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# Force

**Purpose:** Analyze force using graphical analysis.

**Background:** Force is simply a push or a pull. It is defined as F=Ma or force equals mass times acceleration.

**Materials:**

- Laptop with logger pro
- Cart with a fan to propel it
- A weight that is 500g
- A partner to make the cart go
- a flat surface
- meter stick
- sonic ranger
- a flat thing that goes on the cart to reflect sound waves back

**Procedure:**

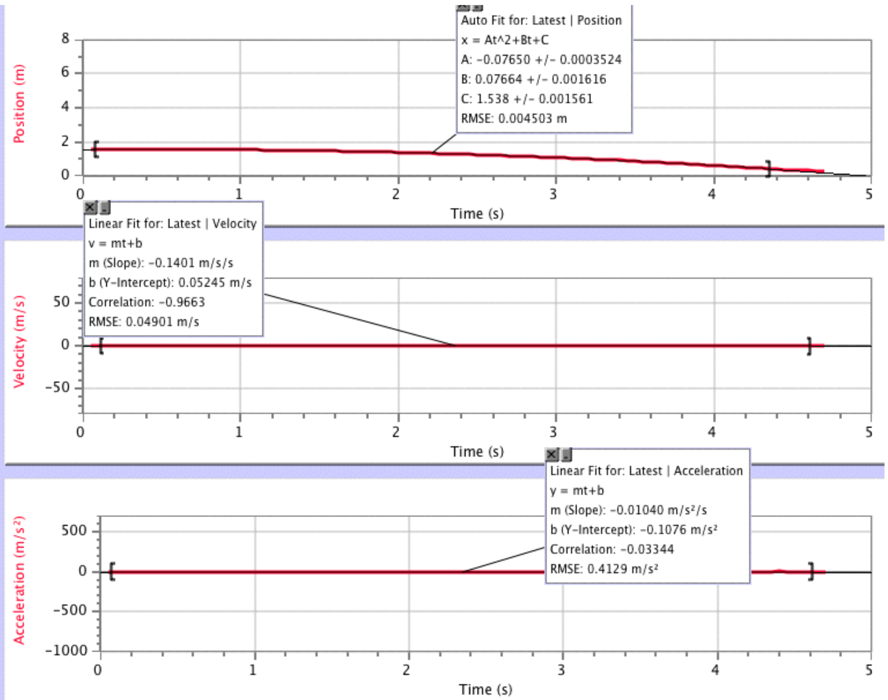
1. Set up the sonic ranger to the laptop and then open logger pro
2. Set up the cart so that it is aimed at the sonic ranger and vice versa
3. now turn the fan on low and see if it goes to the sonic ranger and catch it right before it hits the sonic ranger
4. now do it again but this time record it
5. In logger pro make it so you have three graphs. There should be a graph of position, velocity, and speed.
6. now analyze the graphs so you can find the best fit curve or line
7. Repeat these steps for a fast speed, slow speed with weight, and a fast speed with weight.
8. Slope your flat surface and measure the angle. Be sure that it is a small angle so the slope isn't very steep.
9. Set the cart and the sonic ranger up like in step 1.
10. Record the cart as it is let go down the slope. Now repeat steps 5 and 6 for it.
11. Do steps 8-10 again but with a steeper slope.

**Data:**

## Empty cart fast

| | Time (s) | Position (m) | Velocity (m/s) |
|---|---|---|---|
| 1 | 0.05 | 1.554 | 0.006 |
| 2 | 0.10 | 1.554 | 0.005 |
| 3 | 0.15 | 1.555 | 0.002 |
| 4 | 0.20 | 1.555 | -0.001 |
| 5 | 0.25 | 1.554 | 0.001 |
| 6 | 0.30 | 1.555 | 0.002 |
| 7 | 0.35 | 1.555 | 0.000 |
| 8 | 0.40 | 1.555 | -0.001 |
| 9 | 0.45 | 1.555 | 0.000 |
| 10 | 0.50 | 1.555 | 0.001 |
| 11 | 0.55 | 1.555 | 0.001 |
| 12 | 0.60 | 1.555 | 0.001 |
| 13 | 0.65 | 1.555 | -0.001 |
| 14 | 0.70 | 1.555 | -0.014 |
| 15 | 0.75 | 1.554 | -0.031 |
| 16 | 0.80 | 1.552 | -0.045 |
| 17 | 0.85 | 1.549 | -0.059 |
| 18 | 0.90 | 1.546 | -0.071 |
| 19 | 0.95 | 1.542 | -0.081 |
| 20 | 1.00 | 1.538 | -0.091 |
| 21 | 1.05 | 1.533 | -0.096 |
| 22 | 1.10 | 1.528 | -0.101 |
| 23 | 1.15 | 1.523 | -0.107 |
| 24 | 1.20 | 1.518 | -0.114 |
| 25 | 1.25 | 1.511 | -0.120 |
| 26 | 1.30 | 1.505 | -0.124 |

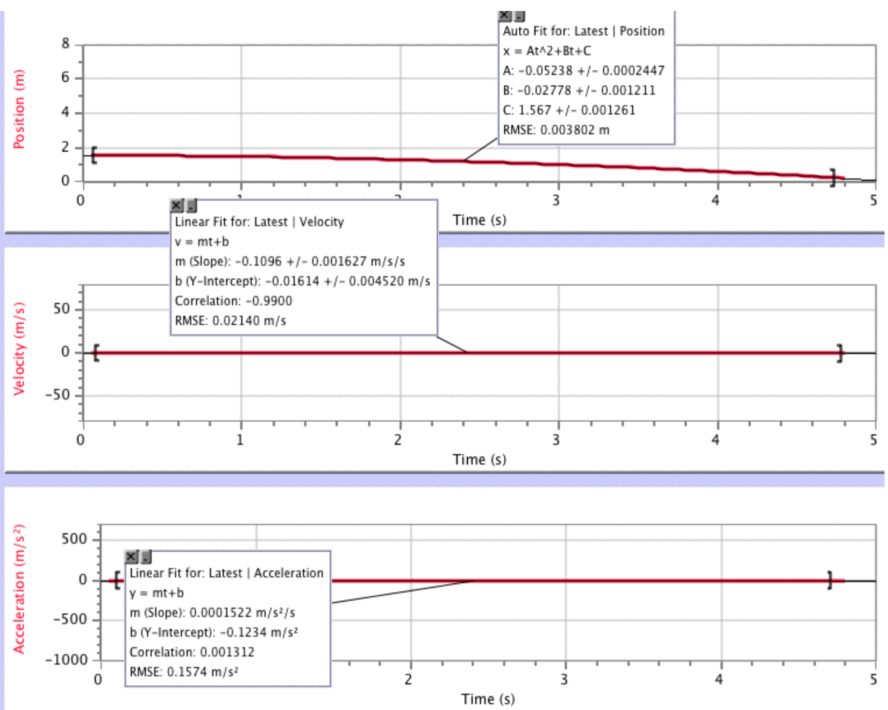
Position m




## Empty cart slow

| | Time (s) | Position (m) | Velocity (m/s) |
|---|---|---|---|
| 1 | 0.05 | 1.555 | 0.018 |
| 2 | 0.10 | 1.557 | -0.003 |
| 3 | 0.15 | 1.554 | -0.007 |
| 4 | 0.20 | 1.555 | 0.019 |
| 5 | 0.25 | 1.557 | 0.029 |
| 6 | 0.30 | 1.559 | 0.003 |
| 7 | 0.35 | 1.558 | -0.037 |
| 8 | 0.40 | 1.556 | -0.084 |
| 9 | 0.45 | 1.548 | -0.105 |
| 10 | 0.50 | 1.545 | -0.109 |
| 11 | 0.55 | 1.538 | -0.114 |
| 12 | 0.60 | 1.533 | -0.108 |
| 13 | 0.65 | 1.527 | -0.113 |
| 14 | 0.70 | 1.521 | -0.117 |
| 15 | 0.75 | 1.516 | -0.121 |
| 16 | 0.80 | 1.509 | -0.123 |
| 17 | 0.85 | 1.503 | -0.123 |
| 18 | 0.90 | 1.497 | -0.115 |
| 19 | 0.95 | 1.492 | -0.107 |
| 20 | 1.00 | 1.486 | -0.098 |
| 21 | 1.05 | 1.482 | -0.090 |
| 22 | 1.10 | 1.478 | -0.101 |
| 23 | 1.15 | 1.473 | -0.129 |
| 24 | 1.20 | 1.465 | -0.163 |
| 25 | 1.25 | 1.456 | -0.180 |
| 26 | 1.30 | 1.447 | -0.191 |

