

High School Schedule of Events

Thursday, March 1, 2012

8:00am – 6:00pm

Collage Competition

“Inertia”

9:00am to 1:00pm – Inside Lobby of Boardwalk Ballroom
(Please pick up your collages by 2:00pm. Collages left after 2:00pm become property of Knott's)

Workshop

Dr. Flubber Paper Airplane

9:00am to 11:00am – Inside Boardwalk Ballroom

Game

Paper Power Tower

9:00am to 9:45am – Inside Boardwalk Ballroom
30 Teams of up to 4 Students

Game

Fermi Questions

10:00am to 10:45am – Inside Boardwalk Ballroom
30 Teams of up to 4 Students

Game

Paper Airplanes for Accuracy

12:15pm to 1:00pm - Inside Boardwalk Ballroom
Limited to First 75 Individuals

Game

Buoyancy Challenge

1:00pm to 2:00pm – Outside Boardwalk Ballroom
100 Teams of up to 3 Students

Guest Speaker

Mr. Thomas Unfried – “Inertia”

2:00pm – at Xcelerator in the Boardwalk area

All Events are First Come, First Serve

A School may have a maximum of 2 teams per competition (Space Available)

(Events & Times Subject To Change)



Physics FUN Day

2012

Presented by

Knott's Berry Farm
and local Physics Teachers

Physics Fun Day at Knott's Berry Farm

Drawings and Notations

Welcome to the 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:

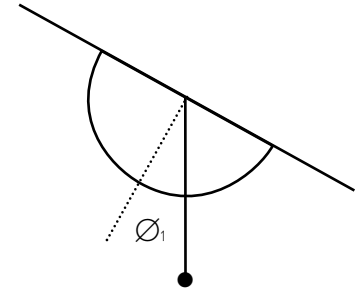
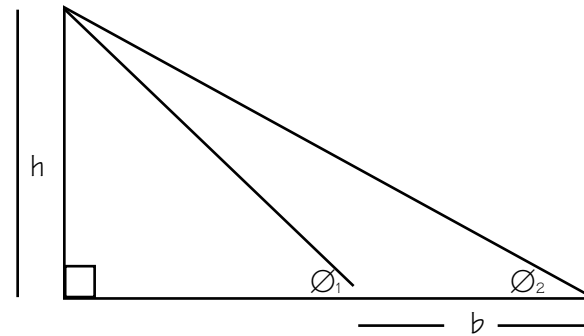
- | | |
|---|--|
| <p>Pencil Vertical Accelerometer Inclinometer Soft linear measuring device (knotted string, cloth measuring tape)</p> | <p>Stop watch 0.01 sec. Horizontal accelerometer</p> |
|---|--|

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 outside of the Boardwalk Ballroom. 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.

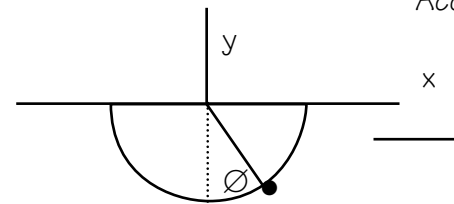
To measure height:

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



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

To measure Horizontal Acceleration use bb in tube



Measure from 90°

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/m²

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 _____ m³/s

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

Minimum Pump Power _____ HP

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:

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

$$PE = mgh$$

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

$$v = d/t$$

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

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

$$v = gt$$

$$a_c = v^2/r$$

$$p = mv$$

$$w = Fd$$

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

$$\omega = \theta/t$$

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

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

$$F = ma$$

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

$$P = w/t$$

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

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. 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

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.

$\theta_1 =$

$\theta_2 =$

$b =$

$h =$ _____

$\theta =$ _____

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, and measuring tape

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

$\theta_1 =$

$\theta_2 =$

$b =$

$h =$ _____ 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

**SUPREME
SCREAM**

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.



$$\theta_1 =$$

$$\theta_2 =$$

$$b =$$

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

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

distance used =

time used =

$$v_{avg} = \text{_____ m/sec}$$

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?

$$v_{theoretical} = \text{_____ m/sec}$$

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

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

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



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

$$\theta_1 =$$

$$\theta_2 =$$

$$b =$$

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

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

$$g = \text{_____ "g's"}$$

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

$$t = \text{_____ sec}$$

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

$$v = \text{_____ m/sec}$$

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

$$g = \text{_____ "g's"}$$

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/s²

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

$a = \underline{\hspace{2cm}}$ m/s²

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



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

V_{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.

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

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

V_{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

DRAGON SWING

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

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

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

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

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

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

- Calculate the theoretical centripetal acceleration at the bottom of the swing.

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

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

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

MONTEZOOMA'S REVENGE

- 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 =

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

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

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

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

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

- 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.



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).

Distance used =

Time =

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

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: Inclinometer, stopwatch, accelerometer, and measuring tape



1. Estimate the length of the Silver Bullet train.

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

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.)

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

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

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

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

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

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

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

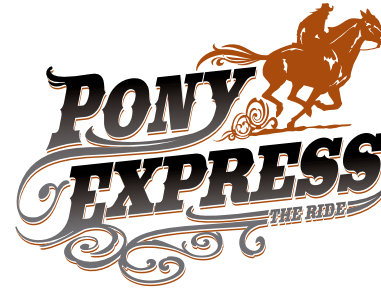
$$\text{Centripetal Acceleration, } a_c \underline{\hspace{2cm}} \text{ m/s}^2$$

Equipment Needed: Stopwatch.



1. Estimate the length (in meters) of the Sierra Sidewinder “train.”
2. Estimate the speed of the Sierra Sidewinder as it travels closest to the station.
3. Calculate the centripetal acceleration of the Sierra Sidewinder as it passes closest to the station.
4. If the speed of the Sierra Sidewinder at the top of the initial drop is 3.1 m/s and 16.5 m/s at the bottom, what is the height of the drop? (Assume a frictionless fall.)
5. Estimate the change in Potential Energy required raising a fully loaded Sierra Sidewinder to the top of the first hill?

Equipment Needed: Stopwatch.



1. Stand in the area in front of the loading area. Look at the mechanism used to push the “horses” for the acceleration. Measure the time the ride is pushed by the accelerating mechanism.
2. If the maximum speed of the ride is 17.00 meters per second, what is the acceleration?
3. Follow the track of the ride along its initial 15 meters. Look for the mechanism that launches the ride. What is this large disc called?
4. Look at the “horses” as they leave the last turn and approach the loading area. Describe the mechanism used to slow the “cars.” How do you think these devices work?
5. If the track is 381 meters what is the average speed of the ride?

WINDSEEKER

1. What is the maximum height (in meters) reached by riders?
(Measure before entering the Park next to the ticket booths)
2. How many seconds might be required for an object to free fall from this height?
3. The radial distance to the fence surrounding the WindSeeker is 13 meters. What is the radius of the circular path traveled by riders reaching maximum height?
4. Use your answer from Question 3 to determine the tangential velocity (in meters/second) of the riders when they reach the maximum height.
5. Use your answer from #4 to determine their centripetal acceleration.
6. Were an object to be dropped from that height, how far from the base of the ride, in meters, would it land?

Notes: