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Claim-Evidence-Reasoning

Question: *Does the* ***battery operated car*** *move at constant speed or does it accelerate? If it moves at constant speed, what is its speed? If it accelerates, what is its acceleration?*

Claim

The battery operated car moves at a constant speed, with no acceleration.

Evidence

In this data collection, 3 trials were conducted for each of the different distances measured. A total of 3 distances were used and they were: 0.5 m, 1 m, and 2 m. However, because the length of the car also was included in these distances, to get the total displacement and distance travelled by the car, the car's length was subtracted from the distances of 2 m, 1 m, and 0.5 m. Below is the data table, before the averages of all of the times was taken.

Experiment 1			Experiment 2			Experiment 3		
Trial #	t (s)	Δx (m)	Trial #	t (s)	Δx (m)	Trial #	t (s)	Δx (m)
1	4.51	2	1	2.23	1	1	1.07	0.5
2	4.26	2	2	2.15	1	2	1.27	0.5
3	4.64	2	3	2.00	1	3	1.18	0.5
time:	**4.47**			**2.13**			**1.17**	

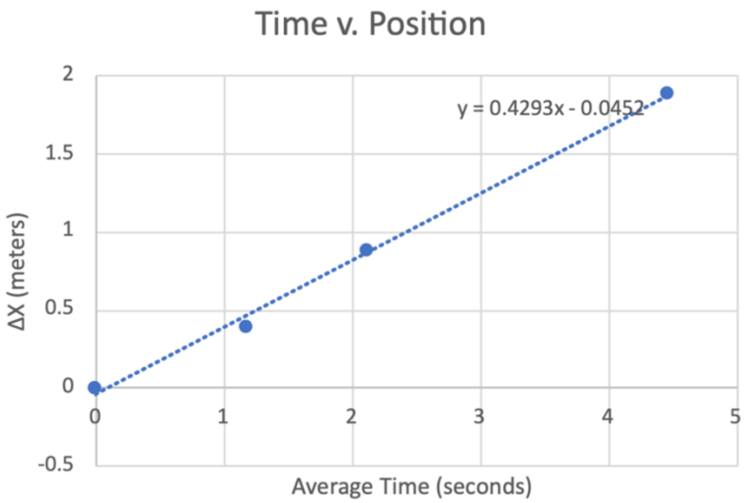
Below, is the data table with all of the averaged data.

Averaged Data			
Distance (m)	Car Length (m)	Average T (s	Δx (m)
2	0.115	4.47	1.885
1	0.115	2.13	0.885
0.5	0.115	1.17	0.385
0	0.115	0	0

Using this, a position versus time graph was created, and used to answer the reasoning.

Reasoning

Using the position vs time graph displayed below, it could be visually seen that the relationship between the displacement of the car (or the position because the car was travelling only in the positive direction) and time was a linear relationship. Using knowledge learned in class, the slope of this line would be the velocity of the car, and since the graph is a line, this means that the velocity is constant. If the velocity is constant and never changes, the acceleration must be 0 because the car's velocity is not changing meaning it is not accelerating at all.



An equation could also be used to find the velocity at any of the given points, and the equation that makes the most sense would be the *Δx= V *t*. This equation is being used instead of other ones, because we know from the graph the velocity is constant, meaning there is no acceleration and using an equation is another way to check the velocity is similar to the slope of the line. Additionally, Δx is represented by y (position) in the equation for the line of best fit, and t (time) is represented by x. The point chosen to check the automatic equation given by Excel would be the point where Δx= 1.885 and the time equals 4.47 seconds. The initial velocity is 0 m/s because the car was at rest when it started when the time was equal to 0 seconds. However, the reason this line y=0.4293x-0.0452 does not seem to go through the origin (even though the data includes a point at the origin) is because it is a line of best fit, not exactly the line that would perfectly model this relationship, and also there is a y-intercept because of the fact the timings and stopwatch was not 100% accurate due to some human error (because my partner and I could not accurately stop the stopwatch without some error since there may have been reaction time). So, this reaction time may be counted for with the -0.0452 part of the model equation/ line of best fit.

That being said, plugging in the points into the equation, we get 1.885 m=*V** 4.47 seconds. This evaluates to *V* being 0.4217 m/s. This is extremely close to the slope of the line of best fit, so we can say that the constant speed of the car is approximately 0.429 m/s.

Once again, since the velocity is constant, the acceleration is 0 and the car moves with a constant velocity of 0.429 m/s, with no acceleration.

Claim-Evidence-Reasoning

***Question**: Does the **cart** move at constant speed or does it accelerate as it travels down the inclined track? If it moves at constant speed, what is its speed? If it accelerates, what is its acceleration?*

Claim

The cart accelerates as it travels down the inclined track with a height of 3 books. This means it does not move with a constant speed, but it does have a constant acceleration.

