HIGH SCHOOL

Math & Science Week

Student Workbook

Greetings,

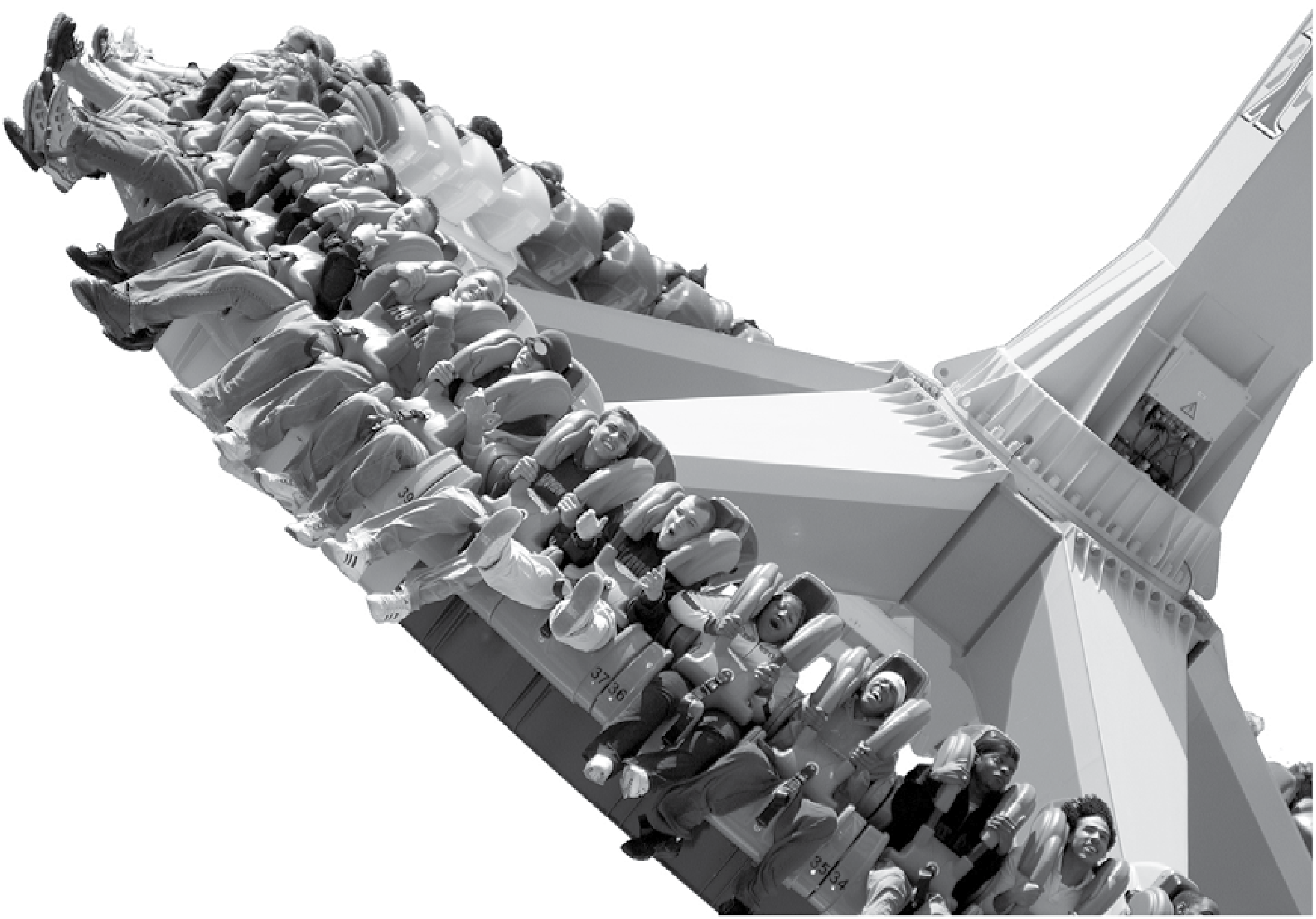
We have created this packet to assist you with your curriculum or your visit to Cedar Point during Math & Science Week. The information can be used as is, or if you wish you may customize the activities/questions for your students.

While every effort has been made to insure accuracy of the information, please remember Cedar Point is not an educational institution and this packet has not been approved by any educational organization. We know this packet can and will add to the educational enjoyment of the day.

See you on the midway!

Sincerely,

Cedar Point Staff



Student Resources

What to Bring

- ✓ Admission ticket or Season Pass (preferably already processed into your ID)
- ✓ Lunch ticket (if purchased)
- ✓ Ride Packet Assignment
- ✓ Tools to complete packet (pen/pencil/scrap paper/ spring accelerometer)
- ✓ You may need one or all of the following based on what packets you are completing: calculator, watch/stopwatch, triangulation instrument.
- ✓ Ziploc bag (to carry your materials on rides)
- ✓ Money (optional – shops and food vendors will be open)
- ✓ Positive attitude and willingness to learn!

Completing the Ride Packets

Check with your teacher to see if each group or each student needs to turn in a completed packet. You will turn in your ride packets to your teacher at the end of Math & Science Week when you board the bus or prepare to leave. When you work on the ride packets, you should answer each question completely, and when working problems, you need to show your calculations clearly. Just putting number answers in answer blanks is insufficient for your teachers, who will be looking for the methods that you used to solve the problems.

