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

Write a statement you believe to be true that fully responds to the question.

The battery-operated car moves at a constant speed. The car's speed is 0.410 m/s.

Evidence

Provide enough relevant data to support your claim. Data may include numbers or observations. It should be clear to someone else what the data represents. Organize with tables when appropriate and be sure to label the data including units.

To determine the car's velocity, we let the car run over a flat metal track with length 2.27m. Since the car itself takes up 0.13m, the length of the car's full travel distance is 2.14m. We measured the time it took for the car to travel halfway along the track (1.07m) and the full track (2.14m).

We took 3 trials at each distance and recorded the time the car took (shown below). Trials 1-3 are with track length 1.07m and trials 4-6 are with track length 2.14m.

Trial Number	Time (seconds)	Track length (meters)
1	2.88	1.07
2	2.47	1.07
3	2.54	1.07
4	5.12	2.14
5	5.07	2.14
6	5.35	2.14

Reasoning

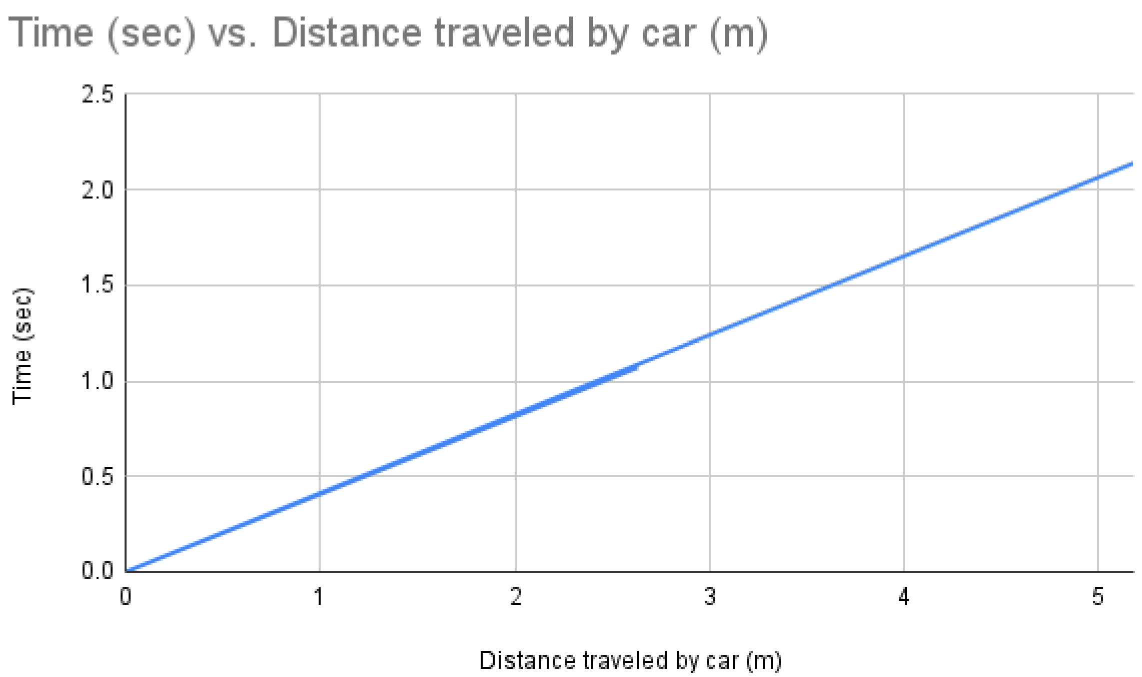
Explain why your evidence supports your claim. If appropriate, graph your data and show and explain any calculations you made with your data.

