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 moved at a constant speed of **0.42 m/s**.

Evidence

Our group measured how long it took for the car to go 2.15m down the ramp, and did this for five trials. We then took the average time for those five trials.

	Ramp distance of 2.15m	
	Distance (m)	Time (s)
Car Trial 1	2.15	5.25
Car Trial 2	2.15	5.08
Car Trial 3	2.15	4.92
Car Trial 4	2.15	5.07
Car Trial 5	2.15	4.93
Average	**2.15**	**5.05**

Next, our group measured how long it took for the car to go 1.15m down the ramp, and did this for five trials. We then took the average time for those five trials.

	Ramp distance of 1.15m	
	Distance (m)	Time(s)
Car Trial 1	1.15	2.61
Car Trial 2	1.15	2.78
Car Trial 3	1.15	2.96
Car Trial 4	1.15	2.75
Car Trial 5	1.15	2.67
Average	**1.15**	**2.754**

Finally, our group measured how long it took for the car to go 0.65m down the ramp, and did this for five trials. We then took the average time for those five trials.

	Ramp distance of 0.65m	
	Distance (m)	Time(s)
Car Trial 1	0.65	1.51
Car Trial 2	0.65	1.25
Car Trial 3	0.65	1.69
Car Trial 4	0.65	1.66
Car Trial 5	0.65	1.35
Average	**0.65**	**1.492**

Reasoning

Assuming acceleration is constant, the car's position at time *t* would be:

$$X = X_0 + V_0 t + \frac{1}{2} a t^2$$

Since x_0 is 0m (we start at the beginning), we can write this equation as:

$$X = V_0 t + \frac{1}{2} a t^2$$

From the average time in the first table (ramp distance 2.15m), we know it would take the car (on average) 5.05 seconds to go 2.15 meters. Similarly, from the second table (ramp distance 2.754m) we know that the car takes on average 2.754 seconds to go 1.15 meters. We can plug these times and distances into the equation, which results in a two-variable system of equations:

$$x = V_0 t + \frac{1}{2} a t^2$$

Plugging in $(x,t) = (2.15m, 5.05s) \Rightarrow 2.15 = V_0(5.05) + \frac{1}{2}(a)(5.05)^2$

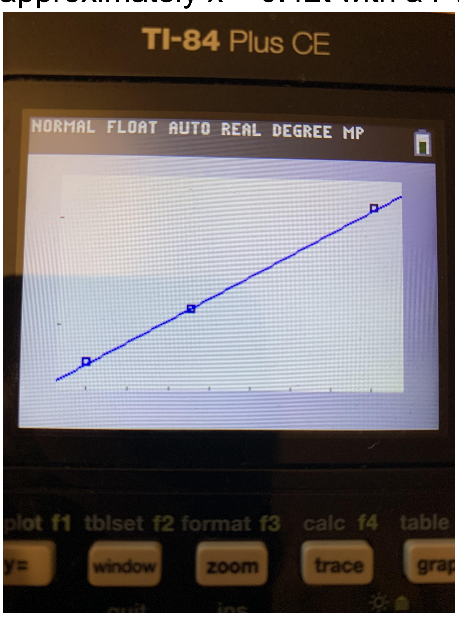
$$5.05 V_0 + 12.75a = 2.15$$

plugging in $(x,t) = (1.15m, 2.754s) \Rightarrow 1.15 = V_0(2.754) + \frac{1}{2}(a)(2.754)^2$

$$2.754 V_0 + 3.79a = 1.15$$

Solving for *a* (using graphing calculator) yields a value of *a* = 0.007. This is very close to 0, and the reason why it's not exactly 0 is because of measurement and rounding errors. This makes sense, since the car was moving on a flat surface so it wouldn't speed up. Therefore, we can assume that *a* = 0, which means that the car **did not accelerate but had a constant velocity**.

Since *a* = 0, the cars position can be linearly modeled by x = v_0 * t. We can estimate this line by finding the line of best fit on the data from the three tables. Using a graphing calculator, we find that the line of best fit on the points (t,x): (5.05s, 2.15m), (2.754s, 1.15m), (1.492s, 0.65m), is approximately x = 0.42t with a r value of 0.9997 (the r value means that the line fits very well):



The slope of this line is 0.42 m/s, which would correspond to v_0 in x = v_0 * t. Since the velocity is constant, the velocity would be approximately **0.42 m/s** throughout.

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 an acceleration of **0.54 m/s^2**.

Evidence

Our group measured how long it took for the cart to go 2.11m down the ramp, and did this for five trials. We then took the average time for those five trials.

	Ramp distance of 2.11m	
	Distance (m)	Time (s)
Cart Trial 1	2.11	2.79
Cart Trial 2	2.11	2.53
Cart Trial 3	2.11	3.19
Cart Trial 4	2.11	2.79
Cart Trial 5	2.11	2.66
Average	**2.11**	**2.792**

Next, our group measured how long it took for the cart to go 1.01m down the ramp, and did this for five trials. We then took the average time for those five trials.

