Cart Motion Lab
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Purpose

The purpose of this lab is to study the motion, including the position, velocity, and acceleration of a cart of different weights and with different methods of propulsion.

Materials
1 Cart with a fan (With batteries)
1 Cart without a fan
1 Track
1 Ruler
1 Sonic Motion Recorder
1 Laptop with Logger Pro 3 installed.
1 Weight
6 Books (Any kind)
1 3x5 note card
1 Roll of Scotch tape.

Procedure

Step One
Get all of your materials ready. Set up the track for the cart with a fan, and put the motion detector in front of it. Plug in your motion detector, open Logger Pro, and get ready to start recording data with it. Place the cart on the track, and make sure the fan works.

Step Two
Test the cart with the fan first. Run it from one end of the track to the other, while recording the data, without a weight and on high first. After this, run the cart on slow, recording the data. Once you have the results for these, place a weight on the cart and repeat the two tests, on high and low.

Step Three
Get cart without the fan and the track that goes with it. Place two books underneath one end of the track so that it is a slight incline. Put the motion detector at one end of the track so that it can record the motion of the card.

Step Four
Put the cart at the high end of the track and let it go while you record its motion data.

Step Five
Place another 4 books underneath the higher end of the track so it is more of an incline.

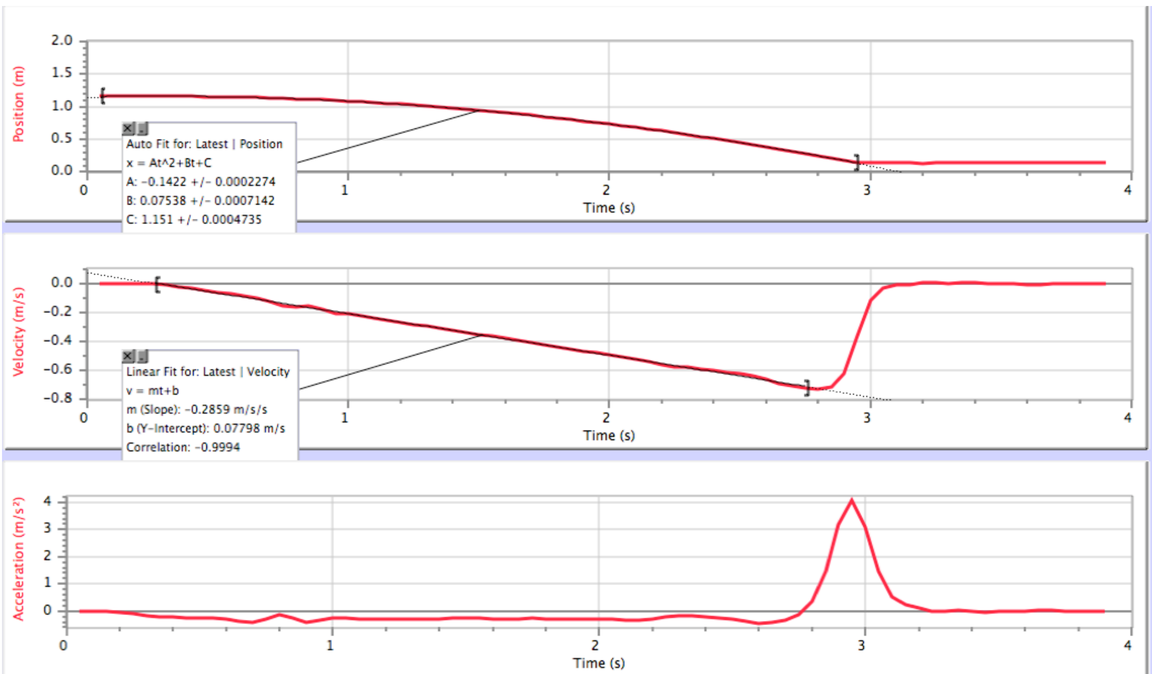
Step Six

Let the cart go at the top of the higher end of the track, while recording the data.

