Magic Mountain overview

- On Monday 4/11:
  - **Go to Rm 109 at 8:30 AM at the beginning of the day (do not go to A Period)**
  - **Once there,** we will take attendance, hand out tickets, and talk logistics.
  - If you're coming home on the bus, you need to go there on the bus. If you're staying late, you'll be in one of the vans.
  - At the park:
    - Take whatever data you need for your problem, with your partner. This shouldn't take a terribly long time if you have a plan going in.
    - Spend the rest of the time roaming the park and having fun!

- When you return:
  - Lab report will be due on **Thursday, April 21**. This is a typed, formal report, following the guidelines on the handout. It is worth 40 lab points (double a normal lab). **EACH STUDENT NEEDS TO WRITE UP THEIR OWN REPORT.**
    - We'll go through that more specifically on Friday. Don't leave the write-up until the 21st!

Physics of Amusement Parks

Tricks, tools, and techniques to use for measuring and analyzing data at the park

Courtesy of Mr. White - thanks!

Details, first...

- Meet in Poly 109 at 8:30 AM - check in with your teacher as you come in
- Arrive at park ~10 AM, get your ticket
- Park opens 10:30 AM
- Special van to leave at 1:00 PM for selected musical students
- Meet again at entrance at 1:45 PM to check in
- Bus leaves at 2:00 PM, returns by 3:00 PM
- Meet again at entrance at 4:45 PM
- Vans leave at 5:00 PM, return by 6:00 PM
- Physics stuff to bring: calculator, problem, pen/pencil, smartphone (or friend with smartphone), your problem
- Other stuff to bring: $$$, sweater or jacket, clothes that dry easily, sunglasses, sunscreen

Your Problem!

When you get it...

- Read through the details
- Your problem statement is at the bottom
- Take a moment to think about what strategies you'll need to help you solve your particular problem
- You'll want to discuss your problem with others:
  - general strategy?
  - data to collect? how to collect?
  - preliminary calculations at park!
- General techniques: kinematics, $F_{net}=ma$, conservation of energy, conservation of momentum...
- Panic at the park? Call one of us...

Measuring Time

- Having some means of measuring *time* is vital to your success: bring a stopwatch of some sort to the park.
- If the object you're trying to measure has some periodic movement, you can reduce error by timing a series of movements, then dividing by the number of movements to get the time for a single motion.

Measuring Length/Height/Distance

Measuring length is best accomplished by using one of two techniques:

1. If the object is physically accessible, pace alongside it and use your known pace distance to calculate the length.

This fountain has a width of 5.5 of my paces:

$$\frac{5.5\,paces}{1} \times \frac{0.85m}{1\,pace} = 4.7m$$

Measuring *Your* Pace

Walk "normally" (stride?) along a 10 meter distance in the hallway and count the number of steps you took. Turn around and do it again. Average the two step counts, and calculate *meters/step* to identify your own pace.

Write this down in your phone someplace.

Measuring Length/Height/Distance

2. If the object is located near something else that you can use as a reference, *estimate* its length/height, and justify your estimation.

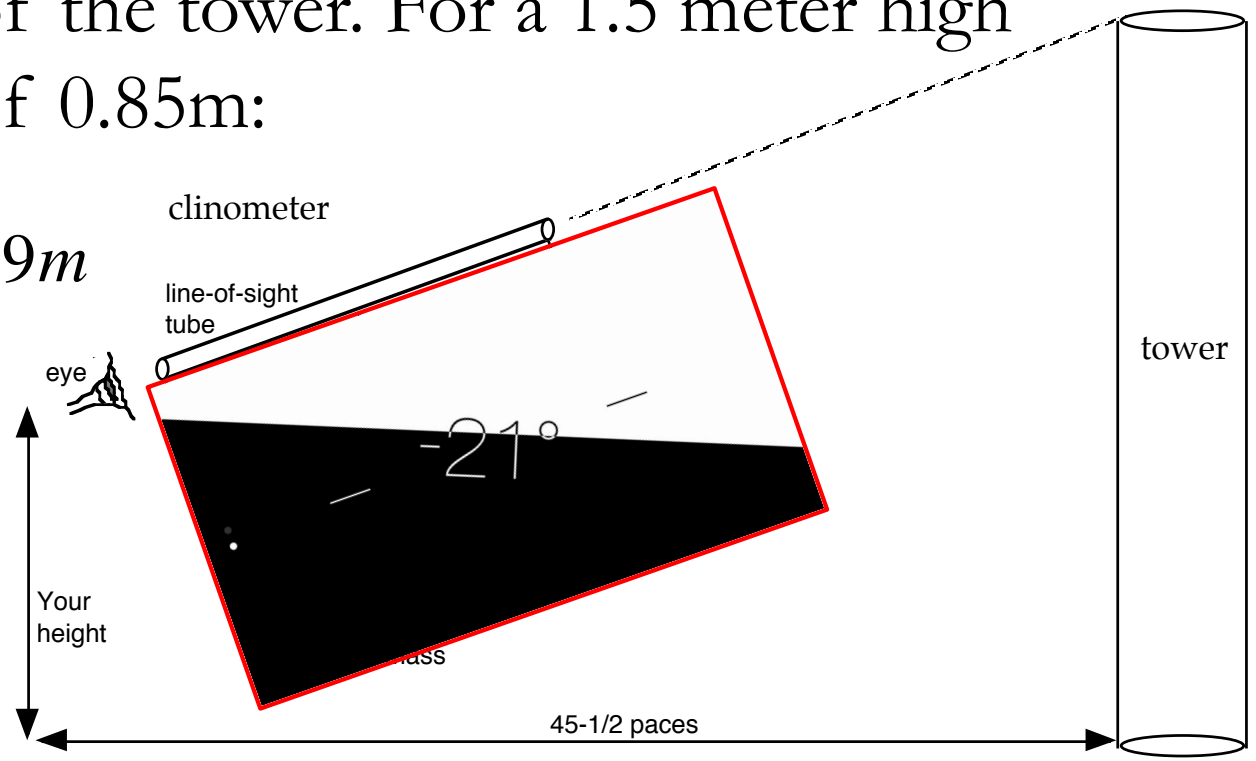
$$\frac{\sim 2meters}{1guy} \times \frac{4guys}{1parachute} \approx 8m$$

$$\frac{\sim 2meters}{1car} \times \frac{20cars}{1wheel} \approx 40m$$

Measuring Length/Height/Distance

3. Another way involves using an angle measurement to get the total height of the tower. For a 1.5 meter high person with a pace of 0.85m:

$$\frac{45.5\,paces}{1}\times\frac{0.85m}{1pace}\approx 39m$$



$$\theta = 20°$$

$$\frac{h}{39m} = \tan\theta$$

$$h = 39m(\tan 20°) = 14m$$

$$h_{total} = 14m + 1.5m \approx 16m$$

Calculating Velocity

Again, there are several techniques that may be used:

1. A slow moving object of a known length can be timed as it passes a fixed point. Knowing the *distance* traveled in a measured *time*, the *average velocity* at that point can be calculated. (Remember the air glider cart?)

$$t = 2.78s$$

$$l \ \ of \ \ \ train \ \ (estimated) = 12m$$

$$v = \frac{l}{t} = \frac{12m}{2.78s} = 4.32m/s$$

Calculating Velocity

2. If you are able to consider friction negligible, you might consider using conservation of energy...

Clearly, some of your measurements will be approximations, which is okay, as long as you:

a. Make sure that they're *good* approximations, and

b. Make sure that you *explain* how you approximated, by

   i. showing calculations, and

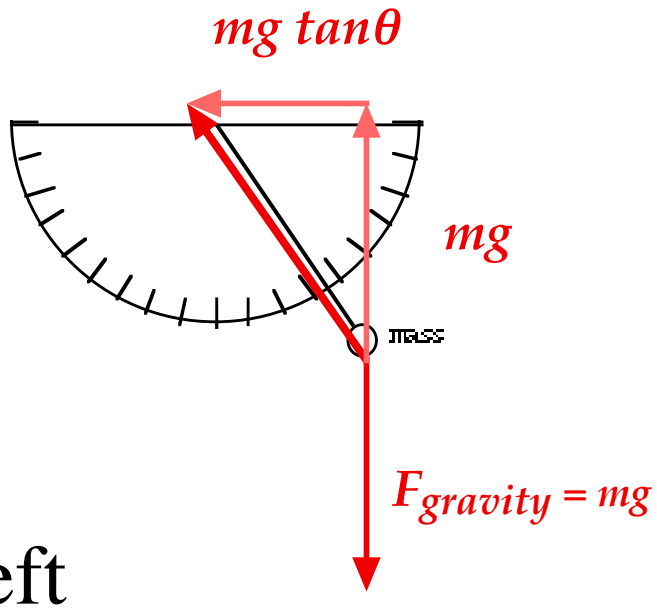
   ii. blurbing well

Calculating Velocity

3. If you measure it over a significant distance using GPS-based speedometer?

Measuring Horizontal Acceleration

Use a *horizontal accelerometer* as shown. What is the magnitude and direction of the acceleration of the accelerometer shown here?



$$F_{net} = ma$$

$$mg\tan\theta = ma$$

$$g\tan\theta = a$$

$$a = 9.8\tan 35° = 6.86 m/s^2, \text{ to the left}$$

Measuring Vertical Acceleration

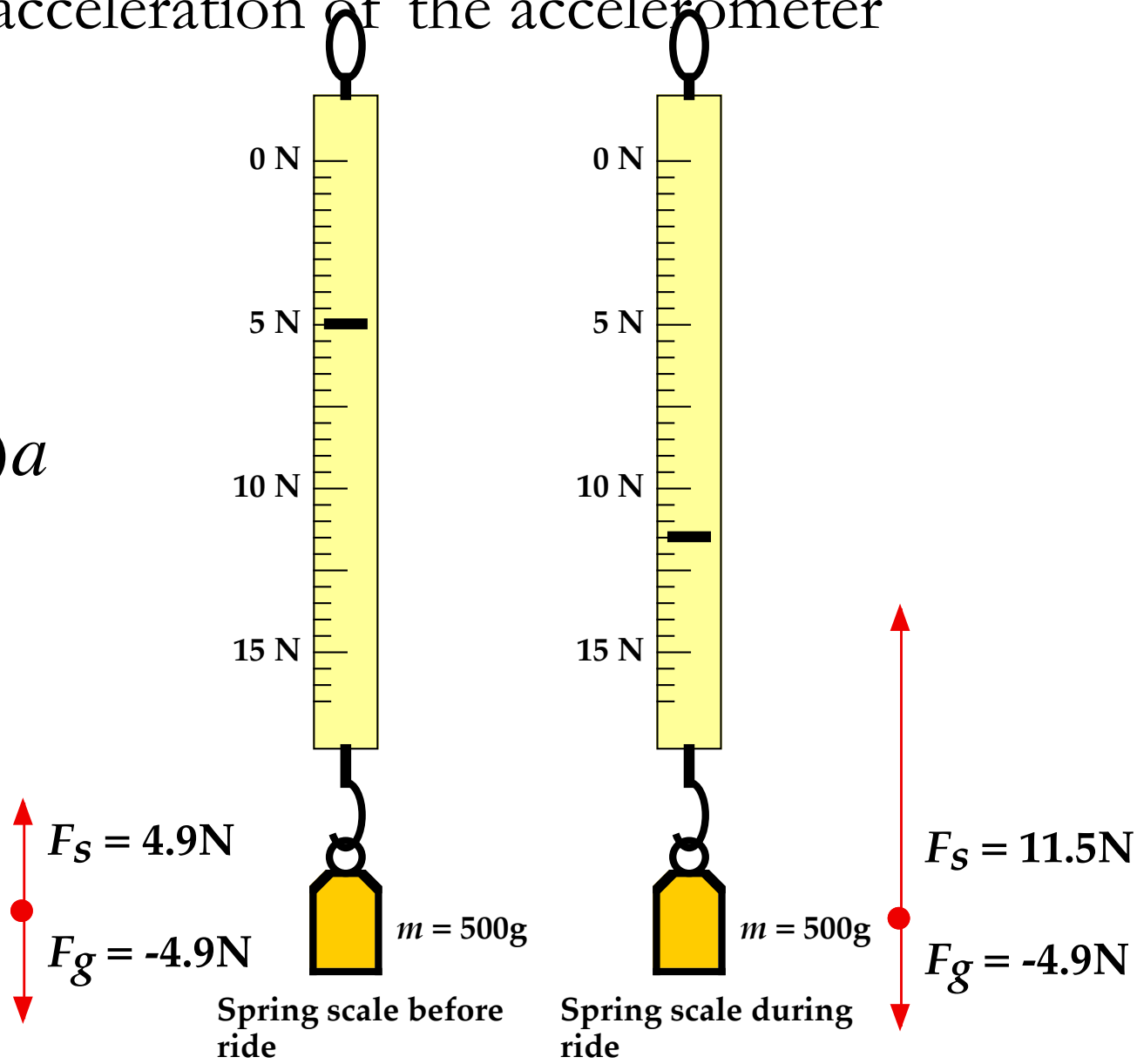
Use a *vertical accelerometer* as shown. What is the magnitude and direction of the acceleration of the accelerometer shown here?

