Paul Chen **Force and Newton's Law** **e**Physics C

Purpose: To study Newton's law and analyze the acceleration of different carts graphically.

Background: There are two labs involved. One of them is the fan cart, while the other one is a *Vernier* car. The equation we're trying to look at is "Net force equals mass times acceleration" (F=ma). This means that when a mass is acted by a force, it will accelerate in that direction. The mass and force are manipulated to see the difference in acceleration. Each of the fan carts will be done with high and low speeds, with and without weights on each.

Car = 305.48 grams (586 grams totals)
Battery = 70.41 grams Ramp 1 = 5 degree
Vernier Car = 510 grams Ramp 2 = 7 degree
Weights = 500 grams

Materials: MacBook, Logger Pro, *Vernier* motion detector, batteries, fan cart, sail and tapes, meter sticks, ramp, weights, digital balance, books(for elevation)

Procedure A: 1. Set up the motion detector on the floor with Logger Pro on.
2. Have a partner hold the fan cart facing towards the motion detector at a reasonable distance(about 1 meter or more) and set on the "low" configuration. Make sure the cart is aligned with the motion detector. Use meter sticks as guides or track if the cart turns. Also, the motion detector stops working at a close range, so the graph will have a bump in the end.
3. Press start on Logger Pro while the partner releases the cart to gather data.(Do auto fit and curve fit on each graph).
4. Repeat steps 1-3 with "high," "low with weights," and "high with weights" configurations. Make sure the weight of the weights are measured before hand(ours was 500 grams)
5. Do auto fit and curve fit for each of the graph to obtain data.

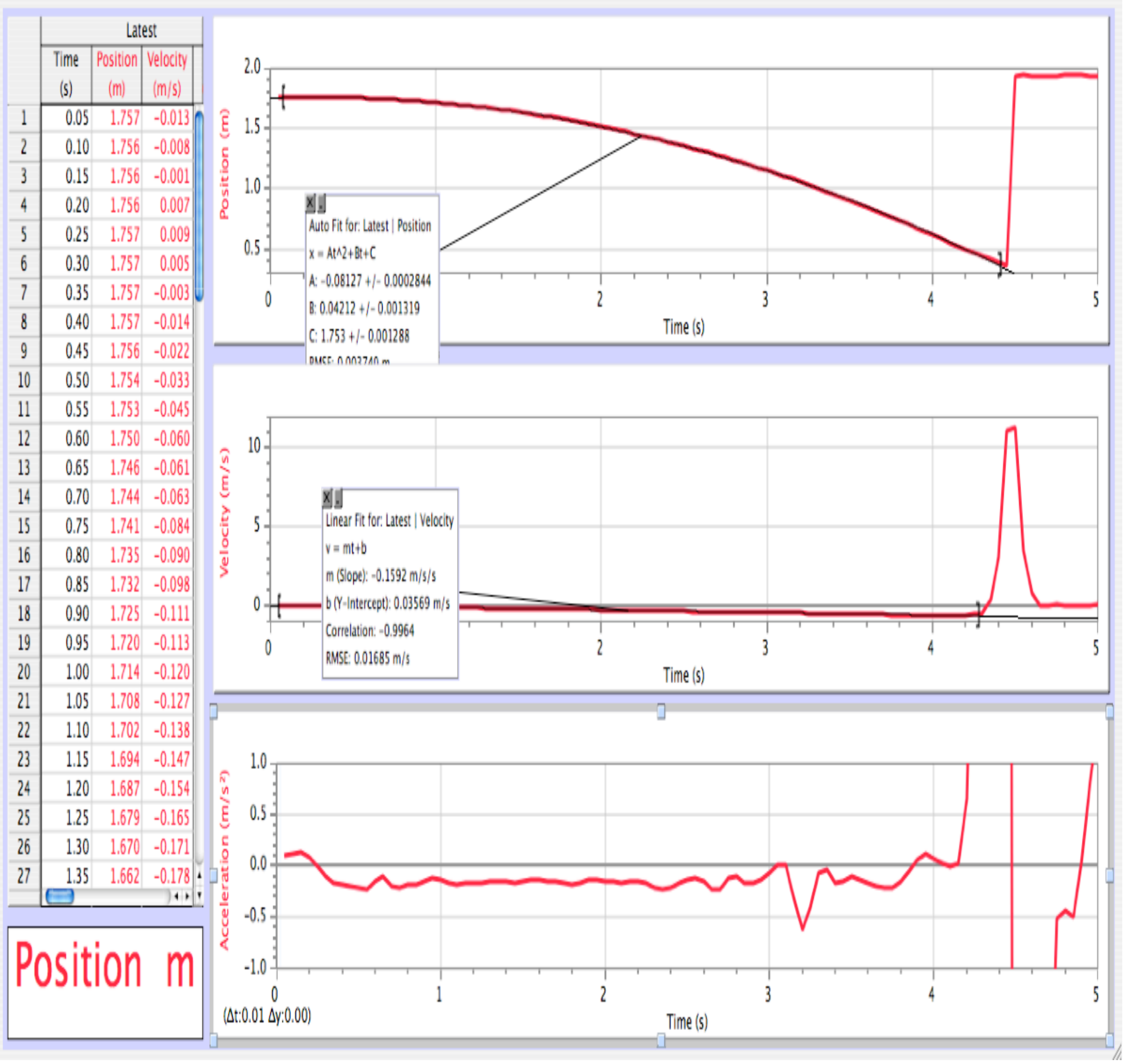
Procedure B: 1. Set the motion detector on the table with Logger Pro on.
2. Measure the height of the angle(degree) of the book stack.
3. Have a partner hold the *Vernier* car on the track facing the motion detector at about 100 cm. Make sure the sails are taped firmly on the car and the spring is facing the end. Also, the motion detector stops working at a close range, so the distance should be corrected.
4. Press start button on Logger Pro while releasing the car. Let the car bounce until it