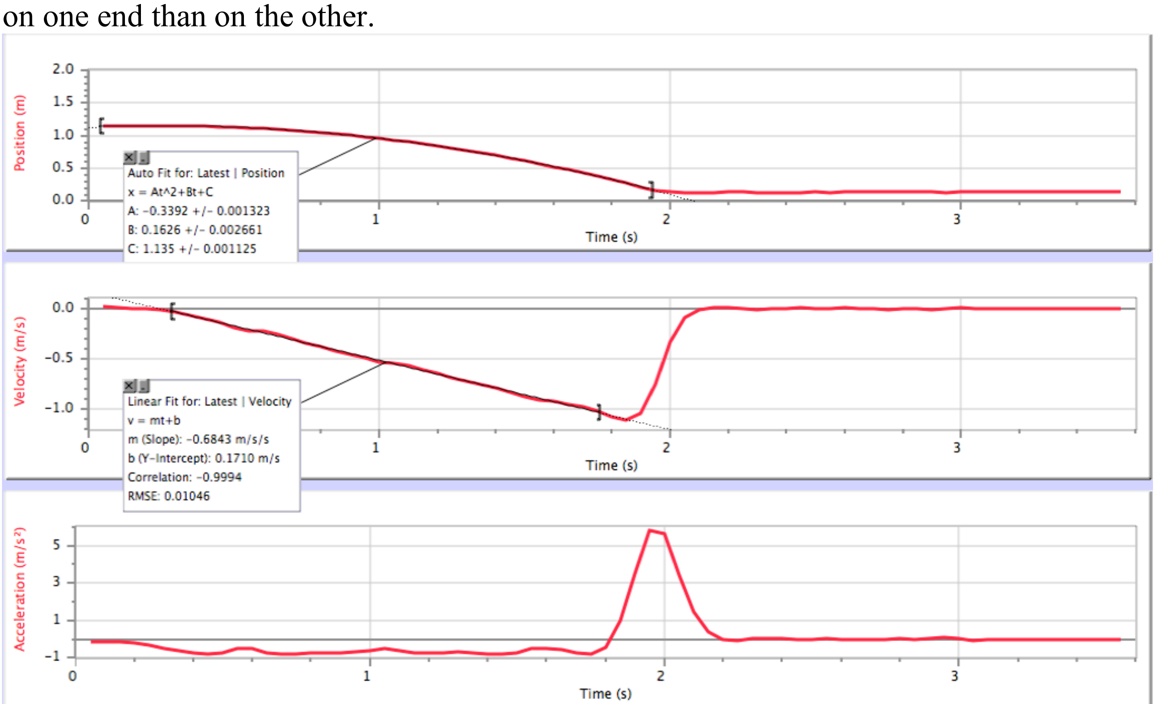
Step Seven

Scale all of your graphs and curve fit your lines. Analyze your data.