	Ramp distance of 1.01m	
	Distance (m)	Time (s)
Cart Trial 1	1.01	1.71
Cart Trial 2	1.01	1.85
Cart Trial 3	1.01	1.88
Cart Trial 4	1.01	1.92
Cart Trial 5	1.01	1.8
Average	**1.01**	**1.832**

Finally, our group measured how long it took for the cart to go 0.51m down the ramp, and did this for five trials. We then took the average time for those five trials.

	Ramp distance of 0.51m	
	Distance (m)	Time (s)
Cart Trial 1	0.51	1.31
Cart Trial 2	0.51	1.4
Cart Trial 3	0.51	1.47
Cart Trial 4	0.51	1.34
Cart Trial 5	0.51	1.36
Average	**0.51**	**1.376**

Reasoning

Explain why your evidence supports your claim. If appropriate, graph your data and show and explain any calculations you made with your data.

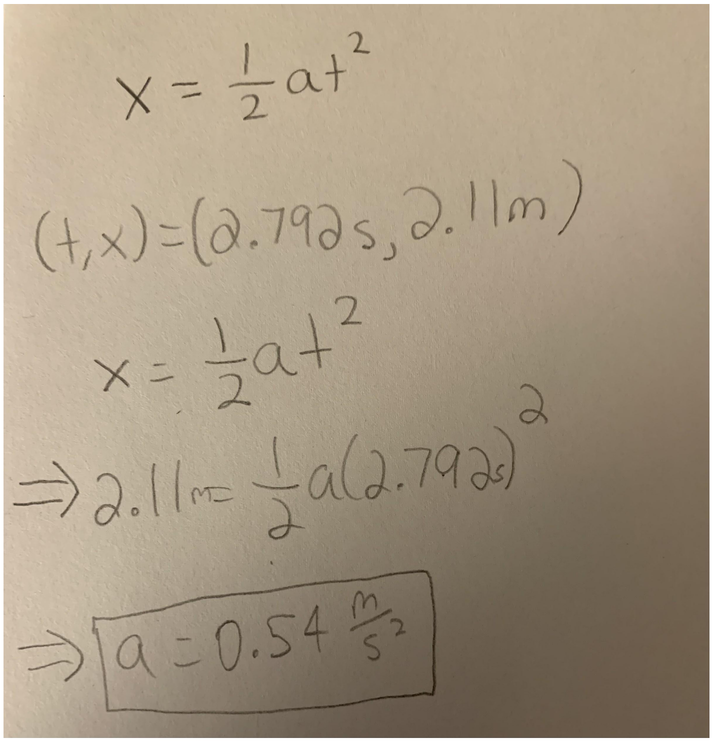
Assuming acceleration is constant, the car's position at time *t* would be:

$$X = X_0 + V_0 t + \frac{1}{2} a t^2$$

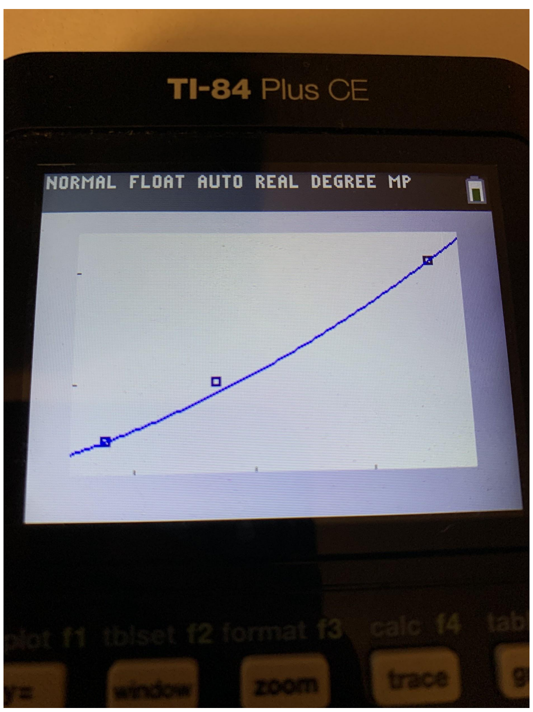
Since x_0 is 0m (we start at the beginning) and v_0 = 0m/s (the cart is not moving when it is released), we can write this equation as:

$$X = \frac{1}{2} a t^2$$

To find *a*, we could plug in the average value of x (distance) and t (time) that we found in our first table (ramp distance 2.11m). Plugging in (t,x) = (2.792s, 2.11m), we can solve for *a*:



To see how accurate this acceleration estimation is, we can plot the graph x = ½(0.54)t^2 alongside the three average time/distance pairs we found in our three tables:



As we can see, the graph for distance in terms of time is consistent with our data when we use *a* as 0.54m/s^2, since the points are very close to the parabola. Since *a* is positive, we can conclude that **the cart was accelerating** as it was moving down the ramp (if it was at a constant speed we would've calculated *a* to be 0). Furthermore, the cart was accelerating at a rate of approximately **0.54 m/s^2**.