stops.

5. Repeat steps 1 – 4 with a different angle of book stack.

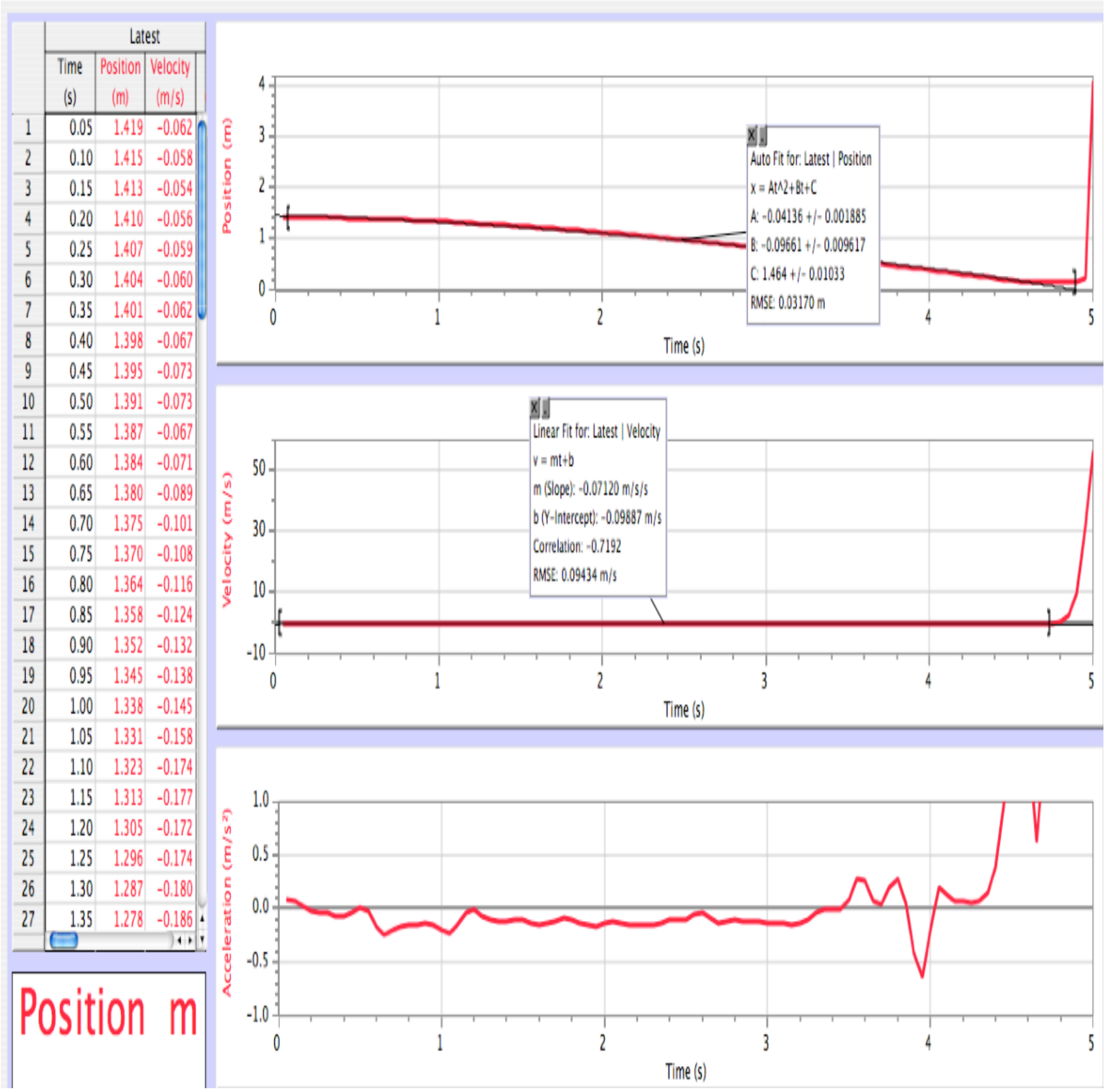
6. Do auto fit and curve fit for each of the graph to obtain data.