Safety and Rules

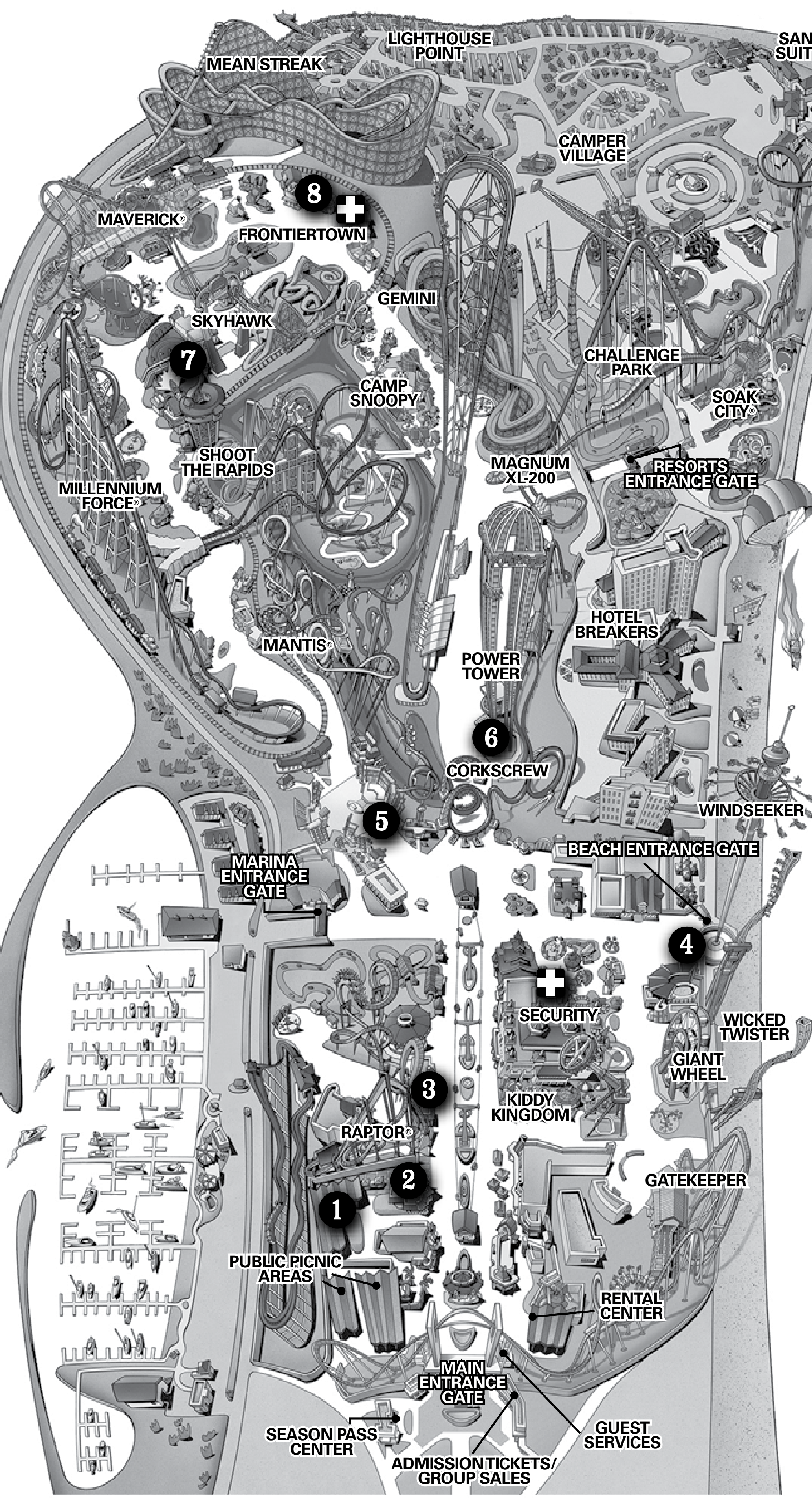
Safety comes first at Cedar Point. You are expected to obey all rules of the Park and any directions given by Park employees. Nothing that you are asked to complete in the packets requires unusual or dangerous behavior. Thus, do not compromise the safety of others or yourself. You are also attending a function of your school, and so all of the rules of your school still apply at the Park.

Preparing for Math & Science Week

Plan. . . plan. . . plan some more. Some of the material in the packets can be completed before you arrive at the Park. You should read through the ride packets and make notes as to different equations that you may use and different measurements that you will have to make. Don't go to the Park without having reviewed the packets or you may have difficulty completing the work!

Miscellaneous

- ✓ Lockers are available for rent inside the Park
- ✓ Dress for the weather – rain or shine, warm or cold!!



Math & Science Week Activities*

Activities are scheduled from 10:00am - 3:00pm unless otherwise noted

1. **Point Pavilion**
   Math & Science Week Meal 11:30pm – 1:30pm
   (advance purchase necessary)
   Special Speaker: Cedar Point Engineer at 2:00pm
2. **Weather Education** - AM
   Monday – Betsy Kling WKYC Cleveland
   Wednesday – Ryan Wichman WTOL Toledo
   Friday – Jim Geyer WLNS Lansing
3. University of Toledo – Physics
4. OSU Stone Lab
   Ohio Sea Grant
   ODNR – Office of Coastal Management
5. COSI – Columbus
   COSI Science Demonstration at 1:00pm
   Imagination Station (Wednesday – Friday)
   Lorain County Community College
   Michigan Science Center
6. NASA Glenn Research Center
   (Wednesday & Thursday)
7. **K'NEX Contest** (inside Town Hall)
   Guess the number of K'NEX pieces
   to win Cedar Point tickets
8. **Chaperone VIP Lounge** 11:00am – 5:00pm

**activities and locations are subject to change*

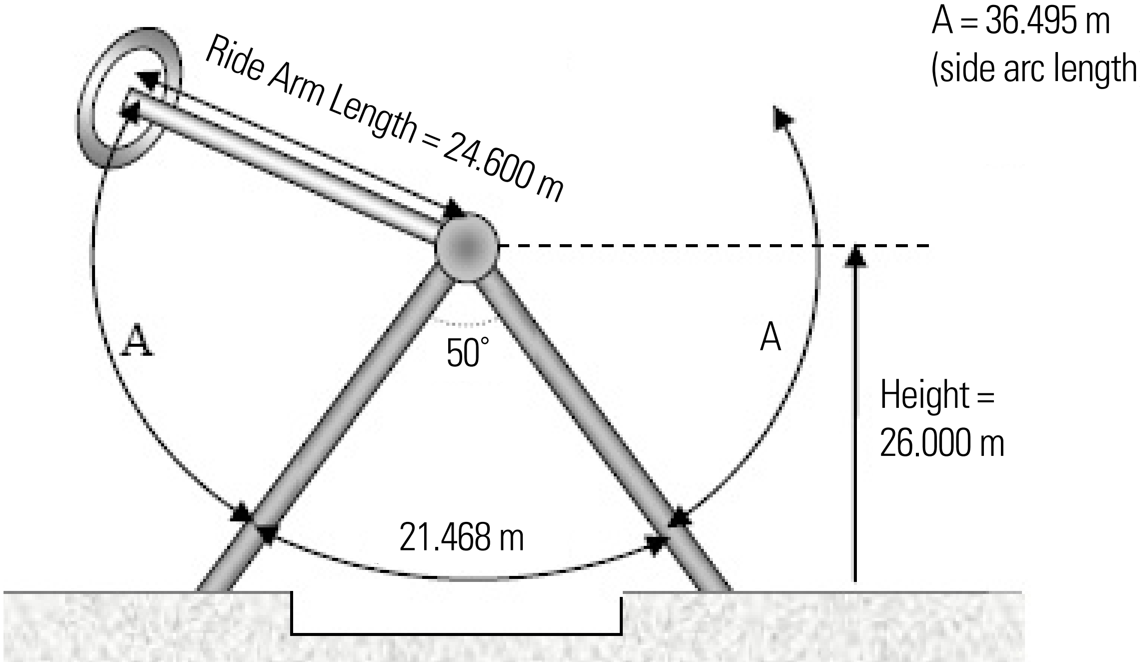
For Our Guests with Disabilities

Our goal is to give all of our guests a safe and enjoyable day. Every guest has different capabilities and limitations, so before waiting in line, please stop at the Park Operations Office. We'll brief you on our Guest Assistance Guide and explain how it applies to your specific situation. For more information, read our Rider Safety Guide, available at Guest Services, Town Hall Museum and the Park Operations Office, or in advance of your visit by calling 419-627-2301.

maXair

Ride Data Bank

- Hourly Capacity 750 guests
- Approximate Gondola Diameter = 9.2 meters
- Ride Length 2 minute, 30 seconds
- Number of Seats 50 outward facing suspended seats
- Max. Rotating Speed of Gondola 8 revolutions per minute
- Manufacturer: Huss, Bremen, Germany



Materials ✓ Pencil or Pen ✓ Worksheet

Instructions

1. Answer the following questions based on observations you make while riding maχair. You could also talk to a friend who has just ridden maχair to answer the questions. It may be helpful for you or your friend to close your eyes during a portion of the ride to more clearly make the observations.
   a. Relax your legs and allow them to move freely. Describe where in the course of the ride's motion your legs are down (along the base of the seat as there were when the ride started).

   ____
   ____
   ____

   b. With legs still relaxed, describe where in the course of the ride's motion your legs tend to be move out away from your body and the base of the seat.

   ____
   ____
   ____

   c. Where in the course of the ride do you experience the greatest force driving you into your seat?

   ____
   ____
   ____

   d. At what point(s) in the ride do you feel like you are leaving contact with the seat (feeling more pressed against the shoulder harness than the base of the seat)? What is happening?

   ____
   ____
   ____

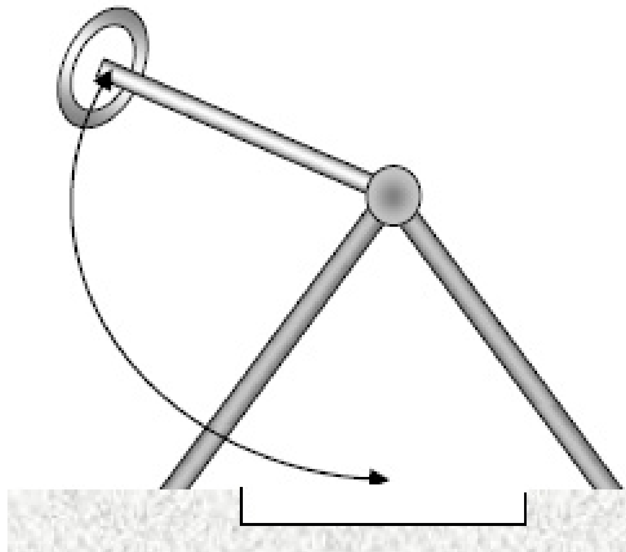
   e. How do you think the ride experience would be different if the gondola did not spin?

   ____
   ____
   ____

2. Once the ride is in full-swing measure the following times:
   a. Time for one swing (from one side to the other side) = __________
   b. Time for the gondola to pass from its highest point on one side down to the support leg on that side = __________
   c. Time for the gondola to pass between the support legs = __________
3. Use the ride data bank/discussion and measured values to calculate the average speed of the gondola (ignoring the gondola's rotation) over the following intervals:
   a. Average speed as the gondola completes one swing (from one side to the other side) = __________
   b. Averages speed as the gondola passes from the highest point on one side down to the support leg on that side = __________
   c. Average speed as the gondola passes between the support legs = __________
4. Describe the types of energy associated with the gondola and the energy transformations that take place in a single swing of the ride.

   ____
   ____
   ____

5. Place the letters of the quantities listed below at the locations on the diagram where they occur on the actual ride.
   a. Maximum Kinetic Energy
   b. Maximum Gravitational Potential Energy
   c. Minimum Linear Velocity
   d. Maximum Linear Velocity
   e. Minimum Centripetal Acceleration
   f. Maximum Centripetal Acceleration



6. Considering only the spin of the gondola, answer the following questions:
   a. Measured or calculated time for one full rotation of the gondola = __________
   b. Calculate the distance a rider travels in one full rotation = __________
   c. Calculate the average speed of a rider due to the rotation = __________
7. Throughout the ride, the spinning motion of the gondola combines with the swinging motion of the ride arm. This results in the riders traveling faster or slower depending on whether the two motions are in the same direction or opposite to each other.
   a. For a full swing, calculate the maximum speed a rider would experience (when the gondola rotation speed and ride arm swing are in the same direction) = __________
   b. For a full swing, calculate the minimum speed a rider would experience (when the gondola rotation speed and ride arm speed are in opposite directions) = __________

Extension for Advanced Physics

8. Circular Motion
   a. Calculate the centripetal acceleration acting on a rider due to the spin of the gondola.
      __________ m/s2 __________ g's
      Describe the direction of this acceleration relative to the ride.
      ____
      ____
      ____
   b. Calculate the range of centripetal accelerations acting on a rider due to the swing of the ride arm at the bottom of the swing.
      __________ m/s2 __________ g's
   c. Discuss the net centripetal acceleration acting on the rider during a swing. (What is happening to its value and also to its direction?)
      ____
      ____
      ____

Corkscrew

Ride Data Bank

• Number of Trains	3
• Cars per Train	8
• Hourly Capacity	1,800 Riders
• Ride Time	2.5 Minutes
• Lift Hill Rise	137ft
• Lift Hill Run	255ft
• Lift Hill Angle	45°

Activity Purpose

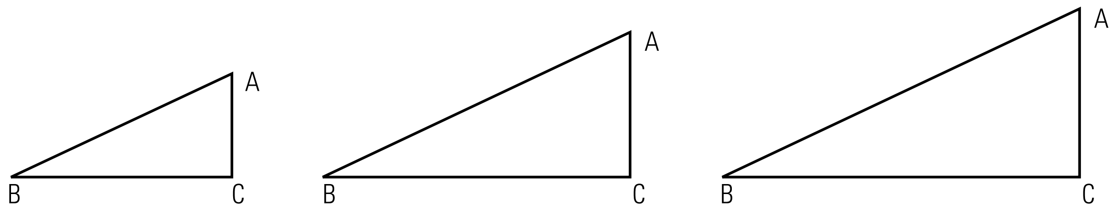
One of the most popular rides at amusement parks is the roller coaster. You can see that by the lines of people waiting to get on. There you wait patiently, all for a few minutes of terror!

Materials ✓ Stopwatch ✓ Calculator ✓ Pencil or Pen ✓ Data Bank

Instructions

Before You Ride

1. Examine each of the right triangles below. How are they alike and how are they different?



Triangle 1 Triangle 2 Triangle 3

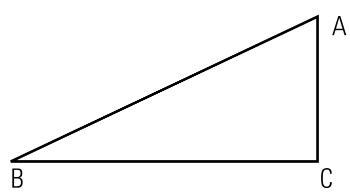
Use the information in the Data Bank to compute and record each of the following

2. The triangles in problem 1 are considered similar because they have the same shape. Use a ruler to estimate the lengths of each side of the three triangles. Then find AC/BC in each triangle. What do you notice?

The fact that corresponding sides of similar right triangles form equal ratios is the basis for trigonometry.
In right $\triangle$ ABC, the ratio is called the tangent of $\angle$ B. In shorthand, it is written as tan B.

3. The tangent is related to a concept studied in algebra class when lines are graphed. What is that concept?

4. The triangle below shows the roller coaster lift. Use information in the Data Bank to find AC, BC, and tan B.



Roller Coaster Lift Triangle

5. When you know the tangent of an angle, you can find the measure of the angle using your calculator.
Using that key, estimate the angle of the roller coaster lift.

