Title: The application of Newton's second law. (F=ma)

Purpose: To study the application of Newton's second law.

Background:
1. F=ma
2. Acceleration is proportional to the net force on an object and inversely proportional to its mass.
3. If the application of multiple forces results in a net force acting on an object, it accelerates.

Material:
- Logger pro
- cart (489g)
- fan cart (586g)
- batteries (70.41×4)
- weight (240g)
- Vernier motion detector
- sail and tapes (198g)
- meter sticks
- books(for elevation)

Procedure:
1. Connect the Vernier motion detector to macbook.
2. The lab includes three seperate groups.
(1) Use the cart and the track, change the angle of the track.
- set up the cart
- Use the books for elevation, the angle of the track now is 5 degree.
- press the record button and release the cart.
- Press the button to stop recording until the cart stops.
- Using Logger Pro and its "curve fit" function to analyze the graph.

- Reset the cart and Logger Pro.
- Add some more books, the angle of the track now is 7 degree.
- press the record button and release the cart.
- Press the button to stop recording until the cart stops.
- Using Logger Pro and its "curve fit" function to analyze the graph.

(2) Use the fan cart, change its speed (low speed/high speed)
- Set up the fan cart and put the sail on it.
- press the record button and turn on low speed to let the cart start moving.
- Press the button to stop recording until the cart almost hit the Vernier motion detector and stop the cart.
- Using Logger Pro, and its "curve fit" function to analyze the graph.

- Reset the fan cart and Logger Pro.
- press the record button and turn on high speed to let the cart start moving.
- Press the button to stop recording until the cart almost hit the Vernier motion detector and stop the cart.
- Using Logger Pro, and its "curve fit" function to analyze the graph.

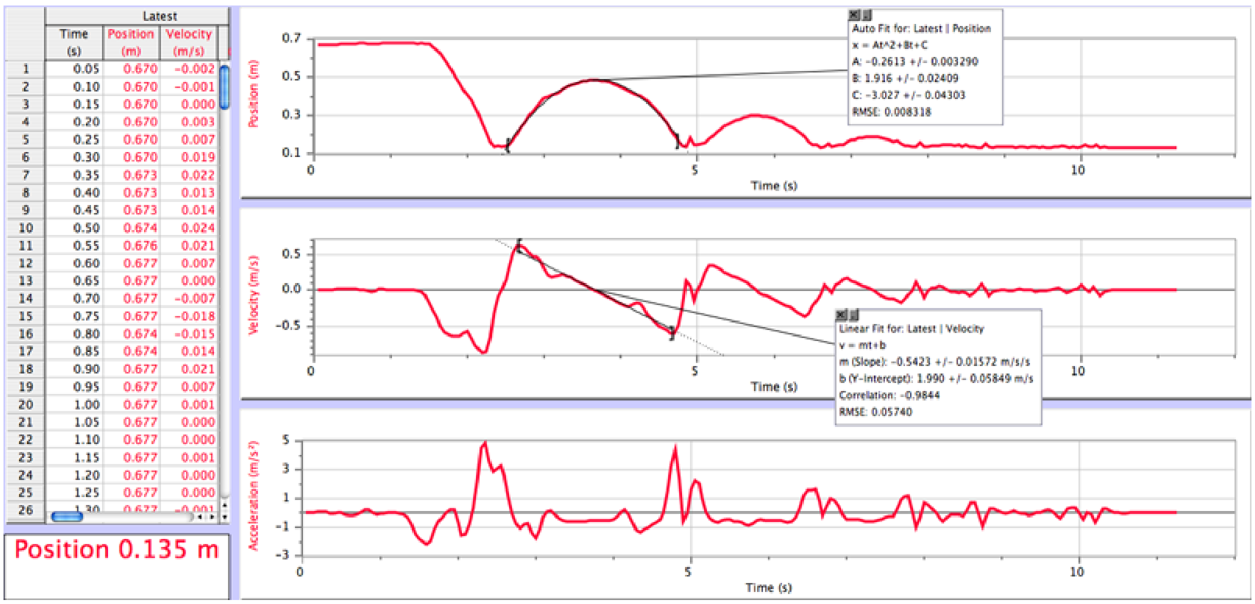
(3) Use the fan cart and weight, change its speed (low speed/high speed)

