Canyon Physics Magic Mountain Info

Mr. Lyle

Objective:
To conduct physics experiments on rides at Magic Mountain and perhaps have a little fun in the process

General information:
1. Groups may work together, but each group must submit its own report. Make sure that all of your group members know how to contact each other!
2. Each student will receive a packet of activities to perform and suggestions for making measurements. Make sure that you take down all the data in your <u>own</u> packet, in case one of your group members doesn't meet their obligation.
3. Each group must perform at least four of the supplied activities.
4. Each group must perform the "Design Your Own Activity."
5. Each group will turn in a report for grading. You need not write the report at the park, but make sure that your group collects sufficient data to complete it later.
6. Each group will be given vertical and horizontal accelerometers, and a ruler. Please take care of these instruments, as they took a lot of time to assemble
7. If you wish to turn in your instruments to Mr. Lyle, you can meet him at the main entrance at 1:00. You are free to conduct independent research until 6:00PM
8. Meet at the bus for our return to Canyon at 6:00 PM. **The bus is scheduled to leave at 6:15PM, so don't be late!**
9. **In case of <u>emergency</u>, you can contact Mr. Lyle by calling Canyon High School at 252-6110 and asking them to contact Mr. Lyle via cellphone.** I will try to circulate about the park, but I can't be everywhere at once!
10. **Any student who leaves the park without giving Mr. Lyle written notification will receive a score of zero (0) points on the day's activities.** I need to know where you are!
11. Your behavior in the park reflects upon Canyon High and upon Mr. Lyle. Abide by all park rules and we'll all be happy.

Reports:
- Each <u>group</u> will turn in a report concerning their performance of the physics activities.
- Put each activity on a separate page.
- The report should have a cover page that includes the <u>names and periods</u> of all group members and a <u>tabulation</u> of activities performed.
- The "Design Your Own Activity should be the <u>last</u> item in your report.
- Appearance and organization are important. Make your paper <u>impressive</u>!
- This assignment is **due the Friday following the field trip!**

Fountains Activity:

At the entrance to the park there is a small pond with fountains. Here's some things to figure out about them:

How much water goes through them each second (flow rate)?
How much power is required to run them?

To determine the flow rate:
Estimate the diameter of the water at the base of the fountain in centimeters. Look at your ruler if you forget how big a cm is. Write the answer here:

____________cm Convert to meters: ____________m

Now figure out the cross-sectional area using $A=1/4\pi D^2$: ____________

You're halfway there! Now estimate the height of the water column in meters (a very tall man is 2m tall. Look at a man about the same distance away from you as the fountains, "bracket" him head to toe with your finger and thumb at arm's length and then turn and use the same "bracket" to measure the fountain.

Write your estimate here: ____________m

Now you need to figure out how fast the water must be going at the bottom of the fountain to shoot the column that high: You can figure this out by using $V=(19.6h)^{0.5}$.

Write your answer here: ____________m/s

Now multiply the cross section area (in m^2) by stream velocity (in m/s) by the number of streams. This gives the flow rate:

Flow rate: ____________m^3/s

Power Requirements:
Next, you need to figure out the power required. Remember that power is the rate of doing work, and work is force times distance. The fountains lift a certain quantity of water a certain distance in a certain time. It will be helpful to know that a cubic meter of water has a mass of 1000kg and a weight of 9800N.

The power is figured by using flow rate, weight density, and height. Use this formula: $P=Q\rho h$, where Q is the volume flow rate, ρ is the weight density, and h is the height.

Write the power here: ____________W

Discuss the accuracy of this power figure. Is it likely to be higher or lower than the actual power usage?

Grinder Gear Works Activities:

Grinder gear works is an excellent attraction on which to study centripetal acceleration.

This activity was adapted from the work of Chika Kondo, Jordan Welty, Alex Krall, Jessica Lopez, and Amber Bliss. Mr. Lyle added the measurement at the end.

Your first task is to find the centripetal acceleration by observing the ride. First, estimate the radius of the ride in meters by whatever method you desire.

Write the radius here: ____________m

Next, find the circumference of the ride by multiplying the radius by $2\pi r$.

Write the circumference here:____________m

Next, have one person count the number of rotations during the course of one ride while another person keeps track of the duration of the ride

Total rotations __________________ Ride Duration __________________s

Now, you determine the angular velocity in rotations per second by dividing the total rotations by the time.

Number rotations per second:____________rot/s

Multiply this number by the circumference to determine the rider's speed in m/s

Rider's speed: ____________m/s

At this point, you can calculate the rider's centripetal acceleration using the formula

$a_c = v^2 / r$

Calculated centripetal Acceleration: ____________m/s^2

Finally, use the horizontal accelerometer to actually measure the centripetal acceleration while riding. Hold the acceleration card against the back wall of the ride with the straw pointing toward the center of the ride. Make sure that the straw is horizontal! Note the angle that the center ball reaches when the ride gets up to full speed.

Write the angle here: ____________degrees

Calculate the centripetal acceleration using the formula: $a_c = 9.8 \tan \theta$

Measured centripetal acceleration: ____________m/s^2

How close were your calculated and measured accelerations? Which do you think is more accurate and why?

Sylvester's Pounce n' Bounce Activities:

This is a kiddie ride that for some reason is very attractive to physics students!

This activity was adapted from the work of Sam Eiben, Matt Rubek, Jared Chok, Cameron Say, and Ivan Chavez.

In this activity, you will measure the acceleration experienced by the riders. You will also determine the work done upon you by the ride.

Your first task is to determine the maximum and minimum acceleration of the ride. Sit in the ride and hold the vertical accelerometer in a vertical position in front of you. As the ride operates, notice the position of the bottom of the weight relative to the lines. The top red line indicates zero gravity. Each line below it represents one additional gravity. You can estimate fractions of a gravity by observing the bottom of the weight between the lines. Find the maximum and minimum accelerations and record them here, along with your calculations of the accelerations in m/s^2:

Maximum Acceleration:___________g x 9.8 = ___________m/s^2

Minimum Acceleration:___________g x 9.8 = ___________m/s^2

Now you will find the work done on you by the ride. Watch other riders from the ground and estimate the height that they are lifted in meters.

Write the distance here: ____________m

Next, figure out the change in gravitational potential energy that you will experience by using the formula GPE = m g h.

Write the energy here: ____________J

Multiply this by the number of riders to find the energy used per ride:___________J.

The ride oscillates up and down. Observe carefully and see if any additional energy is given to the riders during the course of their ride. Do they ever bounce higher than the previous drop? Discuss this in your report.

Scream Activities:

In this activity you will calculate the average speed, the kinetic energy of the train, and the energy required to lift the train to the top of the initial hill. This activity was written by Sydney Lott, Daniel Guzman, Darren Hancock, and Robert Wright, with a couple of modifications by Mr. Lyle

The stated track length is 1200 meters. Use a stopwatch to measure how long a train needs to complete one full ride. You may do this either on the ride or while observing. Put your answer here:

_____________________________________s

Use d = v t to calculate the average speed. Put your answer here:

_____________________________________m/s

Assume the car weights 5000kg and determine the kinetic energy using $KE = (1/2)mv^2$. Put your answer here:

_____________________________________J

Scream has a drop of 43 meters. Determine the energy required to lift the car to the top of the first hill. You might find the formula PE=mgh useful. $g = 9.8 m/s^2$

Write your answer here:

_____________________________________J

Next, you will determine the power that is required during the lift process. Measure the time that the cars are actually moving up the track, then apply the formula P=w/t to get the power in watts.
Write the wattage here: ____________W

Next, convert to kilowatts:

Total Power ____________W divide by 1000 to get ____________kW

Discussion: Is this amount of power surprising? Remember that a kilowatt is a bit more than a horsepower.

Superman Activities:

Superman is a *great* physics ride, because it is extremely simple in design. Your job is to determine its true speed before it turns upward. Conservation of energy works well, since the ride's kinetic energy before the turn is converted to potential energy after the turn.