6. Where in the Data Bank can you find your answer to problem 5?

Two other trigonometric functions, sine and cosine, are used to measure triangles.

In the diagram above, sine of $\angle B = \frac{\text{opposite leg}}{\text{hypotenuse}} = \frac{AC}{AB}$ and cosine of $\angle B = \frac{\text{adjacent leg}}{\text{hypotenuse}} = \frac{BC}{AB}$

7. Use sine or cosine to estimate the length of the roller coaster lift.

8. Use a stopwatch and the information you have from this activity to estimate the average speed at which the roller coaster climbs its lift.

After You Ride

9. After you pass the lift, the roller coaster moves through a series of ups and downs. Look at the track. What shape from algebra class do the curves of the roller coaster resemble?

10. In algebra class, the concept of slope is applied to lines only. But in calculus, slope is extended to describe curves as well. Look back at the roller coaster. If you had to apply the term slope to it, where would you say the slope is positive? Negative? Zero?

Top Thrill Dragster

Ride Data Bank

- Number of trains running at once 5
- Cars per train 5
- Passengers per train 18
- Hourly capacity 1,000
- Length of track 2,800 ft
- Velocity at end of launch track 120 mph
- Ride time 25 seconds
- Launch time from station to end of launch track 4 seconds

Activity Purpose

Top Thrill Dragster is a roller coaster…but not like any you've ridden before. There is some interesting science behind it, too.

Materials ✓ Calculator ✓ Pencil or Pen ✓ Worksheet

Instructions

Before You Ride

1. Why does a traditional roller coaster ride begin by pulling you up a hill?

2. In the 19th century, roller coasters required passengers to walk up a hill before entering the ride. Why do you think that was so?

As You Ride

3. Compare this ride to a traditional roller coaster.

After You Ride

4. A big difference between Top Thrill Dragster and a traditional roller coaster is the acceleration at the beginning. Explain the meaning of acceleration.

5. According to the Data Bank, Top Thrill Dragster goes from 0 to 120 mph in 4 seconds. Convert 120 mph to feet per second. Remember that there are 60 seconds in 1 minute, 60 minutes in 1 hour and 5,280 feet in 1 mile.

6. Acceleration is often stated using a unit such as feet per second per second, which is abbreviated as ft/s2. Explain the meaning of this unit.

7. Use your answer to problem 6 to find the average acceleration on the launch track, in ft/s2. Top Thrill Dragster achieves high velocities and acceleration without a lift hill because it operates under a different system than that of a traditional roller coaster. Top Thrill Dragster uses hydraulics and electricity, whereas a traditional roller coaster relies upon a lift hill and gravity.

8. Gravity acts to accelerate falling objects by 32 ft/s2. Compare the acceleration on Top Thrill Dragster with the acceleration of gravity. Which is greater?

9. What are some reasons that you might perceive the acceleration on this ride to be greater than that felt on a traditional roller coaster?

Ocean Motion

Ride Data Bank

- Max. height at full swing 20 meters
- Length of ship 13 meters
- Width of ship 2.5 meters

Activity Purpose

The Ocean Motion is a good example of a physical pendulum. This ride is computer controlled and uses hydraulic motors which drive two truck tires. The tires give the boat a push in each direction as it passes over the platform and are used to slow the ship safely to a stop.

Materials

✓ Pencil or Pen ✓ Worksheet

Instructions

On this page, place the letter of the correct quantity in the proper place on the diagram

A. Greatest kinetic energy spot

B. Greatest gravity potential energy

C. Free fall area

D. Weightlessness zone

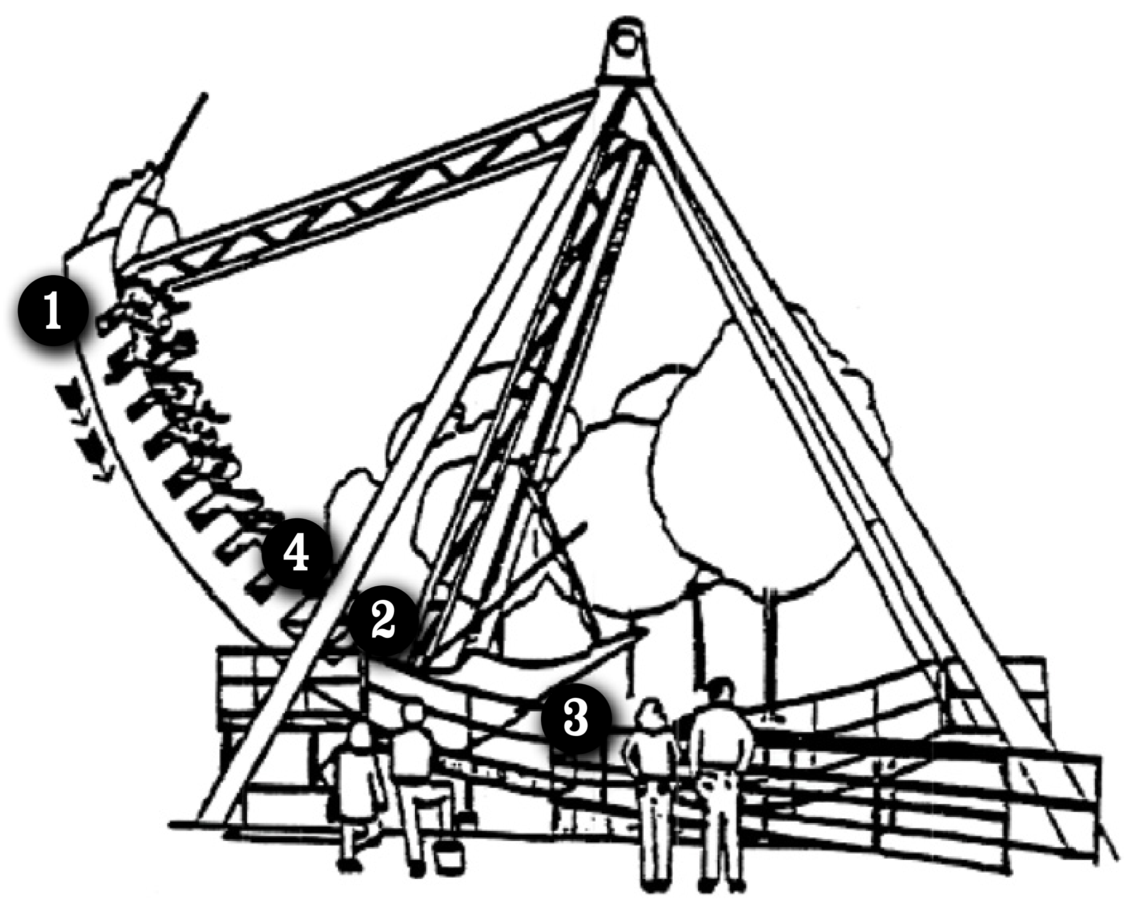
E. Maximum acceleration

F. Maximum velocity

G. Minimum velocity

H. Equilibrium point

I. Maximum centripetal force



Millennium Force

Ride Data Bank

- Manufacturer: Intamin AG of Wollerau, Switzerland
- Ride Time: 2 minutes 19 seconds
- Speed: 93 mph
- Height: 310 ft
- First Drop: 300 ft at 80-degree angle
- Track Length: 6,595 ft
- Year Opened: 2000
- Total Cost: $25 Million

Activity Purpose

Students will compare and contrast new metal coasters with the older classic wooden coasters.

