Physics of Amusement Parks

...being a collection of tricks, tools, and techniques that you will find of near-infinite value.

Details, first...

- Meet in Physics room (Room 109) at 9:05 am—you have to attend D-Period if you have a class in that slot. We'll be back to school by 5-6pm ...
- ... unless you need to get back early. I need to know who you are if this is you. See me.
- Physics stuff to bring: calculator, problem, pen/ pencil, stopwatch, horizontal or vertical accelerometer, your problem, iPhone, whatever (you won't be able to take that stuff on rides, so be prepared to store it)!
- Other stuff to bring: $$$, sweater or jacket, clothes that dry easily, sunglasses, sunscreen, camera

Your Problem!

When you get it...

- Read through the gory 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 have time later in the class to discuss your problem with your partners, make a data table, set up some preliminary equations...
- 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 (iPhone?) 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:

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

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.

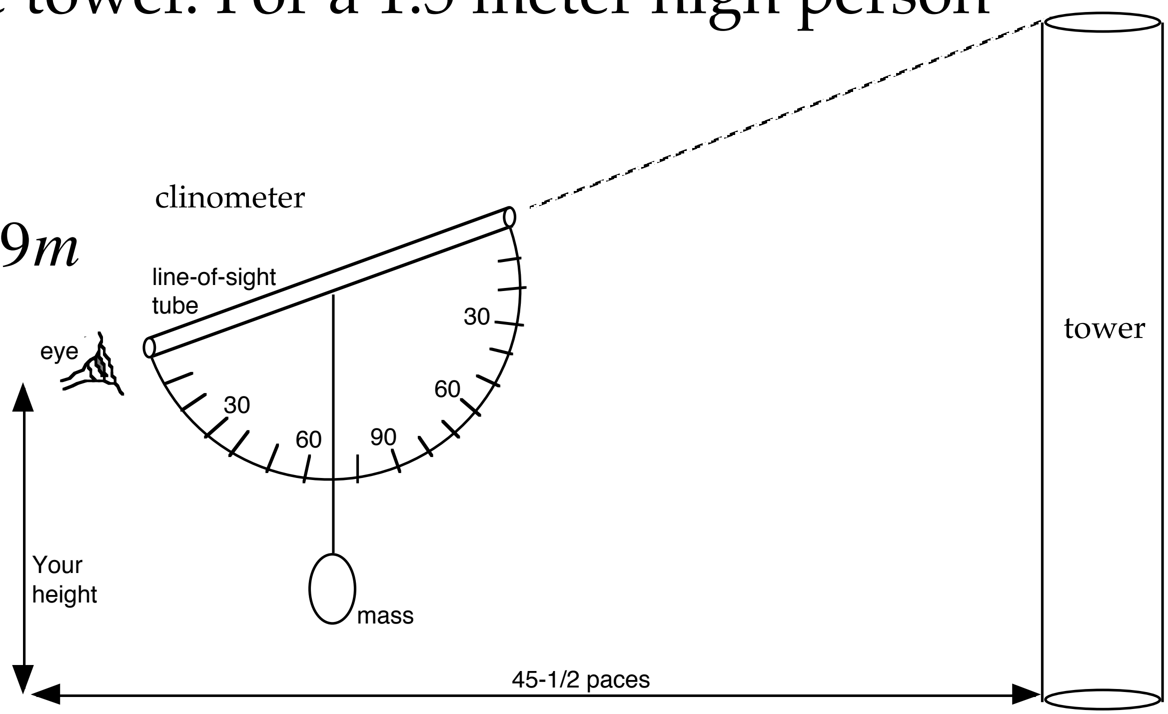
$$\frac{\sim 2meters}{1guy} \times \frac{4guys}{1parachute} \approx 8m$$

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

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:

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



$$\theta = 20°$$

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

$$h = 39m(\tan 20°) = 14m$$

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

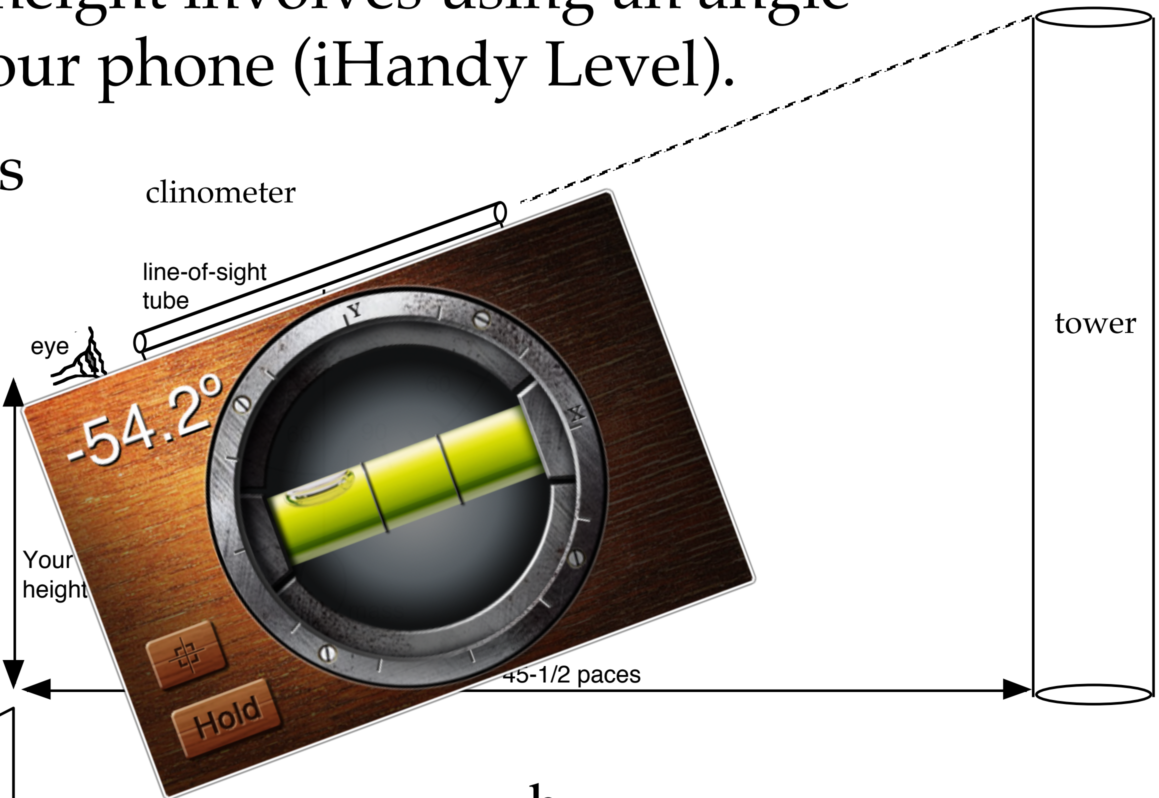
Measuring Length / Height / Distance

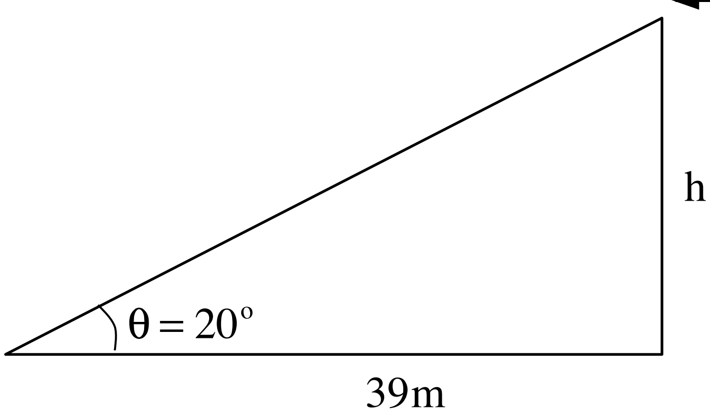
3. If you can pace a distance from the base of a tower, another way to get a height involves using an angle measurement from your phone (iHandy Level).

Ex: Assume 45.5 paces yields $\theta = 20°$.

$$\frac{45.5\text{paces}}{1} \times \frac{0.85\text{m}}{1\text{pace}}$$

$$\approx 39\text{m}$$





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

$$\Rightarrow \quad h = 39\text{m}(\tan 20°) = 14\text{m}$$

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

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

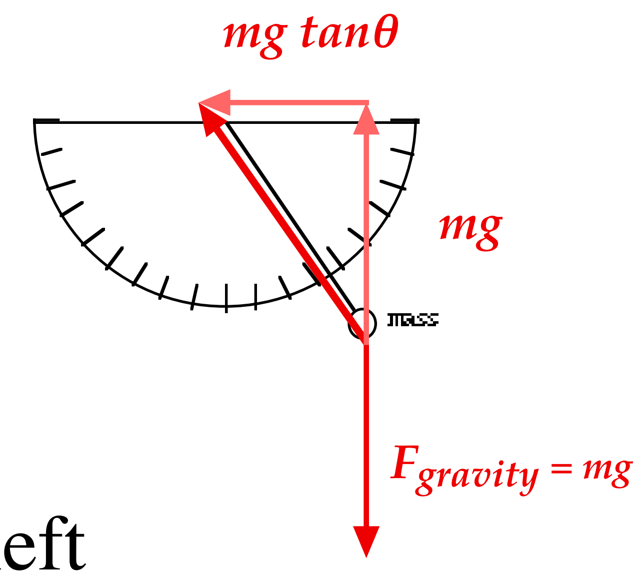
   i. showing calculations, and
   ii. blurbing well

Calculating Velocity

3. If you measure it over a significant distance, you could use GPS-based speedometer like the one in your phone.

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 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

