# Physics of Amusement Parks

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

# Details, first...

- Meet in Poly 109 at 9:05 AM
- Arrive at park ~10 AM, get your ticket
- Park opens 10:30 AM
- Meet again at entrance at 1:30 PM to check in
- Bus leaves at 1:45 PM, returns by 2:45 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 me...

# 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.

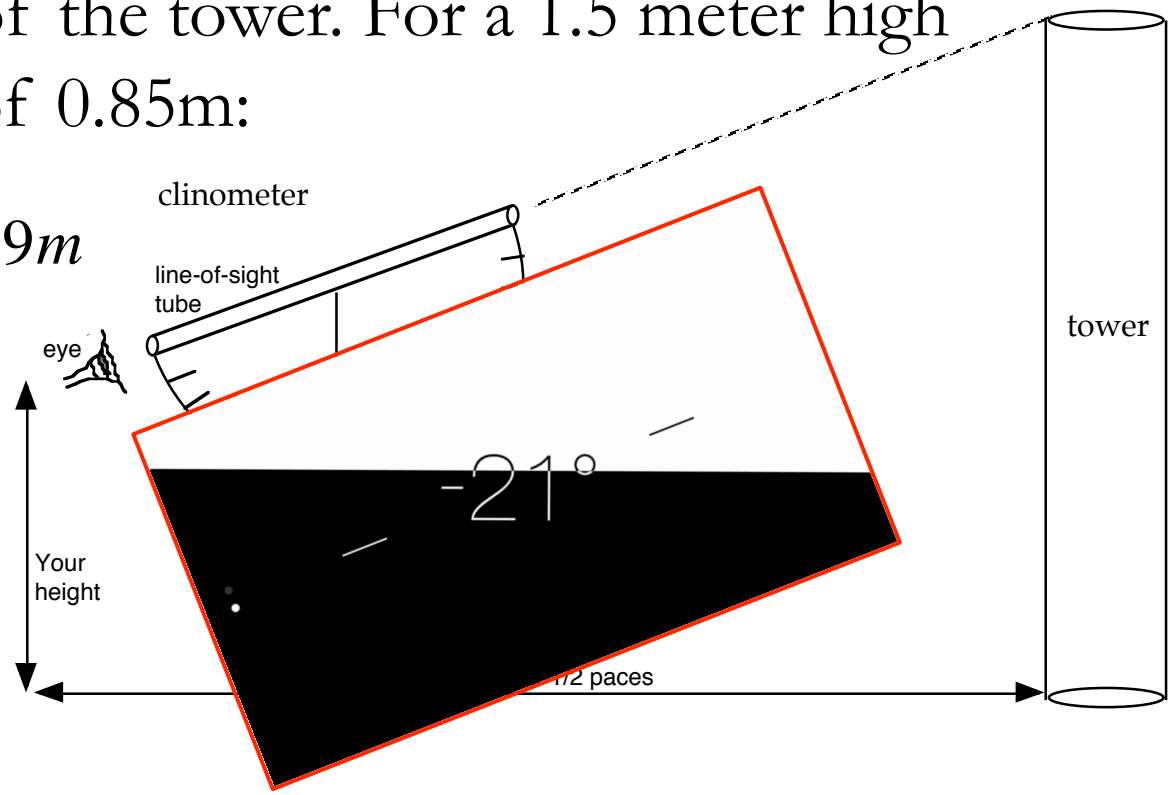
$$\frac{\sim 2meters}{1guy} \times \frac{4guys}{1parachute} \approx 8m$$

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

# 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

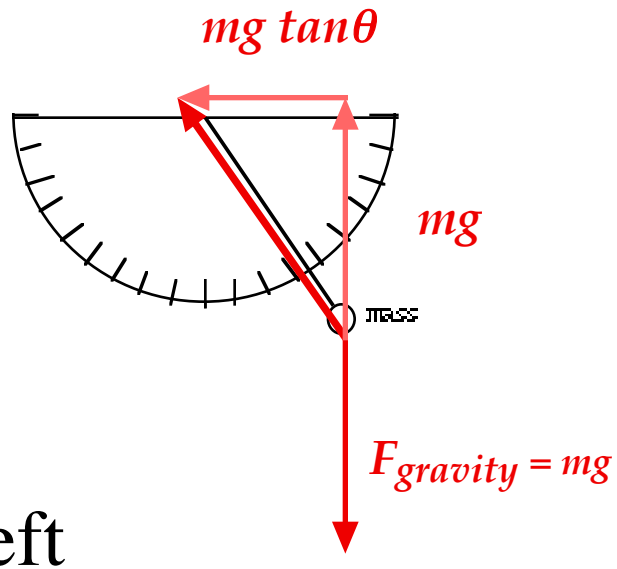
   ii. blurbing well

# Calculating Velocity

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

# 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

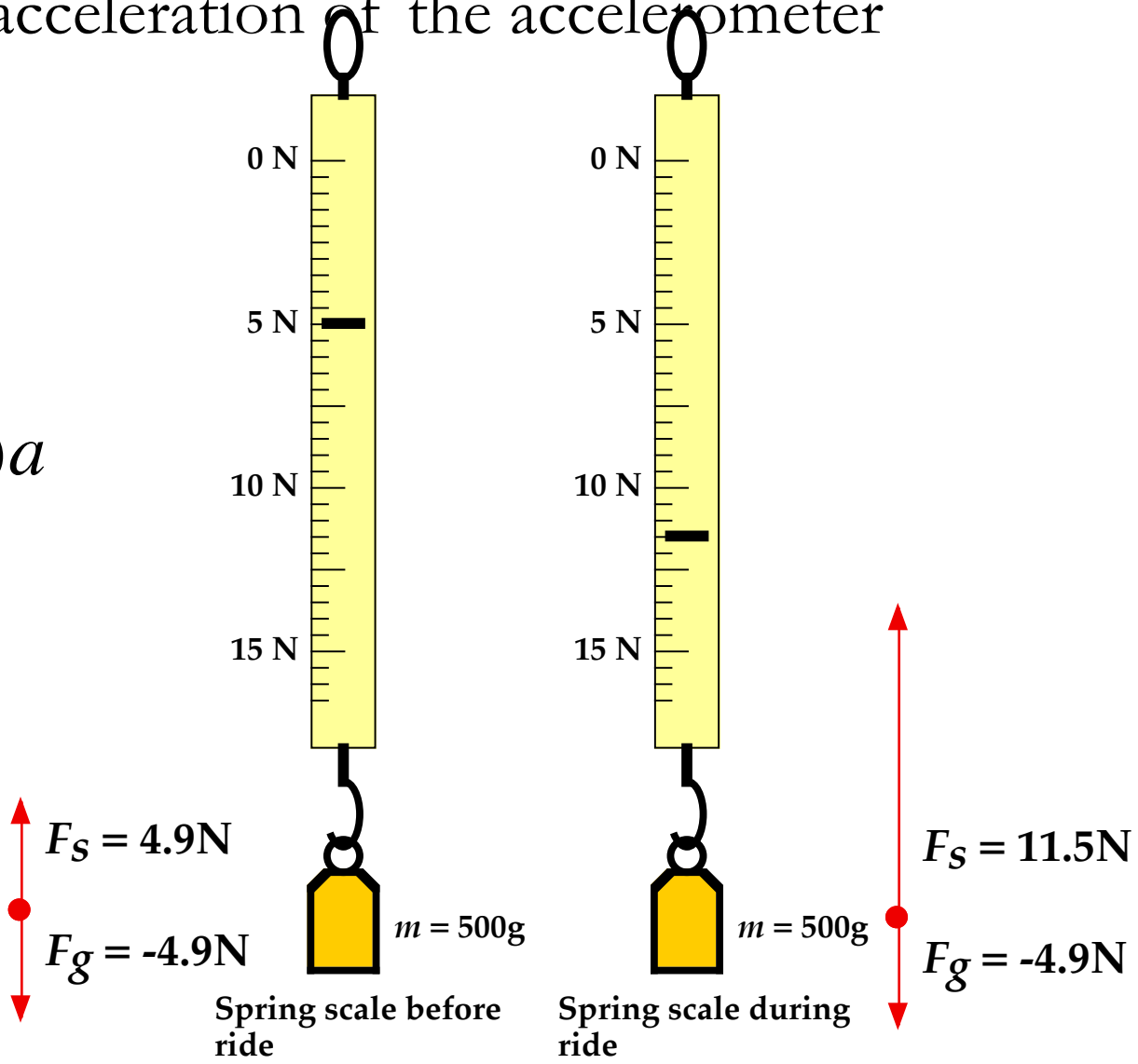
Use a *vertical accelerometer* as shown. What is the magnitude and direction of the acceleration of the accelerometer shown here?

$$F_{net} = ma$$

$$F_s - F_g = ma$$

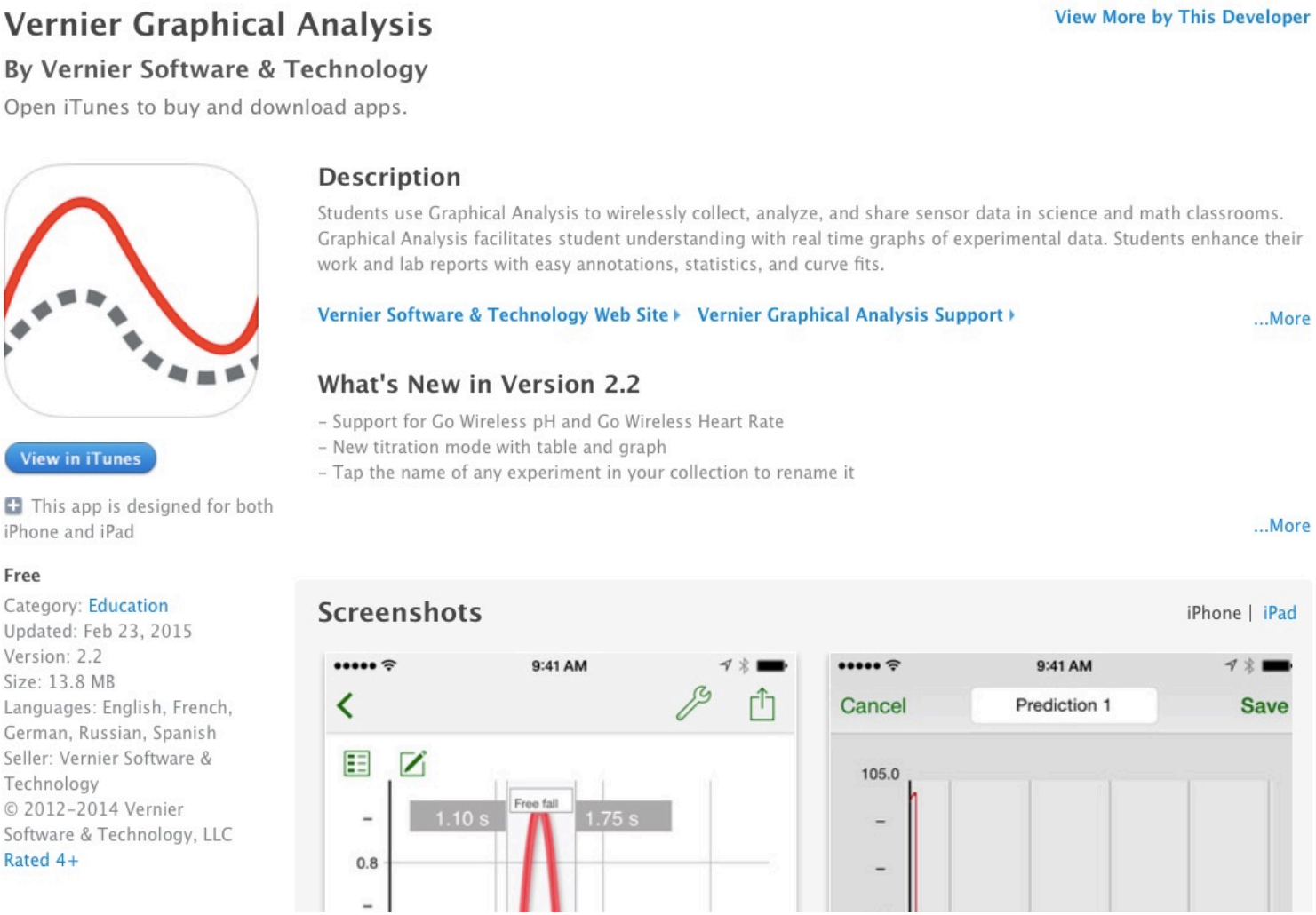
$$11.5 - 4.9 = (.5kg)a$$

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



# 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?

