

## Schedule of Events

Thursday, February 24, 2005

### **Paper Power Tower**

9:00am – Boardwalk Ballroom  
Limited to 30 teams of 1-3 students

### **Paper Airplanes for Accuracy**

10:00am – Boardwalk Ballroom  
Limited to 60 students

### **Edwards Air Force Base Presentations:**

**Lt. Col. Smith,**

**USAF Deputy Director, Project Management Directorate**

**Mr. W. Jones, Project Intergrator**

12:00pm – Boardwalk Ballroom

### **The PHYSICS Behind The Rides**

2:00pm – Boardwalk Ballroom  
Knott's Berry Farm employees

### **DR. FLUBBER**

Ongoing paper airplane workshop/demonstration  
Boardwalk Ballroom

*Games will be cancelled in case of rain*

### **Park Hours:**

**Physics Students: 8:00am – 6:00pm**

**Students & General Public: 10:00am – 6:00pm**

### **Lunch:**

**Auntie Pasta's: 11:00am–2:00 pm**

### **Parking:**

**\$9.00 – Cars & Vans**

**\$15.00 Busses**



# Physics FUN Day 2005

Sponsored by  
Knott's Berry Farm,  
Edwards Airforce Base,  
and  
Physics Teachers

# Physics Fun Day 2005 at Knott's Berry Farm

## EXTRA NOTES & DRAWINGS

Welcome to the Seventh Annual Physics Fun Day at Knott's Berry Farm. The planners hope you have both an enjoyable and educational day. To make the day safe for all we ask you to keep the following rules in mind:

1. Only equipment of the type found in Amusement Park Physics Kits (sold by science vendors) has been approved by Knott's officials for use on the rides this day. Wristbands provided with kits must be used.
2. All digital sensors and their interface units must be secured within devices such as Vernier's Lab Vest. Collecting data using digital sensors is optional.
3. Follow the directions of Knott's employees. Do not distract ride operators. They need to pay attention to the safe operation of the rides.
4. Check in with your teacher and team on a regular basis.
5. Wear appropriate clothing.

To make the most of your day of physics you will need the following pieces of equipment:

Pencil	Stop watch 0.01 sec.
Vertical Accelerometer	Horizontal accelerometer
Inclinometer	
Soft linear measuring device (knotted string, cloth measuring tape)	
TI 83 or 83+ calculator for electronic data collection (optional)	

When making measurements at Knott's, work in a team of two, three, or four. One team member should plan to keep track of the "stuff" while others stand in line for a ride.

Before coming to Knott's you should discuss the measurements you will need to make and calibrate your equipment. Measurement suggestions and useful equations are included in this guide. Plan your day to include the Physics competitions and presentations in the Boardwalk Ballroom. Several thousand physics students are expected to attend Physics Day at Knott's. Knott's will open at approximately 8am exclusively for physics students. There are many rides demonstrating numerous physics concepts. If a line for one ride is too long, go to another ride. When you finish with your measurements, store your equipment in a locker and continue to explore the park in a less quantitative manner.

EXTRA NOTES & DRAWINGS

Equipment Needed: Inclinometer and stopwatch



1. Estimate the maximum height reached by the water jets.

Max. height \_\_\_\_\_ m

2. Calculate the gauge pressure required to elevate the water from one jet to its maximum height.

Gauge Pressure \_\_\_\_\_  $\text{N/m}^2$

3. Assuming each water jet emanates from a 1.27 cm (one half inch) diameter pipe, calculate the total volume flow rate for all water jets.

Volume Flow Rate \_\_\_\_\_  $\text{m}^3/\text{s}$

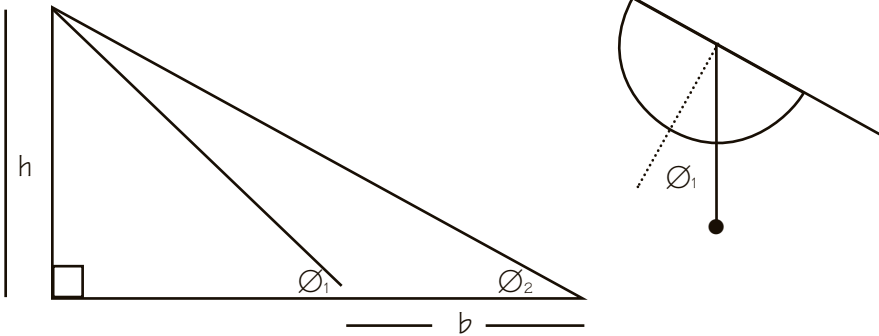
4. Estimate the minimum power required by a single pump to provide the required volume flow rate.

