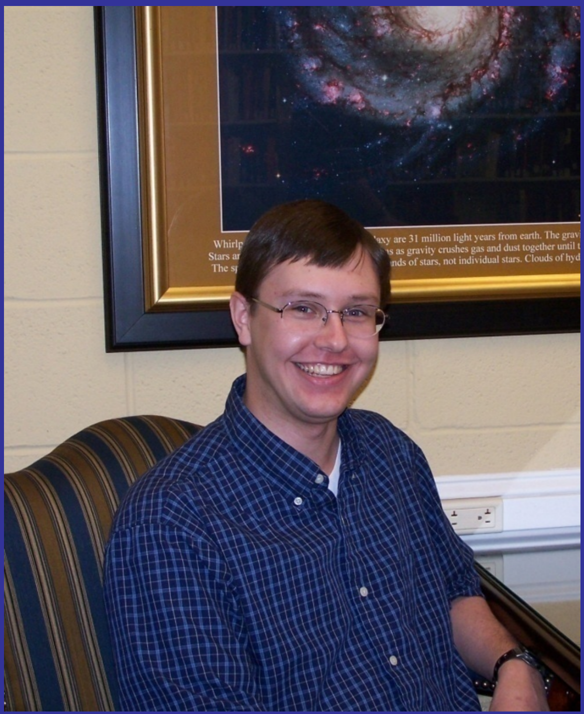
Delaware GK-12 Project
Activity Summary

A partnership between the
University of Delaware
and the
New Castle County Vocational Technical School District

Funded by National Science Foundation Graduate Teaching Fellows Program in K-12 Education (GK-12) DGE 0538555

Teacher/Fellow Pair



Mr. Thomas Madura

University of Delaware

Department of Physics & Astronomy

Mr. Ronney Bythwood

Howard High School of Technology

Physics & Physical Science Teacher

Physics Day at
Six Flags Great Adventure

SixFlags
GREAT ADVENTURE

Took Mr. Bythwood's 12th grade Physics class (23 students).

Trip was April 27, 2007; at park ~ 6 hours.

Funded by GK-12 and students.

It rained all day!

Why do Amusement Park Physics?

- Provides a unique setting to facilitate student learning
  - Students can verify validity of formulas, can see for themselves.
  - Students experience effects that are “counter-intuitive”.
  - Helps students develop experimental techniques (does answer make sense).
  - Offers real-world experiences that help students’ perceptions of the laws of physics.
  - Allows for development of interesting activities, labs, and transfer tasks.

Tools Students Use to Learn

School ____________________ Your Name ____________________

Teacher ____________________ Partners: ____________________

____

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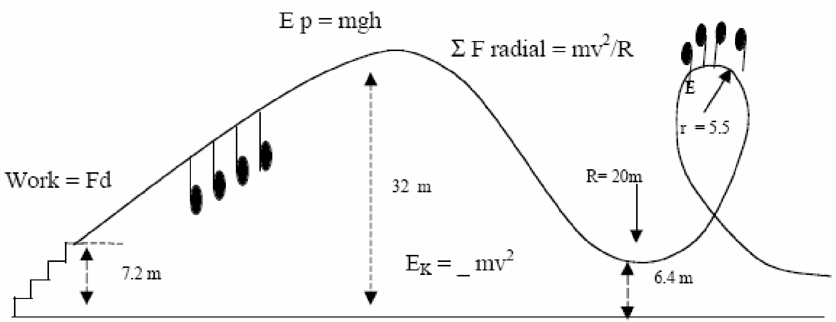

STUDENT HANDBOOK FOR USE AT THE PARK

Your Weight = ________ lbs X 4.45 = __________ newtons

Your Mass = $\frac{\text{Weight in Pounds}}{\text{2.21 pounds/kg}}$ = ________ kilograms

Symbols and formulas used in this handbook:

- d = Distance
- E_K = Kinetic Energy = $1/2\ mv^2$
- E_P = Potential Energy = mgh
- E_T = Total Mechanical Energy = Potential Energy + Kinetic Energy
- ΣF_r = Sum of the radial forces = mv^2/r
- F_c = Centripetal Force
- F_g = weight or gravitational force in newtons = mg
- p = momentum = mass x velocity

Speed Conversions

5 m/s	11 mph
10 m/s	22 mph
15 m/s	34 mph
20 m/s	45 mph
25 m/s	56 mph
30 m/s	67 mph
35 m/s	78 mph

Physics Day Coordinators

Harold Lefcourt: New Jersey Section American Association of Physics Teachers
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Some Materials adapted from student handbooks prepared by Columbia High School, Maplewood, NJ and the Amusement Park Physics Committee of the American Association of Physics Teachers

CONCEPTS COVERED BY EACH RIDE

TO THE STUDENT: Be sure you complete Workbook Units for at least _____ activities at the park . Be sure that you choose the rides so that you have covered all of the concepts checked across the top row.

REMEMBER - Most measurements are made **While Watching**, including **Times.**
The symbol for measurements that must be **Read On the Ride** is ${}^{R}O_{R}\Rightarrow$.

Read about the ride and take measurements before you ride. Usually, you can do this while in line.

Before you leave the ride make sure you have all the information you need.

Activity	Concepts / Rides	Kinematics	Centripetal Force	Energy	Power	Friction	Vertical Circles*	Vectors	Electricity	Momentum
3	Scream Machine 1		X	X	X		X			
4	Scream Machine 2		X	X			XX			
5	Centrifuge		X					X		
6	Taz Twister		X			X		X		
7	Rolling Thunder		X	X	X		X			
8	Viper		X							
9	Runaway Train		X	X				X		
10	Saw Mill Log Flume	X								X
11	Carousel		X					X		
12	Spinmeister		X				X, XX			
13	Flying Wave		X					X		
14	Fantasy Fling		X				X,XX	X		
15	Batman The Ride 1		X	X	X		X			
16	Batman The Ride 2		X	X			XX			
17	Batman The Ride 3		X					X		
18	Stuntman's Freefall	X	X	X	X					X
19	Movietown Water Effect	X								X
20	Chiller Intro & Part 1	X			X					
21	Chiller Part 2	X			X				X	
22	Bumper Cars	X								X
Activity	Rides / Concepts	Kinematics	Centripetal Force	Energy	Power	Friction	Vertical Circles*	Vectors	Electricity	Momentum

* In the Vertical Circles section, X means the Activity concerns forces on a rider at the bottom of a curve. XX means the Activity covers forces on a rider upside down at the top of a vertical circle.

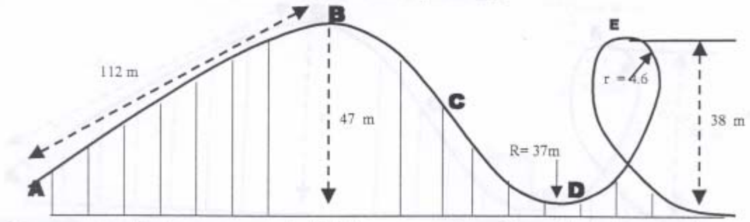
What the Students Learn

- Kinematics
  - Distance, speed, acceleration, etc.
- Forces
  - Newton’s laws, weight, g-force, centripetal force, vector diagrams
- Energy
  - Potential, kinetic, conservation of, etc.
- Circular Motion
- Work and Power
- Impulse and Momentum

Examples: Great American Scream Machine and Nitro

ACTIVITY 3 & 4 : THE GREAT AMERICAN SCREAM MACHINE
CONSOLIDATED DATA PAGE

Before Riding: **Measure required times**
Do all calculations and force factor predictions



Measurements on the diagram are accurate. Vertical measurements are taken relative to the station where h = 0

IMPORTANT: Hold force meter parallel to track on the way up the first incline (A to B). Change just before top

Hold meter parallel to your back after B. You can clutch meter and seat bar simultaneously.