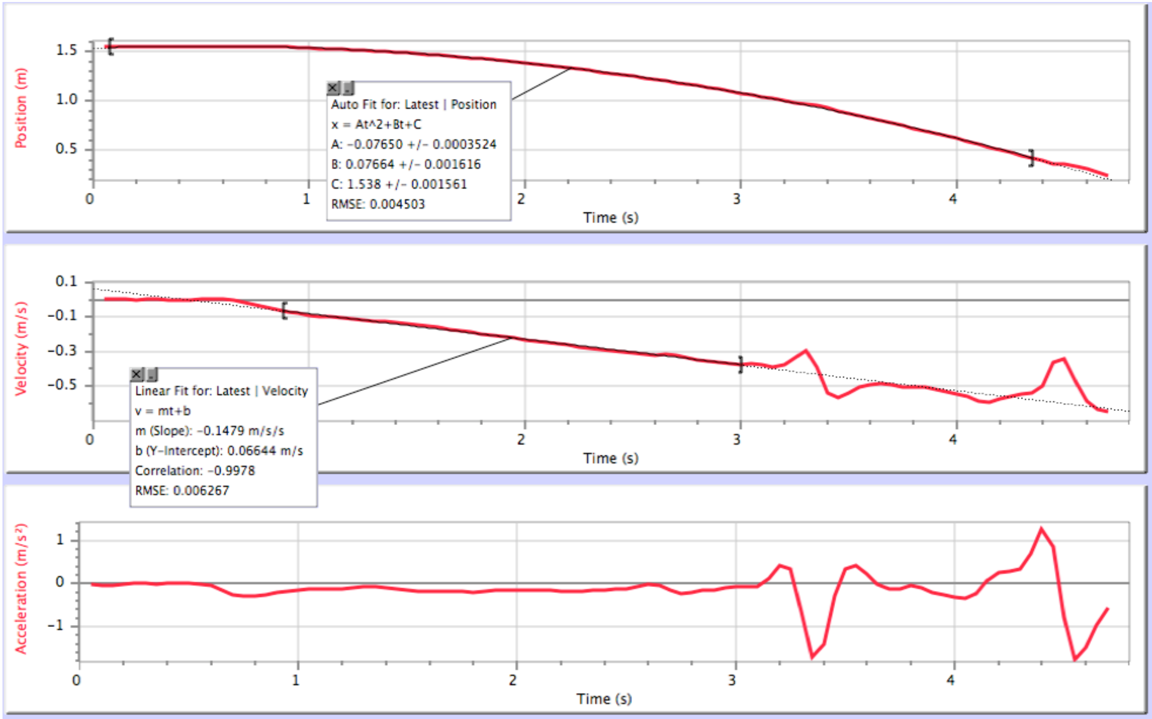
Data



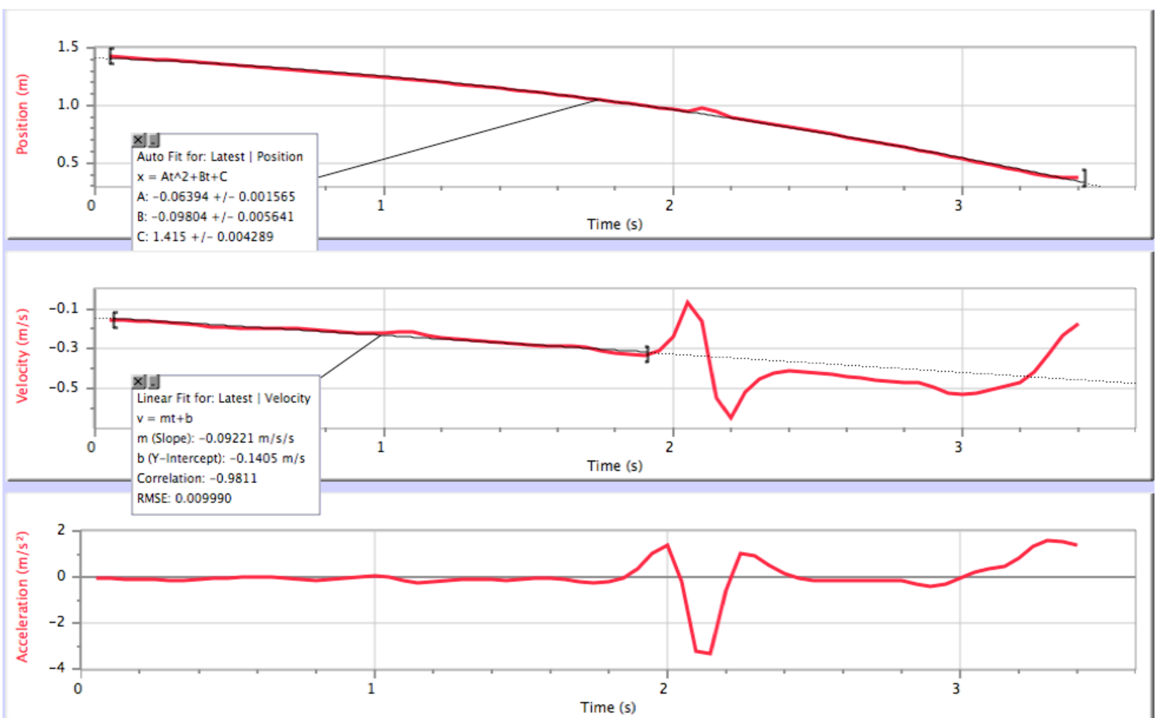
Above is the graph for the cart careening down the track that was six centimeters higher on one end than on the other.