$$F_{net} = ma$$

$$F_s - F_g = ma$$

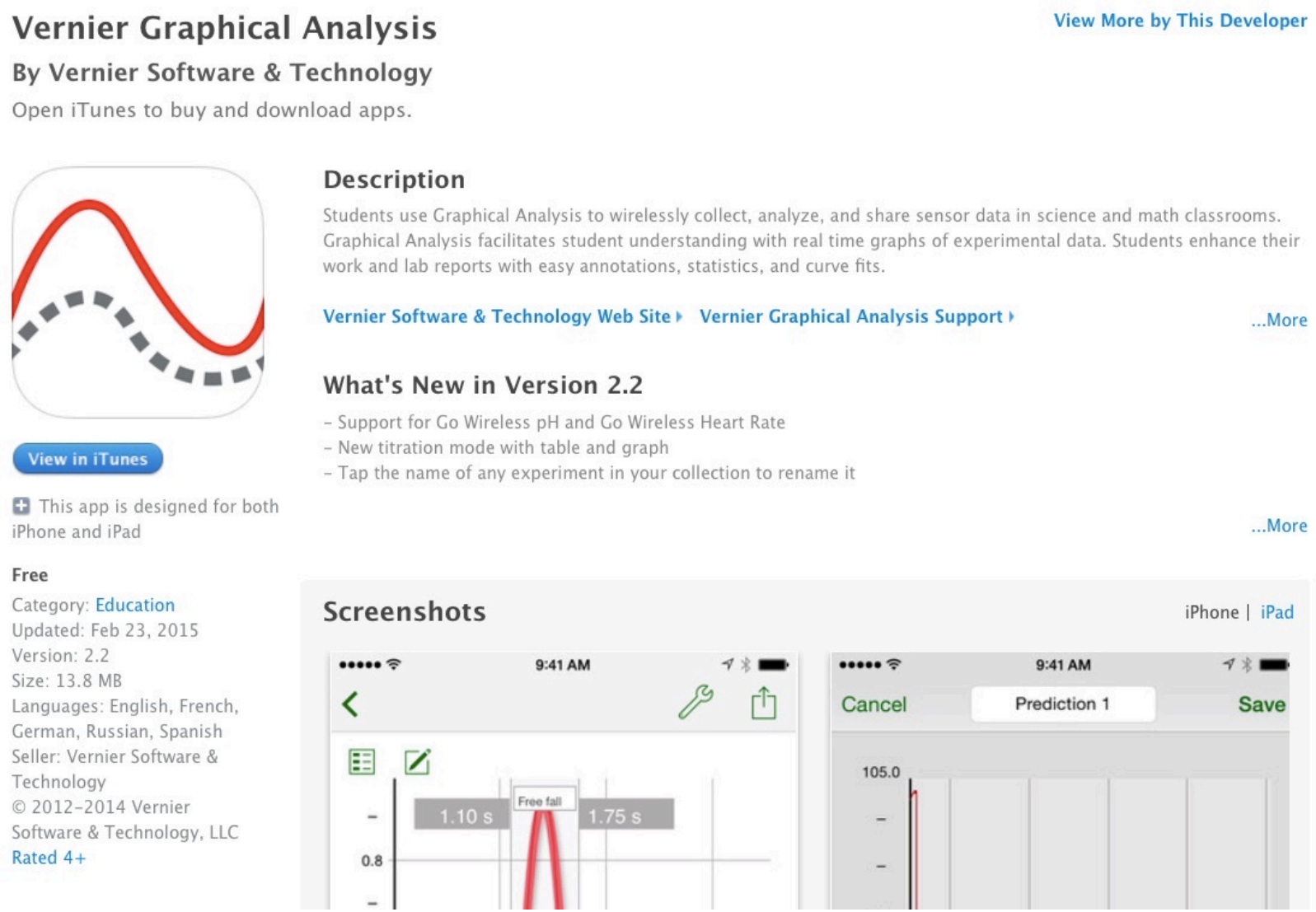
$$11.5 - 4.9 = (.5kg)a$$

$$a = 13.2m/s^2, \ up$$



Smartphone Accelerometers

Smartphones have accelerometers 3-d accelerometers in them. Using an app allow you to access that data, but you'll need to interpret it.



What does Accelerometer Data look like?

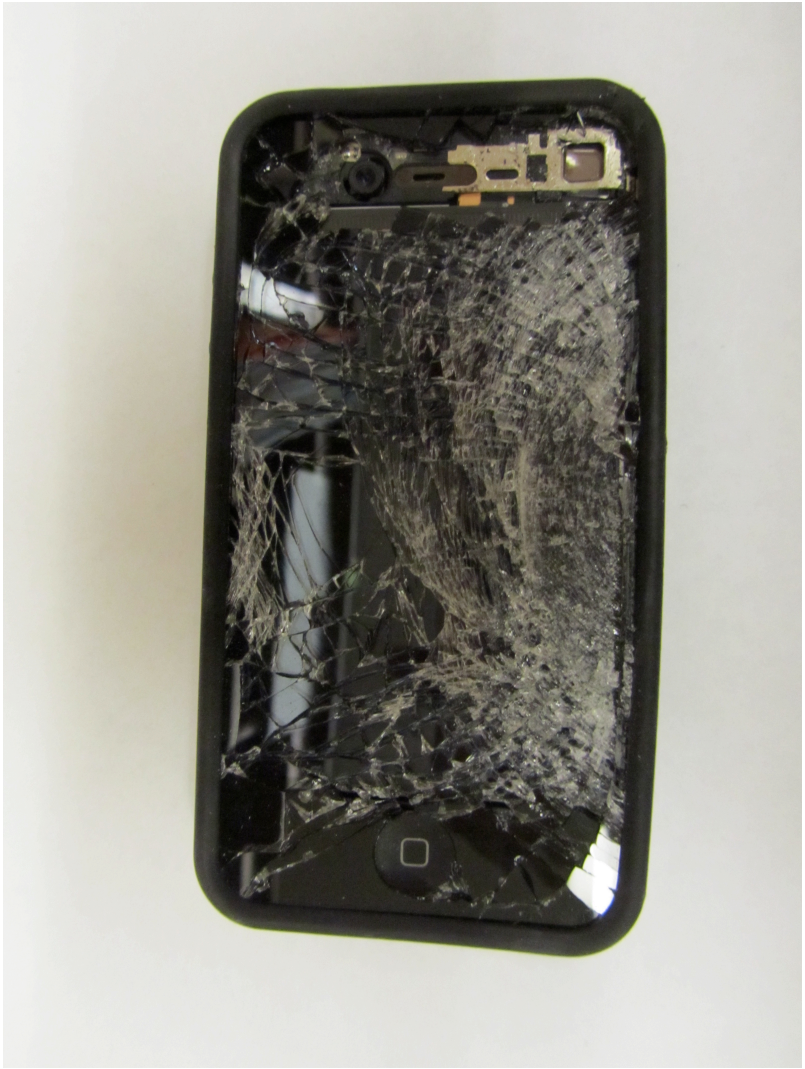
Make sure you do a few tests with your phone so that you know what good data looks like, and how to interpret it!