Minimum Pump Power \_\_\_\_\_ HP

## Drawings and Notations

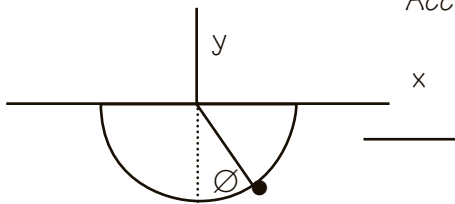
To measure height:

$$h = \left[ \frac{\sin\theta_1 \sin\theta_2}{\sin(\theta_1 - \theta_2)} \right] b + \text{observer height}$$



$$a_x = -g \tan\theta$$

To measure Horizontal  
Acceleration use  $\theta$  in tube



Measure from  
 $90^\circ$

Equipment Needed: Inclinator, stopwatch, accelerometer, measuring tape, CBL/LabPro, Acceleration sensor, and TI83 calculator

1. Estimate the height of the riders before they get shot down (answer in meters).

$$\theta_1 =$$

$$\theta_2 =$$

$$b =$$

$$h = \text{_____ m}$$

2. Measure how many seconds the first drop takes. Use this time and the freefall equation to estimate the distance you fall during the first drop (answer in meters).

$$t =$$

$$d = \text{_____ m}$$

3. Does your answer for #2 make sense or agree with your answer in #1? Explain.

4. Using your accelerometer, measure the vertical acceleration descending from the tower during the first drop.

$$a = \text{_____ m/sec}^2$$

- 5\*. Using your accelerometer, measure the maximum deceleration at the bottom of the first drop.

$$a = \text{_____ m/sec}^2$$

**SUPREME  
SCREAM**

Equipment Needed: Inclinometer, stopwatch, accelerometer, measuring tape, CBL/LabPro, Acceleration sensor, and TI83 calculator

# Xcelerator

1. Estimate the height of the highest point of Xcelerator's track.

$$\theta_1 =$$

$$\theta_2 =$$

$$b =$$

$$h = \underline{\hspace{2cm}} \text{ m}$$

2. While on the ride use your horizontal accelerometer to determine the "g" value as the ride leaves the station.

$$g = \underline{\hspace{2cm}} \text{ "g's"}$$

3. Time the period of acceleration. Calculate the displacement and final velocity.

$$t = \underline{\hspace{2cm}} \text{ sec}$$

$$d = \underline{\hspace{2cm}} \text{ m}$$

$$v = \underline{\hspace{2cm}} \text{ m/sec}$$

4. While on the ride determine the "g's" as the ride "falls" down the first hill.

$$g = \underline{\hspace{2cm}} \text{ "g's"}$$

- \*5. Use a 3-axis digital accelerometer to collect data for the entire ride. Make a printout of a graph showing both vertical and horizontal acceleration vs. time.

## Measurement Suggestions and Useful Formulae

Knott's Berry Farm is compact, so you will need to explore areas appropriate for making measurements, which do not interfere with the operations of the park.

**To find distances** use string knotted at known intervals, cloth measuring tapes or your known pace length.

**To find heights** you will measure the angles from your eye to the height at two locations in line of sight along a measured distance between the two angles. Have someone help you read the angle on the inclinometer because very slight errors in reading angles cause major errors in calculations. (See Diagram on next page)

**When measuring speeds** find a location that parallels the tracks and take several readings to find the average value.

**When using accelerometers**, be sure to have them secured around your wrist so there is no possibility that they may come loose to hurt yourself or others. (See Diagram on next page) A lift is the portion of the track where the ride is "pulled" to a height from which it "falls".

