Six Flags America

1 INTRODUCTION

In this lab, you will use data collected at Six Flags America to estimate various features of the amusement park rides.

2 OBJECTIVES

At the conclusion of this activity you should be able to:

- Use a smartphone to collect acceleration data.
- Analyze your data using Logger Pro.
- Investigate the relationship between acceleration, velocity, and position on an amusement park.

3 BACKGROUND

3.1 TIPS FOR COLLECTING HIGH QUALITY DATA

While on the field trip it is a good idea to record as much information as possible. The following are some tips to collect the highest quality data.

Be Safe. Your top priority is to be safe. This means complying with all of the ride rules.

Keep your phone safe. We will have waist packs available for you to use with your phone at the park. The idea is that your phone will remain secured in the belted pack straped around your waist while you are on the ride.

Keep a detailed record of your activities throughout the day. A list detailing which rides were ridden at specific times along with data file names, video files, and other measurements will be invaluable when it is time to analyze the data. Without a good record, this information is nearly impossible to reconstruct.

Use descriptive file names. As you take data, be sure to give descriptive file names, or e-mail titles. File names like: "Superman - Ride 2 - 14:35.csv" – that contain the ride name, which time you rode, and the time of the ride – are much more useful than a file named "Trial2.csv". Understand that your file name may be the only information that a colleague may have access to when they attempt to analyze your data.

Use reasonable data collection rates. In general, the higher the data collection rate, the better. However, be aware that high sampling rates will produce much larger data files. In some cases, high data collection rates are simply overkill. Consider how quickly things happen on the ride that you are attempting to measure in relation to how many data points will be collected at a given rate. For example, if I am measuring the motion of a ferris wheel, the data rate could be much slower (10 Hz, for example) than a tower drop ride where things are changing much more rapidly.

Record videos or pictures of the rides that you will do. Take pictures or videos of the rides **while you are not riding (of course).** These images and videos may be useful for estimating heights, times, etc. during later analysis of accelerometer data. Keep in mind that you may need to consider what you will use for reference heights.

Record rich data. With some phones (Android), you will have the option to record data from multiple sensors at once. For example, the "Roller Coaster" setting on the Physics Toolbox App will record acceleration data and air pressure data that can be used to determine relative heights throughout the ride. Think about what quantities might be useful for a later analysis.

3.1.1 Blocking Accidental Touches

The Physics Toolbox App only collects data while the phone screen is on. If this becomes an issue, you may want to disable the touch screen while the app is running to avoid accidentally stopping data collection. Depending on your device, this can be done in several different ways.

Android: Install an app like the UnTouch:
`https://play.google.com/store/apps/details?id=com.uDevel.BabyTouch&hl=en`.