Determining the potential energy of the car at its highest point:

First, you have to figure out how high the vehicle goes. This is actually easier than it seems, since the ride's structure consists of repeating modules. If you figure out the height of one module (relative to, say, the height of a tall man), you can easily measure the height that the car reaches. Stand 20 or thirty meters away from the ride where you can clearly see the tower. Find a tall man who is about the same distance away from you as the tower. At arm's length, "bracket" the man with your thumb and index finger. Turn to the tower and figure out how many of these "brackets" make up the height of one tower module. Multiply this by two to get the module height in meters. Write your answer here:

Height of one tower module in meters: ____________m

Number of modules <u>above the horizontal track</u> that the vehicle rises: ____________

Multiply these numbers to get the height it rose: ____________m

Now figure out the potential energy at that height. Assume that the vehicle has a weight of 3000kg. The formula is U_g=mgh

Using the formula, calculate the potential energy: ____________J

Determining the minimum velocity of the car

Now, working backwards, the kinetic energy the car had equals the potential energy of the car at the apex. $U_k = \frac{1}{2}mv^2$ We can rearrange this to get the velocity: $v = (2U_k/m)^{0.5}$

Write the velocity here: ____________m/s

To convert m/s to miles/hour, multiply by 2.2:

The velocity in miles/hour are: ____________mi/h

Compare this velocity with the advertised 100mi/h. List two reasons that there might be a discrepancy:

Riddler's Revenge Activities:

Riddler's Revenge is an excellent ride for calculation of average speed and rider throughput. That's what you are going to do!

Ride Throughput:
While waiting in line, you will calculate the number of people that the ride can accommodate per hour. First, count the number of people that a single car will hold:

Number of people per car: ____________

Now, measure the amount of time between cars with the stopwatch.

Write the time here: ____________s

You now have figures for people/car and seconds/car. Dimensional analysis shows that if you divide the number of people per car by the number of seconds per car you will arrive at the number of people per second.

Write this here by the ____________people/sec

All you have to do now is multiply by 3600 seconds/hour to finish the problem:

Write the answer here: ____________people/hour.

Average Speed:
In order to figure the average speed, you have to know the length of the track. Magic Mountain says that the length of the track is about 1600m.

You also need to know the amount of time that the ride runs. You can measure this with a stopwatch either on the ride or while observing the ride. Note that this is not the time between cars, since more than one car can be in motion at one time!

Write the time here: ____________s

Once you have the data, all you have to do is use the formula V_a=d/t

Write the average speed here: ____________m/s

Multiply by 2.2 to get mi/h: ____________mi/h

Revolution Activities:

On Revolution, you will find the speed of the car at the top of the loop and calculate the maximum radius of the loop.

Determining speed of the train:
First, you need to estimate the speed of the train as it enters the loop. To do this you need to estimate the length of the train in meters. Do this by estimating the length of one car of the train and then multiplying by the number of cars in the train.

Write your estimate here: ____________m

Next, time the train from front to back with the stopwatch as it passes the top of the loop. Since this is a fairly quick event, you should time several trains and average the times.

Time for train to pass the top of the loop: ____________s

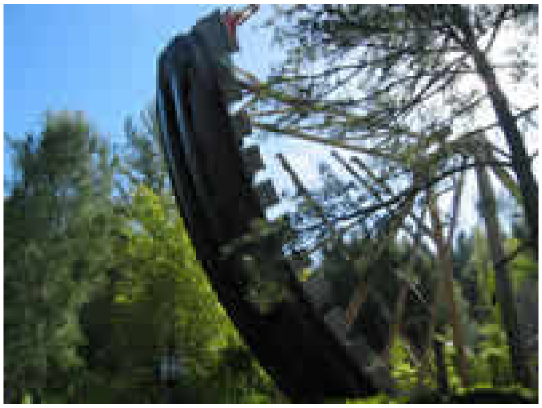
Now, use v=d/t to find the speed of the train: ____________m/s

Finding the minimum radius of the loop
The ride must maintain positive G's at all time, even if the car is upside down. This means that the centripetal acceleration of the car must be more than $9.8 m/s^2$ even when the car is moving at its slowest at the top of the loop. The formula for centripetal acceleration is $a_c=v^2/r$ which we will rearrange to $r=v^2/a_c$

Use your velocity measurement and the gravitational acceleration to determine the minimum radius of the loop:

Write your answer here: ____________m

Look at the loop from the side. Note that it isn't really circular in shape at the bottom. Why is a circular shape <u>not</u> a good idea for a roller coaster loop? Discuss this below:



Buccaneer Activities:

The Buccaneer acts like a large pendulum. Most of its mass is concentrated in the "ship" portion of the ride where the guests sit. You will measure the period of the pendulum and from this determine the height of the pivot.

Estimating the height of the pivot:
First, estimate the height of the pivot above the ship in meters. You can do this with "eyeball" methods, such as imagining how many "people-heights" would be required to reach the pivot. A tall man is a bit less than two meters tall.

Write your estimate here: ____________m

Determining the height of the pivot using the period:
Next, you need to determine the period of swing. Using the stopwatch, measure the time required for the ride to swing to and fro 10 times. Divide this number by 10 to get the period.

Write the period here: ____________s

Next, we get to do some mathematics. The period of a pendulum is given by the equation $T=2\pi(L/g)^{0.5}$
Where T is the period, L is the length of the pendulum, and g is the gravitational acceleration (9.8m/s).

Since we're looking for the length of the pendulum, we can rearrange the formula and insert the known numbers thus: $L=.25T^2$

Use the above formula to calculate the length of the Buccaneer "pendulum"

Write the answer here: ____________m

Discuss how closely your answer came to your visual estimate of the height of the pivot. What is the probable cause of any discrepancies?

Colossus Activities:

For Colossus, you will determine the acceleration of the car as it leaves the station and again as it returns. To do this, you will need a horizontal acceleration card. It helps to have a friend to hold the card while you read the measurement.

If you hold the card with the rounded side down, it will function as an accelerometer. The greater the acceleration force, the more the balls will deviate from the straight down position.

Measuring the acceleration and deceleration of the car:
When you enter the car, hold the card upright. Make sure that the balls line up with the 0 degree marking and that the 80 degree marking is toward the rear of the car.

As the car leaves the station, hold the card steady relative to the car while letting the balls roll freely. Note the position on the scale to which the balls swing. The angle through which the balls swing is the angle you want.

Write the angle here: ____________degrees

Next, repeat the procedure as the train is stopping upon its return to the station.

Write the angle here: ____________degrees

Since the angle is the result of two accelerations pulling on the weight (the acceleration due to gravity and the acceleration of the train) you can easily solve for the acceleration. The result is the formula $a_x=9.8\tan\theta$, where a_x is the acceleration and θ is the angle. Using this formula, determine the following:

Acceleration of the train: ____________m/s^2

Deceleration of the train: ____________m/s^2

Discuss any difficulty you had in obtaining the acceleration measurements. What would you do to improve the accuracy of the data?

Tatsu Activities:

Tatsu is a flying roller coaster that soars at top speeds.

This activity is adapted from the work of Christine Jones, Shawnie Wise-Hawkins, and Mitchell Anderson, along with that of Jose Gomez, Andrew Wong, and Joseph White, who lost his wallet to inspire the last part of the activity!

Let's figure out the work done to lift the train up to the first drop.
First, estimate the height of the first drop. How many man-heights would it be? Remember that one man-height is about 1.8m. Do the multiplication and write your answer here:

____________m

Next, use the formula GPE = mgh to determine the work done to lift the train up the first drop. Assume the train has a mass of 3000kg.
$g = 9.8 m/s^2$. Write your answer here:

____________J

Next, you will determine the speed of the car after it goes down the first drop. The first drop is approximately 30m. The easiest way to do this is to use energy methods:\

PE = KE $\quad mgh = (1/2)mv^2$

Put the speed here: ________________________m/s

Joe White had the misfortune of losing his wallet at the point pictured above, where the cars pass 7 meters above a walkway. Let's see if the wallet could injure someone on the walkway below. To do this, you need to determine the speed of the wallet at the walkway. Since the wallet already had some speed (calculated above), you have to include this in the calculation. It takes the form of:

$KE_{in} + PE_{in} = KE_{out}$

Assume the wallet has a mass of 0.25kg and determine its KE after it falls 7 meters from Joe's pocket. Use the KE to determine the wallet's speed and write the speed here:

______________________________m/s

Discuss: Could getting hit by this wallet cause injury?

Goliath Activities:

Toward the end of Goliath there is a section where you spin in a horizontal circle with a steep bank angle. You experience a lot of G's here, so this is a good place to study acceleration!

Ride Throughput:
While waiting in line, you will calculate the number of people that the ride can accommodate per hour. First, count the number of people that a single car will hold:

Number of people per car: ____________

Now, measure the amount of time between cars with the stopwatch.____________s

You now have figures for people/car and seconds/car. Dimensional analysis shows that if you divide the number of people per car by the number of seconds per car you will arrive at the number of people per second. Write this here

____________people/sec

All you have to do now is multiply by 3600 seconds/hour to finish the problem:

Write the answer here: ____________people/hour.

Measuring the "vertical" G-force using the spring accelerometer
Here you will measure the maximum G force (acceleration) in the "spin" section near the end of the ride. Hold the spring accelerometer vertically and note that the end of the weight aligns with the second ring. This corresponds with 1G. Each ring below this is another G or 9.8m/s^2. As you ride, hold the accelerometer vertically relative to you, not the outside world. Read the acceleration, estimate fractions of a "G", and write it here:

____________G Multiply by 9.8 to get m/s^2: ____________m/s^2

Now, estimate the diameter (in meters) of the circular turn the car was going through. Be sure to describe the estimation method in your report.

Diameter: ____________m

Divide by 2 for radius: ____________m

Since the car was leaned well over, your acceleration approximates the centripetal acceleration. Since $a_c=v^2/r$, you can find the speed of the car by rearranging thus: $v=(ra_c)^{0.5}$ write your answer here:

____________m/s

In your report, discuss the safety ramifications of rides such as Goliath. What are the physiological effects you felt from the G forces in this ride?

Dive Devil Activities:

The Dive Devil is a giant pendulum, with people as the bob! Thrill seekers are suspended by cables, dropped from a height, and left alone to swing back and forth.

This activity was designed by Donovan Llanes, Monica Gobran, Ashley Gastil, and Harrison Hall.

You need not go on the ride to do this activity. In fact, it is easier if you keep your feet on the ground!

Determining the length of the cables:
First, you need to determine the period of one to-and-fro swing. Measure this with a watch and write the number here:

___________________s

Note that the weight of the people does not make any difference, only the length of the cables and the acceleration due to gravity $g=9.81 m/s^2$.

The formula for period is $T = 2\pi\sqrt{\frac{l}{g}}$ which rearranges to $l = \left(\frac{T}{2\pi}\right)^2 g$

The length of the cables is: _____________m

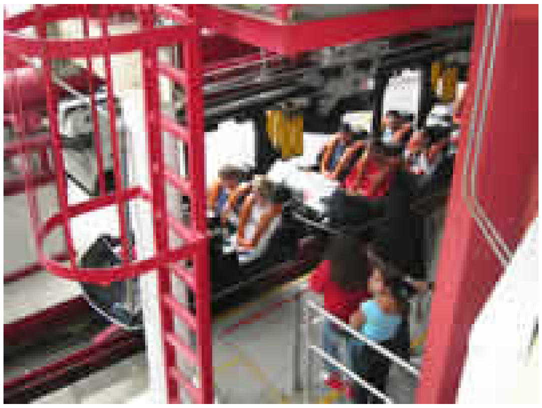
Now you are going to determine the centripetal acceleration of the thrill-seekers using energy methods and kinematics. Before the thrill-seekers are dropped, they have a potential energy such that PE = mgh. All of this is converted to kinetic energy at the rides lowest point. The kinetic energy formula is $KE = (1/2)mv^2$. Setting these formulas equal to each other and solving for v gives $v = \sqrt{2gh}$

Write the velocity here:___________________m/s

Knowing the velocity and the length of the cables, we can now find the centripetal acceleration using the formula $a_c = v^2/r$.

Write the acceleration of the riders here: _____________m/s^2

Discussion: Is this an accurate measurement of the centripetal acceleration? Why or why not?



Ninja Activities:

Ninja is advertised as the fastest suspended roller coaster on the west coast. Let's investigate the energy required to create that speed.

A roller coaster acquires its energy by being lifted up a hill. In the case of Ninja, you start at the top of the hill and are lifted at the end. Your first task is to determine how much work lifting the car and passengers would entail.

The height of the hill can be estimated by counting the steps along the inclined track. Each step is about 0.18m high, so the height of the hill can be found by multiplying the height per step by the number of steps you count.

Write the height here: ____________m

Next you will determine the work required to do this. A loaded train has a mass of about 2500kg. The change in potential energy is given by U_g=mgh. You have just found the height, and the gravitation acceleration is 9.8m/s^2. Use the formula to determine the work done. Write the answer here:

____________J

Next, you will determine the minimum horsepower of the motor that lifts the train. Power is simply work divided by time, and you've already determined the work done. The missing piece of data is the time that it takes to lift the train. Use the stopwatch to measure this and write the time here:

____________s

Power is simply work divided by time (P=w/t) so go ahead and plug your numbers into the formula and calculate the power:

____________W

Finally, large motors are usually rated in horsepower, so let's do the conversion. All you have to do is take the wattage and divide by 746W/HP:

____________HP

Where does this energy go? Obviously, it is used up as friction, so you should me much more specific in your answer.

Viper Activities:

Magic Mountain advertises that the first drop in Viper is 52m and that the curvature of the track at the bottom of the first hill is also 52m. Let's figure out what acceleration the rider will feel, first by calculation, then by measurement.

The potential energy at the top of the hill is given by $U_g=mgh$. This turns into kinetic energy $U_k=½mv^2$. You can set these two formulas equal to each other thus: $mgh=½mv^2$. The masses cancel and we can solve for v by rearranging: $v=(2gh)^{0.5}$. Since $g=9.8m/s^2$, you can solve for v. Write your answer here:

____________m/s

Now you can solve for centripetal acceleration by using $a_c=v^2/r$. Again, you have all the data required, so all you need to do is plug it into the formula to get the acceleration.

Write your answer here: ____________m/s^2

To get the true acceleration, you must add the gravitational acceleration that is always pulling us down.

Simply add $9.8m/s^2$ to the previous acceleration: ____________m/s^2

Measuring the "vertical" G-force using the spring accelerometer
Hold the spring accelerometer vertically and note that the end of the weight aligns with the second ring. This corresponds with 1G. Each ring below this is another G or $9.8m/s^2$ As you ride, hold the accelerometer vertically <u>relative to you, not the outside world</u>. Read the acceleration, estimate fractions of a gravity, and write your reading here:

____________G Multiply by 9.8 to get m/s^2: ____________m/s^2

Now, estimate the diameter (in meters) of the circular turn the car was going through. Be sure to describe the estimation method in your report.

Diameter: ____________m

Divide by 2 for radius: ____________m

Since the car was leaned well over, your acceleration approximates the centripetal acceleration. Since $a_c=v^2/r$, you can find the speed of the car by rearranging thus: $v=(ra_c)^{0.5}$ write your answer here:

____________m/s

Discuss any discrepancies in your measurements and calculations. Do your figures support each other or are they considerably different? Discuss possible sources of error and how they would affect this activity.

Roaring Rapids Activities:

Roaring Rapids give us the opportunity to study flow rates and power!

First, we need to determine the velocity of the water in the river. Since most of the ride is at a leisurely pace, you might try estimating the diameter of the boat in meters and then measure the amount of time the boat takes to pass over a fixed point. Divide the diameter of the boat by the time to get the velocity:

____________m/s

Next, let's assume that the water flows at the above speed. You'll have to estimate the width of the river (hint: how many boats will sit side by side in the river?). The water averages about 0.5m deep. To find the volume flow rate, simply multiply the velocity in m/s by the width in meters by the depth in meters:

____________m^3/s

The total drop of the river is about 4m. All of the water that came down with you has to be lifted back up again. A cubic meter of water has a weight of 9800N. Since you know the flow rate in meters per second, the weight density of the water, and the distance the water is to be lifted, you can easily figure out the work done each second. By multiplying these three numbers together. Dimensional analysis shows that $(m^3/s)(N/m^3)(m)=Nm/s$, which is power in Watts! Thus, the formula is:
P=(volume flow rate)(weight density)(height lifted)

Use this formula to determine the power required: ____________W

The pumps are run electrically. Electrical energy usage is measured in kilowatt hours. Let's figure out how much money it costs to pump water for Roaring Rapids for a day.

First, divide the power usage by 1000 to put it in kW: ____________kW

Next, multiply this number by the number of hours that Roaring Rapids is in operation each day. Add an hour to this figure to allow for startup and shutdown:

____________kWh

Finally, power costs $0.16 per kWh. Multiply this by the energy usage to get the cost per day:

____________$/day

Do you think that the power usage is a large part of the overall cost of running the attraction? Justify your answer.

Batman Activities:

Batman is perhaps a bit too violent to allow much measurement on the ride, but that doesn't mean that there isn't some interesting physics to it!

Batman is powered by electricity, which pulls the train up an initial hill. This is the only power input the train receives during its trip. Let's figure out how much power this requires.

First you need to estimate the height of the first hill. Observe that there is a stairway next to the track. Each step of this stairway is 0.18m high. Count the steps and multiply by 0.18m to get the height of the hill:

____________m

The mass of an unloaded train is 9500kg. Assume that the average passenger weighs 60kg. Count the number of seats on each train and multiply by 60kg to determine the passenger weight. Add 9500kg to get the loaded train weight:

____________kg

Now that you know the mass and the height, finding the work done on the car is simply a matter of applying U_g=mgh. The value of g is 9.8m/s^2. Calculate the work done on each train:

____________J

Next, you need to figure out the power needed to lift each train. To do this, you need to know the amount of time it takes for a train to be lifted. Measure this with a stopwatch and note the time here:

____________s

Since power is the rate of doing work, all you need to do is divide the work done by the time to get the power:

____________W. Divide this by 1000: ____________kW

Finally, let's figure out how much it costs to run the ride. You know how much energy is required to lift one car. Now you need to figure out how many cars are lifted per day. Measure the time between trains. Divide the time that the park is open per day (10 hours) by the time between trains. This will give the number of trains per day:

____________Trains/day

Multiply this by the number of Joules that it takes to lift each train to get the total energy used:

____________J

Power companies don't use joules on the power bills, so you have to convert to kilowatt-hours. Divide by 3,600,000J/kWh to put it in KWH:

____________kWh

Finally, multiply this by the cost of power, $0.16 per kWh:

____________$/day

Is the power usage a major part of the cost of running the ride? Justify your answer.

Swashbuckler Activities:

The swashbuckler is a series of seats attached to a rotating overhead framework. It is ideal for investigation of centripetal acceleration!

First, you will determine the centripetal (center-seeking) acceleration of the riders. Observe the ride at full speed. Use the horizontal acceleration card as a protractor to measure the angle between the chains suspending the riders and the vertical. Write the angle here:

____________degrees

Next, a little math will reveal the acceleration. The chains are providing a force that counteracts the pull of gravity and accelerates the rider toward the center of rotation. The gravity is defined by F=mg where g is the gravitational acceleration ($9.8m/s^2$). The centripetal force is defined by $F=ma_c$. Note that these forces act at right angles to each other and both are proportional to the mass of the object. With a little right-angle trig, it can be shown that the relationship between the forces is defined by: $\tan\theta=F_c/F_g$. Since mass is part of both F_c and F_g, we can omit it and get $\tan\theta=a_c/g$. This can be rearranged to solve for a_c: $a_c=g\tan\theta$ Since you know that $g=9.8m/s^2$ and you have measured the angle θ, solve for the centripetal acceleration:

____________m/s^2

Now that you know the centripetal acceleration, you can easily figure out the speed of the riders. The only other piece of information that you need is the radius of rotation. One way of estimating this is by using the pattern in the concrete below the ride. Be sure that your radius is that of the riders when they are fully swung out on their swings!

The radius estimate is ____________m

The formula for centripetal acceleration is $a_c=v^2/r$. Since you know a_c and r, let's solve for v: $v=(a_cr)^{0.5}$. Use this formula to solve for the speed of the riders:

____________m/s

You can also use the radius and the time that each rider takes to make a complete circle to calculate the rider speed. The formula for this is $v=2\pi r/t$, where t is the time to complete one revolution. You might want to time several revolutions to get a more accurate number for t. Calculate the velocity in this way and write the answer here:

____________m/s

Compare these two speeds. Account for any discrepancies between them. Which speed do you think is the more accurate? Why?

Gold Rusher Activities

Gold Rusher is often seen as a relatively slow ride with not much speed or excitement. We want to prove that this original Magic Mountain ride can measure up to its newer cousins as a physics activity. In this activity, you will measure the accelerations of the cars, the average velocity of the trains, and the ride throughput.

This activity was designed by Bree Mobley, Melissa Naoum, Kaely Smith, Christina Djokic, and Jessicah Starke.

Measuring the acceleration and deceleration of the train:

Use your horizontal accelerometer. Hold it upright with the straw horizontal and pointing fore-aft. It might be helpful to hold it against a vertical surface of your seat. Read the position of the center bar against the angle scale.

Angle of ball when the car leaves the station:____________degrees.

Angle of ball when the car returns to the station:_________degrees.

Use the formula $a = 9.8 \tan \theta$ to determine the accelerations:

Acceleration leaving:_______m/s^2. Acceleration returning:_____m/s^2.

Measuring the average velocity of the trains:

Magic Mountain says that the track length of Gold Rusher is 2500feet. Convert this to meters using the conversion factor of 1ft = 0.3048m.

Length of track:___________m.

Measure the time that the train takes to make one complete circuit, from start to stop.

Time for complete circuit:_________s.

Next, use the formula $d = vt$ to calculate the average speed of the train.

Average speed of the train:________m/s.

Measuring ride throughput:

While waiting in line, let's calculate the number of people who can actually ride Gold Rusher in one hour. First count the number of people who may ride in each train:

Capacity of train:__________persons.

Next, use the stopwatch to measure the time between cars leaving the station:

Time between dispatches:_________s.

Divide train capacity by the dispatch time to determine the number of people per second:

Throughput:________persons/second

Multiply this by 3600s/hr to get the number of people per hour who may ride:

Throughput:________persons/hour.

Design Your Own Activity!

There are several new attractions at Magic Mountain, as well as old attractions that aren't included in this handout. Your job is to create an activity for one of these new attractions!

Keep in mind that you do not have to design this activity around a ride. You could also design activities around anything that you can observe in the park. You may also design activities around the attractions in Bugs Bunny World, or even the food service areas!

Look over the other activities in this handout. Write up you activity in a similar format, leading the students through the process.

- The principles being examined should be clearly stated.
- There should be a step by step process to a solution. There should be blanks where students fill in key pieces of data
- Try to use at least one of the supplied instruments in your activity.
- The last part of the activity should be a higher level question that allows the student to apply what they have observed to a more general concept. This will help students write better activity reports.

After designing your activity, you should try it out yourself to work out the bugs. Make sure that you can really perform all the instructions and get good results.

Magic Mountain Alternative Assignment
Amusement Park Ride Design

This assignment is for students who are not attending the field trip

Your task: Create a design proposal for a new ride at Magic Mountain. This design is preliminary, so it won't have much in the way of detail or dimensions. The goal of your proposal is to "sell" the executives on using the design.

Design Criteria:
1. The design must be unique. It can use elements of other attractions, but is shouldn't be a "rehash" of an old design
2. The design must complement the existing theme of Magic Mountain and fit in well with existing attractions.
3. The attraction must be able to accommodate a large number of guests per hour, yet give each guest a satisfying experience.
4. Safety of guests is paramount. There must be no way that a guest can be injured by an attraction, even if the guest tries to place himself in harm's way.

Your written presentation should include:
1. The name of the attraction and how it ties into the existing theme of the park
2. A description of the physical form of the attraction.
3. A description of how the ride operates, including how guests enter, are assembled for boarding, and exit. Don't forget to design in a waiting line for high-traffic times.
4. A description of the ride's safety features
5. A guest's-eye walkthrough of the ride experience. Tell what the guest will see as he experiences the attraction. Be descriptive!

Remember:
A picture is worth 1000 words! Use drawings, sketches, models and diagrams whenever possible, but include enough text to make sure that your audience understands what they are seeing.
Make a good presentation! Remember that you're trying to sell this design to the bigwigs. Appearance counts!
This assignment is **due the Friday after the field trip**!
You may work in groups of **not more than three persons**. Each group will turn in a report.
Stay on task and keep noise to a minimum

Any disturbances reported by teacher in whose care you have been placed will subject you to disciplinary action. Remember, you are representing Mr. Lyle or Mr. Crawford with your behavior.