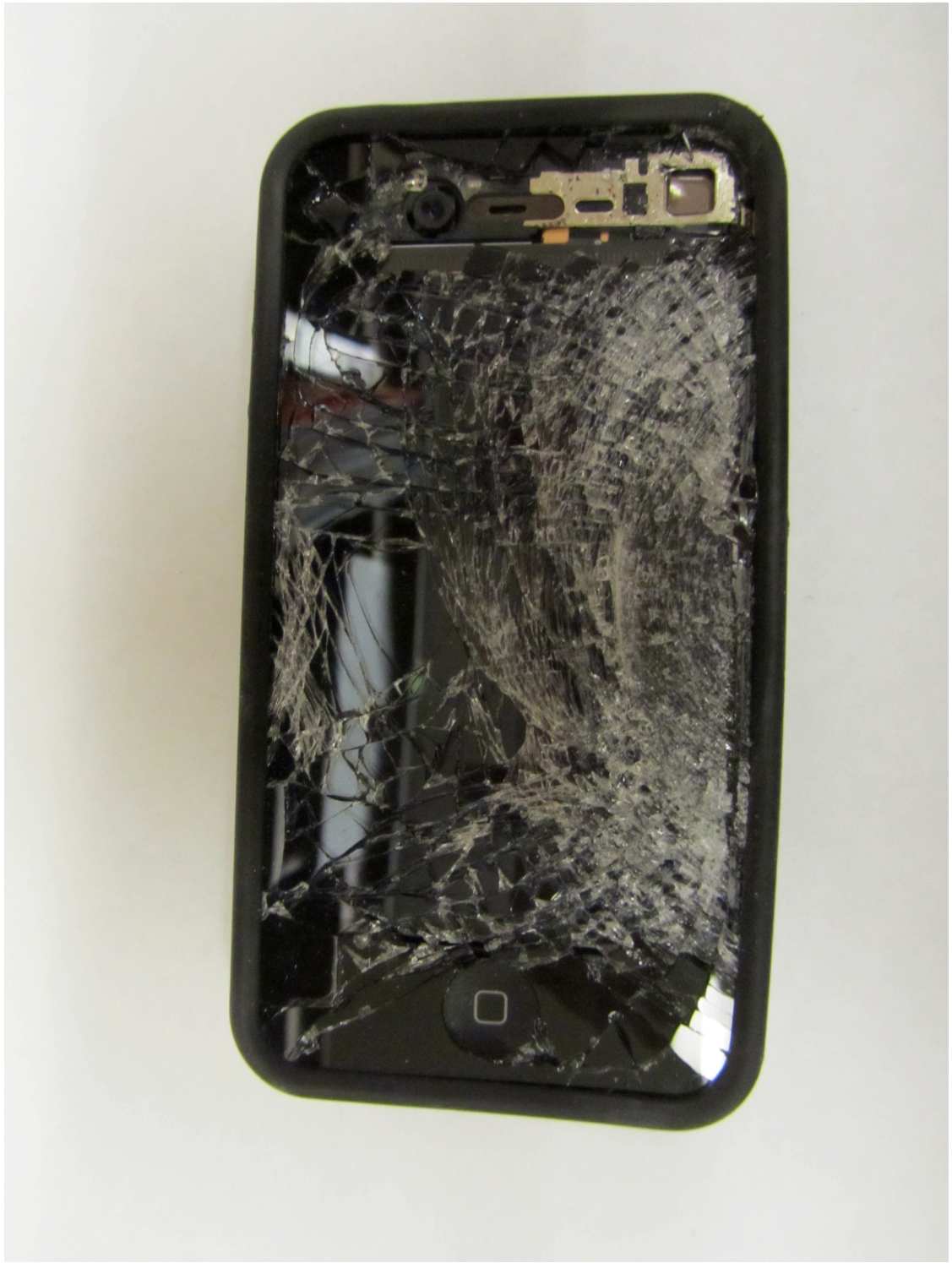


Fletch's phone after falling out of shirt pocket on Superman Ride—don't do that . . . it's bad for the phone . . .

Physics of Amusement Parks

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

Magic Mountain overview

- On Monday 4/3:
  - **Go to Rm 109 at 8:30 AM at the beginning of the day**
  - **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 **Wednesday, April 12**. 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 11st!

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
- Meet again at entrance at 1:45 PM to check in
- Bus leaves at 2:00 PM, returns by 3:00 PM
- For staying folks, 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, some way to record data, phone (or friend with phone), 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.

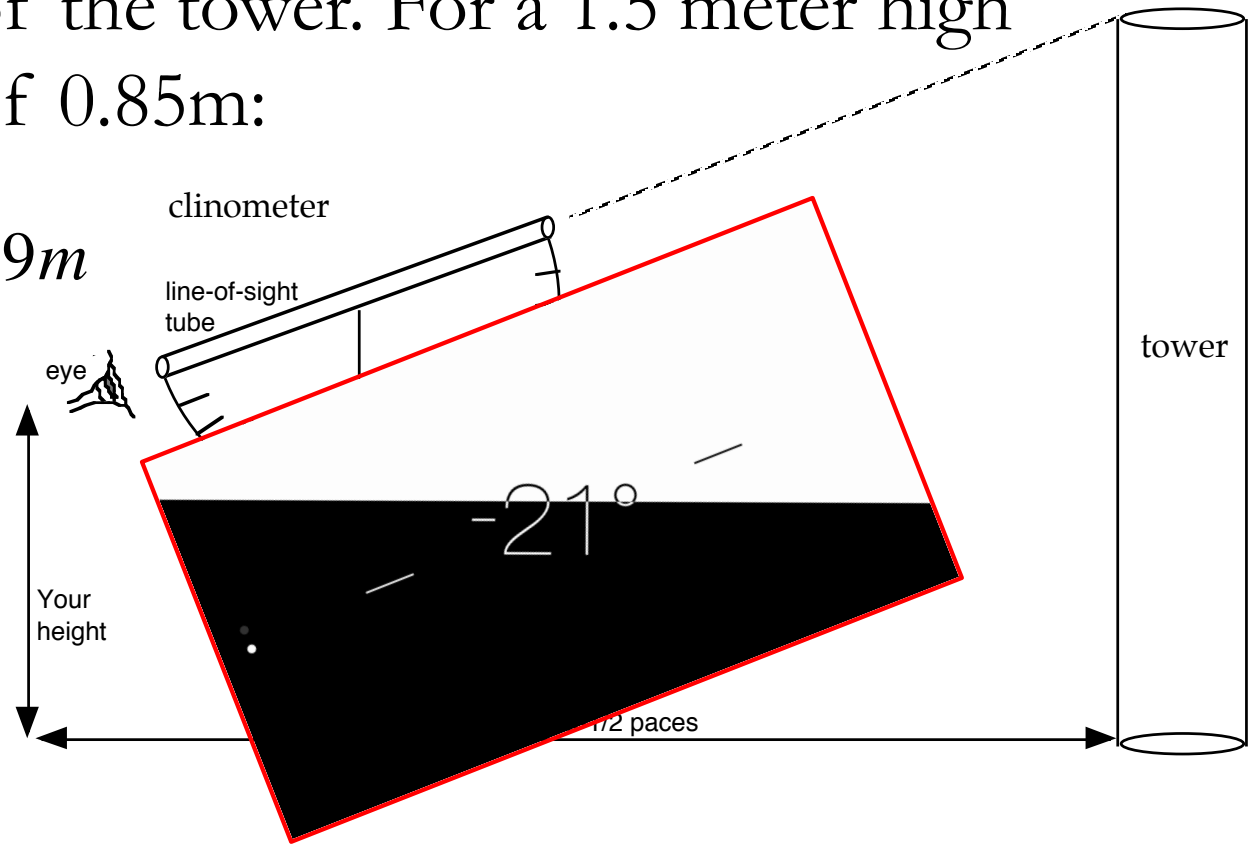
$$\frac{\sim 2meters}{1guy} \times \frac{4guys}{1parachute} \approx 8m$$

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

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:

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



$$\theta = 20°$$

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

$$h = 39m(\tan 20°) = 14m$$

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

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

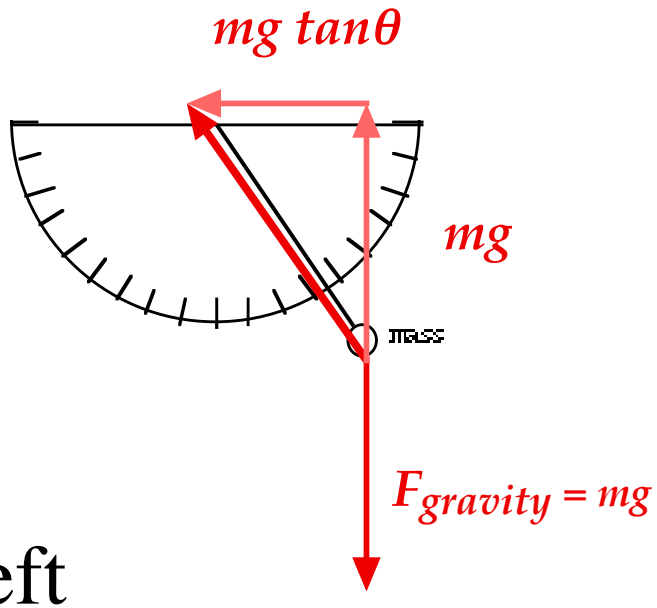
   ii. blurbing well

Calculating Velocity

3. If you measure it over a significant distance using GPS-based speedometer? (don't do this—it's more fun to do it old-school)

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

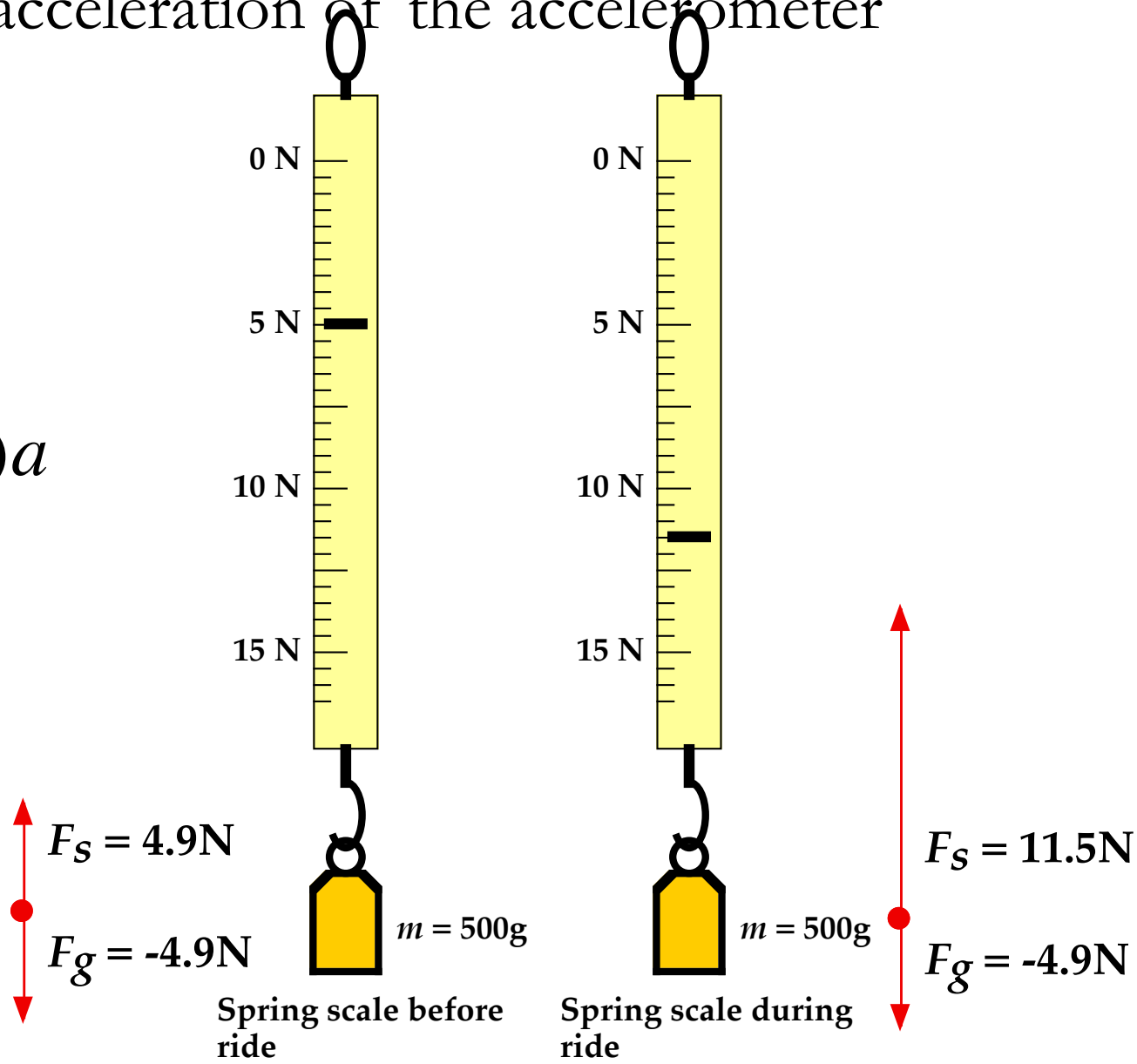
Use a *vertical accelerometer* as shown. What is the magnitude and direction of the acceleration of the accelerometer shown here?

$$F_{net} = ma$$

$$F_s - F_g = ma$$

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

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

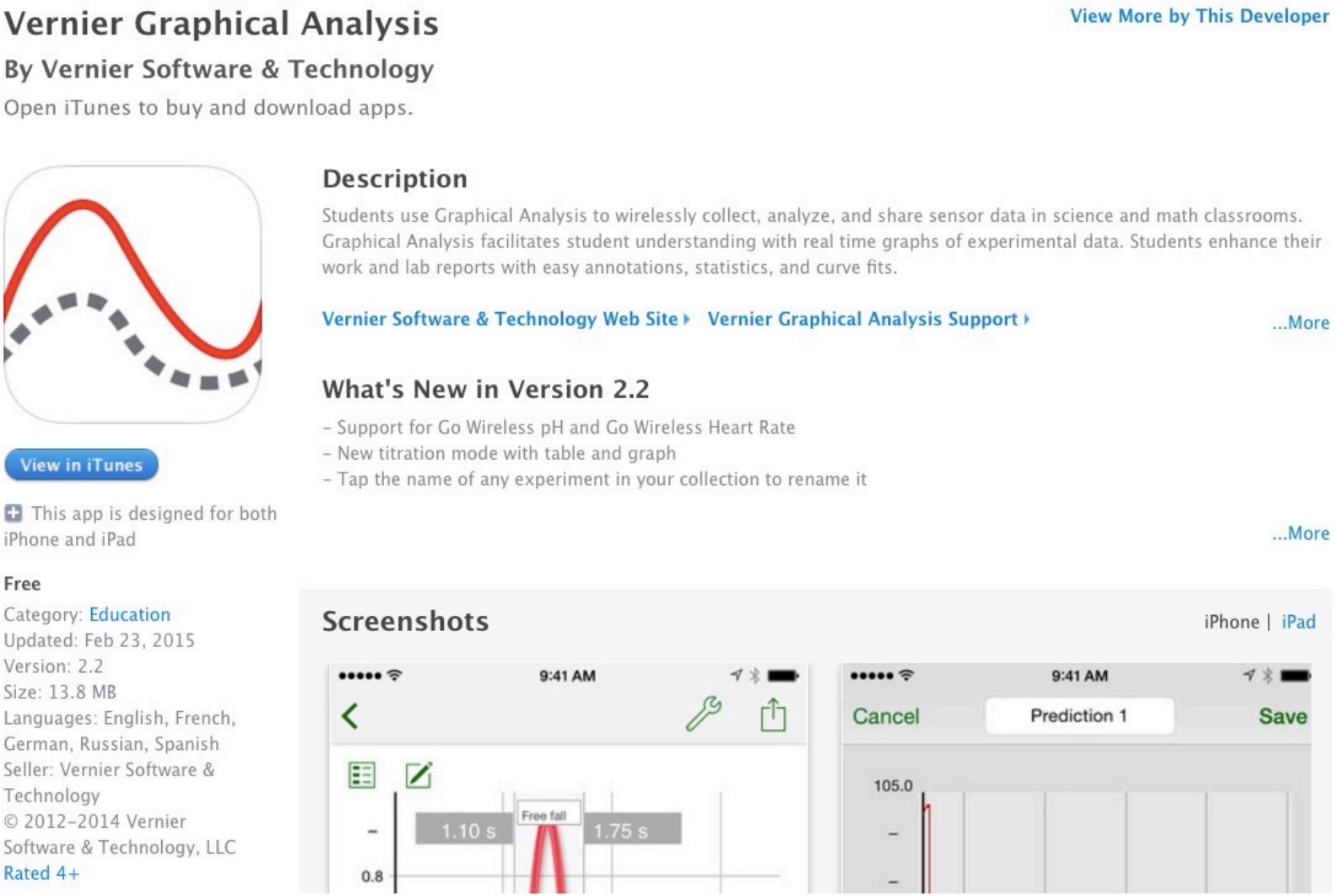


Smartphones

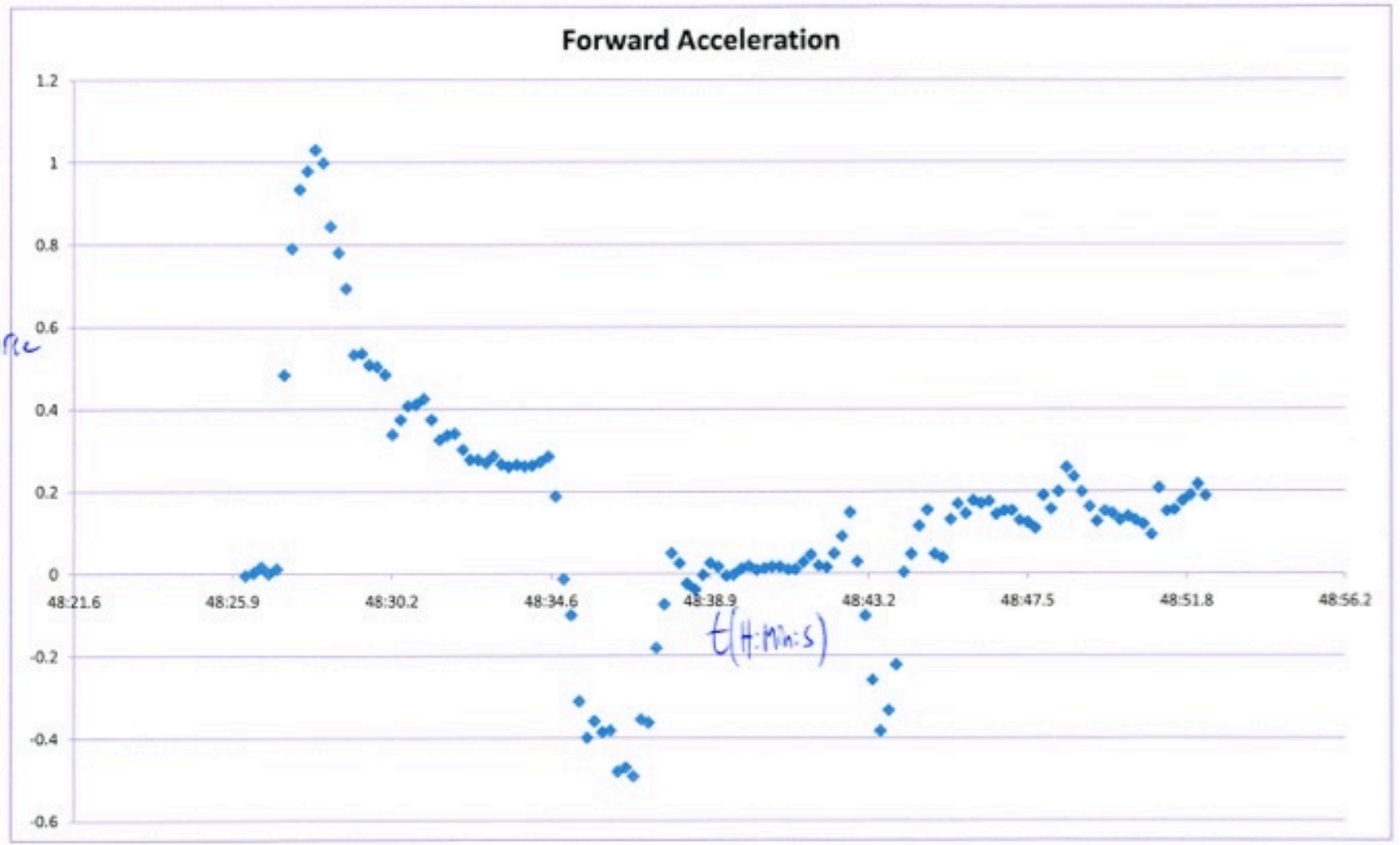
Use to get velocity: If you can approximate the distance an object travels over some time interval, you can use a cell phone to video the object's motion, then count frames to determine the amount of time it took to travel the distance. With the distance and time, you can determine the velocity.

Smartphone Accelerometers

To determine accelerations: There are smartphone apps that can be used to determine accelerations (specifically, Vernier's Graphical GW app). There are problems with these, though (don't use them).



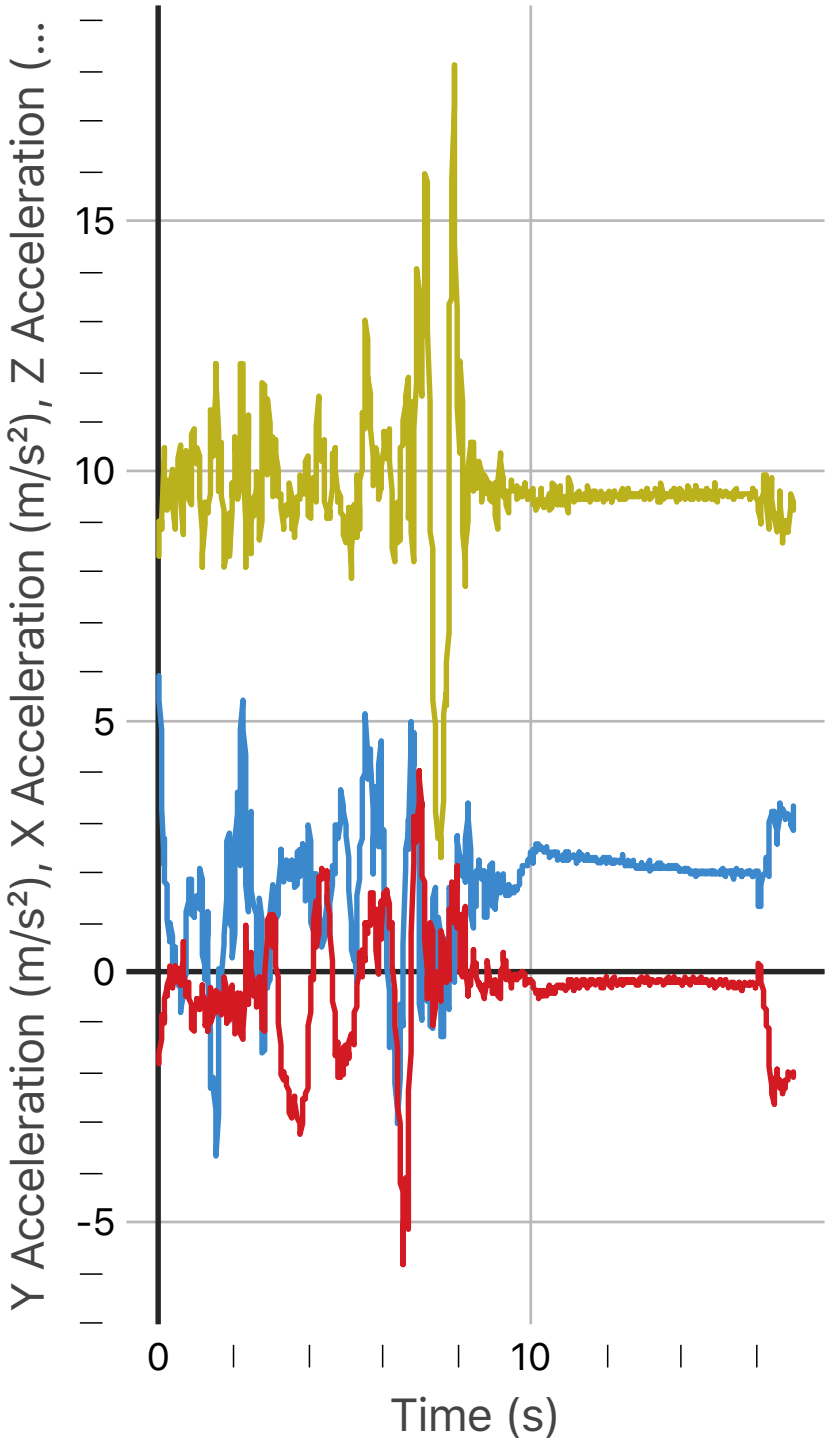
Example of Data Display



Smartphone Accelerometers

Specifically, most of the apps are orientation driven, which means that if they are not held exactly in the horizontal, you will get a component of gravity adding into your data (notice that the y-data for the graph to the right is 9.8 m/s/s—that's due to gravity).