Materials ✓ Calculator ✓ Pencil or Pen ✓ Worksheet

Instructions

Roller coasters can be wooden or steel, and can be looping or non-looping. You'll notice a big difference in the ride depending on the type of material used. In general, wooden coasters are non-looping. They're also not as tall and not as fast, and they don't feature very steep hills or as long a track as steel ones do. Wooden coasters do offer one advantage over steel coasters, assuming you're looking for palm-sweating thrills: they sway a lot more. Tubular steel coasters allow more looping, higher and steeper hills, greater drops and rolls, and faster speeds.

In this activity take some time to ride Millennium Force and record your observations:

Before the Ride

1. Record your heart rate:
    a. _________ bpm
2. How do you feel as you make your way through the line, up the ramp, and eventually into the loading zone?

____
____
____
____
____

During the Ride

3. Remember the total time, in seconds, that it took you to reach the bottom of the first drop. _______ Seconds

After the Ride

4. Using the number you recall from the first decent, what average speed did you travel down the hill? ________ mph
5. How did your experience on the Millennium Force, a steel coaster, compare to other steel or wooden coasters?

____
____
____
____
____

Raptor

Ride Data Bank

- Cars/Train: 3
- Train Capacity: 32
- Hourly Capacity: 1800
- Train Mass: 2380 lbs/car
- Incline Length: 225 ft.
- Incline Height: 137 ft.
- Decent Angle: 45°
- Track Length: 3790 ft.
- Ride Time: 2 minutes, 16 seconds

Raptor Part One

Purpose

In this activity, students estimate the capacity of a roller coaster, the length of its lift, and the speeds it attains. Through their work, students see real-world applications of formulas and methods learned in the classroom. Among the mathematical ideas students deal with in this activity are:

- indirect measurement
- the Pythagorean Theorem
- dimensional analysis
- the relationship $d = rt$

One of the most popular amusement park rides is the roller coaster. You can see that by the lines of people waiting to get on. There you wait patiently, all for a few minutes of terror!

Materials ✓ Stopwatch ✓ Calculator ✓ Pencil or Pen ✓ Roller Coasters Data Bank

Instructions

Before You Ride

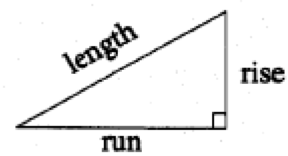
As you wait for the ride to begin, use the information in the Data Bank to compute and record each of the following.

1. Approximately how many riders can a train carry in 1 hour?

2. Estimate how many times a train can ride each hour. Explain your reasoning.

3. Use your answers to problems 1 and 2 to estimate how many passengers a train can carry.

4. The Data Bank lists Lift Rise and Lift Run, but it does not tell you the length of the lift. But you can estimate that length using the Pythagorean Theorem, as given in the model to the right. Do that here.



Pythagorean Theorem

$$(\text{length})^2 = (\text{rise})^2 + (\text{run})^2$$

5. Estimate the amount of time it takes to climb the lift at the start of the ride. You may want to use your wristwatch or a stopwatch.

As You Ride

6. Count the number of people on your train and compare this answer with your estimate from problem 3.

After You Ride

7. Using your work from problem 5 and problem 4, estimate the average speed of the roller coaster while climbing the lift.

8. Convert your answer to problem 7 to miles per hour. Remember that there are 60 seconds in 1 minute, 60 minutes in 1 hour, and 5,280 feet in one mile.

9. Based upon your answer to problem 8 and your experience on the ride, how many times as fast do you think the roller coaster was moving when it reached its greatest speed?

10. During the lift at the beginning of the ride, a roller coaster moves very slowly and requires outside power to move it. During the remainder of the ride, a roller coaster moves very quickly, while requiring no outside power. Explain why this is so.

Raptor Part Two

Purpose

What happens when you hurtle down a hill at 57 mph in a roller coaster? When you find yourself in a stressful situation, your body makes a choice faster than you can think: stick around and fight, or retreat to safety. This initial response to stress is called the fight or flight response. Many changes begin just a few seconds after adrenaline pumps through your body. You will investigate some of these responses in this activity.

Materials

- ✓ Stopwatch
- ✓ Calculator
- ✓ Pencil or Pen
- ✓ Roller Coasters Data Bank

Instructions

Before You Ride

1. As you wait to ride, measure your pulse using the following procedure:
    a. Locate your pulse by placing two fingers on the carotid artery on the side of your neck (HINT: For accurate results, do not use your index finger or thumb.)
    b. Ask a friend to time 30 seconds using a stopwatch or a wristwatch; count the number of beats during 30 seconds
    c. Multiply the number you obtain by 2. The result is your pulse rate in beats per minute. Record the rate here.

    ____

2. While resting, measure your breathing rate by counting the number of breaths in 30 seconds. Multiply this number by 2 to calculate the breathing rate in breaths/minute.

    ____

3. Do you think your pulse rate will be higher, lower, or the same after you finish the ride? Predict how your breathing rate might change during the ride.

    ____

    ____

As You Ride

4. After you go down the first big hill, see if you can observe any changes in your body:
    a. Can you feel your heart pounding? ______________
    b. Has your breathing changed? ______________
    c. Are your muscles relaxed or tense? ______________
    d. How does your stomach feel? Do you notice sweaty palms? ______________
    e. Do you have any sensations in your throat? ______________
    f. Do you feel more or less alert than usual? ______________
    g. Does your hearing or vision feel different than usual? ______________

After You Ride

5. Take your pulse again immediately following the ride and record it here. Measure and record your breathing rate. How have these rates changed compared to the rates before the ride? What would be the advantage to your body of changing your breathing or pulse rates?

    ____

    ____

    ____

6. Record your observations about your body's responses to the first big hill. For each response, try to think of advantages it would give your body for either fight or flight.

    ____

    ____

    ____

7. Predict what would happen to your body if you rode the roller coaster many times without resting.

    ____

    ____

Instructions

Answer the following questions while waiting in line for one of your favorite rides:

Power Tower

1. A person on this ride will drop 240 feet. How many times would you have to ride this ride to travel a mile?

2. The height from which a rider drops is 240 feet. There is 5280 feet in a mile. What is the length of the fall expressed in miles?

Millennium Force

1. The park runs this ride for 13 hours a day. The ride lasts 2 minute 19 seconds. If you and a friend rode this ride continuously, with no stops, how many times would you "Feel the Force" with your partner?

GateKeeper

1. GateKeeper is 4,164 feet long. One sheet of toilet paper in the park is 4.5" x 4.5" and there are 500 sheets in the roll. The park will use 700 cases of toilet paper a year. Each case contains 96 rolls. How many times could we cover GateKeper's track with all this toilet paper?

