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

There are two conditions for the battery-powered car: when the battery is off and on. When the battery is off, the car does not move at a constant speed, it accelerates. The acceleration is 0.0882m/s^2. When the battery is on, the car moves at a constant speed of 0.427m/s.

Evidence

A data table of all three vehicle types is shown below, showing how far the vehicle got along the track (m) and the time (s) it took to get there. The car (battery on and off) is highlighted in this table.

Time (s)	Cart Position (m)	Car Position (m) (Battery Off)	Car Position (m) (Battery On)
0	0	0	0
0.4			0.20
0.8			0.40
0.86	0.20		
1.1		0.20	
1.13	0.40		
1.26			0.60
1.42	0.60		
1.61		0.40	
1.7			
1.83	1.00		
1.91			0.80
2.02	1.20		
2.05	1.40		
2.07		0.60	
2.16		0.80	
2.26			1.00
2.35	1.60		
2.46	1.80		

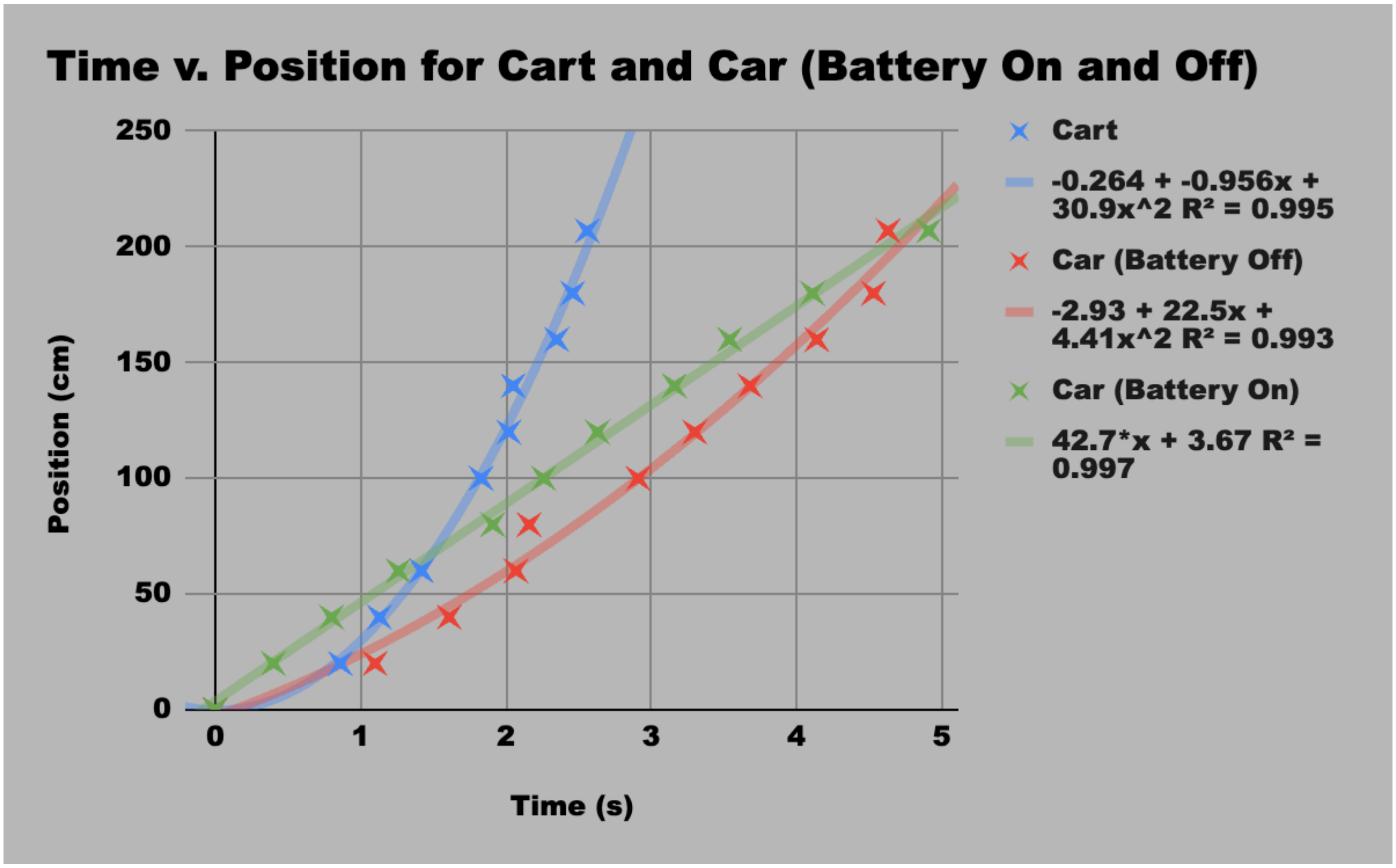
2.56	2.07		
2.63			1.20
2.91		1.00	
3.16			1.40
3.3		1.20	
3.54			1.60
3.68		1.40	
4.11			1.80
4.14		1.60	
4.53		1.80	
4.63		2.07	
4.91			2.07