We averaged the time of trials 1-3, which gave us $\frac{2.88s + 2.47s + 2.54s}{3} \approx 2.63s$. Doing the same for trials 4-6 gives $\frac{5.12s+5.07s+5.35s}{3} = 5.18s$. Dividing the track length by these average velocities gives the velocity for the car traveling halfway and the full journey:

- $v_{halfway} = \frac{1.07m}{2.63s} \approx 0.407\ m/s.$
- $v_{total} = \frac{2.14m}{5.18s} \approx 0.413\ m/s.$

Since the velocity is essentially the same (only a 1.47% percent increase in velocity), there is negligible acceleration. The car is traveling at a constant rate. Averaging out $v_{halfway}$ and v_{total} gives us $v_{overall} = \frac{v_{halfway} + v_{total}}{2} = \frac{0.407\ \frac{m}{s} + 0.413\ \frac{m}{s}}{2} = 0.410 \frac{m}{s}$.

I also graphed the two Position. Vs Time graphs to show that both the travel halfway and the full-length travel have essentially the same slope.



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

Write a statement you believe to be true that fully responds to the question.

The cart had a constant acceleration of 0.51 m/s^2.

Evidence

Provide enough relevant data to support your claim. Data may include numbers or observations. It should be clear to someone else what the data represents. Organize with tables when appropriate and be sure to label the data including units.

We measured how long the cart took to travel different distances down a metal inclined ramp with length 2.27 meters. Since the cart itself is 0.17m long, the maximum travel distance down the ramp is 2.10m. We recorded 5 trials of the time it took for the cart to travel halfway along the track (1.05m) and 5 trials of the time it took for the cart to travel down the full track (2.14m).

Trials 1-5 are at 1.05m and trials 6-10 are at 2.10m.

Trial Number	Time (seconds)	Track length (meters)
1	2.06	1.05
2	1.96	1.05
3	2.02	1.05
4	2.03	1.05
5	2.09	1.05
6	2.81	2.10
7	2.98	2.10
8	2.86	2.10
9	2.88	2.10
10	2.85	2.10

Reasoning

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

Before I go into how the data supports our claim that the cart was accelerating, I'll explain some qualitative data that I used to back up the idea that the cart's accelerating. When we let go of the cart (at t = 0 sec), the cart was at rest and therefore had a speed of 0 m/s. However, when the cart reached the end of the track, a collision occurred and we could see that the cart had a positive velocity. If the velocity goes from 0 to positive during this experiment, it means that there was a positive acceleration because velocity increased.

We averaged the time of trials 1-5, which gave us $\frac{2.06s + 1.96s + 2.02s + 2.03s + 2.09s}{5} \approx 2.03s$. Doing the same for trials 4-6 gives $\frac{2.81s+2.98s+2.86s + 2.88s + 2.85s}{5} \approx 2.88s$.

I will use the equation $\Delta x = v_0 t + \frac{1}{2}at^2$ to find the acceleration from the start to halfway along the track and from the start to the end.

NOTE: We have $v_0 = 0$ from our initial observations and by the setup of the experiment, so if $a = 0$ then Δx must equal 0 but we know it doesn't because the cart moved. So this means that a cannot equal 0, and so the cart accelerated.

Start to halfway acceleration:

$$\Delta x = v_0 t + \frac{1}{2}at^2.$$

$$1.05 = 0\times2.03 + \frac{1}{2}(a)(2.03)^2$$

$$a = \frac{1.05}{\frac{1}{2}(2.03)^2}$$

$$a \approx 0.51 m/s^2.$$

Start to end acceleration:

$$\Delta x = v_0 t + \frac{1}{2}at^2.$$

$$2.10 = 0\times2.88 + \frac{1}{2}(a)(2.88)^2$$

$$a = \frac{1.05}{\frac{1}{2}(2.88)^2}$$

$$a \approx 0.51 m/s^2.$$

Therefore the acceleration of the cart is 0.51 m/s^2.

NOTE: I graphed the motion of the cart and the equation of its position is

$x = 0.249t^2 + 0.111t + - 2.17\times10^{-34}$. So taking the derivative of this would give about 0.48 m/s^2 as acceleration.