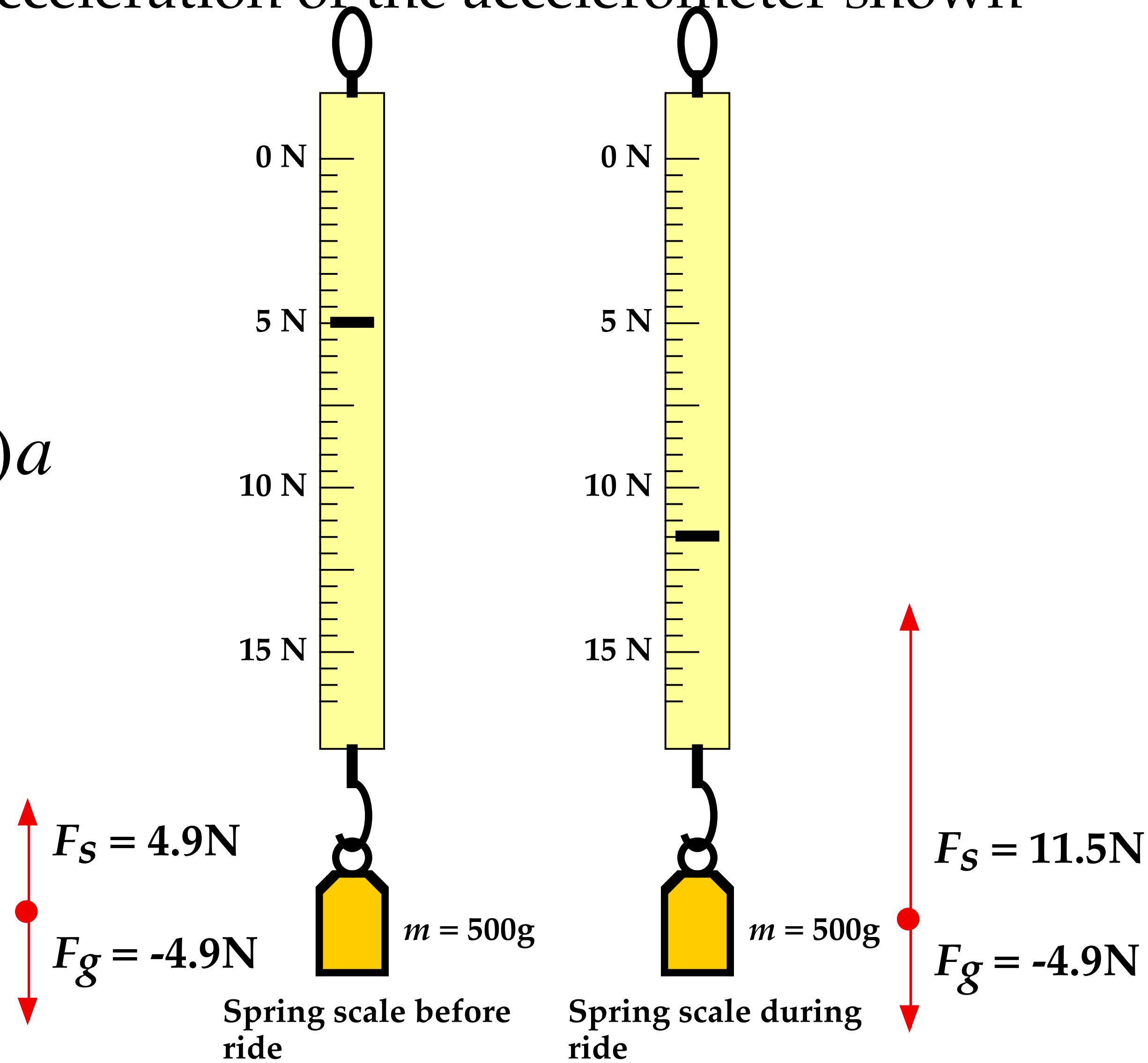
Use a *vertical accelerometer* as shown. What is the magnitude and direction of the acceleration of the accelerometer shown here?

$$F_{net} = ma$$

$$F_s - F_g = ma$$

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

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



New School

Many smart phones have accelerometers built-in... all you need is an app to access that data!

New School

VERNIER GRAPHICAL ANALYSIS

App Store › Utilities › Wavefront Labs

$4.99 Buy App ▾

Category: Utilities
Updated: Mar 09, 2011
Current Version: 1.16
1.16
Size: 0.5 MB
Language: English
Seller: Wavefront Labs

Rated 4+

Requirements: Compatible with iPhone, iPod touch, and iPad. Requires iOS 4.0 or later.

More iPhone Apps by Wavefront Labs

Sensor Data
Tube Runner
System Toolbox
Calendar View

Accelerometer Data Pro

Description

!! Gives you direct access to the iPhone accelerometer data!
...

...More

Wavefront Labs Web Site › **Accelerometer Data Pro Support ›**

What's New in Version 1.16

Fix crash on Capture with some non-US region formats.

iPhone Screenshots