Data:



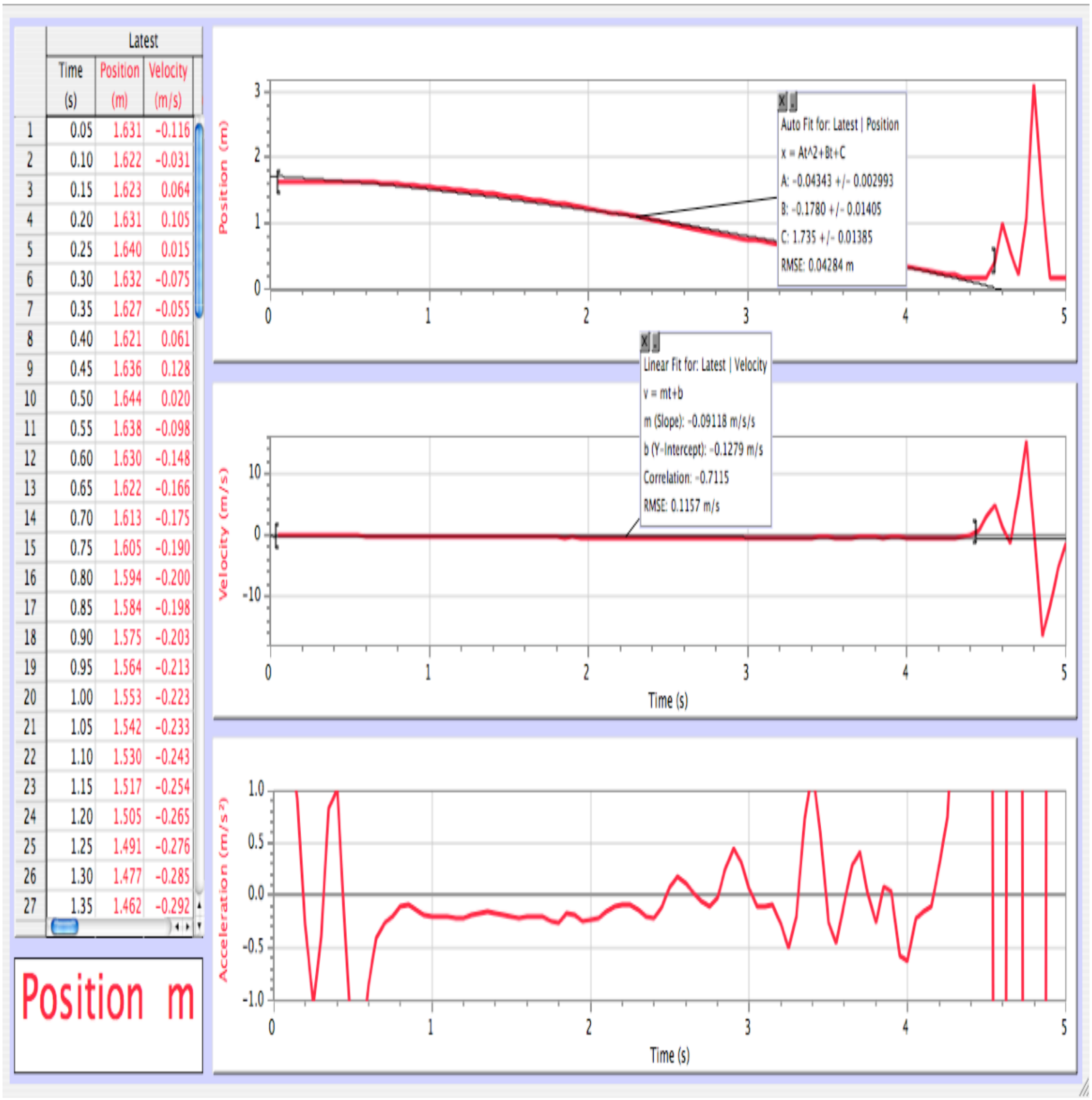
	Latest		
	Time (s)	Position (m)	Velocity (m/s)
1	0.05	1.757	-0.013
2	0.10	1.756	-0.008
3	0.15	1.756	-0.001
4	0.20	1.756	0.007
5	0.25	1.757	0.009
6	0.30	1.757	0.005
7	0.35	1.757	-0.003
8	0.40	1.757	-0.014
9	0.45	1.756	-0.022
10	0.50	1.754	-0.033
11	0.55	1.753	-0.045
12	0.60	1.750	-0.060
13	0.65	1.746	-0.061
14	0.70	1.744	-0.063
15	0.75	1.741	-0.084
16	0.80	1.735	-0.090
17	0.85	1.732	-0.098
18	0.90	1.725	-0.111
19	0.95	1.720	-0.113
20	1.00	1.714	-0.120
21	1.05	1.708	-0.127
22	1.10	1.702	-0.138
23	1.15	1.694	-0.147
24	1.20	1.687	-0.154
25	1.25	1.679	-0.165
26	1.30	1.670	-0.171
27	1.35	1.662	-0.178

Low Without Weights

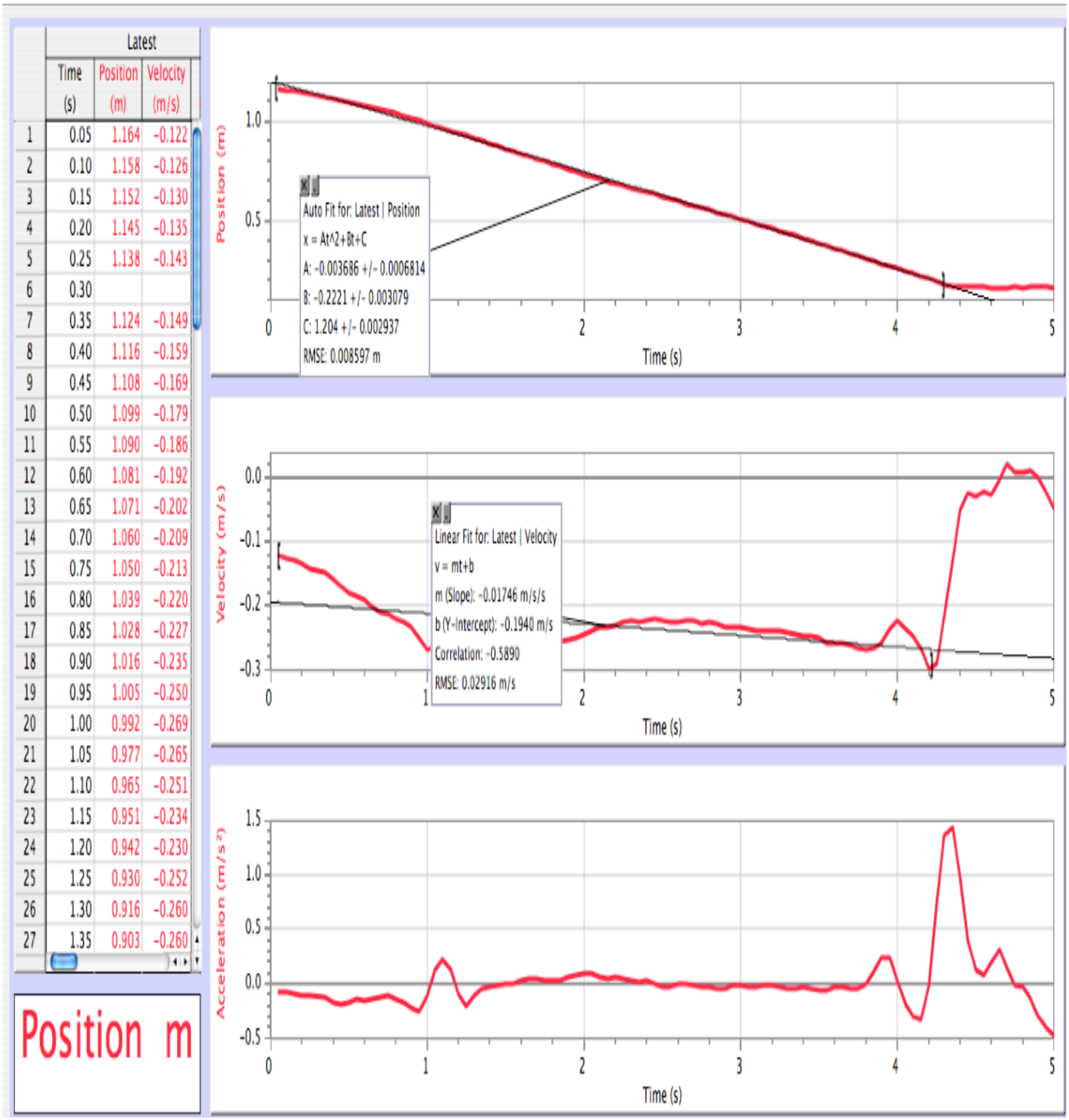


	Latest		
	Time (s)	Position (m)	Velocity (m/s)
1	0.05	1.419	-0.062
2	0.10	1.415	-0.058
3	0.15	1.413	-0.054
4	0.20	1.410	-0.056
5	0.25	1.407	-0.059
6	0.30	1.404	-0.060
7	0.35	1.401	-0.062
8	0.40	1.398	-0.067
9	0.45	1.395	-0.073
10	0.50	1.391	-0.073
11	0.55	1.387	-0.067
12	0.60	1.384	-0.071
13	0.65	1.380	-0.089
14	0.70	1.375	-0.101
15	0.75	1.370	-0.108
16	0.80	1.364	-0.116
17	0.85	1.358	-0.124
18	0.90	1.352	-0.132
19	0.95	1.345	-0.138
20	1.00	1.338	-0.145
21	1.05	1.331	-0.158
22	1.10	1.323	-0.174
23	1.15	1.313	-0.177
24	1.20	1.305	-0.172
25	1.25	1.296	-0.174
26	1.30	1.287	-0.180
27	1.35	1.278	-0.186

