Physics Day 2008

Teacher's Introduction

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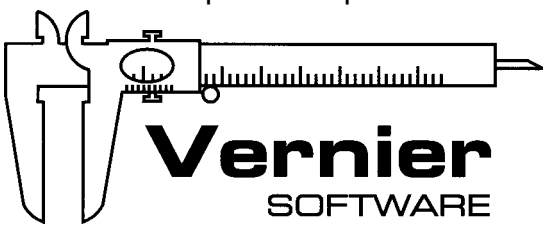

Teacher's Introduction

Dear Physics Teacher:

The curriculum materials on the enclosed CD have been specifically developed to help you integrate amusement park physics activities within your physics curriculum. These materials have evolved over the past twenty 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 CD 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. **New for 2008:** 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. Therefore, the student activity files are labeled "full" and "short." The CD also contains Microsoft Word versions of the materials to provide 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 CD 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 *Appendix* file.
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. Each student group will need a calculator, a stopwatch, and a sextant. (See the *Equipment* document for details on constructing a sextant easily and inexpensively.)
4. 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.
5. **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 Bill Brinkhorst at bbrink@jburroughs.org 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 two complimentary admissions tickets to return to Six Flags any time during the coming season. Your help is essential. Please email Bill and volunteer today!

6. We encourage your students to take advantage of Six Flags' Physics Day **meal deal** – a good value that will make the students' time at the park more productive. The meal deal is served buffet style in the World's Fair Pavilion; there is little or no waiting; it is less expensive that purchasing food at park concessions; it is "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 "meal deal" well in advance** of Physics Day.
7. 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 *Measurement* document. Please study this and point it out to your students.
8. 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:

Bill Brinkhorst
John Burroughs School
755 S. Price Rd.
St. Louis, MO 63124
(636) 256-1736 (Home)
bbrink@jburroughs.org

Mark Schober
John Burroughs School
755 S. Price Rd.
St. Louis, MO 63124
(314) 993-4040 (School)
mschober@jburroughs.org

Rex Rice
Clayton High School
#1 Mark Twain Circle
Clayton, MO 63105
(314) 854-6760 (School)
rex_rice@clayton.k12.mo.us

Notes on Materials, Spring 2008:

Short versions have been added for most rides. The files are indicated by "short" in the filename and there is a white rectangle within the black bar at the top of each page.

Mr. Freeze, Joker, Superman, Rush Street Flyer, Batman, and Xcalibur all have important updates and corrections.

Answer keys have been added for Superman and Rush Street Flyer

It is now 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.

Questions for Tony Hawk and Six Flags' new rollercoaster, Evel Knievel, are planned for 2009.

Contents of the Six Flags Physics Day CD

A_Introduction2008

1_Teacher_Introduction2008.pdf *(This is the document you are currently reading.)*
Introduction, Contents of the Six Flags Physics Day CD, Guidelines for Teachers, Learning Goals and Objectives, Organizational Checklist, History

2_Measurement2008.pdf (Suggestions for Making Measurements)
Time, Distance, Speed, Acceleration, "accelerometers" and Force Factor Meters, Useful Formulas

3_Equpment2008.pdf
Sextant, Hand held Force Factor meters, Possible Sources for Equipment

4_Map_SFSL2008.pdf
A labeled map of the park.

B_StudentActivities_pdf

.pdf files of the suggested student activities

C_StudentActivities_Word

Editable Microsoft Word files of the suggested student activities

00_Student_Introduction2008
Rider Responsibilities; A Note About Vertical Accelerometers

01full_MrFreeze2008*
01short_MrFreeze2008*
Qualitative & Quantitative Questions; accompanies use of high tech data vests provided for student use on physics day.

02full_Superman2008*
02short_Superman2008*
Qualitative & Quantitative Questions; excellent questions for students who have not studied circular motion.

