Physics Day

Six Flags® St. Louis

Teacher's Introduction

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Teacher's Introduction

Dear Physics Teacher:

The curriculum materials available on the St. Louis Area Physics Teachers (SLAPT) website at http://www.slapt.org/resources/sixflags/index.html, have been specifically developed to help you integrate amusement park physics activities within your physics curriculum. These materials have evolved over the past twenty-five years due to work by area physics teachers with influence from physics educators nationwide.

In order to get the most from Physics Day and these materials, please note the following:

1. We suggest that you have your students **focus on a small number of the activities at the park** (for instance, one roller coaster and one or two circular motion rides). There are many more activities included on the website than could ever be done in one day at the park. We would rather provide too many activities than too few, so we have left it up to you, the teacher, to decide which activities are most appropriate for your students. To help you, most of the ride activities have a qualitative section consisting of conceptually oriented questions and a quantitative section that involves calculations. Recently we have edited the full versions of the materials to create a shorter version for each ride that may be more appropriate for some introductory physics courses. We have also included versions that the physics teachers at Clayton High School have edited for use with their freshman physics and honors freshman physics classes. Therefore, the student activity files are labeled "full," "short," "FP" and "HFP." The website contains both pdf and Microsoft Word versions of the materials. You are encouraged to make use of the MS Word files provides you with the ability to edit materials so that they best fit your curriculum.
2. We strongly encourage you to **use these materials throughout the year** as they fit in to your physics course. Physics Day at Six Flags will be a far more valuable experience for your students if they are already familiar with the types of analyses that are used on the rides prior to going to Six Flags. Activities that your students do not do at the park can be modified and used for pre-trip preparation, post-trip follow-up, or anywhere else they fit into your curriculum. This "beyond Physics Day" use is possible because the website includes movies and data files for a large number of the rides. We have also included some activities which do not involve the rides themselves, but which may be related to the field trip as a whole. See the *Appendices* section of the website.
3. **Mr. Freeze** is the "flagship" activity that we have written for physics day. It is the only ride for which "high tech" equipment is provided, and the Mr. Freeze questions explore a wider variety of physics concepts than those for any other ride. If you have your students do no other activities at the park (which we don't recommend) please consider at least having them work as much of the Mr. Freeze packet as is appropriate for their level of physics course.
4. Each student group will need a calculator, a stopwatch, and a sextant. See the *Constructing Measurement Equipment* document for details on constructing a sextant easily and inexpensively. Many companies sell kits for making accelerometers (Pasco and Sargent-Welch, for instance). The *Constructing Measurement Equipment* document also describes how to build your own accelerometer, but finding parts has become more difficult lately. We are working on developing kits that will be available directly from Six Flags, and plan to make these available once we have procured the necessary parts.
5. Please ask your students to **bring a photo ID** to the Physics Day so that they can use the high-tech equipment for collecting data on Mr. Freeze free of charge. (*Since students usually work in groups of 2 to 4 on the activities, it is really only necessary to check out one vest, and thus require only one I.D., per group*.) Students borrow the equipment by trading a photo I.D. (such as a driver's license or school I.D.) for a data collection vest just before boarding Mr. Freeze. The I.D. cards are returned to the students when they turn in the vests at a computer downloading and printing station at the ride exit. This equipment is available due to generous equipment lending by Vernier Software, the pooling of equipment from local high schools, and the purchase of equipment by Six Flags St. Louis.

6. **Please volunteer to help** with the "high tech" data collection at Mr. Freeze. Physics teachers and other chaperones are needed to operate laptop computers for downloading and printing data, to shuttle vests and IDs, to issue data vests, and to familiarize students with using the data vest. You don't need to know anything about the equipment—we will train volunteers on the day of the event. Please email Jen Meyer at jenmeyer82@gmail.com to volunteer for as little as a couple of hours or as much as the whole day. Six Flags will provide each volunteer with a free meal ticket for Physics Day and a complimentary admissions tickets to return to Six Flags any time during the coming season. Your help is essential. Please email Jen and volunteer today!
7. Six Flags offers a Physics Day picnic combo. The lines for the food concessions can have long wait times and the picnic combo can make the students' time at the park more productive. The picnic combo is served buffet style in the World's Fair Pavilion. There is little or no waiting, "all you care to eat;" and the large, sheltered tables in the Pavilion allow students to work on the ride analyses while eating lunch. The food caterers require a definite cutoff date, so **be sure to order tickets for the "picnic combo" well in advance** of Physics Day.
8. Please note that the devices that are commonly called "accelerometers" do not measure acceleration! These devices, that we call Force Factor meters, can be calibrated to measure the ratio of the normal force in the direction of measurement to the magnitude of the gravitational force. That ratio, the Force Factor, is a multiplier that can be used to find the normal force on an object. In other words, the Force Factor in a given direction multiplied by the magnitude of the gravitational force equals the normal force in that direction. Because of this, the labels on the graphs included in the materials do not read Acceleration vs. Time, but rather Force Factor vs. time. These ideas are explained in detail in the Suggestions for Making Measurements document. Additionally, there is a PowerPoint presentation called How to Measure Acceleration that you might want to use with your students. There is an accompanying student document called How to Measure Acceleration Notes that you can use (with the PowerPoint presentation) to give them practice with the process of converting from a reading on the force factor meter to an acceleration value. In any event, you will want to be certain that your students understand how to interpret "accelerometer" readings.
9. The **St. Louis Area Physics Teachers** association works closely with Six Flags St. Louis to promote Physics Day. Join the St. Louis Area Physics Teachers email list for free by visiting http://www.slapt.org. Doing so will ensure that you receive regular email updates of the events and activities of the group, including the latest information about Physics Day at Six Flags St. Louis. SLAPT is a non-profit group of physics teachers (middle school, high school, and college) that organize regular workshops for the purpose of improving the physics education.

It is hoped that you and your students will find these materials conducive to an enjoyable and educational day at Six Flags. We are very interested in your reactions and comments about this set of materials as we continue to revise/edit the materials. Any help you can give will be appreciated.

If you have any questions about these materials or anything else related to Physics Day at Six Flags St. Louis, please feel free to contact any one of us:

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Teacher's Introduction

Materials available for download at http://www.slapt.org/resources/sixflags/index.html

- Teacher Introduction
- Suggestions for making measurements
- Constructing measurement equipment
- How to Measure Acceleration Power Point with NOTES
- Six Flags St. Louis Park Map
- Student Introduction (Word,.pdf)
- Answer keys to most rides are available -- email Rex Rice for more information.

Ride Activities (Links take you to suggested student activities)					Ride Photo/ Diagram and Description	Logger Pro 3.4 WDSS Data Demo version of Logger Pro	Lower resolution Quicktime Movie Get Quicktime	Higher resolution Quicktime Movie
Ride	Honors Freshman Version	Freshman Version	Full Upper Division High School Version	Short Upper Division High School Version				
Batman, the Ride	(word,.pdf)	(word,.pdf)	(word,.pdf)	(word,.pdf)		Data	Movie (4.5 MB)	Movie (140 MB)
Mr. Freeze	(word,.pdf)	(word,.pdf)	(word,.pdf)	(word,.pdf)		Data	Movie (3.2 MB)	Movie (229 MB)
Highland Fling	(word,.pdf)	(word,.pdf)	(word,.pdf)	(word,.pdf)	Diagram	Data	Movie (3.4 MB)	Movie (42.6 MB)
Rush Street Flyer	(word,.pdf)	(word,.pdf)	(word,.pdf)	(word,.pdf)		Data	Movie (4.1 MB)	Movie (67.8 MB)
The Joker	(word,.pdf)	(word,.pdf)	(word,.pdf)	(word,.pdf)	Diagram	Data	Movie (3.0 MB)	Movie (56.2 MB)
The Ninja	(word,.pdf)	(word,.pdf)	(word,.pdf)			Data	Movie (2.4 MB)	
Superman	(word,.pdf)	(word,.pdf)	(word,.pdf)	(word,.pdf)		Data	Movie (4.4 MB)	
Xcalibur	(word,.pdf)	(word,.pdf)	(word,.pdf)	(word,.pdf)		Data		
American Thunder				preview		Data1Data 2		
Carousel	(word,.pdf)	(word,.pdf)	(word,.pdf)			Data		
Mine Train		(word,.pdf)				Data		
The Boss		(word,.pdf)				Data		

Matching Graphs of Ride Data to Videos Activity (all files .pdf) *The necessary videos can be downloaded from the table above.*		
Activity description	Student instructions	Set of numbered graphs

Appendicies		
Bus Activities	Fermi Questions	Make Up Data
Make Up Problems	Physiology (word,.pdf)	Evaluations

The following rides are either not operating or activities are pending changes.

Activities Before Arriving (Links take you to suggested student activities)			Ride Photo/ Diagram and Description	Logger Pro 3.4 WDSS Data Demo version of Logger Pro	Lower resolution Quicktime Movie Get Quicktime	Higher resolution Quicktime Movie
Ride	Upper Div	Freshman				
Screamin' Eagle	(word,.pdf)	(word,.pdf)	Diagram	Data		
Riverview Racer	(word,.pdf)	(word,.pdf)		Data		
Waterstreet Cab	(word,.pdf)	(word,.pdf)				

It has become difficult, if not impossible, to collect data from the ground for Screamin' Eagle and Ninja because of the growth of trees around the rides. We hope to breathe new life into these rides with the addition of aerial videos so that these rides may be used in preparation for physics day or as a makeup assignment. We also plan to add activities for the *American Thunder* and the new *Boomerang* roller coasters. If you have suggestions for the development of these activities, we'd love to hear your ideas.

PRE-TRIP PREPARATION

1. You may want to do a sample page from the workbook in class a day or so before the trip.
2. Present a lesson on the use of the "force factor" meter. Consider using the available PowerPoint presentation for this purpose
3. **On the bus** pages are important as they set the tone for the day.
4. Post a **map** of the park with important points highlighted. Students should know where to find you or leave a message for you. You may want to consider sharing cell phone numbers to facilitate communication while at the park. Students should know where the First Aid station is located.
5. Remind students to wear **secure shoes** (no sandals) and bring sun block cream and extra clothing.
6. Remind students that the weather in St. Louis can be highly variable in late April, and that they should prepare for the possibility of a chilly or rainy day.

ORGANIZATION SUGGESTIONS

1. Assign students to **lab groups** of two to four. This will allow each student to have another student with which to discuss results, less equipment is needed, and there will be someone available to seek help if the need should arise.
2. If you choose to have students check in with you, **set aside a large block of time** so that they are not forced to leave in the middle of a long line.
3. Distribute **tickets** as students leave the bus so that entry to the park is efficient.
4. Recommend that students **go to the most important** of the assigned rides early before the park gets crowded.
5. Many teachers **collect the workbooks** at the end of the day, either as students arrive at the bus or as they depart back at school. This assures that work is done during the day and even on the ride back to school.

EQUIPMENT FOR THE PARK

- **Stopwatch**. At least one per group, but as many as possible in order to average results.
- **Horizontal Accelerometer (Sextant)** with a rubber stopper hanging from a string attached at the vertex. This will be used to measure the angle of sight for triangulation.
- **Measuring string** - Measure out about 2 meters of string and store it by winding around a 35 mm film can. Secure the ends between the can and the snap lid. This is easier if a knot is made in each end of the string and a small notch is cut in the rim of the can. You can mark off 10 cm segments on the string with magic markers.
- **Accelerometers (Force Factor Meters)** - Have students design and build accelerometers, use the plans in the Measurement booklet or order from one of the science suppliers who carry amusement park physics kits. Be sure each accelerometer has a tether to prevent accidental loss on the ride.
- **Have students measure their pace** as described in the suggestions for making measurements at school prior to physics day where proper distance measuring equipment is available.
- **Calculator, pen & pencil**.
- **Zip-lock plastic bag** large enough for the booklet and other materials.
- **Measuring devices must be evaluated for safety**. Sharp or pointed ends should be avoided. If students are making accelerometers they should be light. If they are tied to a wrist to prevent loss, the tie should break easily in case the meter is caught on something.

LEARNING GOALS AND OBJECTIVES

I. COGNITIVE GOAL:

Upon the completion of the activities, the student will have enhanced understanding of the following laws and concepts of physics on the macroscopic scale:

a. Conservation of Energy
b. Work
c. Power
d. Force
e. Newton's Laws of Motion
f. Kinematics
g. Rotational motion
h. Friction

The student will:

1. apply the principles of kinematics and conservation of energy to determine the velocity and acceleration of an object after falling through a given vertical distance in a gravitational field or moving along an incline.
2. calculate the work done by friction on roller coasters.
3. estimate the power required to haul a roller coaster and its contents up the high rise
4. measure the centripetal acceleration of a passenger in a circular motion ride by the use of an accelerometer.
5. determine the forces acting on a passenger in circular motion rides.
6. measure the linear displacement of a chair on the swings as it moves through a complete revolution.
7. apply the method of triangulation to determine heights at and distances to various structures.
8. apply Newton's Laws of Motion to explain the effects of forces on passengers on various rides.
9. measure and record their personal physiological responses to their experiences during amusement park activities.

II. ATTITUDES

A. GOAL:

Upon completion of the activities, the student will develop a positive attitude toward the physical sciences.

The student will:

1. be motivated to study physics by being challenged with a meaningful task which allows them to accurately predict personal experience.
2. gain an appreciation of the physics involved in the design and engineering of the rides.

B. GOAL:

Upon the completion of the activities, the student will bridge the gap between school work and life education by seeing them as not isolated from one another.

The student will:

1. gain an appreciation of the applicability of physical principles studied in the classroom to large-scale phenomena.
2. be encouraged to work as a member of a team in order to attain common goals.

ORGANIZATIONAL CHECKLIST

Go through the following checklist in detail as you plan your trip to Physics Day.

_____ 1. **Authorization** from school/district administration. Review your school's liability coverage to be sure all necessary precautions are met to assure coverage. Distribute and collect student field trip permission forms.

_____ 2. **Transportation**
Contact the bus company and reserve a bus as soon as possible.
Cost per bus $_____
Seats per bus _____
Deadline for finalizing or canceling_____

_____ 3. **Ticket Information**
Contact the Six Flags St. Louis sales office at 636-938-5300, ext 288 or go to sixflags.com
Cost per ticket without lunch $_____ with lunch $ _____
Deadline to receive tickets by mail_____

_____ 4. **Student Workbook**
Reproduce workbook early enough to use practice problems in class. Decide on your grading system.

_____ 5. **In-Class Activities**
Early on have a review of necessary concepts, formulas and measurement techniques. Just before the trip, give instructions on lab group size, supplies to bring, forbidden materials, workbook requirements and options, and when the workbook will be collected.

Let students know where and when you will be available in the park. The computer area at Mr. Freeze will always have teachers present. Be sure students know where First Aid is located and remind them to stay in their lab groups for both efficiency and safety. Announce meeting time and place in the morning. Reiterate meeting times and places for leaving the park and penalties for lateness.

_____ 6. **Chaperones**
Arrange for faculty, administrators or parents to help chaperone.

_____ 7. **Lesson plan for substitute teacher**
Consider using the same workbook with supplied data for the students who are unable to attend.

_____ 8. **Send in money** for bus & tickets.
Call and reconfirm the bus times. Park is open 9am – 5pm.

A LITTLE HISTORY

In the early 1990s, a committee of the St. Louis Area Physics Teachers Association put the initial curriculum materials for Six Flags Physics Day together. This packet consists largely of activities that have been written by many physics teachers for many amusement parks nationwide. We have attempted to bring together those activities that are best suited for use at Six Flags St. Louis, and have edited them for use there.

Much of the material in this packet borrows heavily from the Physics of the Amusement Park Curriculum Guide by Nathan A Unterman, and the Amusement Park Physics Handbook published by the American Association of Physics Teachers. There is also a substantial influence by the Mechanics of Motion manual produced for Playland Amusement Park by James Wiese. There are parts of the packet which are also influenced by the materials produced for Six Flags Magic Mountain (John McGehee) in Valencia, California, Physics at Riverside, and the older materials produced for Six Flags over Mid-America by Bill Brinkhorst and Valerie Michael. One thing has become obvious in the collection of the background materials for this project: considerable sharing has gone on in the area of Amusement Park Physics. Almost every packet produced has areas of conspicuous similarity to nearly every other packet. This one is obviously no exception.

The 1991 Amusement Park Physics Committee
of
The St. Louis Area Physics Teachers Association

Joan Biela .....Lindbergh High School
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The materials compiled by the committee above have been revised, updated and added to by Bill Brinkhorst, Rex Rice, and Mark Schober under the sponsorship of Six Flags St. Louis during the 1999-2010 school years, and have continued to be revised by Gabe de la Paz, Jen Meyer, and Rex Rice in recent years.