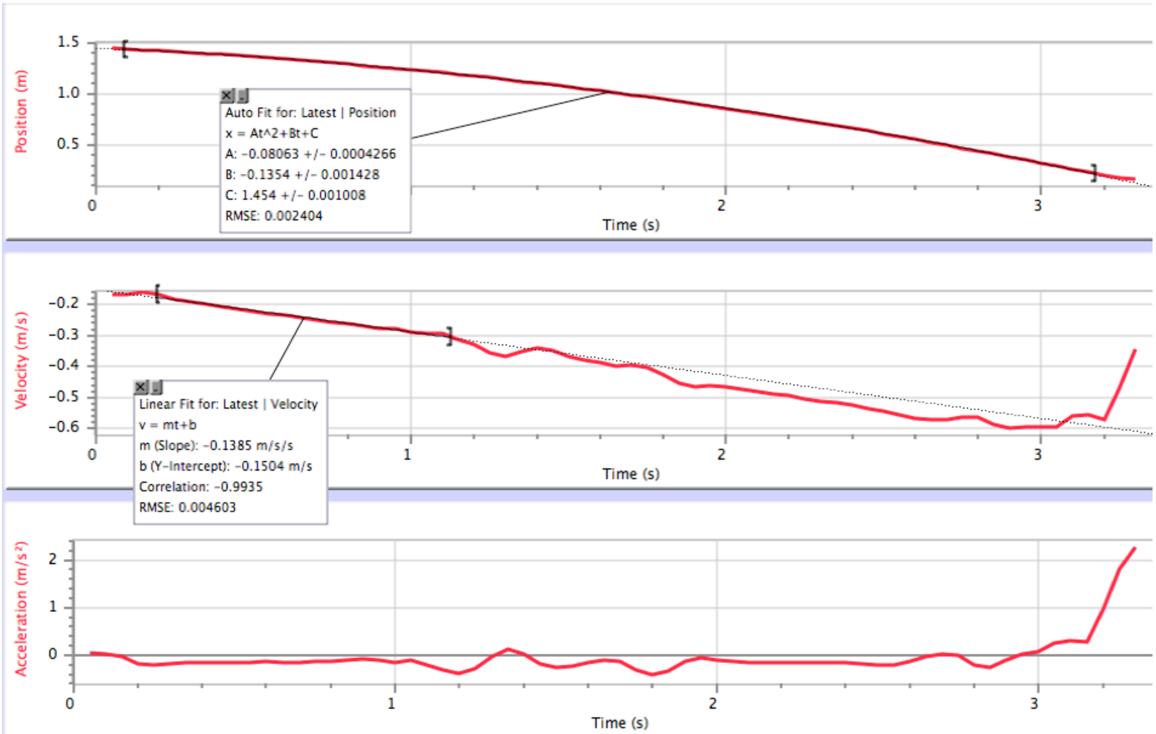
Above is the graph of the movement of the cart on the track that was elevated eleven centimeters on one end.



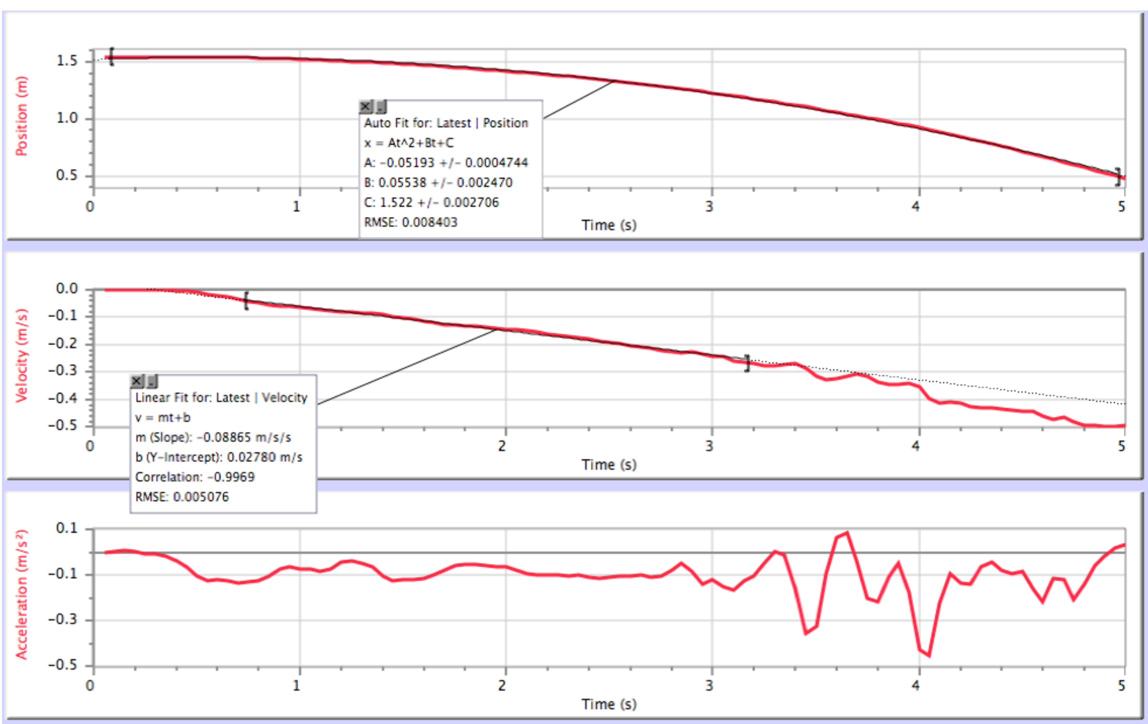
Above is the graph of the cart who's fan was sent to "Fast," and was not carrying a weight.



Above is the motion graph of an empty cart set to "Slow".



Above is the graph of the movement of a weighted cart with the fan set to “Fast”.



Above is the motion graph of a weighted cart set to ”Slow”.

Example Data Table:
This is the data table for the graph of the weighted cart with a fan set to fast.

	Latest			
	Time (s)	Position (m)	Velocity (m/s)	acc (m/s²)
1	0.05	1.449	-0.169	0.057
2	0.10	1.440	-0.166	0.036
3	0.15	1.432	-0.161	-0.040
4	0.20	1.425	-0.167	-0.170
5	0.25	1.416	-0.183	-0.214
6	0.30	1.406	-0.192	-0.178
7	0.35	1.396	-0.199	-0.154
8	0.40	1.387	-0.206	-0.153
9	0.45	1.376	-0.214	-0.156
10	0.50	1.365	-0.222	-0.152
11	0.55	1.354	-0.230	-0.145
12	0.60	1.342	-0.237	-0.142
13	0.65	1.330	-0.244	-0.145
14	0.70	1.318	-0.251	-0.144
15	0.75	1.305	-0.259	-0.131
16	0.80	1.292	-0.264	-0.123
17	0.85	1.279	-0.271	-0.116
18	0.90	1.264	-0.277	-0.085
19	0.95	1.250	-0.276	-0.113
20	1.00	1.238	-0.289	-0.143
21	1.05	1.221	-0.295	-0.112
22	1.10	1.208	-0.293	-0.200
23	1.15	1.193	-0.313	-0.319
24	1.20	1.176	-0.328	-0.373
25	1.25	1.161	-0.356	-0.293
26	1.30	1.140	-0.367	-0.031
27	1.35	1.123	-0.354	0.119
28	1.40	1.105	-0.342	0.019
29	1.45	1.089	-0.347	-0.184
30	1.50	1.071	-0.368	-0.265

