1.073	1.061	1.069	1.064	1.065
0.800	1.168	1.148	1.162	1.163	1.167
0.900	1.271	1.250	1.263	1.255	1.263

Table 1: Raw data collected from the experiment. The distance travelled is on the first column and time taken for each reading is shown in the other five.

Table 2 displays the processed data with error values.

Distance (m) [± 0.001]	**Average time (s)**	**Average time error ($\pm$ s)**
0.100	0.252	0.003
0.200	0.437	0.003
0.300	0.588	0.007
0.400	0.728	0.003
0.500	0.846	0.012
0.600	0.963	0.009
0.700	1.066	0.006
0.800	1.162	0.010
0.900	1.260	0.011

Table 2: Processed data. An average time of each distance was calculated, as well as an error value.

Calculation of average time

$\frac{\sum_{i=1}^{n} R_i}{n}$, where n is the number of readings and R_i is the ith reading.

For example, for the distance of 0.3 m,

$\frac{0.596+0.587+0.583+0.588+0.587}{5} \approx 0.588\,\mathrm{s}$

Calculation of average time error

$\frac{\max(R)-\min(R)}{2}$, where R is the set of readings.

For example, for the distance of 0.5 m,

$\frac{0.861-0.837}{2} = 0.012\,\mathrm{s}$

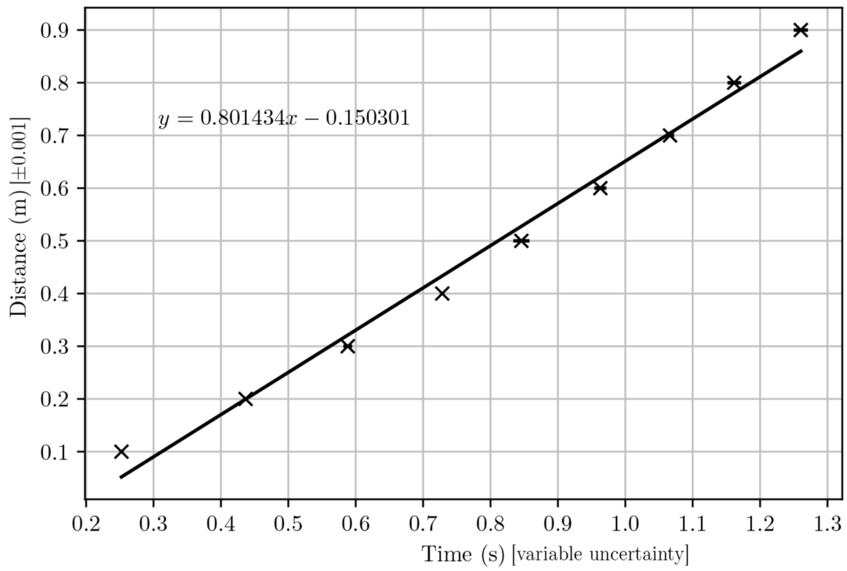

Figure 2: Plot of distance travelled against time taken. Its purpose is to visualise how velocity changes as distance changes by looking at its slope.

The figure above is a plot of the processed data. It shows that the two quantities have some correlation. The best fit line has a y-intercept of -0.15031, which shows that there is almost a direct proportion between the two variables. However, it doesn't go through all of the points' error bars and therefore shows that the pattern is not linear. This suggests that the velocity wasn't constant between trials and there could have been some external factor like gravity or some other phenomenon which introduced acceleration. Max and min lines were not included here due to the lack of linearity.

Evaluation and Conclusion

Upon reflection and evaluation, the use of lightgates was a huge advantage to this experiment. It let us make very precise measurements of the times (to the nearest milisecond). Also, it decreased the amount of tedious work we had to do as the lightgate software recorded everything on a graph and then we could export it to excel. This saved a lot of time and eliminated any human errors that could have been present it we had done it manually. The conservation of time also allowed us to make more measurements and further eliminated random errors.

However, there was room for improvement. First of all, we could have created some sort of releasing mechanism to ensure that the balls didn't have any initial velocity. Furthermore, we could have ensured that the light gates were set up perpendicular to the ramp to ensure precise measurement.

In conclusion, the two variables are correlated, but not linearly. The fact that the accuracy of our measurements was high suggests that the result is valid and an external factor like drag, friction or gravitational acceleration affected the proportionality of the variables.