Low With Weights



High Without Weights

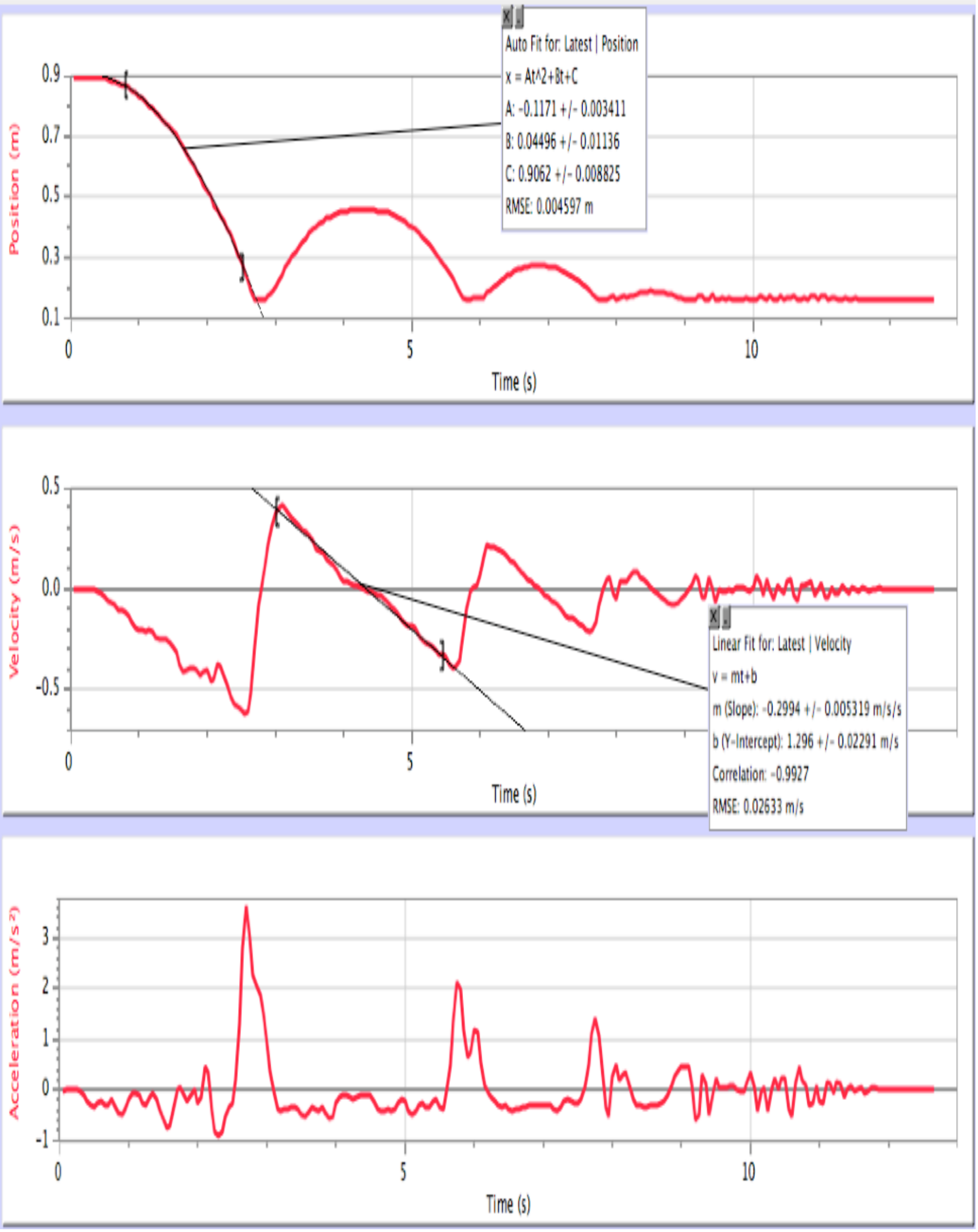


	Time (s)	Position (m)	Velocity (m/s)
1	0.05	1.164	-0.122
2	0.10	1.158	-0.126
3	0.15	1.152	-0.130
4	0.20	1.145	-0.135
5	0.25	1.138	-0.143
6	0.30		
7	0.35	1.124	-0.149
8	0.40	1.116	-0.159
9	0.45	1.108	-0.169
10	0.50	1.099	-0.179
11	0.55	1.090	-0.186
12	0.60	1.081	-0.192
13	0.65	1.071	-0.202
14	0.70	1.060	-0.209
15	0.75	1.050	-0.213
16	0.80	1.039	-0.220
17	0.85	1.028	-0.227
18	0.90	1.016	-0.235
19	0.95	1.005	-0.250
20	1.00	0.992	-0.269
21	1.05	0.977	-0.265
22	1.10	0.965	-0.251
23	1.15	0.951	-0.234
24	1.20	0.942	-0.230
25	1.25	0.930	-0.252
26	1.30	0.916	-0.260
27	1.35	0.903	-0.260