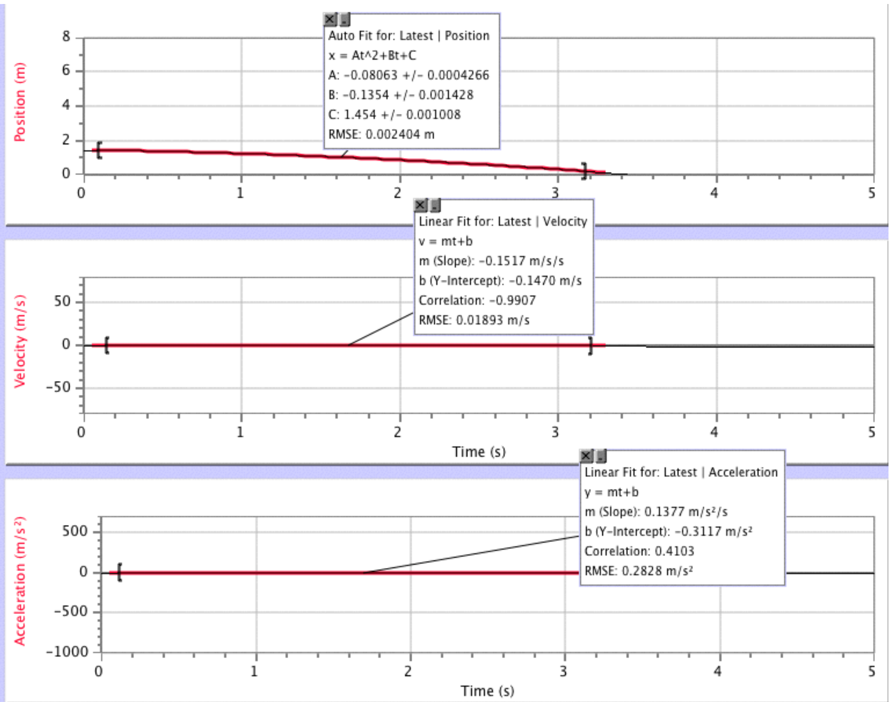
Position m



## Weighted cart fast

| Latest | | | |
|---|---|---|---|
| | Time (s) | Position (m) | Velocity (m/s) |
| 1 | 0.05 | 1.449 | -0.169 |
| 2 | 0.10 | 1.440 | -0.166 |
| 3 | 0.15 | 1.432 | -0.161 |
| 4 | 0.20 | 1.425 | -0.167 |
| 5 | 0.25 | 1.416 | -0.183 |
| 6 | 0.30 | 1.406 | -0.192 |
| 7 | 0.35 | 1.396 | -0.199 |
| 8 | 0.40 | 1.387 | -0.206 |
| 9 | 0.45 | 1.376 | -0.214 |
| 10 | 0.50 | 1.365 | -0.222 |
| 11 | 0.55 | 1.354 | -0.230 |
| 12 | 0.60 | 1.342 | -0.237 |
| 13 | 0.65 | 1.330 | -0.244 |
| 14 | 0.70 | 1.318 | -0.251 |
| 15 | 0.75 | 1.305 | -0.259 |
| 16 | 0.80 | 1.292 | -0.264 |
| 17 | 0.85 | 1.279 | -0.271 |
| 18 | 0.90 | 1.264 | -0.277 |
| 19 | 0.95 | 1.250 | -0.276 |
| 20 | 1.00 | 1.238 | -0.289 |
| 21 | 1.05 | 1.221 | -0.295 |
| 22 | 1.10 | 1.208 | -0.293 |
| 23 | 1.15 | 1.193 | -0.313 |
| 24 | 1.20 | 1.176 | -0.328 |
| 25 | 1.25 | 1.161 | -0.356 |
| 26 | 1.30 | 1.140 | -0.367 |

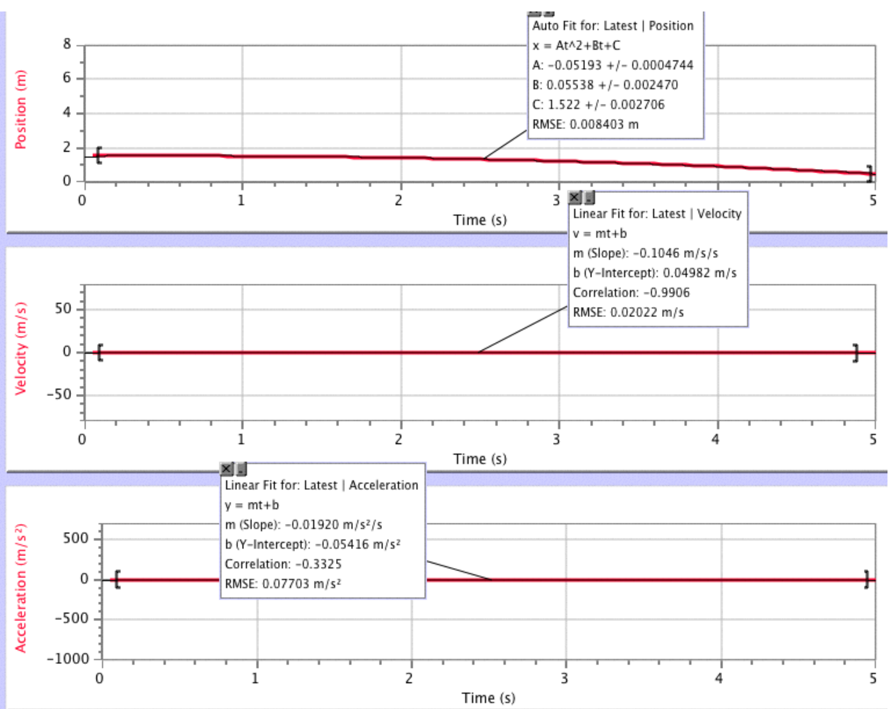
Position m



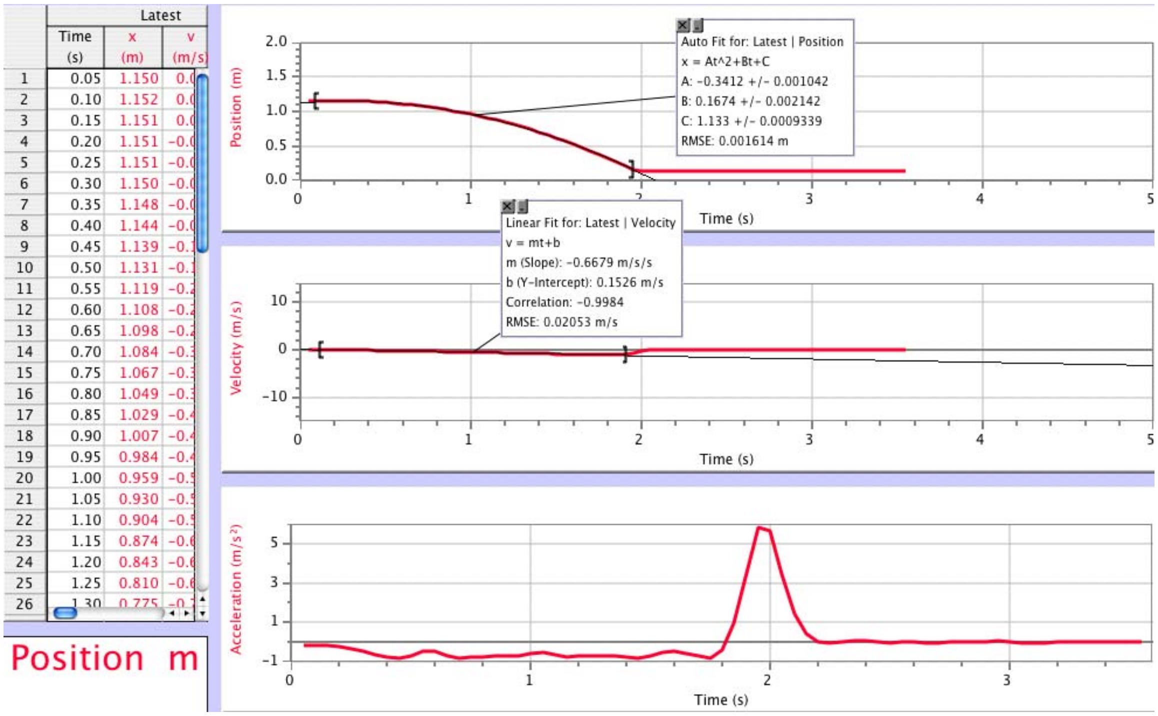

## Weighted cart slow

| Latest | | | |
|---|---|---|---|
| | Time (s) | Position (m) | Velocity (m/s) |
| 1 | 0.05 | 1.542 | -0.002 |
| 2 | 0.10 | 1.542 | -0.002 |
| 3 | 0.15 | 1.542 | -0.002 |
| 4 | 0.20 | 1.542 | -0.001 |
| 5 | 0.25 | 1.542 | -0.002 |
| 6 | 0.30 | 1.541 | -0.002 |
| 7 | 0.35 | 1.541 | -0.001 |
| 8 | 0.40 | 1.541 | -0.004 |
| 9 | 0.45 | 1.541 | -0.005 |
| 10 | 0.50 | 1.541 | -0.009 |
| 11 | 0.55 | 1.540 | -0.017 |
| 12 | 0.60 | 1.539 | -0.023 |
| 13 | 0.65 | 1.538 | -0.028 |
| 14 | 0.70 | 1.537 | -0.035 |
| 15 | 0.75 | 1.534 | -0.042 |
| 16 | 0.80 | 1.532 | -0.048 |
| 17 | 0.85 | 1.530 | -0.055 |
| 18 | 0.90 | 1.527 | -0.059 |
| 19 | 0.95 | 1.524 | -0.061 |
| 20 | 1.00 | 1.521 | -0.065 |
| 21 | 1.05 | 1.517 | -0.069 |
| 22 | 1.10 | 1.514 | -0.072 |
| 23 | 1.15 | 1.510 | -0.078 |
| 24 | 1.20 | 1.506 | -0.081 |
| 25 | 1.25 | 1.502 | -0.081 |
| 26 | 1.30 | 1.498 | -0.084 |