Reasoning

Focusing on the car only (both battery on and off), when the battery is off, the car reaches the end of the track faster than when it is on. This shows that gravity is accelerating the velocity of the car to be faster than the motor when the car is on. Looking at the car with the battery on, the data entries are spaced evenly apart timewise. This suggests that the acceleration of the car when the battery is on is zero, and that the velocity is constant.

Furthermore, when using the data points for the "big four" equations, it can be found that the acceleration is nearly zero for data points for when the battery on car and substantially larger for when the car battery is off. The "big four" equation I am using here for acceleration is: $y = y_0 + v_0 t + \frac{1}{2}at^2$. When the battery is off, and the last point is substituted in, $2.07 = 0 + 0 \cdot 4.63 + \frac{1}{2}a \cdot 4.63^2$. Solving for a, it can be seen that $a = 0.19m/s^2$. When the battery is on, this number is gets closer to zero ($a = 0.17m/s^2$). When calculating the velocity when the battery is on and using the $v = \frac{\Delta y}{t}$ equation with the last point, velocity can be calculated to be $v = 0.42m/s$.

In the chart below, regression was used to graph the three different vehicles. From the equations given by the regression, the double derivative (using the power rule) of the position vs. time graph when the battery is on proves to be zero (no acceleration). The single derivative (velocity) turns out to be $0.427m/s$. When the double derivative of when the car's battery is off is taken, it turns out to be $0.082m/s^2$. These results from the graph further bolster the accuracy of the data points and the calculated velocities and accelerations from the "big four" equations.



Note: the graph is in cm, not m, for more tangible coefficients and units, it was converted to m afterwards

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. The acceleration is $0.618 m/s^2$.

Evidence

A data table of all three vehicle types is shown below, showing how far the vehicle got along the track (m) and the time (s) it took to get there. The cart is highlighted in this table.

Time (s)	Cart Position (m)	Car Position (m) (Battery Off)	Car Position (m) (Battery On)
0	0	0	0