Toilet Paper

1. A sheet of toilet paper is 4.5" x 4.5"". There are 500 sheets in one roll. If a roll was laid out in a straight line, it would form a rectangle. What would be the area of that rectangle?

Hamburgers

1. We sell over 280,000 pounds of hamburger a year. How many quarter pound burgers would that make? (label your answer)

Pizza

1. We will sell over 800,000 slices of pizza. If we sold just 800,000 slices, how many pizzas would we make? (Hint: We cut completely across the pizza 4 times.)

Soap

1. Don't forget to wash your hands! The park is open a total of 139 days a year. If we use 1,000 gallons of liquid soap in the restrooms. About how many gallons do we use per day?

Acceleration at Cedar Point - A Closer Look at G's

Introduction

Spring accelerometers measure acceleration by measuring forces. Each full space on the spring accelerometer will measure a **force factor** relative to the local equivalent acceleration of gravity (9.8 m/s/s). We use **"g"** to express the value of acceleration due to the force of gravity. When you are standing still, the local gravitational force will feel normal, so the spring accelerometer will read 1*g*. If you are on a ride and the accelerometer reads 1.5*g*, you will feel 1.5 times heavier than when you were at rest. On the other hand, if you get a reading of .5*g*, you will feel .5 lighter than normal. On some rides, you may feel two to three times heavier than normal, and this would correspond to *g's* of two or three respectively.

Objective

Many thrill rides at Cedar Point are exciting because riders "feel" heavier or lighter than normal due to the motion of a particular ride. These experiments will help students measure the acceleration of certain rides at Cedar Point and compare that measurement to the force of gravity.

Procedure

1. For these experiments, the rider or riders of the group will need to observe the highest (or lowest) force factor reading on various rides at Cedar Point. The readings will change as acceleration changes, but we are watching for the "extreme" force factors in the Park.
2. Use a spring accelerometer to collect this data for the:
   Ocean Motion, Gemini, Magnum XL-200, Iron Dragon, and Blue Streak.
3. Refer to Chart I below and pay close attention to the information listed with the names of the rides. **HINT:** those are specific points on the ride that you should see the largest (or smallest) force factor reading.
4. Record the data for trial one and trial two on Chart I and find the average force factor.
5. Calculate your "apparent weight" for each of the rides listed. Use the force factors and your "normal weight" (in pounds) to calculate how heavy or light you felt at that particular point on each ride. After finding your apparent weight, record those calculations on Chart II.
6. Answer the questions provided in the data analysis and conclusions section of the laboratory.
7. Complete the bar graph "Watching your Weight" using the information from Chart I. To simplify the graphing, round the average force factor to the closest .5*g* when recording data onto the graph.

CHART I	**TRIAL I FORCE FACTOR** (*g's*)	**TRIAL II FORCE FACTOR** (*g's*)	**AVERAGE FORCE FACTOR** (*g's*)
Ocean Motion Lowest point of the swing			
Gemini Bottom of first hill			
Magnum XL-200 Top of second hill			
Iron Dragon Bottom of the first hill			
Blue Streak Bottom of the first hill			
Blue Streak Top of the second hill			

* To simplify, round the average force factor to the nearest .5*g*

Force Factor X Normal Weight = Apparent Weight

CHART II	**FORCE FACTOR** (*g's*)	**NORMAL WEIGHT** (*lbs.*)	**APPARENT WEIGHT** (*lbs.*)
Ocean Motion Lowest point of the swing			
Gemini Bottom of first hill			
Magnum XL-200 Top of second hill			
Iron Dragon Bottom of the first hill			
Blue Streak Bottom of the first hill			
Blue Streak Top of the second hill			

Data Analysis

1. What was the ride that provided the highest *g's* in the park? How about the lowest?

   Highest: ______________________ ________ *g's*

   Lowest: ______________________ ________ *g's*

2. Were you able to feel the difference between positive and negative force factors? Describe how you felt.

Conclusions

1. Using the information on Chart II, What was the heaviest and lightest amount that you weighed during your day at Cedar Point?

2. Sometimes the spring accelerometer didn't show any change from normal (remained at the 1*g* mark) even though you were moving very fast. Explain how this is possible.

3. Were there any extreme *g* forces you observed that were not recorded on the charts? Name the ride, the *g's*, and the place that it was observed.

Watching your Weight - A Closer Look at G's

Positive Force Factor (*g*)

4.0							4.0
3.5							3.5
3.0							3.0
2.5							2.5
2.0							2.0
1.5							1.5
1.0 (9.8 m/s/s) Normal	**Ocean Motion** Lowest part of swing	**Gemini** Bottom of the first hill	**Magnum XL-200** Top of the second hill	**Iron Dragon** Bottom of the first hill	**Blue Streak** Bottom of the first hill	**Blue Streak** Top of the second hill	1.0 (9.8 m/s/s) Normal
0.5							0.5
0							0
–0.5							–0.5
–1.0							–1.0
–1.5							–1.5
–2.0							–2.0

Negative Force Factor (*g*)

*Use the data from Chart I to complete the bar graph above. To simplify the graphing, round your average force factor reading to the nearest 0.5*g*

Midway Carousel

Information Sheet

Topics

- radius and circumference of a circle
- average distance
- average velocity
- use of formulas **($C = 2\pi \ \pi \ r$, $v = \frac{3d}{3t}$, etc.)**
- use conversion formulas (meters to feet, meters per second to miles per hout)

Objectives

- to use formulas
- to calculate the average linear velocities of different rows of the Carousel

Notes for the Teacher

Activities that are marked “optional” are not “harder” than those not so designated. These are optional because of the amount of time that students would need to complete the entire set of activities for this ride.

The Midway Carousel takes about 1 revolution to get to full speed, which is relatively constant. It begins slowing down by the end of the fourth revolution. Timing of 3 revolutions should take place between the first and fourth revolutions.

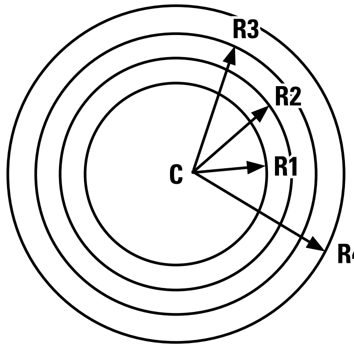
Materials

✓ Stopwatch ✓ Calculator ✓ Pencil or Pen ✓ Activity Sheets

PART 1:

The Midway Carousel is a “circular” ride at Cedar Point. Because of its historical significance, it is a most treasured ride as well. Here are several algebra connections to the Midway Carousel.

There are four rows of “seats” that comprise the Midway Carousel, each of which revolve around a fixed point (its center, C). While it revolves, the seats on three of the rows also make a vertical movement, while the seats on the row on the outside remain vertically stationary. In order to reach our goals of this activity, **we will ignore the vertical movement of the seats**.



1. To find the distance that you travel (in meters) in one revolution on a given row, use the formula for the circumference of a circle, $\mathbf{C = 2\pi r}$ (Use $\pi = 3.14$.)