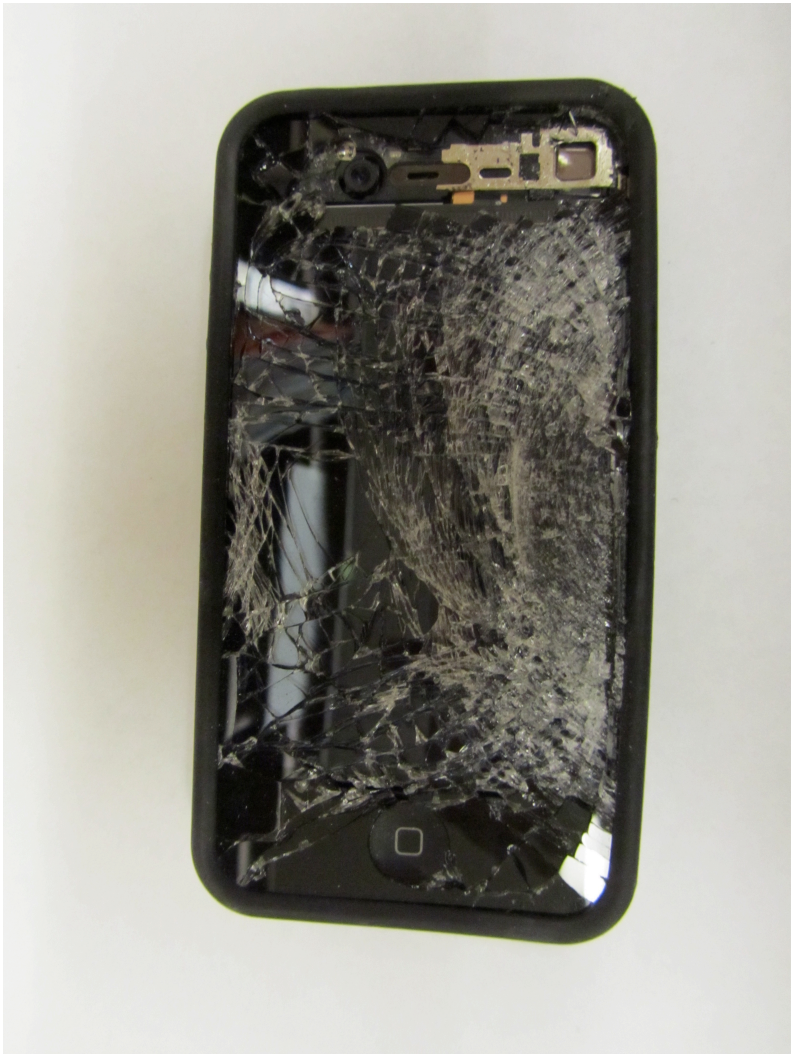
Translation: don't use these. It is too hard to extract meaningful data from them.



Don't Lose Your Phone
or
Your Stuff!

Fletch on Superman . . .

Student backpack (we've had stuff stolen at the park before . . .



What does your Lab Report look like?

- 3-5 pages for the Honors folks, 4-10 pages for the AP folks . . . word-processed. UNDERSTAND, I don't have the solutions to any of the problems. All I will have to go on is what you write . . .
- Cover page, including partner's name, period AND A STATEMENT OF YOUR PROBLEM!
- General lab report format, with well-presented documentation
  - data tables, with clear explanations of assumptions where estimation involved
  - graphs
  - photos with annotations, highlights, explanations
  - calculations with BLURBS
  - conclusions clearly explained
  - sources of error explained clearly
  - possible references to external sources of information, with percent error or percent difference calculated

Your task before you go:

- With your partner, decide which **ONE** of the two questions you want to tackle. Brainstorm and chat about what you see.

- 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?

- If you wish feedback from me before you leave, answer the questions above as completely as possible. **Please make sure you have stated the original question in its entirety at the top of your page.** I will look on Friday if you wish feedback.