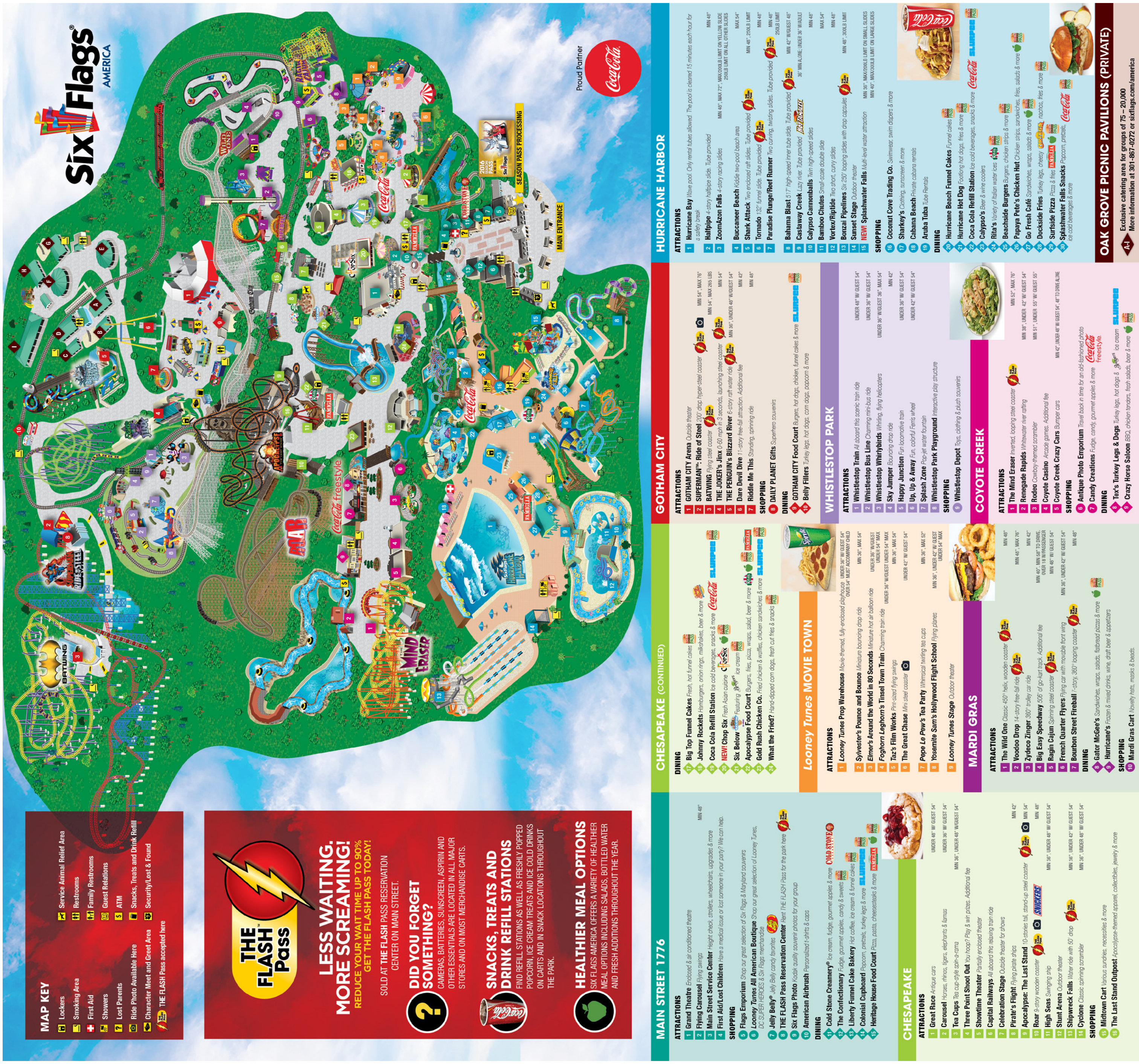
iOS: You can temporarily disable the touch screen by accessing: Settings › General › Accessibility › Guided Access on your iOS device. Turn on "Guided Access".

To block the screen when taking data do the following:

1. Open the Physics Analysis Sensor Suite App.
2. Delete the old data file with the trash can icon and configure the sensors as you normally would.
3. Start collecting data with the go icon.
4. Triple-click the home button on your iPhone – this brings up the "Guided Access" menu. You may have to put in your PIN.
5. Disable the touch screen.
6. Start Guided Access with the start button at the top of the screen. The touch screen should now be non-responsive.
7. To re-enable the touch screen, triple-click the home button again to return to the "Guided Access" menu. You will need to re-enter your PIN.

For more complete directions see: `https://support.apple.com/en-au/HT202612`.

3.2 Map of Six Flags America



3.3 The Rides of Six Flags America

Any of the rides at Six Flags America can be used to collect data. The following is a brief list of rides and some possible questions that are meant to seed your analysis project.

The descriptions of each ride are taken directly from the Six Flags America website (`https://www.sixflags.com/america`) along with published top speeds, elevations, etc. whenever they available.

3.3.1 Voodo Drop

The Voodoo Drop is a tower drop ride.

> "In one thrilling instant, you're released and bullet all the way back down at an incredible adrenaline-charged 56 miles per hour – so fast you'll barely have time to scream.
>
> | | |
> |---|---|
> | Top Speed | 56 mph |
> | Elevation | 14 stories |
> | Duration | 60 sec" |

Possible Analysis Questions:

- Using a method besides the accelerometer data, what is your estimate of the vertical drop of the ride?
- Using your accelerometer data:
  - What vertical drop do you measure?
  - What maximum speed do you measure?

3.3.2 Riddle Me This

Riddle Me This is a tilting rotor ride.

> "The spinning force will push you to your limit! You'll be pinned to the side by sheer gravity, like in a giant centrifuge. As the wheel tilts to 45 degrees, you'll be spinning wildly out of control, but the forces of nature will magically hold you in place.
>
> | | |
> |---|---|
> | Top Speed | 7 rpm |
> | Duration | 2 min" |

Possible Analysis Questions:

- Measure the angular velocity, ω, of the ride (while you are not riding). How does this compare with the published value?
- Using your acceleration data and the observed angular velocity, what is the diameter of the ride?
- What is the angular acceleration, α, of the ride as it accelerates from rest to its maximum angular velocity?
- What is the maximum acceleration measured on the ride?
- Based on the collected acceleration data, what is the maximum tilt angle?"

3.3.3 SUPERMAN: RIDE OF STEEL

Superman: Ride of Steel is a modern steel roller coaster.

> "Welcome to the world of the hypercoaster. This all-new category of roller coaster is so intense they had to come up with a whole new category for it. Hypercoasters are the modern breed of oversized roller coaster that are pumped up to more than 200 feet tall. SUPERMAN: Ride of Steel easily clears that distinction, with a height of 215 feet and a mind-blowing 208-foot drop.
>
> At a whopping 73 miles per hour, you will zoom through a staggering 5,400 feet of twisting red track, on a wide-open layout that will truly give you a sense of the superhuman. You'll take low-banked turns just skimming right over the ground. Then, a series of hills and DNA helixes will show you what's possible once you put on a cape and fly.

Maximum height	215 ft
Maximum drop	208 ft
Maximum speed	73 mph"

Possible Analysis Questions:

- What is the maximum vertical drop measured using acceleration data?
- What is the average acceleration during this drop?
- What is the maximum speed measured using acceleration data?
- Superman: The Ride of Steel has 2 full-circle loops, using your acceleration data, what is the diameter of each loop?
- What is the maximum/minimum acceleration measured on the ride? Where are they measured on the ride?

3.3.4 THE JOKER'S JINX

The THE JOKER'S Jinx is a modern steel roller coaster.

> "THE JOKER, begins with a launch – a very fast launch. THE JOKER's Jinx has a cutting-edge linear induction motor launch system that will get you from 0 to 60 miles per hour in just over three seconds. That'll wipe that smirk off your face, as you are shot like a bullet into four inversions compressed into a half-mile pile of twisted steel.

Top Speed	60 mph
Length	2705 ft
Duration	75 sec"

Possible Analysis Questions:

- THE JOKER's Jinx boasts that it uses a linear induction motor to launch the ride. What is the initial acceleration of the ride?
- Over what distance (and time) does the linear induction motor accelerate the ride?
- Estimate the mass of the fully loaded JOKER's Jinx roller coaster train.

- What is the average force exerted to initially accelerate the ride?
- Work* (measured in Joules) is given by:

$$W = \vec{F} \cdot \vec{s}, \tag{3.1}$$

  where $\vec{s}$ is the displacement vector. Using the estimated force during acceleration and distance over which the linear induction motor acts, how much work is done to accelerate the ride?
- Power (measured in Watts) is defined as the rate of work:

$$P_{average} = \frac{W}{t}. \tag{3.2}$$

  Estimate the power required to initially accelerate the Jinx.

4 PROCEDURE

Choose 1 ride to analyze. The ride you choose may be from the list above or one of your own choice. The questions that you decide to answer with the data can either be chosen from the suggested lists above or others of your own choice.

5 LAB NOTEBOOK

Your submission will be evaluated using the following rubric:

LAB NOTEBOOK PRACTICES

- Lab Notebook Mechanics (4 points)
  - Relevant information *e.g.*: your name, your lab partner's name, date, *etc.* is present.
  - The notebook is organized and easy to read. Markdown cells are used for narrative text. Code cells are clearly organized and commented.
  - The ZIP file of the notebook is healthy and runs correctly.
- Experiment Purpose (2 points)
  - In your own words, state the purpose of this experiment.
  - The work you record in your notebook should specifically address the stated purpose.
- Calculations & Error Propagation (6 points)
  - Present the equations used to analyze your collected data.
  - Present the equations used to account for and propagate error.
- Data Collection & Analysis (6 points)
  - The notebook tells a scientific story; it is an accurate record of the work that you did.
  - Record the informal observations you made during the experiment.

*see Resnick, Halliday, Krane, *Physics (5th Ed.)* (Wiley, 2002), Chapter 11 for a more detailed description of the concepts of work and energy.

- The notebook should show evidence of trial and error. Keep a good record of your work – recording mistakes is useful.
- *Briefly* describe the methods you used to collect your data.
- Measured quantities – that do not appear directly in your plot(s) – are clearly recorded.
- Record rough data and plots that you used to verify that the analysis was on the right track.

Results and Interpretation

- Results (5 points)
  - Clearly state the final result(s) of your experiment. Remember to quote your result with units and appropriate significant digits.
  - Final result plots are well formatted and meet the standards described in the Figure Formatting reference.
- Physical Interpretation (4 points)
  - Throughout the notebook, interpret the data, rough plots, and final results in terms of the underlying physics.
- Significance (5 points)
  - Compare measured results to each other and/or to a known/expected value.
  - Choose the best available tools for your comparison (*e.g.* plots, pictures, discrepancy, significance, etc).
- Confidence (8 points)
  - Communicate to your audience how seriously your result should be taken. How confident you are in your result?
  - Discuss factors that may be affecting the *accuracy* and *precision* of your result.
  - Suggest improvements to your experiment to address your confidence, accuracy, and precision.