   The radius of Row 1 is R1 = 4.48 meters.

   The radius of Row 3 is R3 = 6.24 meters.

   d1 = distance traveled on one revolution in Row 1 = ______________________________m.

   d3 = distance traveled on one revolution in Row 3 =______________________________m.

2. (Remember that this activity is ignoring vertical motion.)

   In your opinion, does Row 1 or Row 3 have the higher speed? Why?

   ____

   ____

   ____

Ride the Midway Carousel <u>at least twice</u>. One time, sit on the inside row of horses (Row 1) and the other time that you ride, sit on a seat in Row 3. As you ride, try to feel the difference in speeds between the two rows. Why can’t you feel the difference in speeds as you ride?

____

____

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The <u>average linear velocity</u> (the measure that tells you about how fast you are moving) can be computed by dividing the distance that you travel by the time it takes to travel that distance.

In formula form, this is: $\mathbf{v = \frac{3d}{3t}}$ where **(v)** is the linear velocity, **(d)** is the distance traveled, and **(t)** is the time that it takes to travel that distance.

In practice, it is sometimes difficult to measure time accurately. Since $\mathbf{1 \times \frac{d}{t} = \frac{3}{3} \times \frac{d}{t} = \frac{3d}{3t}}$

one “reasonable way” to estimate the linear velocity is to find. $\mathbf{v = \frac{3d}{3t}}$

3. Find **3d**: three times the distance traveled will be 3 times the circumference of the specified row. Use the results from #1 **($d = 2\pi r$)** and compute the distances traveled for 3 revolutions. Record your work in the table below.

4. Find **3t**: use a stopwatch and measure the time (in seconds, rounded to the nearest hundredth of a second) it takes for 3 revolutions of one seat (in each of the specified rows). (Do this at least twice and obtain an average time for the three revolutions.) Record your average times for the three revolutions in the table below.

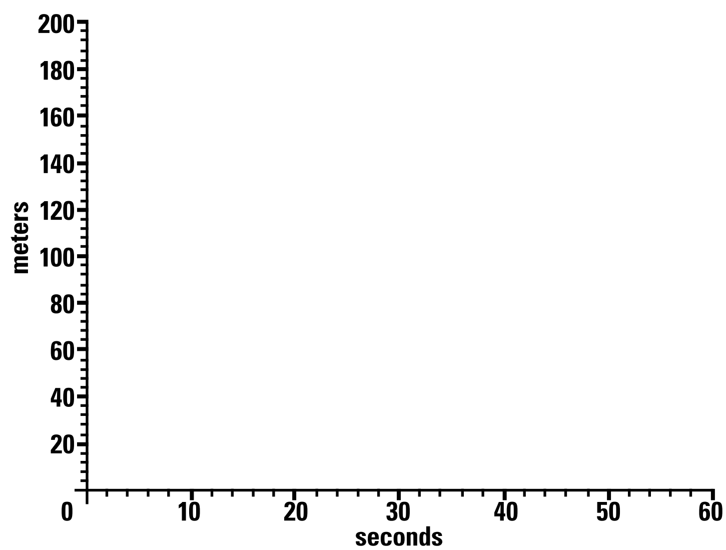
   You should begin timing AFTER the Carousel has made one revolution and continue to time for three consecutive revolutions.

	3d meters	3t sec.	$v = \frac{3d}{3t}$ m/sec.
Row 1			
Row 3			

   Complete the table by computing the velocities.

5. Compare your "feelings" from #2 with the results in the last column in the table above. Do your results make sense? (That is, comment on the difference in speeds that you calculated with the difference in speeds you felt in #2.)
6. On the axes provided, plot the ordered pair **(3t, 3d)** for Row 1 and label it. Draw a line through it and the origin. Label the line, R1.

   Repeat these steps for Row 3 on the same set of axes and label this line R3.



7. (Optional) Using your graphs, find the slopes of the lines.
   slope of the line R1 = _____________ slope of the line R3 = _____________

8. (Optional) Describe the relationship between the slope of the line for R1 and the average velocity for Row 1. What is the relationship between the slope of the line for R3 and the average velocity for Row 3?

9. (Optional)
   a. Based on your results for the computed values of average velocity and on your graphs, guess the average velocity of a person seated in Row 2.

   b. Compute $v = \frac{3d}{3t}$ for a person who rides in Row 2.

   (The radius of Row 2 is **5.3** meters. Why do you NOT need to measure **3t** again?)

   c. Is your answer in #9b reasonable? Support your claim.

____

____

PART 2

1. Suppose that **x** represents the number of meters and **y** represents the number of feet.

   Then **x = .3048y.** Solve this equation for **y**.

2. The radii of Rows 1 and 3 are given in the table below (in meters).

Radii of two rows on Midway Carousel

	radius (in meters)	radius (in feet)
Row 1	**4.48** meters	
Row 3	**6.24** meters	

Use your calculator and the conversion formula **y = 3.281x** to complete the table for the measure of each radii in <u>feet</u>. Record your answers on the table.

3. If you have not already done so, complete PART 1, #4 of this activity. (Compute the average velocities for riders in Row 1 and Row 3, where the unit measure is meters per second.)

   Use the conversion formula **1 m/sec. = 2.237 mph.** to convert your answers so that the unit measure for these velocities are in **miles per hour**. Record your answers in the table.

	velocity (in m/sec.) **see PART 1, #4**	velocity (in mph.)
Row 1		
Row 3		

4. Are the speeds on the Carousel similar to the speed of a person walking, a person running, a person bike riding, or a person driving a car in town?

5. (Optional)
   Recall that 1 mile = 5, 280 feet and that a rider travels a linear distance of **$2\pi r$** on one revolution of the ride.

   a. How many revolutions must you ride in Row 1 to have ridden one mile?

   b. How many revolutions must you ride in Row 3 to have ridden one mile?

   c. What is the least number of revolutions that one must ride in Row 1 in order to exceed the distance traveled by someone who rides in Row 3 for one revolution?

   d. How long would the ride need to be in continuous operation for you to be able to ride on Row 3 and travel one mile?

The Witches' Wheel

PART 1

When objects are traveling in straight lines, their speeds can be measured by simply dividing the time it takes them to travel a certain distance. However, this ride does not travel a linear path; it travels in a circle. The linear speed of this ride can be measured by timing each revolution, but the distance around the circle, the circumference, must be determined.

1. Using a stopwatch, find the time for the *Witches' Wheel* to make two complete revolutions. One of the cars of the *Witches' Wheel* has a "red dot" on it. Watch for the dot to pass you two times to be sure that two revolutions have occurred. Take this measurement three times, and use the average of the three trials.

   Trial 1: Time for two revolutions = ________ sec.

   Trial 2: Time for two revolutions = ________ sec.

   Trial 3: Time for two revolutions = ________ sec.

   Average time for two revolutions = ________ sec.

2. Divide the average time by two, resulting in the average time for one revolution:

   $$\textbf{Average time for one revolution} = \frac{\textbf{Average time for two revolutions}}{\textbf{two}}$$

   Average time for one revolution = ________ sec.

3. The radius of this ride is **7.92 m** meters. What is the length of the circumference of the circle through which this ride travels? ________________

   Circumference = **2π π r**
   Circumference = ________ m.

4. In order to determine the average speed of this ride, the distance must be divided by the time for one revolution.

   Average time for one revolution = ________ sec.

   $$\textbf{Average speed} = \frac{\textbf{circumference}}{\textbf{time}}$$

   Average speed = ________ m/sec.

5. (Extension) What is the average speed if measured in miles per hour? ____________ Recall that 1 mile = 5,280 feet and 1 hour = 3,600 seconds.

PART 2

In the first part of this activity, the linear speed of this ride was determined. Here, the average angular speed will be computed.

1. In PART 1, #2, the average time for one revolution was determined. The average angular speed can be determined by dividing sixty seconds by the average time for one revolution, resulting in the number of revolutions per minute.

   Average time for 1 revolution = ________ sec.

$$\textbf{Average angular speed} = \frac{\textbf{sixty seconds}}{\textbf{Average time for one revolution}}$$

   Average angular speed = ________ rev/min.

The Witches' Wheel

Introduction

The Witches' Wheel is a good ride to experience and measure what people call "**g's** of force." What they are actually measuring are the forces a body experiences as compared to the standard contact force of **mg**, which we experience in equilibrium. When contact forces accelerate a body, it is natural to compare the sensation and value to **mg**, thus the ratio of the force on a body to **mg** gives rise to "**g's** of force." When standing or sitting with no acceleration, the contact force on our body = **mg**, and we experience a "**g**" value of **mg/mg = 1**.

Objective

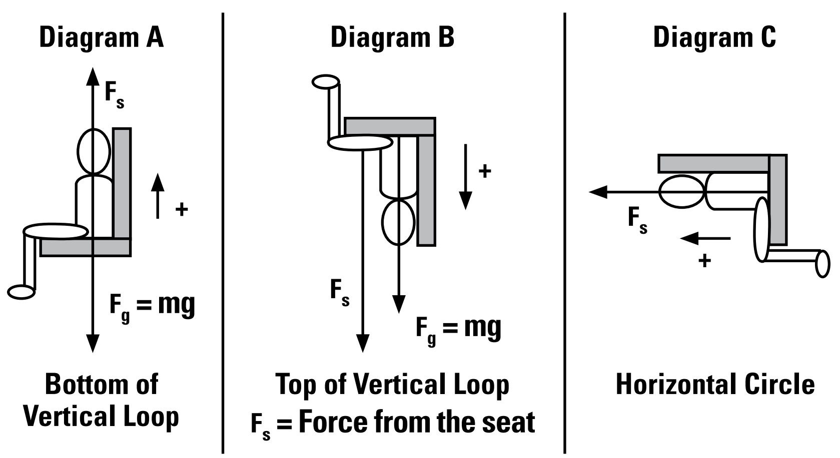
In this lab you will compare calculated "**g**" values of force of your experience with force meter values as measured on the Witches' Wheel ride.

Procedure

Part 1 Theoretical Values

During this ride you will be able to experience and measure "**g**" values for three different situations: moving in a horizontal circle, at the top of a vertical circle, and at the bottom of a vertical circle. Place all responses on the data/calculation tables that can be found within the laboratory. Using the diagrams below, write the equation for the net force on the rider. In the first two cases, it is the net vertical force, in the third case it is the horizontal force.

Based on the diagrams, fill in the blanks on the data table, and then solve for the contact force $\mathbf{F_s}$.



Theoretical Results

Fill in the blanks based on the diagrams.

Diagram A	Diagram B	Diagram C
F_{net} = ______ – mg	$F_{net} = F_s$ + ______	F_{net} = ______

Newton's Second Law says F_{net} = _____

Finally, solving for the contact force F_s

Bottom	Top	Horizontal
F_s = ma + ___	F_s= ____ – mg	F_s= ____

Part 2 The Experience

To do this part you must go on the ride.

When you are on the ride, sit on your hands, if possible, so you can better feel the force of the seat on your body. It may also be beneficial to shut your eyes at the key points of the ride so your sensations are not biased.

As the ride commences take note of the push of the seat on your body, and try to compare it to the **1g** feeling of the seat when you are first strapped in.

When the ride is over, record on your data table whether the **g's** are greater than, less than, or equal to 1 at each of the key positions.

g values >, <, or = 1

Horizontal	Top of vertical	Bottom of vertical
____________	___________	____________

Part 3 Numerical

Before going on the ride, you will need the centripetal acceleration of the ride at top speed by using the period and radius. The radius is **7.92 m**.

From the midway in front of the Witches' Wheel you should have a good view of the ride. Choose a rider or car that is easily identified. Wait until the ride is at full speed (you can tell by the sound) and time. (**two revolutions**). Calculate the period, which is the time for one revolution. *Car # 5 is marked with a red dot.*

1. **r = 7.92 meters**

Number of revolutions	Total time	Time for one revolution
__________	_________	_____________

2. Calculate the centripetal acceleration using $\mathbf{a_c = 4\pi^2 r / T^2}$

a_c = _____/ _____ = ____________

number substitutes answer

The Wave Swinger

Information Sheet

Topics

- circumference
- speed

Objectives

- to determine the circumference of the circle through which the Wave Swinger revolves
- to determine the Wave Swinger's average speed

When choosing a person to sight in timing the revolutions, a person on the outer ring of swings can be more easily observed.

When objects are traveling in straight lines, their speeds can be measured by simply dividing distance by time. However, this ride does not travel a linear path; it travels in a circle. The linear speed of this ride can be measured by timing each revolution, but the distance around the circle, the circumference, must be determined.

1. Using a stopwatch, measure the time for the Wave Swinger to make three complete revolutions when the ride has reached its maximum speed. If you listen to the motor that turns this ride, you should notice that the sound becomes constant when the ride has reached this speed. Measure the time for three complete revolutions three separate times.

   Trial 1: Time for three revolutions = ________ sec.

   Trial 2: Time for three revolutions = ________ sec.

   Trial 3: Time for three revolutions = ________ sec.

   Average time for three revolutions = ________ sec.

2. Divide the average time by three, resulting in the average time for one revolution:

   $$\textbf{Average time for one revolution} = \frac{\textbf{Average time for three revolutions}}{\textbf{three}}$$

   Average time for one revolution = ________ sec.

3. The radius of this ride is **9** meters.

   What is the length of the circumference of the circle through which this ride travels?

   Circumference = 2πr

   Circumference = ________ m.

4. In order to determine the average linear speed of this ride, the distance must be divided by the time for one revolution.

   Time for one revolution = ________ sec.

   $$\textbf{Average Speed} = \frac{\textbf{circumference}}{\textbf{time}}$$

   Average speed = ________ m/sec.

5. (Extension) What is the average speed if measured in miles per hour?

   Recall that 1 mile = 5,280 feet and 1 hour = 3,600 seconds.

Materials ✓ Stopwatch ✓ Calculator ✓ Pencil or Pen ✓ Activity Sheets