Watching from the Ground

Time for first car to reach top of first hill t_{uphill} = 37.5 sec. s

Time for entire train, first car to last, to pass point E $t_{past\ E}$ = 1.5 sec. s

Length of train = 18 m

Force Meter Predictions and Verification Measurements — Calculate ff before riding so you know approximately what to expect			
Where	Calculated ff	ff Measured on Ride	Sensation light, heavy, normal
Force on back going uphill (A to B) Meter pointed uphill		R_{OR} = 1	Normal
Force on seat at D, bottom of curve Meter parallel to back		R_{OR} = 1.5	heavier
At E, top of loop while upside down Meter parallel to back		R_{OR} = 2	heavier

Things To Notice While Watching and Questions To Have Riders Answer

1. Watch a rider with long hair. When the rider is upside down, is the hair hanging down as it would if the rider were stationary?
   It would be the same upside down & stationary.
2. Did the rider feel upside down in the first loop?
   no
3. Consider how the pressure from the seat and harness varied during the ride.
   a. Was there pressure on a rider's shoulders at any time during the ride? If so where?
   yes
   b. Where did the pressure from the seat seem greatest?
   going up the hoop
   c. Where did the pressure from the seat seem the least?
   down the hoop
4. Describe the sensation of coming down a hill.
   you feel weightless

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CALCULATIONS
(Show all substitutions)

FINDING YOUR TOTAL ENERGY

$E_p = mgh$

1. Your potential energy at B, the top of the first hill is the ideal total energy you will have throughout the ride. If we ignore friction, this total energy is the sum of your potential energy and kinetic energy at any given moment. Let potential energy be 0 on the ground and calculate your potential energy at B. This is now your total energy for the ride.
   (85.9)(9.8)(47)
   Total Energy E_T = 39,565.54

IDEAL VERSUS ACTUAL SPEED AND ENERGY AT THE TOP OF THE LOOP

$E_p = mgh$

2. During the ride you must account for your total energy. At E your total energy is partially potential and partially kinetic. Calculate your potential energy at E, the top of the loop.
   (85.9)(9.8)(38)
   E_p = 31989.16

$E_T = E_p + E_k$

3. Calculate your IDEAL KINETIC ENERGY at the top of the loop. We are assuming that the total energy is still the same. What factors affect the validity of this assumption? Explain.
   39,565.54−31989.16
   E_K = 7576.38

$2E_k = \frac{1}{2} mv^2$ 2

4. Calculate your IDEAL speed at E, the top of the loop.
   $\sqrt{2E_K/m} = \sqrt{2(7576.38)/85.9}$
   Ideal $V_{at\ E}$ = 13.28

$v = \frac{L}{t_E}$

5. Calculate your EXPERIMENTAL speed by using the time it took the entire train of cars to pass point E at the top of the loop.
   18/1.5
   Experimental $V_{at\ E}$ = 12

$E_k = \frac{1}{2} mv^2$

6. Calculate the value of the kinetic energy using the experimental velocity at point E.
   1/2(85.9)(12²)
   Experimental E_K = 6184.8

$E_T = E_k + E_p$

7. Calculate the experimental value of the total energy at this point. Note: you still have the same potential energy as you did in # 2.
   Experimental E_T = 38,173.96

8. Find the difference between your experimental value of total energy and the ideal value you calculated in #1.
   Difference = 1391.58

% = Difference / ~~Original ET~~ X100

9. Find the percent deviation between your experimental value found in #7 and the ideal value found in #1.
   Percent = 4%

10. How would you account for the energy difference you found?
    Friction, height lost,

A 18

Example: Flying Wave

Conclusions

- Trip was a success despite the rain.
- Post-trip interviews show that students make connection between physics and real-world.
- Pre-trip and workbook activities make great PBL and transfer task problems.
- Definitely worth doing again with future classes.
- Already have many ideas for future improvement (alternate dates, new parks, student designed activities, presentations, etc.)

Thank You