- Set up the fan cart, put the sail and weight on it.
- press the record button and turn on low speed to let the cart start moving.
- Press the button to stop recording until the cart almost hit the Vernier motion detector and stop the cart.
- Using Logger Pro, and its "curve fit" function to analyze the graph.

- Reset the fan cart and Logger Pro, put the sail and weight on it.
- press the record button and turn on high speed to let the cart start moving.
- Press the button to stop recording until the cart almost hit the Vernier motion detector and stop the cart.
- Using Logger Pro, and its "curve fit" function to analyze the graph.

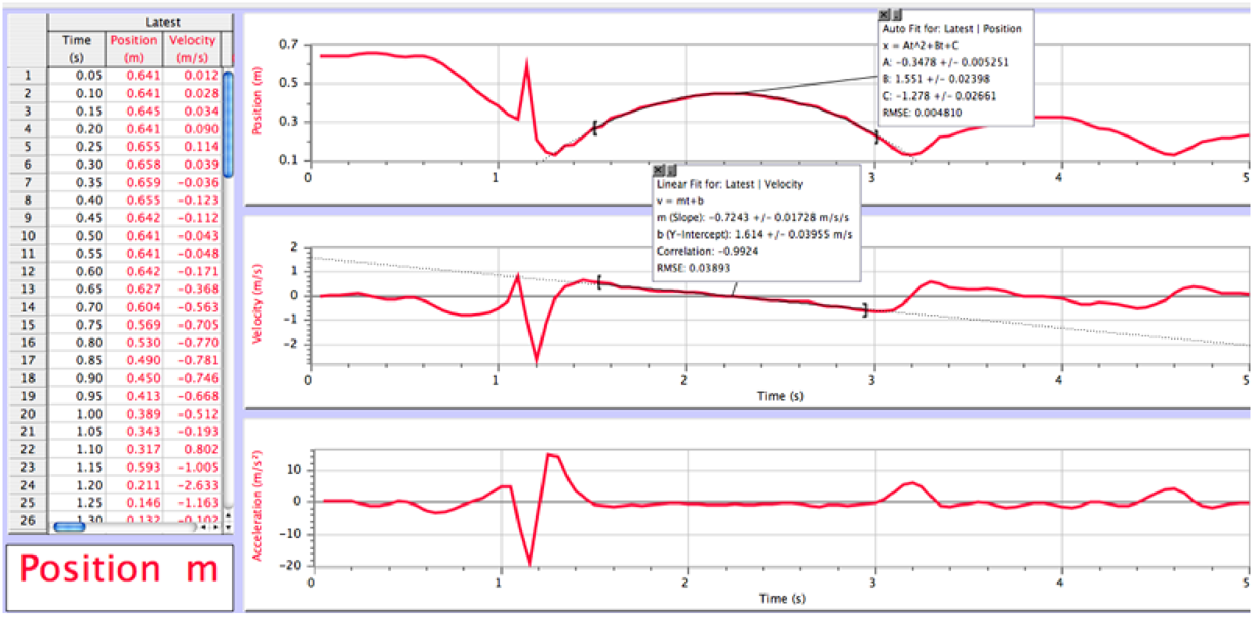
Data:

1.1 Cart moves on 5 degree track.

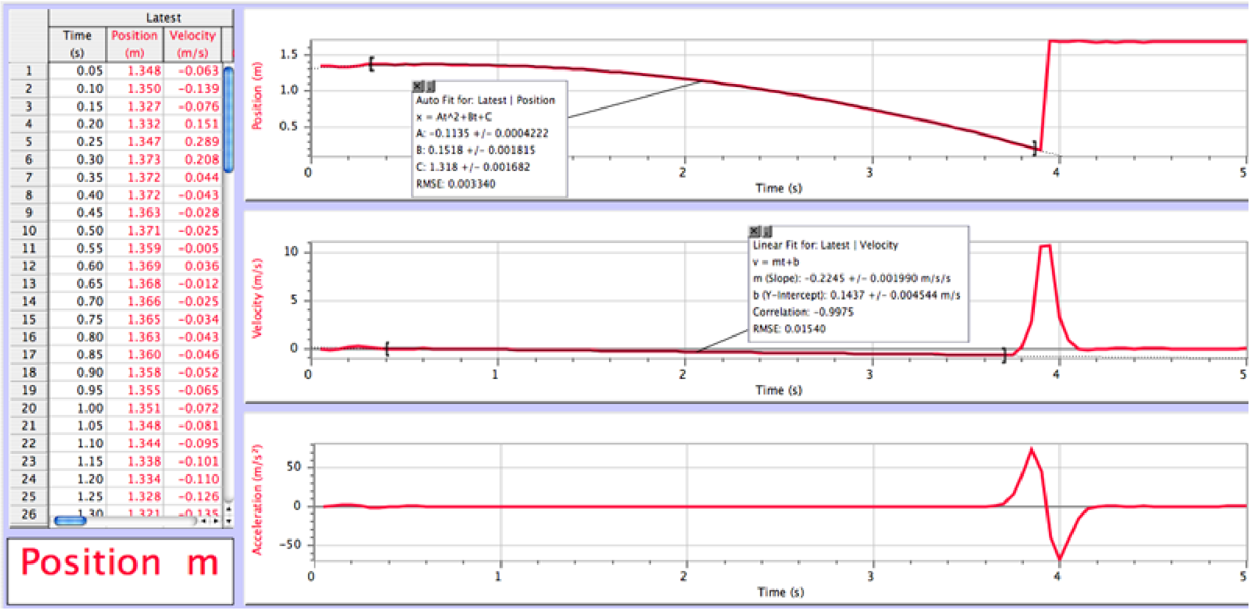


	Latest		
	Time (s)	Position (m)	Velocity (m/s)
1	0.05	0.670	-0.002
2	0.10	0.670	-0.001
3	0.15	0.670	0.000
4	0.20	0.670	0.003
5	0.25	0.670	0.007
6	0.30	0.670	0.019
7	0.35	0.673	0.022
8	0.40	0.673	0.013
9	0.45	0.673	0.014
10	0.50	0.674	0.024
11	0.55	0.676	0.021
12	0.60	0.677	0.007
13	0.65	0.677	0.000
14	0.70	0.677	-0.007
15	0.75	0.677	-0.018
16	0.80	0.674	-0.015
17	0.85	0.674	0.014
18	0.90	0.677	0.021
19	0.95	0.677	0.007
20	1.00	0.677	0.001
21	1.05	0.677	0.000
22	1.10	0.677	0.000
23	1.15	0.677	0.001
24	1.20	0.677	0.000
25	1.25	0.677	0.000
26	1.30	0.677	-0.001

1.2 Cart moves on 7 degree track.

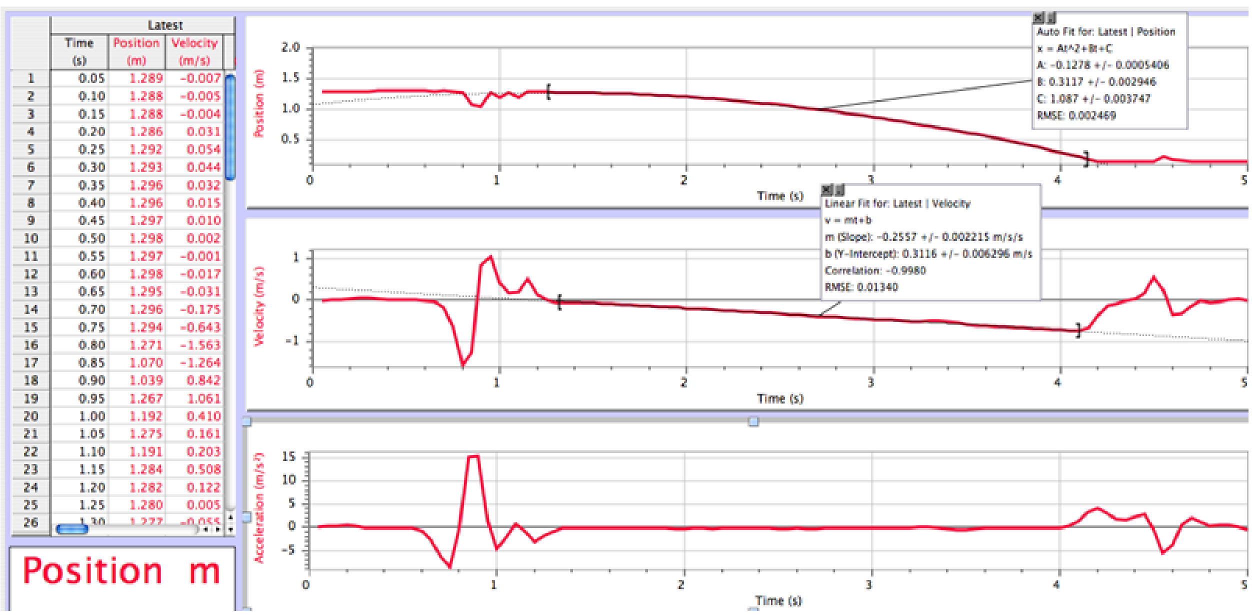


2.1 Fan cart moves in low speed.



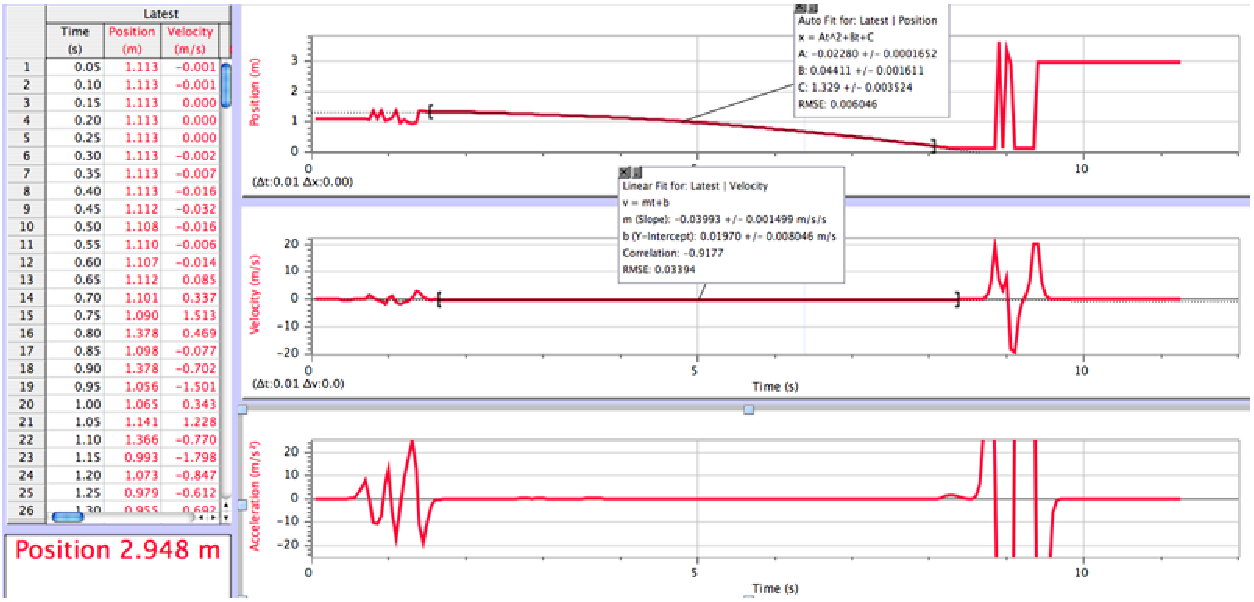
	Time (s)	Position (m)	Velocity (m/s)
1	0.05	1.348	-0.063
2	0.10	1.350	-0.139
3	0.15	1.327	-0.076
4	0.20	1.332	0.151
5	0.25	1.347	0.289
6	0.30	1.373	0.208
7	0.35	1.372	0.044
8	0.40	1.372	-0.043
9	0.45	1.363	-0.028
10	0.50	1.371	-0.025
11	0.55	1.359	-0.005
12	0.60	1.369	0.036
13	0.65	1.368	-0.012
14	0.70	1.366	-0.025
15	0.75	1.365	-0.034
16	0.80	1.363	-0.043
17	0.85	1.360	-0.046
18	0.90	1.358	-0.052
19	0.95	1.355	-0.065
20	1.00	1.351	-0.072
21	1.05	1.348	-0.081
22	1.10	1.344	-0.095
23	1.15	1.338	-0.101
24	1.20	1.334	-0.110
25	1.25	1.328	-0.126
26	1.30	1.321	-0.135

2.2 Fan cart moves on high speed.



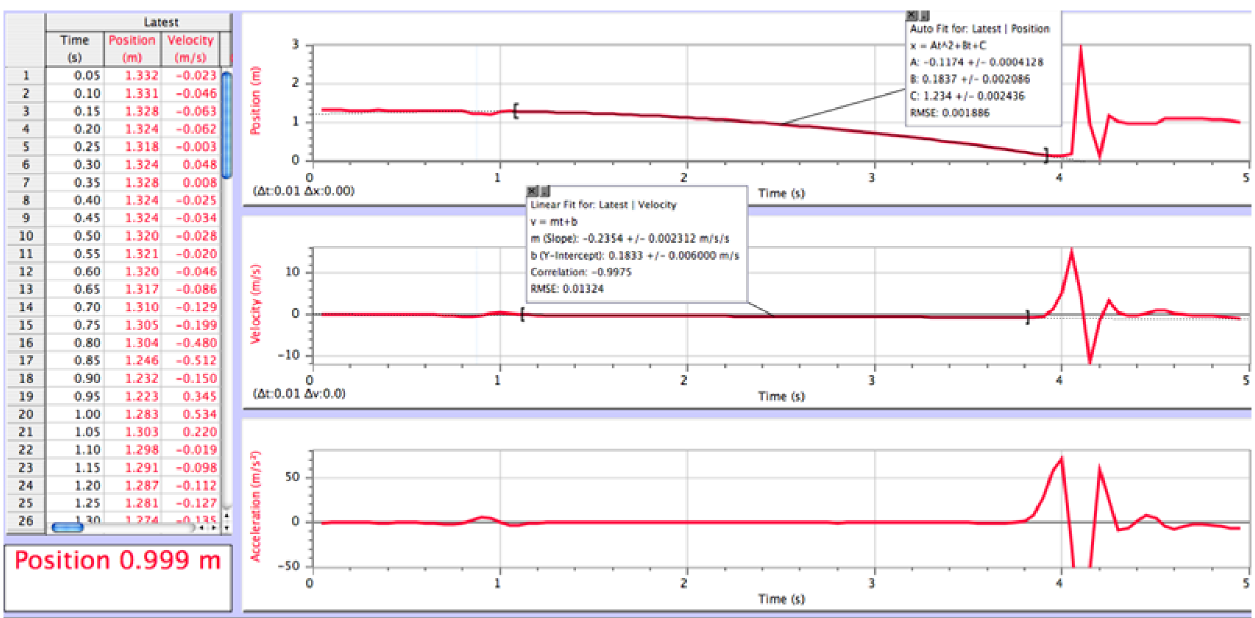
	Time (s)	Position (m)	Velocity (m/s)
1	0.05	1.289	-0.007
2	0.10	1.288	-0.005
3	0.15	1.288	-0.004
4	0.20	1.286	0.031
5	0.25	1.292	0.054
6	0.30	1.293	0.044
7	0.35	1.296	0.032
8	0.40	1.296	0.015
9	0.45	1.297	0.010
10	0.50	1.298	0.002
11	0.55	1.297	-0.001
12	0.60	1.298	-0.017
13	0.65	1.295	-0.031
14	0.70	1.296	-0.175
15	0.75	1.294	-0.643
16	0.80	1.271	-1.563
17	0.85	1.070	-1.264
18	0.90	1.039	0.842
19	0.95	1.267	1.061
20	1.00	1.192	0.410
21	1.05	1.275	0.161
22	1.10	1.191	0.203
23	1.15	1.284	0.508
24	1.20	1.282	0.122
25	1.25	1.280	0.005
26	1.30	1.277	-0.055