Evidence

In this data collection, 3 trials were conducted for each of the different distances measured. A total of 3 distances were used and they were: 0.5 m, 1 m, and 2 m. This process was very similar to the data collection process for the battery car, except for the fact the car was on an incline. Similarly to the car, because the length of the cart also was included in these distances, to get the total displacement and distance travelled by the cart, the cart's length was subtracted from the distances of 2 m, 1 m, and 0.5 m. Below is the data table, before the averages of all of the times was taken.

Experiment 1			Experiment 2			Experiment 3		
Trial #	t (s)	Distance (m)	Trial #	t (s)	Δx (m)	Trial #	t (s)	Δx (m)
1	2.28	2	1	1.45	1	1	0.95	0.5
2	2.37	2	2	1.57	1	2	0.90	0.5
3	2.64	2	3	1.50	1	3	1.00	0.5

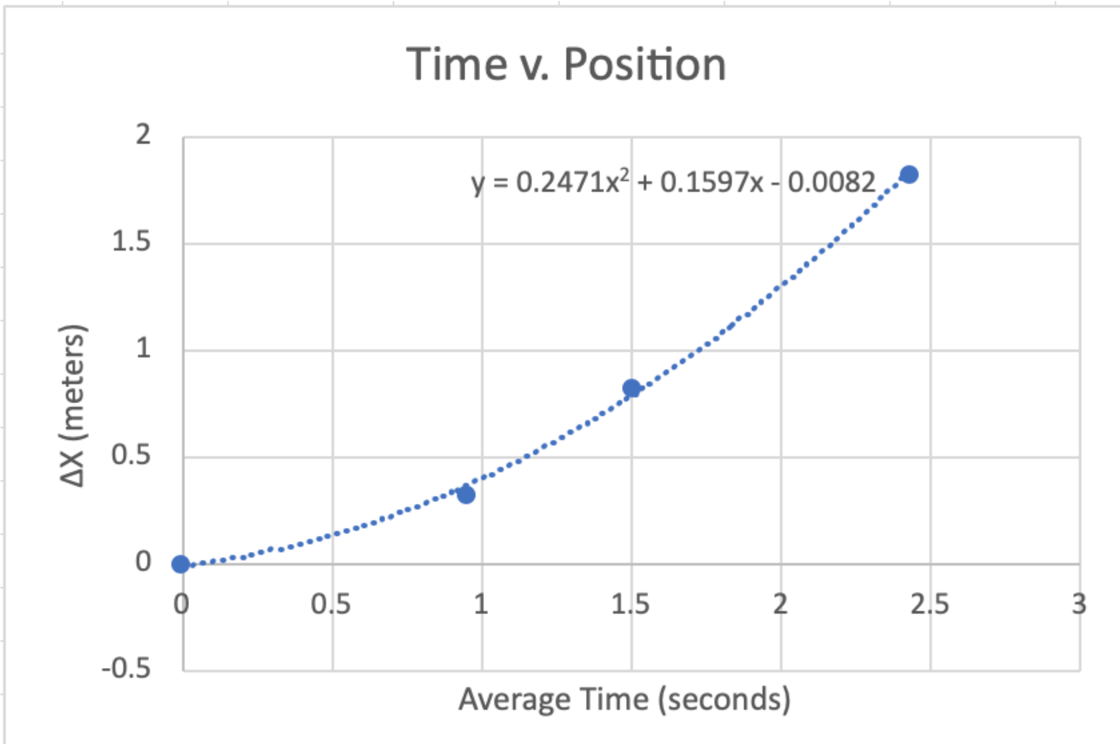
Here is the data table after finding the Δx and taking the average time taken to travel that distance.

Averaged Data			
Total Distance (m	Cart Length (m)	Average T (s)	Δx (m)
2	0.17	2.43	1.83
1	0.17	1.51	0.83
0.5	0.17	0.95	0.33
0	0.17	0	0

Then, using this averaged data table, a position vs time graph was produced again to analyze.

Reasoning

Below is the position vs time graph made using the data table of averaged values, and as seen it is not linear, but more of a curve pointed up. What this means is that the velocity is not changing at a constant rate (because there is no straight line present on the graph) and that some acceleration is present, which is causing a non-constant velocity. Knowing acceleration is present, this curved line can be represented using the kinematic equation $\Delta x = \frac{1}{2} * a * t^2 + V_0 t$. The given equation for the model, uses x and y, but the x is basically synonymous for *t* (time), and y is position, so in this case y is *Δx* because the cart only moves in a positive direction. For the equation, $y = 0.2471x^2 + 0.1597x - 0.0082$, we can substitute all of the analogous parts in. What is meant by this is that, x^2 is equal to t^2 if we just switch what the variables represent. So, $0.2471\ x^2$ is equal to $\frac{1}{2}\ a*t^2$. Solving this and cancelling out the x^2 and t^2 because they are the same thing, we get $0.2471 = \frac{1}{2}$ a. **Then, a is equal to 0.4942 m/ s².**



So, to summarize, the cart traveling down an incline does not have a constant speed because the velocity is always changing as it rolls down the ramp. However, the cart does have a positive, constant acceleration of 0.4942 m/ s².