Emmanuel Demard

Esteban Perez

Miguel Fernandez

Sophia Toney

U2 Cart Lab

Purpose:

The purpose of this experiment is to determine the graphical and mathematical relationship between position, velocity, and acceleration vs time.

Apparatus:

Procedure:

1. Place the Vernier track on a flat table and elevate one end using a cardboard box to create a consistent incline.
2. Connect the motion sensor to the Graphical Analysis app and calibrate the system.
3. Position the cart at the top of the track with its rear end aligned at 0 cm.
4. Release the cart without applying force, allowing it to accelerate freely down the incline.
5. Record position and velocity data using the motion sensor at a sampling rate of 2.35 samples per second.
6. Trim the raw data to exclude the initial offset and select representative data points starting at t=0.
7. Generate graphs for:

- Position vs Time
- Position vs Time Squared (for linearization)
- Velocity vs Time

8. Apply regression analysis to extract mathematical models from the graphs.

Data:

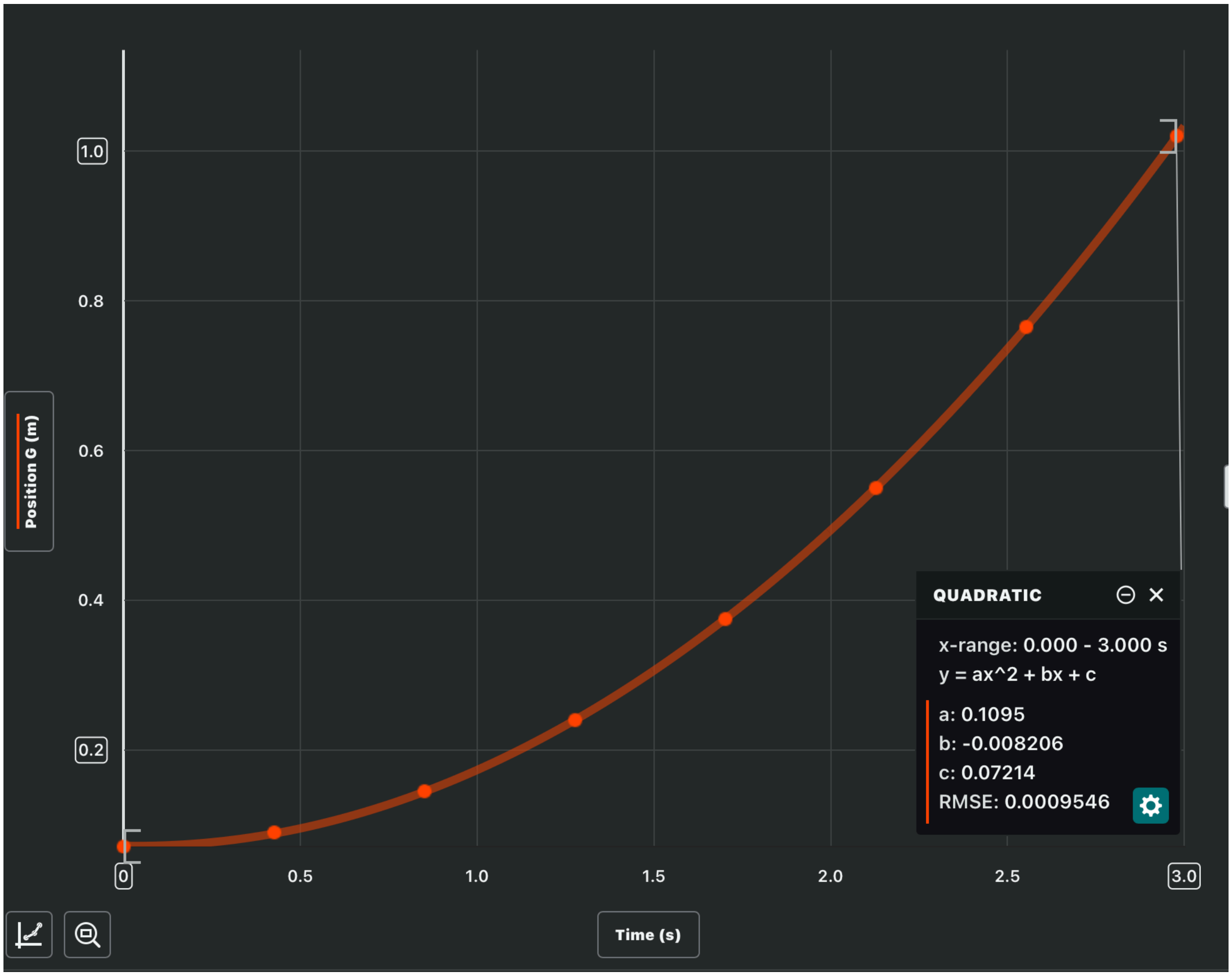
	Data Set 1			
	Time (s)	Position G (m)	Time^2 (s^2)	Velocity (m/s)
1	0.000	0.071	0.000	0.073
2	0.426	0.090	0.181	0.117
3	0.851	0.145	0.724	0.185
4	1.277	0.240	1.631	0.271
5	1.702	0.375	2.897	0.364
6	2.128	0.550	4.528	0.450
7	2.553	0.765	6.518	0.521
8	2.979	1.020	8.874	0.568

Analysis:

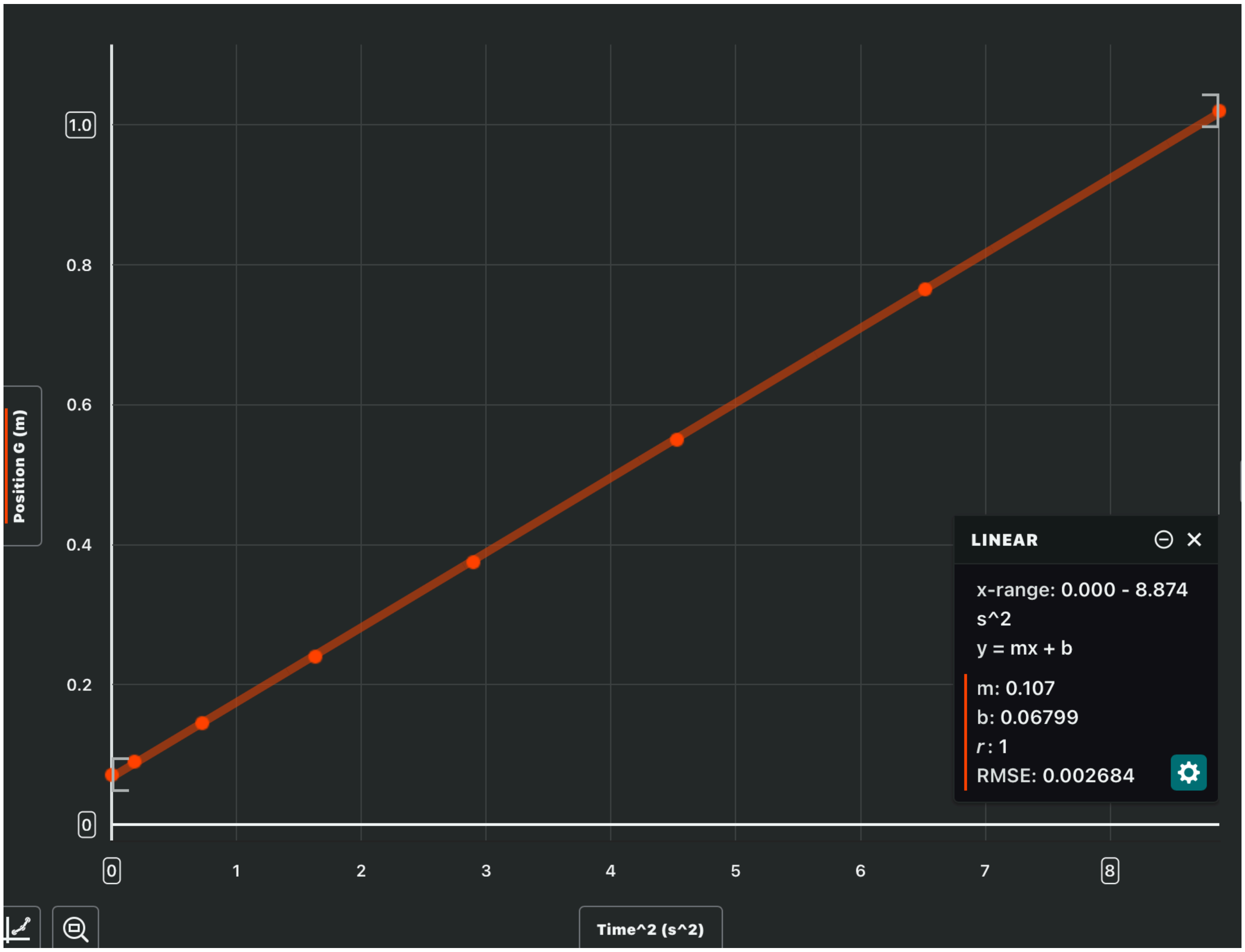
For the data we collected during this experiment, we had to exclude the last 4 data points since all of those points were measured after the cart had already hit the end point. Some data points may be subject for error due to Vernier Analysis's computing system.

Sample Calculations:

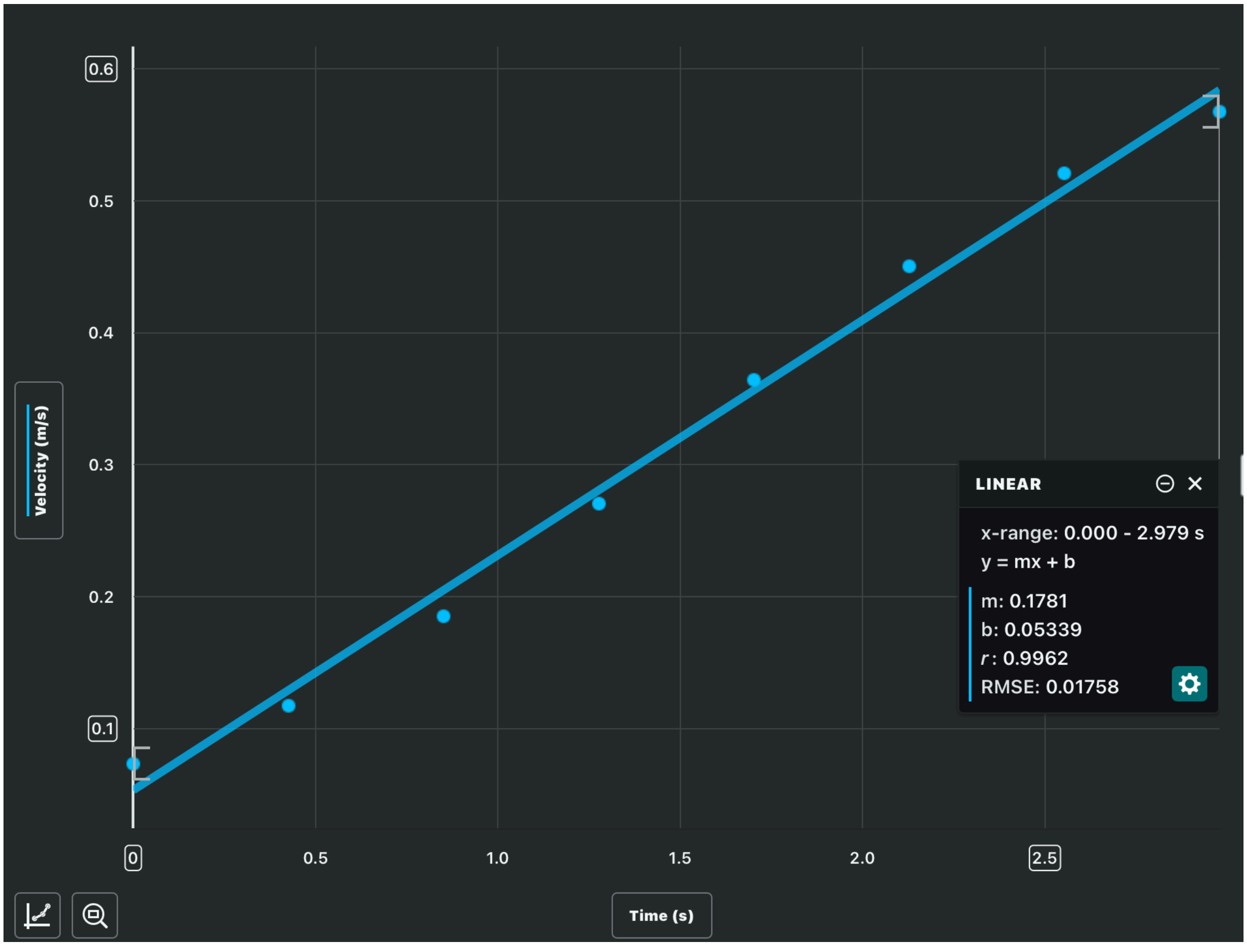
- $0.426\ s\ (0.426\ s) = 0.181\ s^2$
- $0.145\ m / 0.851\ s \approx 0.17\ m/s$



x(t)=(0.1095m/s^2)t^2 - (0.008206m/s)t+(0.0721m)



x(t^2)= (0.107 m/s^2) t^2+(0.06799m)



v(t)= (0.1781 m/s^2) t +(0.05339m/s)

Conclusion:

The first position vs. time graph had a clear quadratic curve, and therefore the cart's motion was uniformly accelerated on the slope. To obtain the equation of relationship mathematically, we performed regression on the raw position-time data and obtained the equation x(t)=0.1095t2−0.0082t+0.0721, in which the coefficient of t2 is the acceleration and the constant term is the initial position. To linearize the data, we plotted position against time squared, and obtained a linear line with the expression x(t2)=0.107t2+0.0680. This confirmed the parabolic nature of the original plot, but also indicated a deficiency: even though the linearized plot is more convenient to curve fit, it hides the time-dependent nature of acceleration and cannot readily show instantaneous velocity. Velocity was calculated from the change in position over change in time between consecutive data points, e.g., from 1.277 m to 0.851 m for a change in time of 0.724 s, thus a velocity of approximately 0.271 m/s. The plot of velocity vs. time was linear, given by $v(t)=0.1781t+0.0534$, showing that the cart's velocity increased at a constant rate with time. Here, the slope is the cart's acceleration (0.1781 m/s^2) and the intercept is its starting velocity (0.0534 m/s). These values are directly applied to the position vs. time squared graph, the slope of which is half the acceleration and the intercept of which is initial displacement. From all three graphs, we confirmed that the motion of the cart was explained by the equation x(t)=12at2+v0t+x0, where a=0.1781 m/s2, v0=0.0534 m/s, and x0=0.0721 m. Error sources were lag in the sensor, inconsistent cart release, and small amount of friction on the track. For improved precision, future trials can utilize a smoother slope, even release technique, and increase the sampling rate to have greater resolution.