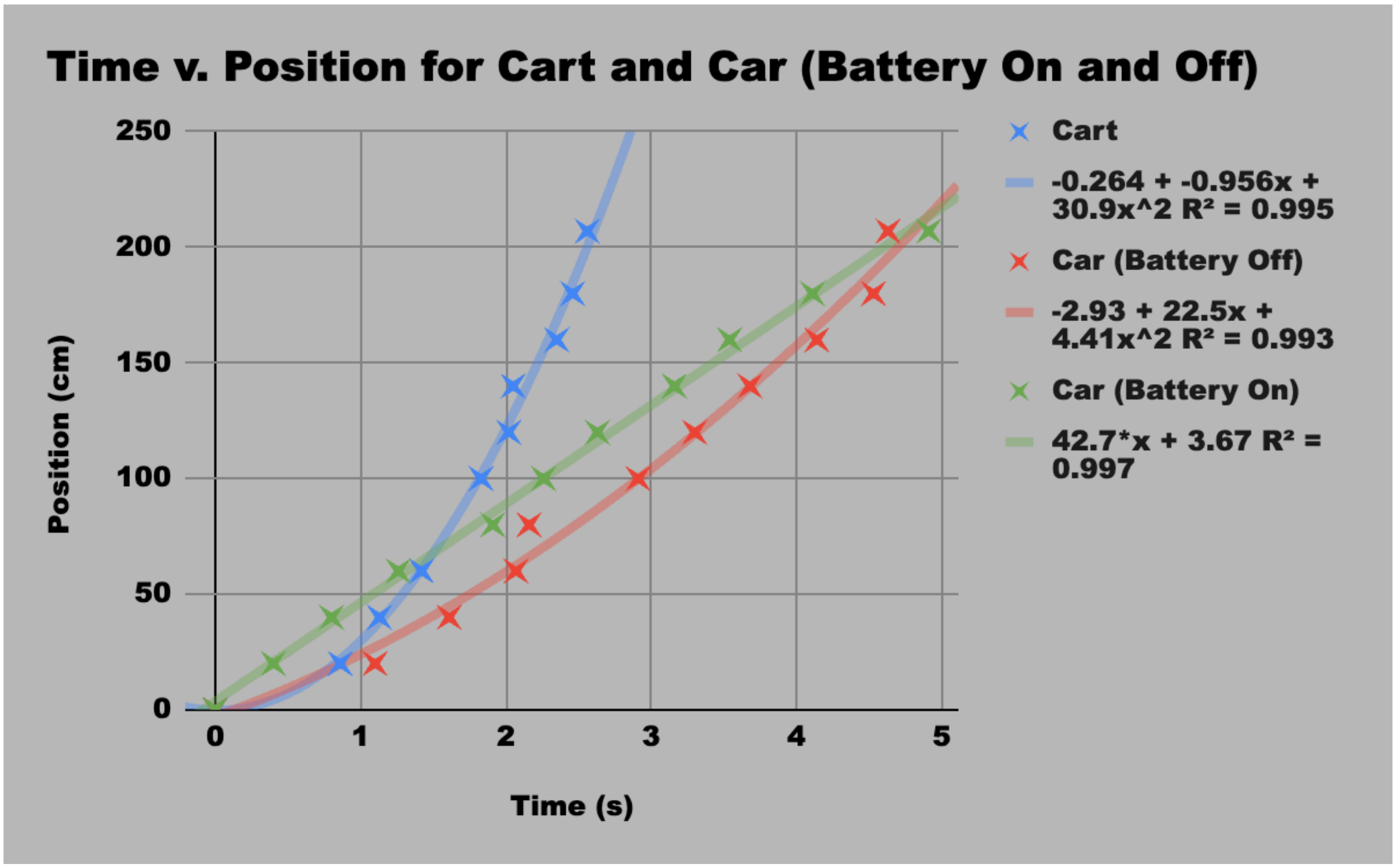
0.4			0.20
0.8			0.40
0.86	0.20		
1.1		0.20	
1.13	0.40		
1.26			0.60
1.42	0.60		
1.61		0.40	
1.7			
1.83	1.00		
1.91			0.80
2.02	1.20		
2.05	1.40		
2.07		0.60	
2.16		0.80	
2.26			1.00
2.35	1.60		
2.46	1.80		
2.56	2.07		
2.63			1.20
2.91		1.00	
3.16			1.40
3.3		1.20	
3.54			1.60
3.68		1.40	
4.11			1.80
4.14		1.60	
4.53		1.80	
4.63		2.07	
4.91			2.07

Reasoning

Focusing on the cart only, the data entries are spaced closer and closer together as time increases. This suggests that the velocity of the cart is increasing, meaning that the acceleration is not zero.

Furthermore, when using the data points for the “big four” equations, the acceleration of the cart can be found. The “big four” equation I am using here for acceleration is: $y = y_0 + v_0 t + \frac{1}{2}at^2$. When the last point is substituted in the equation becomes, $2.07 = 0 + 0 \cdot 2.56 + \frac{1}{2}a \cdot 2.56^2$. Solving for a, it can be seen that $a = 0.63 m/s^2$.

In the chart below, regression was used to graph the three different vehicles. From the equations given by the regression, the double derivative (using the power rule) of the position vs. time graph (of the cart) proves to be $0.618 m/s^2$. These results from the graph further bolster the accuracy of the data points and the calculated velocities and accelerations from the “big four” equations.



Note: the graph is in cm, not m, for more tangible coefficients and units, it was converted to m afterwards