3.1 Fan cart with weight moves in low speed.



	Time (s)	Position (m)	Velocity (m/s)
1	0.05	1.113	-0.001
2	0.10	1.113	-0.001
3	0.15	1.113	0.000
4	0.20	1.113	0.000
5	0.25	1.113	0.000
6	0.30	1.113	-0.002
7	0.35	1.113	-0.007
8	0.40	1.113	-0.016
9	0.45	1.112	-0.032
10	0.50	1.108	-0.016
11	0.55	1.110	-0.006
12	0.60	1.107	-0.014
13	0.65	1.112	0.085
14	0.70	1.101	0.337
15	0.75	1.090	1.513
16	0.80	1.378	0.469
17	0.85	1.098	-0.077
18	0.90	1.378	-0.702
19	0.95	1.056	-1.501
20	1.00	1.065	0.343
21	1.05	1.141	1.228
22	1.10	1.366	-0.770
23	1.15	0.993	-1.798
24	1.20	1.073	-0.847
25	1.25	0.979	-0.612
26	1.30	0.955	-0.692

3.2 Fan cart with weight moves in high speed.



	Time (s)	Position (m)	Velocity (m/s)
1	0.05	1.332	-0.023
2	0.10	1.331	-0.046
3	0.15	1.328	-0.063
4	0.20	1.324	-0.062
5	0.25	1.318	-0.003
6	0.30	1.324	0.048
7	0.35	1.328	0.008
8	0.40	1.324	-0.025
9	0.45	1.324	-0.034
10	0.50	1.320	-0.028
11	0.55	1.321	-0.020
12	0.60	1.320	-0.046
13	0.65	1.317	-0.086
14	0.70	1.310	-0.129
15	0.75	1.305	-0.199
16	0.80	1.304	-0.480
17	0.85	1.246	-0.512
18	0.90	1.232	-0.150
19	0.95	1.223	0.345
20	1.00	1.283	0.534
21	1.05	1.303	0.220
22	1.10	1.298	-0.019
23	1.15	1.291	-0.098
24	1.20	1.287	-0.112
25	1.25	1.281	-0.127
26	1.30	1.274	-0.135

Obervations:

1. a) The cart moved down the ramp, accelerated and hit the end of the ramp.
b) When the cart hit the end of the ramp, it went up and then moved down again. Repeat this motion untile the cart stopped, but bounce became shorter and slower.

2. a) After turned on the low speed button, the fan chart started moving. It accelerated and moved on a straight line.
b) The fan cart would not stop until the button had been turned off.

3. a) After turned on the low speed button, the fan chart started moving. But compare to the second lab, the fan cart moved slower. It also accelerated and moved on a straight oine.
b) The fan cart would not stop until the button had been turned off.