03full_Xcalibur2008*
03short_Xcalibur2008*
Qualitative & Quantitative Questions

04full_Batman2008*
04short_Batman2008*
Qualitative & Quantitative Questions

05full_HighlandFling2008*
05short_HighlandFling2008*
Qualitative & Quantitative Questions

06full_Joker2008*
06short_Joker2008*
Qualitative & Quantitative Questions

07full_RushStreetFlyer2008*
07short_RushStreetFlyer2008*
Qualitative & Quantitative Questions

08_Carousel2008*
Qualitative & Quantitative Questions

09_RiverviewRacer2008*
Qualitative & Quantitative Questions

10_WaterstreetCabCo2008
Qualitative & Quantitative Questions

11_ScreaminEagle2008
Qualitative & Quantitative Questions; tree growth has made many measurements impossible.

12_Ninja2008
Qualitative & Quantitative Questions; awaiting rewrite.

13_Physiology2008
Physiology of Amusement Park Rides

D_AnswerKeys

The starred (*) files above have corresponding answer keys.

E_Appendicies2008

1_BusActivities.doc
Physics activities for the ride to Six Flags

2_FermiQuestions.doc
Order-of-magnitude estimation problems

3_PracticeProblems.doc
These need editing – use with care.

4_PracticeProblemsKey.pdf

5_MakeUpData.doc
Fake data for Mr. Freeze, Highland Fling, Rush Street Flyer, and Superman that can be given to students unable to attend the park so that they can complete the ride questions.

6_MakeUpProblems.pdf
These need editing – use with care.

7_Evaluations.doc
Evaluation forms to collect Teacher and Student comments about the Six Flags Physics Day experience.

8_RideData-LoggerPro
Ride data taken with Vernier's Wireless Dynamics Sensor System and graphed with Vernier's Logger Pro software. A demo version of Logger Pro 3 can be downloaded from http://www.vernier.com

Evel Knievel2009.doc
A preview of Six Flags' newest rollercoaster.

MrFreeze_Photos-explanations
This folder contains pictures and explanations of the inner workings of Mr. Freeze.

F_MatchingGraphsToVideos

Copy the video files onto your hard drive before you view them. They will not play correctly from the CD.

0_GraphMatchingActivity-teacher.pdf
1_SetofNumberedGraphs.pdf
2_GraphMatchingActivity-student.doc
2_GraphMatchingActivity-student.pdf
Batman.mov
Freeze.mov
HighlandFling.mov
Joker.mov
RiverviewRacer.mov
RushStreetFlyer.mov

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. **On the bus** pages are important as they set the tone for the day.
3. Post a **map** of the park with important points highlighted. Students should know where to find you or leave a message for you. A bulletin board will be set up at the computer station near the Screamin' Eagle ride for this purpose. Students should know where the First Aid station is located.
4. Remind students to wear **secure shoes** (no sandals) and bring sun block cream and extra clothing.

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** - 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. Conservation of Momentum
c. Work
d. Power
e. Force
f. Newton's Laws of Motion
g. Kinematics
h. Rotational motion
i. 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 momenta of objects and qualitatively determine conservation of momentum (particularly bumper cars).
3. calculate the work done by friction on roller coasters.
4. estimate the power required to haul a roller coaster and its contents up the high rise
5. measure the centripetal acceleration of a passenger in a circular motion ride by the use of an accelerometer.
6. determine the forces acting on a passenger in circular motion rides.
7. measure the linear displacement of a chair on the swings as it moves through a complete revolution.
8. apply the method of triangulation to determine heights at and distances to various structures.
9. apply Newton's Laws of Motion to explain the effects of forces on passengers on various rides.
10. 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 636-938-4800
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
Bill Brinkhorst.....John Burroughs School
Francis Cange.....Trinity High School
Bill McConnell.....Webster University
Deborah McKenzie .....Hazelwood East High School
Rex Rice .....Clayton High School

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 1999-2008 school years.