### Useful Formulae:

$$KE = 1/2 mv^2$$

$$PE = mgh$$

$$\text{height} = \{[\sin\theta_1 \sin\theta_2 / (\sin(\theta_1 - \theta_2))] \cdot b\} + \text{observer's height}$$

$$v = d/t$$

$$g = 10 \text{ m/s}^2$$

$$v = 2\pi r / T$$

$$v = gt$$

$$a_c = v^2/r$$

$$p = mv$$

$$w = Fd$$

$$a = \frac{V_f - V_i}{t}$$

$$\omega = \theta/t$$

$$J = kg \cdot \text{m}^2/\text{s}^2$$

$$\text{freefall: } d = 1/2gt^2$$

$$F = ma$$

$$T = 2\pi(L/g)^{1/2}$$

$$P = w/t$$

$$a = \frac{4\pi^2 r}{t}$$

# Wheeler Dealer Bumper Cars

1. Which of Newton's Laws is best used to describe what happens most between the bumper cars?

2. Where do the cars get their power?

3. What is the purpose of the rubber bumpers on the cars?

4. Observe a collision and describe it using conservation of momentum concepts.

Equipment Needed: Inclinometer, stopwatch, accelerometer, and measuring tape

1. Estimate the height (in meters) of the last car when it reaches its highest point on the track.



$\theta_1 =$

$\theta_2 =$

$b =$

$h =$  \_\_\_\_\_ m

2. Calculate the average speed of the last car on the train during the first descent.

distance used =

time used =

$v_{avg} =$  \_\_\_\_\_ m/sec

3. Knott's Berry Farm gives the maximum speed obtained by the train as 22.4m/s. Assuming all the train's potential energy is transferred to kinetic energy, what is its theoretical maximum speed?

$v_{theoretical} =$  \_\_\_\_\_ m/sec

4\*. Measure the acceleration as you go through the bottom of the loop.

$a =$  \_\_\_\_\_ m/sec<sup>2</sup>

Equipment Needed: Inclinometer, stopwatch, accelerometer, measuring tape, CBL/LabPro, Acceleration sensor, and TI83 calculator



1. Measure the angle of the drop path and the drop time.

$$\theta = \underline{\hspace{2cm}}$$

2. Estimate the height of the drop. (Explain how you did this.)

$$h = \underline{\hspace{2cm}} \text{ m}$$

3. Determine the theoretical acceleration along the drop path if there was no water and no friction.

$$a = \underline{\hspace{2cm}} \text{ m/sec}^2$$

4. Measure the acceleration on the drop path using an accelerometer.

$$a = \underline{\hspace{2cm}} \text{ m/sec}^2$$

5. Compare the measured and the theoretical acceleration.

Equipment Needed: Inclinometer, stopwatch, accelerometer, and measuring tape

## DRAGON SWING

1. Using an accelerometer, measure the centripetal acceleration experienced at the bottom of the arc of the Dragon Swing.

$$a = \underline{\hspace{2cm}} \text{ m/sec}^2$$

2. Estimate the length of the pendulum "arm" or "radius of the rotation of the ship" (in meters). Explain how you did this.

$$L = \underline{\hspace{2cm}} \text{ m}$$

3. Assuming mechanical energy is conserved, calculate the speed of the ship at the bottom of the swing.

$$v = \underline{\hspace{2cm}} \text{ m/sec}$$

4. Using the centripetal acceleration (using  $v$  and  $r$ ) calculate the theoretical acceleration at the bottom of the swing.

$$a = \underline{\hspace{2cm}} \text{ m/sec}^2$$

5. Compare the measured acceleration from question #1 and the theoretical acceleration from question # 4 and explain the difference.

Equipment Needed: Inclinometer, stopwatch, accelerometer, measuring tape, CBL/LabPro, Acceleration sensor, and TI83 calculator

## MONTAZOOMA'S REVENGE

1. Knott's reports the train leaves the station moving at 24.6 m/s. Time how long the train is pushed and based upon this, calculate the train's acceleration. (Show your work)

**t** =

$a = \underline{\hspace{2cm}}$

2. Use an accelerometer to estimate the train's take off acceleration. (Show data and calculations)

$a = \underline{\hspace{2cm}}$

3. What is the deceleration of the coaster when the first big braking starts? (Explain your method and calculations).

$a = \underline{\hspace{2cm}}$

4. Use the ratio of the return tower height and forward tower height to estimate the efficiency of the roller coaster as a percent (%).

Forward tower height:  $\emptyset_1 =$        $\emptyset_2 =$        $b =$        $h_f =$

Return tower height:  $\emptyset_1 =$        $\emptyset_2 =$        $b =$        $h_r =$

$e = \underline{\hspace{2cm}} \%$

Equipment Needed: Inclinometer, stopwatch, accelerometer, and measuring tape

## TIMBER MOUNTAIN LOG RIDE

1. Estimate the number of riders to ride the log ride as of its 30<sup>th</sup> anniversary on July 11, 1999 (Assume the ride is operational 340 days a year for an average of 10 hours per day).

