Physics FUN Day 2006

Presented by

Knott's Berry Farm,
Educational Tours,
Discovery Science Center
and
our Local Physics Teachers

Schedule of Events

Thursday, February 23, 2006

Dr. Flubber Paper Airplane Workshop
Ongoing Workshop
9:00 am to 11:30 am – Boardwalk Ballroom

Paper Power Tower/Game
9:00am – Boardwalk Ballroom
9:30 am Limited to 30 teams of 1-3 students (9th – 12th)
10:15 am Limited to 10 teams of 1-3 students (3rd – 8th)

Discovery Science Center/Presetation
11:00 am – Charles M. Schulz Theatre

Paper Airplanes for Accuracy/Game
12:00 pm – Boardwalk Ballroom
12:00 pm Limited to 30 students (9th – 12th)
12:40 pm Limited to 20 students (3rd – 8th)

The PHYSICS Behind The Rides/Presentation
1:30 pm – Charles M. Schulz Theatre
Mr. Joey Toyoshiba & Mr. Raul Rehnborg

Lunch:
Auntie Pasta's: 11:00 am – 2:00 pm
$7.00 Pre-Paid or $8.00 at the door

Park Hours:
Physics Students: 8:00 am – 6:00 pm
General Public: 10:00 am – 6:00 pm
(Selected Rides will be open early 8:00 am - 10:00 am)

Parking:
$9.00 – Cars & Vans
$15.00 Buses

(Prices & Times subject to change)

Physics Fun Day 2006
at Knott's Berry Farm

Welcome to the Eighth 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 hand-held 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. Follow the directions of Knott's employees. Do not distract ride operators. They need to pay attention to the safe operation of the rides.
3. Check in with your teacher and team on a regular basis.
4. Wear appropriate clothing.

To make the most of your day of physics, the following pieces of equipment would be helpful:

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 Charles M. Schulz Theatre. Several thousand physics students are expected to attend Physics Day at Knott's. Knott's will open at 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.

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:

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

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

$PE = mgh$

height = $\{[\sin\varnothing_1 \sin\varnothing_2 / (\sin(\varnothing_1 - \varnothing_2)] \bullet b\}$ + observer's height

$v = d/t$

$\omega = \varnothing/t$

$g = 10\ m/s^2$

$J = kg \bullet m^2/s^2$

$v = 2\pi r/T$

freefall: $d = 1/2gt^2$

$v = gt$

$F = ma$

$a_c = v^2/r$

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

$p = mv$

$P = w/t$

$w = Fd$

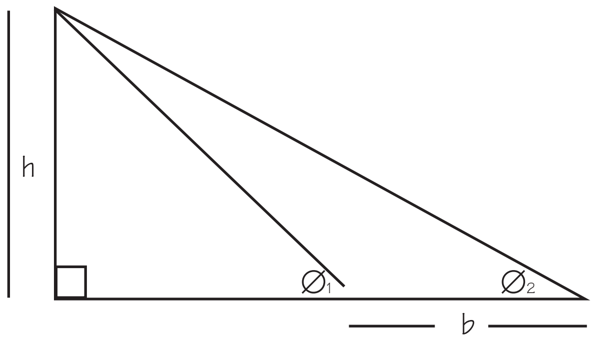
$a = \frac{4\pi^2 r}{t}$

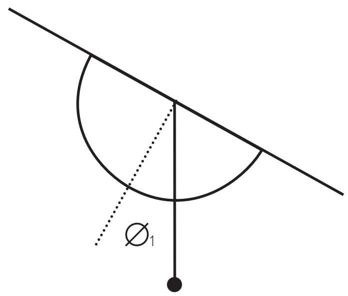
Drawings and Notations

Drawings and Notations

To measure height:

$$h = \left[\frac{\sin\varnothing_1 \sin\varnothing_2}{\sin(\varnothing_1-\varnothing_2)}\right]b + \text{observer height}$$

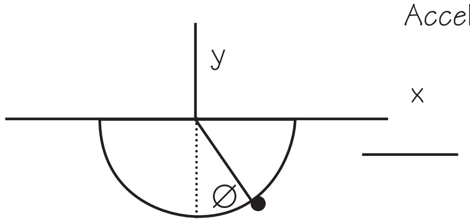




$a_x = -g \tan\varnothing$

To measure Horizontal

Acceleration use bb in tube



Measure from
90°

Drawings and Notations

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 __________ N/m^2

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

Volume Flow Rate __________ m^3/s

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

Minimum Pump Power __________ HP

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.

$\varnothing_1$ =

$\varnothing_2$ =

b =

h = ___________ m

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

g = ___________ "g's"

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

t = ______ sec | d = ______ m | v = ______ m/sec

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

g = ___________ "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.

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

Supreme Scream

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

$\varnothing_1$ =

$\varnothing_2$ =

b =

h = ___________ 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 = ___________ 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 = ___________ m/sec^2

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

a = ___________ m/sec^2

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

BOOMERANG

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

$\varnothing_1$ =

$\varnothing_2$ =

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 it's theoretical maximum speed?

$v_{theorectical}$ = ____________ m/sec

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

a = ____________ m/sec^2

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

PERILOUS PLUNGE

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

$\varnothing$ = ___________

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

h = ___________ m

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

a = ___________ m/sec^2

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

a = ___________ 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 = ___________ 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 = ___________ m

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

v = ___________ m/sec

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

a = ___________ 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

Montezooma'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 = ____________

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

a = ____________

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

a = ____________

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: $\varnothing_1$ = $\varnothing_2$ = b = h_f =

Return tower height: $\varnothing_1$ = $\varnothing_2$ = b = h_r =

e = ____________ %

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 30th 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} = ____________

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

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

h = ____________	$\varnothing$ = ____________

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: Inclinometer, 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.

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

$h =$ ___________

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

Distance used =
Time =

$V_{avg} =$ ___________

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: Inclinometer, 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.

Distance before turn = Time before turn =
Distance after turn = Time after turn =

$V_{avg\ before} =$ ___________	$V_{avg\ after} =$ ___________

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.

time = ______	distance = ______	$V_{avg} =$ ______

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 = __________ degrees

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

L = __________ m

3. Determine the period of La Revolucion.

t = __________ sec

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

a = __________ m/s^2

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

a = __________ m/s^2

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

SILVER BULLET

1. Estimate the length of the Silver Bullet train.

L = __________ 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. __________ HP

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

Speed Increase __________ m/s

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

Angular Velocity __________ rad/sec

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

Radius __________ m

Centripetal Acceleration, a_c __________ m/s^2