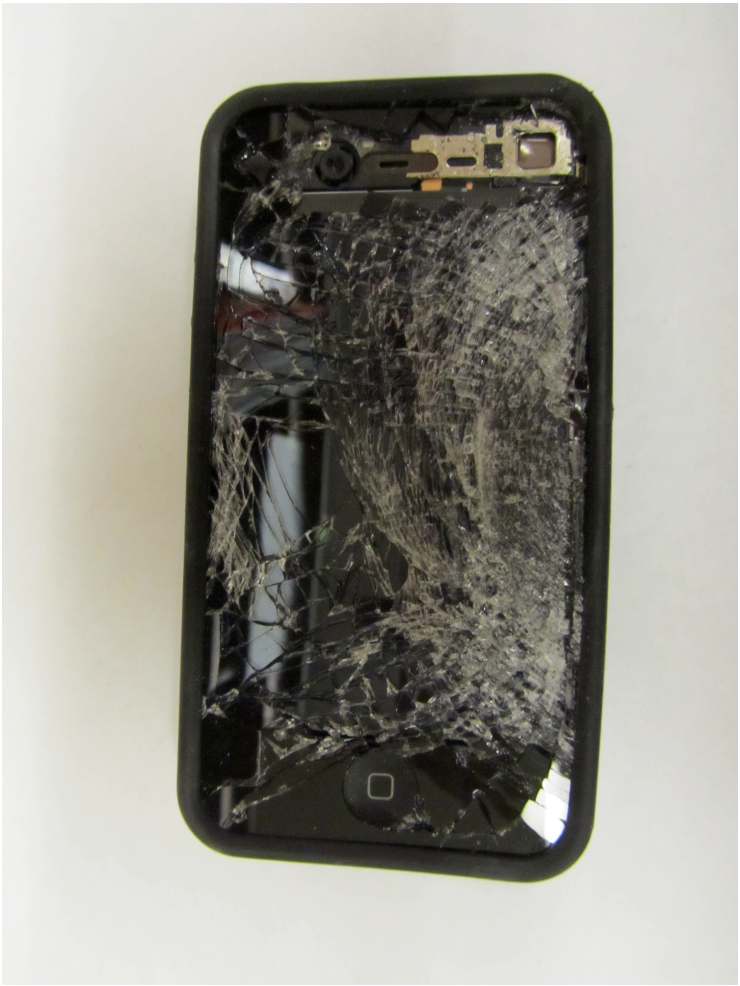
Make sure you do a few tests with your phone so that you know what good data looks like, and how to interpret it!

AirPlay Demo?

# Don’t Lose Your Phone
# or
# Your Stuff!

Fletcher on Superman

Student backpack



# What does your Lab Report look like?

- 4-10 pages, word-processed.
- Cover page
- 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

# Lab Report

Calcul
To be
loade
The a

$t = 7$

$d = 2$

200 y

$d = \frac{1}{2}$

182.9

$a = 6$

$mass$

$m_{car}$

$m_{peo}$

Total

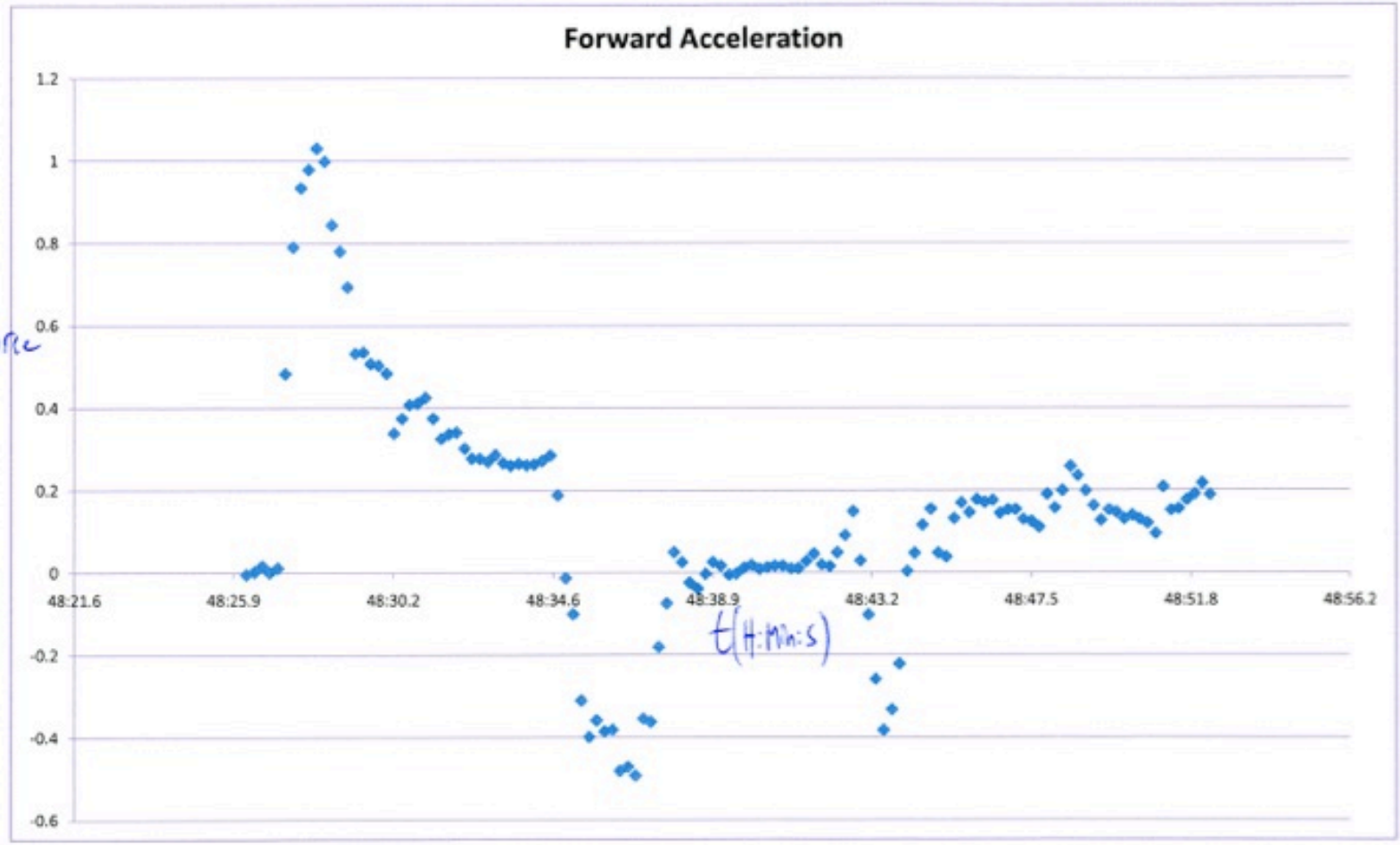
$\sum F =$

Force

$ma =$

Using
Avera

.465(




G-Force