2. Knott's reports that the water's path is 670 m in length. What is your average velocity on the trip?

Time used =

$V_{avg} = \underline{\hspace{2cm}}$

3. Determine the height and angle of the outside chute at the end of the ride.

$\emptyset_1 =$

$\emptyset_2 =$

$b =$

$h = \underline{\hspace{2cm}}$

$\emptyset = \underline{\hspace{2cm}}$

4. Using conservation of energy, estimate the speed at the bottom of the outside chute. Show your work.

5. The weight of a log is 2224N. Estimate the momentum of a fully loaded log at the base of the outside chute. Show your work.



Equipment Needed: Inclinator, stopwatch, accelerometer, measuring tape, CBL/LabPro, Acceleration sensor, and TI83 calculator



1. Estimate the height of the cover on the top of the first lift.

$$\varnothing_1 = \quad \varnothing_2 = \quad b =$$

$$h = \underline{\hspace{2cm}}$$

2. Estimate the speed in m/s of the outbound coaster as it crosses over Grand Avenue (the street outside of the main gates).

$$\begin{aligned} \text{Distance used} &= \\ \text{Time} &= \end{aligned}$$

$$V_{\text{avg}} = \underline{\hspace{2cm}}$$

3. Determine your acceleration as you go down the first hill and explain how you found it.

Questions 1 & 2 are to be completed **in the parking area** in front of the park **BEFORE** you enter or **AFTER** you leave.

Equipment Needed: Inclinator, stopwatch, accelerometer, measuring tape, CBL/LabPro, Acceleration sensor, and TI83 calculator



1. Compare the speed of Jaguar from post 98 to 104 as it passes the Carousel and Cantina to its speed after it leaves the U-turn from post 124 to 130.

$$\begin{aligned} \text{Distance before turn} &= \\ \text{Distance after turn} &= \end{aligned}$$

$$\begin{aligned} \text{Time before turn} &= \\ \text{Time after turn} &= \end{aligned}$$

$$V_{\text{avg before}} = \underline{\hspace{2cm}}$$

$$V_{\text{avg after}} = \underline{\hspace{2cm}}$$

2. Estimate the radius of the circular loop above Jaguar's water gun fountain in meters.

3. Estimate the cars average speed around the loop in #2 in meters.

$$\text{time} = \underline{\hspace{2cm}}$$

$$\text{distance} = \underline{\hspace{2cm}}$$

$$V_{\text{avg}} = \underline{\hspace{2cm}}$$

4. Calculate the centripetal acceleration of the riders as they go around the loop.

5. Now compare the calculated value to the measured acceleration using an accelerometer.

Equipment Needed: Inclinometer, stopwatch, accelerometer, and measuring tape

# LA REVOLUCION

1. Determine the complete angle through which the riders move.

$a = \underline{\hspace{2cm}}$  degrees

2. Estimate the length of the swinging arm from the pivot point to the passenger end.

$L = \underline{\hspace{2cm}}$  m

3. Determine the period of La Revolucion.

$t = \underline{\hspace{2cm}}$  sec

4. Calculate the centripetal acceleration at the lowest point in the swinging motion.

$a = \underline{\hspace{2cm}}$  m/s<sup>2</sup>

5. Measure the centripetal acceleration at the lowest point in the swinging motion.

$a = \underline{\hspace{2cm}}$  m/s<sup>2</sup>

Equipment Needed: Inclinometer, stopwatch, accelerometer, and measuring tape



1. Estimate the length of the Silver Bullet train.

$L = \underline{\hspace{2cm}}$  m

2. What is the minimum power of the motor which lifts the Silver Bullet and riders to the top of the first incline? (Assume the Silver Bullet has a mass of 10,000 kg and each rider averages 73.0 kg.)

Power, min.  $\underline{\hspace{2cm}}$  HP

3. Calculate the increase in speed resulting from the initial drop of 33.2 m (109 ft.).

Speed Increase  $\underline{\hspace{2cm}}$  m/s

4. Estimate the angular velocity,  $\omega$ , of the Silver Bullet as it travels through the lower elevated spiral.

Angular Velocity  $\underline{\hspace{2cm}}$  rad/sec

5. Estimate the radius of the lower elevated spiral and calculate the anticipated centripetal acceleration.

Radius  $\underline{\hspace{2cm}}$  m

Centripetal Acceleration,  $a_c$   $\underline{\hspace{2cm}}$  m/s<sup>2</sup>