31	1.55	1.052	-0.379	-0.219
32	1.60	1.033	-0.389	-0.168
33	1.65	1.013	-0.397	-0.110
34	1.70	0.993	-0.396	-0.142
35	1.75	0.974	-0.404	-0.298
36	1.80	0.953	-0.428	-0.404
37	1.85	0.931	-0.455	-0.325
38	1.90	0.907	-0.466	-0.140
39	1.95	0.884	-0.462	-0.062
40	2.00	0.861	-0.467	-0.093
41	2.05	0.837	-0.472	-0.130
42	2.10	0.814	-0.481	-0.147
43	2.15	0.789	-0.488	-0.143
44	2.20	0.765	-0.494	-0.152
45	2.25	0.740	-0.503	-0.160
46	2.30	0.715	-0.511	-0.150
47	2.35	0.689	-0.518	-0.152
48	2.40	0.663	-0.526	-0.167
49	2.45	0.636	-0.535	-0.182
50	2.50	0.609	-0.543	-0.210
51	2.55	0.582	-0.557	-0.211
52	2.60	0.554	-0.568	-0.129
53	2.65	0.525	-0.570	-0.035
54	2.70	0.497	-0.571	0.031
55	2.75	0.467	-0.562	-0.013
56	2.80	0.441	-0.564	-0.195
57	2.85	0.412	-0.588	-0.250
58	2.90	0.381	-0.601	-0.100
59	2.95	0.351	-0.595	0.024
60	3.00	0.323	-0.593	0.074
61	3.05	0.292	-0.597	0.242
62	3.10	0.260	-0.560	0.301
63	3.15	0.238	-0.557	0.288
64	3.20	0.206	-0.573	0.972
65	3.25	0.174	-0.469	1.806
66	3.30	0.162	-0.343	2.262

Formulas:
Net Force=Mass x Acceleration
This can be used to determine the net force on the carts.
Velocity=Distance / Time
Acceleration=Change in Velocity / Change in Time
Constants:
Free Fall Acceleration: 9.8 m/s squared.
Weights
Sail: 211.42g
Cart: 302.55g
Weight: 500g
Batteries: 282.42 (all together)

Observations
The carts moved down the ramps at varying speeds due to changes in the incline. The speed of the carts also varied because of fan speeds and weights. The Distance and Time graph lines were curves, the velocity graphs were slanted lines (representing a steady increase in velocity), and acceleration graphs were flat lines (or should have been). The graphs of the data are not completely accurate, for example, the acceleration graphs are wobbly while they should be flat. Also, there are sometimes discrepancies towards the end of the graphs.

Analysis
The Position-Time graphs are fairly accurate and error-free, but problems arose in the velocity and acceleration graphs. The data is somewhat skewed towards the ends of these graphs because of reflections and repetitions of the sound waves from the sonar motion detector. There were too many sound sensors bouncing around in too small of a space, so it recorded the same one twice, or more. This is responsible for the irregularities in these graphs. Also, on some of the graphs, the motion sensor was still recording when the cart hit the end of the track and stopped. This caused irregularities in some of the graphs as well, such as drops in acceleration or velocity at the ends of some graphs.

Conclusion

I think that overall, this lab was a good demonstration of the movement of these carts under different variables. While there was some trouble with the sonar motion recorders skewing some of the data, you can see the differences in speed and acceleration with the different variables, like slope of the track or speed of the fan. We were able to get accurate curve fit and linear fit lines for the graphs, as well, showing how all of this is driven by mathematics.

Problems:

1)

The acceleration was based on gravity from two different levels of incline. In our tests, the acceleration stayed just below 1 (because the cart was coming towards the motion detector). It should have been related directly to gravity.
2) 796.44g Slow: A=-.1
Fast: -.2 W=mg
M=81.26
Force of slow fan: -8.126 N
Force of fast fan: -16.253 N
3) If we kept recording after the cart bounced, the velocity/time graph would look like the teeth of a saw, because the direction changes suddenly followed by a high amount of acceleration.
4) If the fan cart was pulling another cart, it would slow down. the x/t graph's curve would be longer and less bent, the slope of the v/t graph would be smaller, and the flat line on the a/t graph would be closer to zero.

Note: The data tables for this were too long to fit in this document, so I will be submitting the lab with the .cmbl files so you can look at them.