Analysis:

1. a) When the cart moved down the ramp, ignore any friction ot air resistance, there are two forces acting on the car---the gravity of the earth and the normal force from the ramp. Since the y component of the cart's weight and the normal force from the ramp sum to 0, there is only a net force (x component of the cart's weight) parallel to the ramp.

b) When the cart hit the end of the ramp, it reached its highest speed. The wall gave the cart an upward force, so the cart went up. It decelerated and when the speed equals 0, the cart moved down again.

c) From the 1.1 graph, using the "curve fit" function, there's an equation $y=-0.2613t^2+1.916t-3.027$ in s/t graph, and an equation $y=-0.5423t+1.990$ in v/t graph. From both equations, the acceleration can be found roughly equals $0.54m/s^2$ when the cart first bounced.

d) Newton's second law, $F=ma= 489g \times 0.54m/s^2=264.06N$

e) After the angle has been changed, the cart accelerated more since the x component force (the net force) is bigger. Due to F=ma, so acceleration became bigger as well.

f) From the 1.2 graph, using the "curve fit" function, there's an equation $y=-0.3478t^2+1.551t-1.278$ in s/t graph, and an equation $y=-0.7243t+1.614$ in v/t graph. From both equations, the acceleration can be found roughly equals $0.72m/s^2$ when the cart first bounced.
d) Newton's second law, $F=ma= 489g \times 0.72m/s^2=352.08N$

2.a) When the "low speed" button turned on, three forces acts on the fan cart. The gravity from the earth, the normal force from the ground which equals the gravity and a net force from the fan.
b) Since only one net force acts on the fan cart and the cart moved on a flat ground, the cart moved constantly. Its velocity and acceleration stay constant.
c) From the 2.1 graph, using the "curve fit" function, there's an equation $y=-0.1135t^2+0.1518t+1.318$ in s/t graph, and an equation $y=-0.2245t+0.1437$ in v/t graph. From both equations, the acceleration can be found roughly equals $0.22m/s^2$.
d) Newton's second law, $F=ma= 586g \times 0.22m/s^2=128.92N$
e) After the speed increased, due to $Vt^2-Vo^2=2as$, $a=(Vt^2-Vo^2)/2s$, since s does not change, V increased, so a became bigger, too.
e) From the 2.2 graph, using the "curve fit" function, there's an equation $y=-0.1278t^2+0.3117t+1.087$ in s/t graph, and an equation $y=-0.2557t+0.3116$ in v/t graph. From both equations, the acceleration can be found roughly equals $0.26m/s^2$.
d) Newton's second law, $F=ma= 586g \times 0.26m/s^2=152.36N$

3.a) Put the weight on the cart, increase the mass. But because the mass became heavier, the acceleration decreased. The same as the second group, three forces acts on the fan cart. The gravity from the earth, the normal force from the ground which equals the gravity and a net force from the fan. Since only one net force acts on the fan cart and the cart moved on a flat ground, the cart moved constantly. Its velocity and acceleration stay constant.
b) From the 3.1 graph, the acceleration roughly equals $0.04m/s^2$.
c) Newton's second law, $F=ma= (586g+240g) \times 0.04m/s^2=33.04N$
d) From the 3.1 graph, the acceleration roughly equals $0.23m/s^2$.
c) Newton's second law, $F=ma= (586g+240g) \times 0.23m/s^2=189.98N$

Conclusions:

From this lab, analyzing from the graph and using Newton’s second law,the acceleration of different objects and the force that acting on the objects can be determined. When the object moves on the ramp, the bigger the angel, the bigger the acceleration. Since F=ma, as acceleration increases, the net force increases. In the same amount of displacement, the bigger the speed, the bigger the acceleration. By adding weights, the mass becomes bigger, although the acceleration might decrease, the final force increases. There still some error exist in the lab. In the third group of the lab, the acceleration of the cart is too small, because the cart was run out of battery. Thus, next time when do this lab, we should make sure the battery of the cart and try to use only one cart in the whole lab.