AirPlay Demo?

Don’t Lose Your Phone or Your Stuff!

Fletch’s phone after falling out of shirt pocket on Superman Ride—don’t do that . . . it’s bad for the phone . . .

And don’t leave backpacks lying around at the gates to rides…



What does your Lab Report look like?

The final report will be word-processed, with a paper version submitted in class and a PDF version emailed to the instructor by **Friday, April 22**

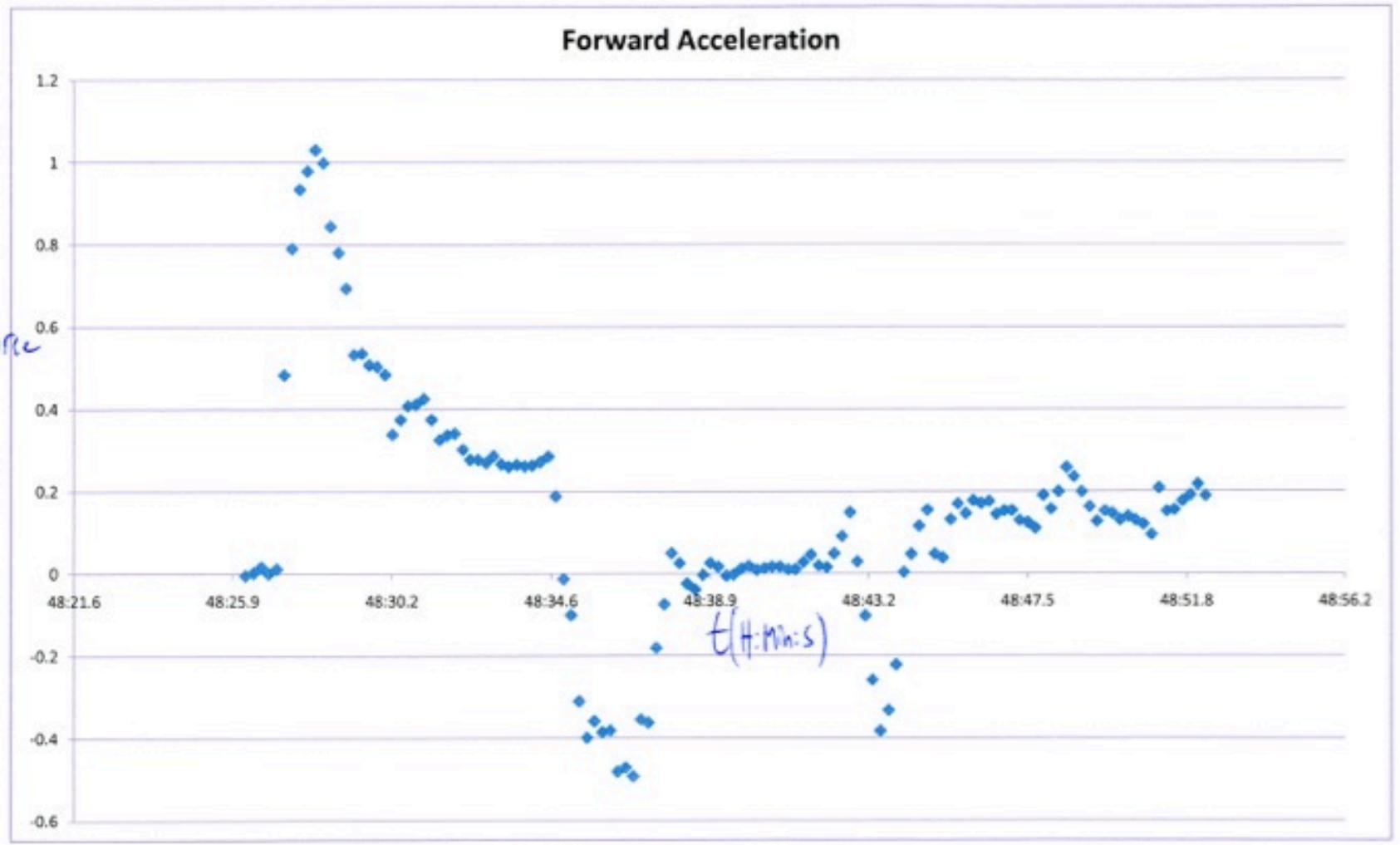
The report should be 3-5 pages in length, and include:

- *Purpose:* State the task you are assigned.
- *Materials*: List the materials used.
- *Procedure*: Write a brief summary of the procedure you developed to answer your problem.
- *Data*: Include data tables of ALL measured values, and annotated photos or diagrams used in your data collection.
- *Calculations*: Show how you calculated any values used in developing your solution to the problem. Be sure to provide plentiful blurbs (comments) on your strategy. Clearly state your final answer to the problem at then end of this section.
- *Experimental Error Discussion*: Discuss significant sources of error, their likely effect on your results, and provide quantitative analysis where possible regarding the degree of error.
- *Summary*: Include a brief restatement of your problem, the procedure used to solve the problem, the results of your analysis and calculations, and experimental error.

Attach any raw data that you took to the back of your report.

The report is worth 40 lab points (2x a normal lab). Don't leave this until the night before!

Example of Raw Data



Your task for Thursday:

- With your partner, decide which **ONE** of the two questions you want to tackle. You are welcome to brainstorm and chat about it, but **independently you must write up your answers to the prompt below.**

- For the question you have decided to tackle, consider how you would go about determining the answer. This means:

  a. What principle(s) and equation(s) can be used to find a solution? How will they be helpful? What assumptions do you need to make to use them? Are those assumptions reasonable?

  b. What measurement(s) will you need to take in order to use those principles? How will you take those measurements? How will you ensure they are as accurate as possible?

- Please answer as completely as possible, as this allows your instructor to give you the best feedback on whether you're on the right track or have missed a key point. **Please make sure you have stated the original question in its entirety at the top of your submission. This is worth 5 homework points**.

I will take a look before Thursday's class at what you've turned in and give you feedback on whether you're on the right track, need to consider something else, etc. I'm grading this on completeness, thoughtfulness, and something in the ballpark of correct, not whether you've got a 100% stellar procedure already down. Don't spend ages on this - brush up on the relevant topic for a few minutes, sketch or jot down your ideas with enough detail that I can understand your logic (bullet are fine, but blurb!), and we'll go from there.