AMUSEMENT PARK PHYSICS

A Teacher's Guide

Second Edition

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RATIONALE

Examples of physics are all around us. To encourage and maintain student interest throughout the year, a culminating field trip to an amusement park can be an enjoyable, memorable, and meaningful learning experience. It also helps those teachers whose seniors have come down with the dreaded contagious disease called *lapsus animi seniorum*.

The purpose of this book is to provide a potpourri of activities that can be completed in most amusement parks and even some carnivals. Since no two amusement parks are the same, the collection provided here is a pool from which to select a reasonable set of activities appropriate for your situation.

For those not fortunate enough to be able to attend an amusement park, activities have been designed with supplied "ballpark" numbers. These data dovetail with the Question Bank (found near the end of this volume). Using these data either as a pre-trip learning experience or for individual students unable to attend the excursion itself, would be valid.

Please do not think that this text is the final word on amusement park activities. Be creative; write your own questions! The author is open to and welcomes all suggestions, corrections, and additions. Please send yours to the author c/o Science Editor, J. Weston Walch, Publisher, Box 658, Portland, Maine 04104-0658, or send us a message at www.walch.com.

HOW TO USE THIS BOOK

The beginning sections of this book cover the administrative questions and details about how to arrange an amusement park field trip. Educational objectives, a review of the literature, Web keywords, and equipment construction are also addressed. Since each school has its own authorized permission form, please check to see that yours will cover this trip. Sometimes an amusement park is actually in a neighboring state, province, or other jurisdiction. Please review any special arrangements that may be necessary as you cross these political boundaries.

The main body of this book presents several different kinds of learning experiences. These include a teacher-centered question-bank approach, a problem-based learning method, and a student-centered process. Each has specific suggestions for execution. Sample worksheets and other support materials are supplied. Please use this book as a guide to your instruction, not as the only way to execute this unit of study.

Suggested forms are supplied for post-trip evaluations. You may wish to add your own evaluation questions to these forms. In addition, laboratory exercises for triangulation and the use of accelerometers, along with whiteboard and practice problems, are included for further reinforcement. Answers to exercises begin on page 173.

For those who are not able to attend an amusement park, sufficient laboratory activities, sample problems, and supplied data for the Physics Is Everywhere (PIE) Park will more than fill your curricular needs. Check the Web for any local data that may be available. Be flexible and creative; tailor this experience to your own situation; have fun with your students as they learn.

Name ______________________________ Date ____________________

Roller Coasters

Student Activity Page

NON-LOOPING ROLLER COASTERS

Group A

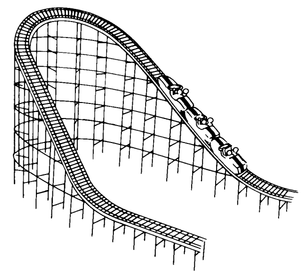

Figure 66
Non-Looping Roller Coaster

1. Draw the profile of the track or a track layout. Label the following: minimum potential energy, G; maximum potential energy, F; minimum kinetic energy, K; maximum kinetic energy, J; weightless sensation, W; heavy sensation, H.

2. Why is the second hill shorter than the first?

3. (a) How long does it take the coaster to climb the first and second hills?
   (b) How long does it take to descend the first and second hills?

4. Determine the angles of ascent and descent of the first hill.

5. Determine the shapes of the first hill and valley.

6. Identify at least three (3) sources of friction in this ride.

7. As compared with the beginning of the ride, do you expect friction and air resistance losses to be greater or less in the latter part of the ride? Why?

8. From a physics point of view, the passengers in the first car, middle car, and last car experience the ride differently. This is despite the fact that the whole train is being acted upon as a unit. Please explain the differences in the experiences of the three passengers listed above between the time of the first climb and reaching the top of the second hill.

9. Describe the sensations of weight at the following points, and compare them with the readings on your spring accelerometer:
   (a) climbing the first hill
   (b) at the top of the hill
   (c) going down the hill
   (d) at the bottom of the hill
   (e) ascending the second hill

(continued)

10. "An empty roller coaster and a full roller coaster will take the same amount of time for a single trip." Is this statement true or false? Defend your answer.

11. Determine the hourly capacity and cycle time of this ride.

Group B

12. Determine the height of the first and second hills.

13. Determine the velocity of the train when it rounds the peak of the lift hill as it is detached from the lift chain.

14. Determine the kinetic energy of the ride just after it is released from the lift chain.

15. Determine the gravitational potential energy at the peaks of the first and second hills.

16. Find the total energy of the system.

17. Determine the maximum kinetic energy of the ride.

18. Determine the maximum velocity of the ride.

19. Determine the acceleration of the roller coaster on the first drop in two different ways. State these answers in both *g*'s and m/s^2.

(continued)

Name ____________________ Date ____________________

Roller Coasters *(continued)*

Student Activity Page

20. Draw a force diagram of a passenger at each of the locations listed in the table below.

21. Draw energy bar charts of the roller coaster at each of the locations listed in the table.

22. Fill in the table representing the values of: velocity, acceleration, potential energy, kinetic energy, momentum, and force on the train at the points listed in the table. Do this for the center of mass of the train.

	v (m/s)	a (m/s^2)	GPE (J)	KE (J)	p (kg m/s)	F (N)
Top of first hill						
1/4 way down						
1/2 way down						
3/4 way down						
At bottom						
Top of second hill						

23. Using the accelerometer and barometer of a calculator-based system, compare these measurements with the measurements obtained by a spring accelerometer and triangulation.

24. Draw velocity-time and acceleration-time graphs for the roller coaster.

(continued)

Group C

25. Assuming the speed of the roller coaster is the same at the first and second valleys, but the top of the second hill is shorter than first, determine the amount of mechanical energy exchanged into thermal energy due to frictional effects.

26. If the roller coaster had the same frictional losses for the whole trip as it does between the lift hill and the second valley, would it reach the station? Support your answer.

27. Measure the approximate banking angle of the first curve after the first valley. Draw a force diagram for the center of mass of the train as it is moving over the maximum-banked part of the first curve. Is this the optimal banking angle for the speed of the low-friction train?

28. The train cars of steel roller coasters ride on Urethane® wheels in contact with a metal track anchored to the ground. The train acquires a sizeable static electrical charge and is periodically discharged. How can this be?

29. An electric motor that is 30 percent efficient lifts a fully loaded roller coaster up the first hill. Each of the cars of the eight-car train has a mass of 1250 kg.

    (a) Calculate the power necessary to raise the train.

    (b) If the electric company charges 12.5 cents per kilowatt-hour, determine the cost of the electricity used to power this ride for one hour. Assume that it is a busy day with ridership at 1,800 patrons per hour.

(continued)