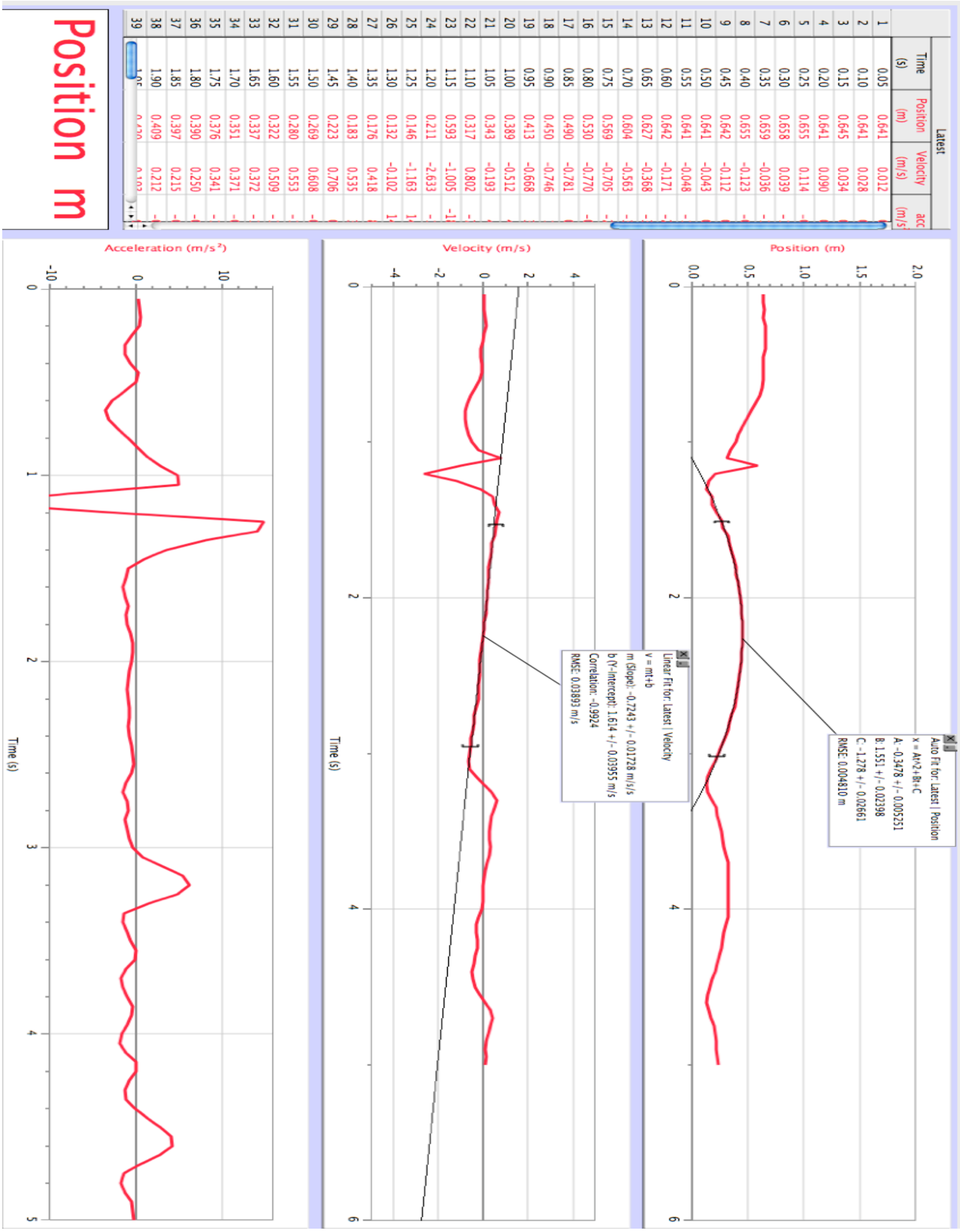
High With Weights

	Latest		
	Time (s)	Position (m)	Velocity (m/s)
22	1.10	0.812	-0.209
23	1.15	0.801	-0.205
24	1.20	0.792	-0.214
25	1.25	0.780	-0.237
26	1.30	0.768	-0.252
27	1.35	0.754	-0.251
28	1.40	0.743	-0.246
29	1.45	0.731	-0.266
30	1.50	0.716	-0.286
31	1.55	0.703	-0.317
32	1.60	0.686	-0.374
33	1.65	0.664	-0.408
34	1.70	0.643	-0.405
35	1.75	0.624	-0.394
36	1.80	0.604	-0.389
37	1.85	0.586	-0.404
38	1.90	0.564	-0.430
39	1.95	0.540	-0.411
40	2.00	0.523	-0.402
41	2.05	0.504	-0.461
42	2.10	0.473	-0.449
43	2.15	0.455	-0.371
44	2.20	0.441	-0.381
45	2.25	0.419	-0.438
46	2.30	0.396	-0.478
47	2.35	0.373	-0.534
48	2.40	0.342	-0.571

Position m



Ramp (5 degree)



	Latest Time (s)	Latest Position (m)	Latest Velocity (m/s)
1	0.05	0.641	0.012
2	0.10	0.641	0.028
3	0.15	0.645	0.034
4	0.20	0.641	0.090
5	0.25	0.655	0.114
6	0.30	0.658	0.039
7	0.35	0.659	-0.036
8	0.40	0.655	-0.123
9	0.45	0.642	-0.112
10	0.50	0.641	-0.043
11	0.55	0.641	-0.048
12	0.60	0.642	-0.171
13	0.65	0.627	-0.368
14	0.70	0.604	-0.563
15	0.75	0.569	-0.705
16	0.80	0.530	-0.770
17	0.85	0.490	-0.781
18	0.90	0.450	-0.746
19	0.95	0.413	-0.668
20	1.00	0.389	-0.512
21	1.05	0.343	-0.193
22	1.10	0.317	0.802
23	1.15	0.593	-1.005
24	1.20	0.211	-2.633
25	1.25	0.146	-1.163
26	1.30	0.132	-0.102
27	1.35	0.176	0.418
28	1.40	0.183	0.535
29	1.45	0.223	0.706
30	1.50	0.269	0.608
31	1.55	0.280	0.553
32	1.60	0.322	0.509
33	1.65	0.337	0.372
34	1.70	0.351	0.371
35	1.75	0.376	0.341
36	1.80	0.390	0.250
37	1.85	0.397	0.215
38	1.90	0.409	0.212
39	[illegible]	[illegible]	[illegible]

Ramp (7 Degree)

Observations: The carts without weights accelerate at a high or low speed according to the configuration. When the weights are added to carts, the acceleration decreased. Also, the carts tend to turn to the left because the wheels aren't aligned perfectly. The motion detectors also didn't work when the cart was too close.
In the second lab, the car bounced after hitting the end, and each bounce become shorter and slower.

Analysis: The data gathered are acceptable since take "low without weights" for example, -0.081 x 2 of x/t is approximately -0.159 for v/t graph. This is because S=1/2at^2 and a(acceleration) is divided by 2. The A in At^2+bt+c should be equal to the slope (v/t) and acceleration(a/t) when multiplied by 2. When comparing the high and low with and without weights, a clear difference can be seen. For "high without weights" the acceleration is -0.043 while the one with weights is -0.003. This difference is due to the fact that when F=ma, a is determined by F/m. When the mass increases, the acceleration decreases. Although the graph is about 60% correct, the trend can still be seen. For the ramp graphs, the higher degree of the elevation increases the acceleration of the car. This can be seen because the 5 degree had -0.11 while the 7 degree had -0.34. Sin(theta) x 9.8 also gave the acceleration due to gravity. Each bounce from the car gave smaller amplitude to the graph, so only the first parabola selected for curve fit. The bumps on the ends of the graphs are due to close range the carts get when it hits the motion detector. This may have shifted the data, but by editing the Y-scale, the percent error is reduced. Also, some error in this lab might be due to the roughness of the ground. For example, a little stone or sand might decrease the acceleration of the carts.

Conclusions: From this lab, the concept of Newton's second law and acceleration of different objects can be determined. In the equation F=ma, the mass and the acceleration both determines the force F. By adding weights on the carts, the final proportion is altered. This is because acceleration a is determined by F/m, and when the mass increases, the acceleration decreases. In the future, one might want to tune the wheels of the carts correctly so it doesn't change direction. When the carts turn, the data might be altered because of that.

In each case, determine the acceleration by three methods, then answer the questions below:
1. How was the acceleration of the inclined cart related to g? How should it be related?
Sin(theta)x9.8 = Sin(5) x 9.8 = 0.854 m/s^2. Sin(theta)x9.8 = Sin(7) x 9.8 = 1.19

m/s^2. It should be related because as the angle rises, the force of the gravity acting will be bigger. The acceleration can be determined by finding the sine of the degree of angle, then multiplied by 9.8.

2. Determine the force from the fan on low and high speeds.
F=ma. F=0.586kg X 0.16 F=0.09376 Low
F=ma. F=0.586kg X 0.086 F=0.050396 High
They should be the same, but the numbers are a bit off(0.04) because the graphs are not 100% correct due outside factors affecting the cart.

3. If you allowed the ramp to bounce, what would the v/t graph look like and why?
The x/t and v/t graph would both have repeating high and low loops, or sometimes jagged lines. Each bounce however, the loop will be smaller. This is because the car stops for a while when it hits the end, and it accelerates back, with a slower speed each time until it stops.

4. If the fan cart had another identical cart hooked to it, what would this do to the three curves: x/t v/t a/t?
The x/t graph would be smoother, almost flat because the identical cart on the back drags the cart in front to a slower speed, therefore the change in position is slower. Both the v/t and a/t graph would decrease in the Y-axis because the acceleration of the cart is slower than without pulling the cart on the back. It is like adding weights to the car, which adds friction and tension to slow the cart's acceleration.