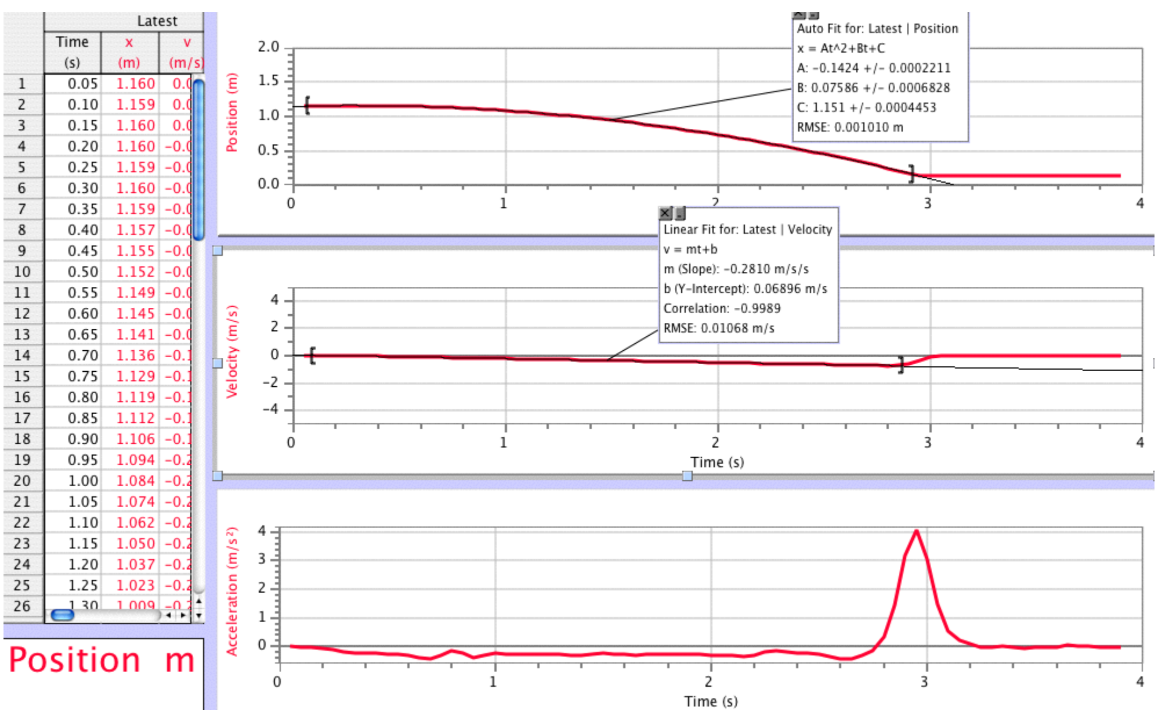
Position m



# High incline slope




# Low incline slope



**Observations:** The graphs all seem to be similar, except for the high and low incline slope graphs. They are different from the rest. Their acceleration graphs are different than the others probably due to the fact that we recorded it all the way through instead of stopping the sonar ranger right when it got there. Also on some of my graphs for acceleration appear to be at zero but they aren't. This is because it got all messed up in the program and I didn't know how to change it. But at least you know where it is because of the analysis of the graph.

**Analysis:** Some of my data doesn't make sense because the scales are off. But most of the other graphs make sense. The acceleration of the graph of the high incline slope and low incline slope has a spike in them because that is where we stopped the carts. Some error may be from the sonar ranger because if you too got to close to it, it would get its measurements all messed up. Another thing is that I may have not got accurate readings because the sound waves weren't bouncing off of the cart correctly or aimed right. My graphs look ok to. The faster carts also had faster accelerations than the slow ones, so my graphs where somewhat accurate.

**Conclusion:** we did what we set out to do. We analyzed force using graphical analysis. Ways to improve this is to get better sonar rangers, get a better cart so that it is easier to aim at so the sound waves bounce back, or get the cart on tracks so that it goes in a perfectly straight line.

A. Acceleration found by multiplying the position graph's first term of the equation of the curve fit by two.
B. Acceleration found by taking the slope of the velocity graph
C. Acceleration found by looking at the acceleration graph

<u>Acceleration</u>

| **Empty cart fast:** | **Empty cart slow:** | **Weighted car fast:** | **Weighted car slow:** |
|---|---|---|---|
| A) 0.153 | A) 0.105 | A) 0.161 | A) 0.104 |
| B) 0.14 | B) 0.1096 | B) 0.152 | B) 0.105 |
| C) 0.108 | C) 0.123 | C) 0.312 | C) 0.054 |

| **High inclined slope:** | **Low inclined slope:** |
|---|---|
| A) 0.6824 | A) 0.285 |
| B) 0.668 | B) 0.281 |
| C) 0.75 | C) 0.25 |

<u>Weight of the cart</u>

**Empty cart:** 800.13g or 0.8kg **Weighted Car:** 1300.13g or 1.3kg

<u>Angles of slopes</u>

**High incline:** 6.28° **Low incline:** 3.43°

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?
2. Determine the force from the fan on low and high speeds
3. If you allowed the ramp to bounce, what would the v/t graph look like and why?
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?

1. It is related because gravity is the only force causing it to move on the inclined cart. It can be written in the equation $a=g\cdot\sin(\theta)$ meaning acceleration equals gravity times sine of the angel of the inclined area. The gravity that I got in my experiment for the low incline is 4.75 and the one I got for the high incline is 6.24, but both of them should be 9.8 instead. I got ties number by dividing the acceleration by the sine of the angle.
2. The force of the fan on low speed is about 0.085 N. The force of the fan on high speed is about 0.195 N.
3. It would look like parabolas bouncing or a bunch of hills getting smaller as they go further. The velocity would go positive then negative as the cart bounced.
4. The curves would be longer or stretched out width wise.