Kings Island®

MIDDLE SCHOOL

Education days

STUDENT WORKBOOK

APRIL 28, MAY 5, 12, 15–19, 26

THRILL U

Table of Contents

Welcome Students,

Congratulations on your decision to attend Kings Island's Education Days! This day will challenge you to apply your problem-solving skills and integrate much of your knowledge of mathematics and science to analyze and unravel some of the mysteries of the attractions at the Park. Your teacher has selected several different ride packets for you to complete. Plan on spending most of Education Days completing the measurements, calculations and questions in these packets. Schools from all over the region will be at Education Days, so plan on the Park being filled with other students doing exactly what you are – working on packets! Good luck on the grand adventure on which you are preparing to embark.

Sincerely,

Kings Island 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)
- ✓ You may need one or all of the following based on what packets you are completing: calculator, watch/stopwatch, triangulation instrument. Please note: Accelerometers are not permitted on any rides at Kings Island.
- ✓ 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:

You will probably be working in groups of two to complete 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 Education Days 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 Kings Island. 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 Education Days:

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
- ✓ Coolers are not permitted in the Park. Picnic-in-the-Park tickets or pizza meal vouchers may be purchased in advance for lunch in the Group Outing Picnic Grove or throughout the park (for pizza meal).
- ✓ Dress for the weather – rain or shine, warm or cold!!

Ohio Science Content Standards

Physical Sciences 9 – 10 Forces and Motion:

Explain the movement of objects by applying Newton's three laws of motion.

- ✓ Demonstrate that motion is a measurable quantity that depends on the observer's frame of reference and describe the object's motion in terms of position, velocity, acceleration and time.
- ✓ Demonstrate that any object does not accelerate (remains at rest or maintains a constant speed and direction of motion) unless an unbalanced (net) force acts on it.
- ✓ Explain the change in motion (acceleration) of an object. Demonstrate that the acceleration is proportional to the net force acting on the object and inversely proportional to the mass of the object. ($F_{net}=ma$. Note that weight is the gravitational force on a mass.)
- ✓ Demonstrate that whenever one object exerts a force on another, an equal amount of force is exerted back on the first object.
- ✓ Demonstrate the ways in which frictional forces constrain the motion of objects (e.g., a car traveling around a curve, a block on an inclined plane, a person running, and an airplane in flight).

Physical Sciences 9 – 10 Energy and Waves:

Demonstrate that energy can be considered to be either kinetic (motion) or potential (stored).

- ✓ Explain how an object's kinetic energy depends on its mass and its speed ($KE=\frac{1}{2}mv^2$).
- ✓ Demonstrate that near Earth's surface an object's gravitational potential energy depends upon its weight (mg where m is the object's mass and g is the acceleration due to gravity) and height (h) above a reference surface ($PE=mgh$).

Physical Sciences 11 – 12 Energy and Waves:

Apply principles of forces and motion to mathematically analyze, describe and predict the net effects on objects or systems.

- ✓ Use and apply the laws of motion to analyze, describe and predict the effects of forces on the motions of objects mathematically.

National Science Content Standards

Grades 9th – 12th: Physical Science: Content Standard B

As a result of their activities in grades 9-12, all students should develop an understanding of:

- Motions and Forces
  - ✓ Objects change their motion only when a net force is applied. Laws of motion are used to calculate precisely the effects of forces on the motion of objects. The magnitude of the change in motion can be calculated using the relationship $F = ma$, which is independent of the nature of the force. Whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted on the first object.
  - ✓ Gravitation is a universal force that each mass exerts on any other mass. The strength of the gravitational attractive force between two masses is proportional to the masses and inversely proportional to the square of the distance between them.

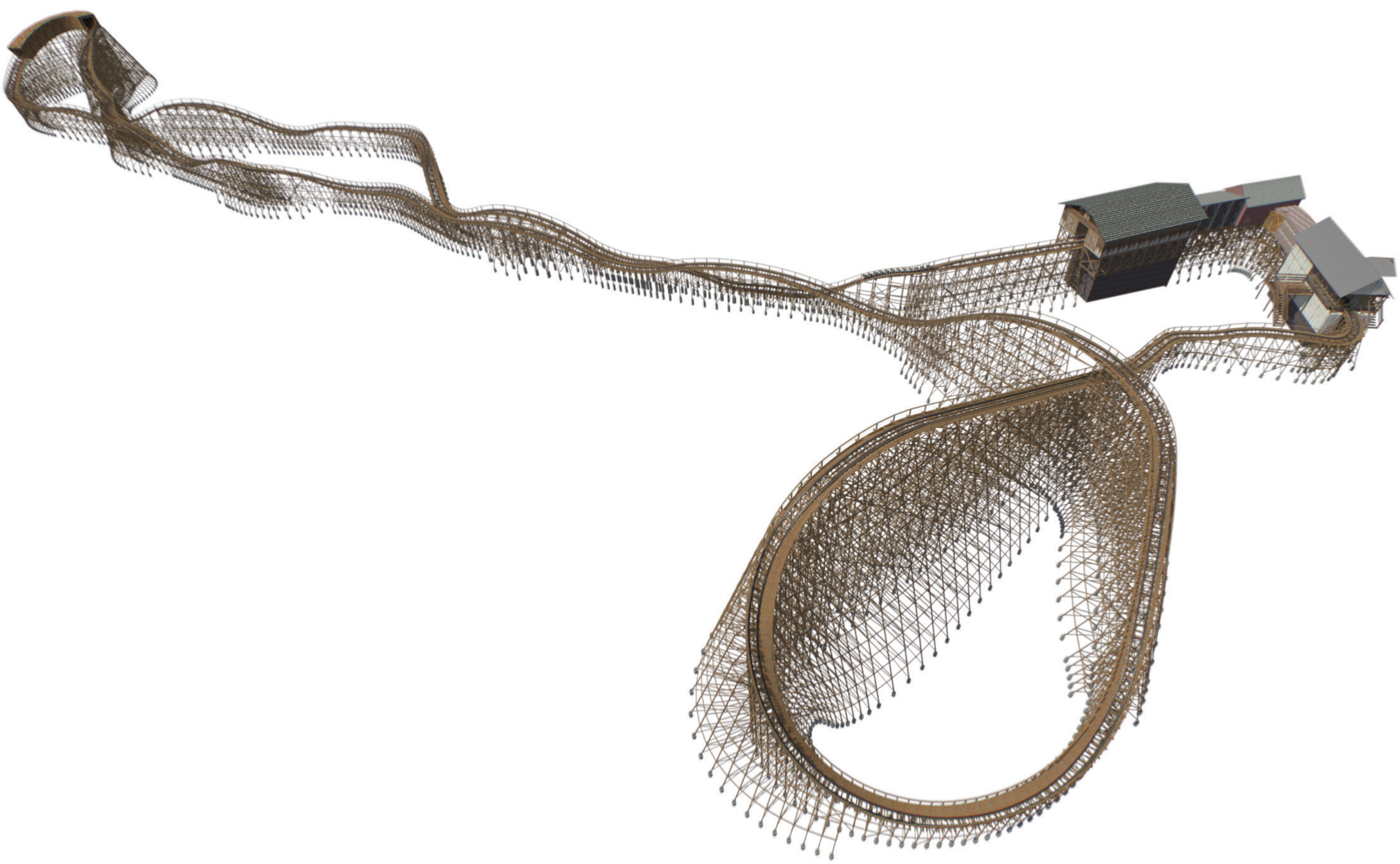
Park Map

Mystic Timbers

Name:

Ride Data Bank

- Length: 995.2 meters (3265 Feet)
- Max Height: 33.2 meters (109 feet)
- Top Speed: 23.7 m/s (53 mph)
- Airtime Hills: 16
- Trains: 24 passengers (four riders per car and six cars per train)
- Hourly Ride Capacity: 1275 riders
- Time: Rider experience lasts more than two minutes



Materials

✓ Pencil or Pen ✓ Worksheet

Instructions

Before You Ride

Make observations both while on the ride and while viewing the ride from other locations to be able to answer the following questions.

1. Find a location to observe the ride so that you can see the first hill clearly from the side. Assume that the vertical supports for the uphill section are each 3.1 meters (10 feet) apart. Make an approximation for the diagonal length of the 1st uphill section.

   ____

2. Measure the time it takes the train to travel from the bottom of the 1st hill to the top of the hill.

   ____

3. Calculate the average speed of the train traveling up the 1st hill. ______________________________

4. Consider energy conversions throughout the ride. Kinetic energy is energy associated with an object due to the object's motion. Potential energy is energy associated with an object due to its position—when an object is at a position raised above the ground it has potential energy because it is positioned such that it has the potential to fall and to do work.

   a. What object or system causes the train to move up the 1st hill? ______________________________

   b. This object/system that moves the train up the 1st hill does work on the train. As a result of this work done on the train, what kind(s) of energy does the train have associated with it at the top of the hill? ______________________________

   c. At the bottom of the 1st hill, what kind(s) of energy does the train have associated with it? ______________________________

   d. Each time the train goes down a hill, it gains __________ energy and it loses __________ energy.

   e. Each time the train goes up a hill, it gains __________ energy and it loses __________ energy.

   f. When the train pulls into the shed at the end of the ride, it has very little kinetic energy (it's not moving fast) and it has very little potential energy (it is not raised to the heights that is was on the hills). What other kinds of energy were the kinetic energy and potential energies converted into?

      ____

      ____

      ____

      ____

5. Consider the 16 times that you experience airtime on the ride. Much of the length of the ride consists of sections where the track goes up and down as diagrammed below:

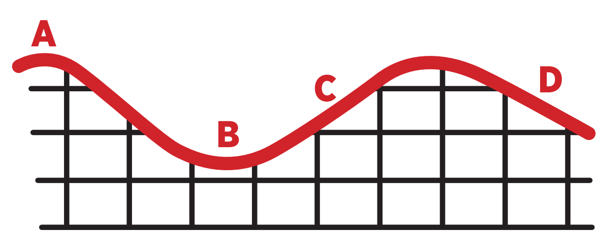
   a. Close your eyes for a section of the ride where it is going through this up and down motion. Specifically, where do you experience this airtime sensation?

      A. At the top of each hill

      B. At the bottom each hill

      C. On the way up each hill

      D. On the way down each hill



b. When you experience airtime, your body is starting to come out of your seat (you are no longer being fully supported by the seat of the train). When this occurs,

A. What is the direction of motion of the train? ______________________________

B. What is the direction of motion of your body? ______________________________

6. Consider the entire ride.

a. Looking at the car that you sit in for the ride, what different physical objects apply forces to you? Name each object or part of the car that touches you and state a direction that it can apply a force to you during the ride.

____

b. At what location do you feel the most force on your body? What part of the car applies the force to you?

____

c. What is happening to the motion of your body at the location where you experience the most force?

____

d. At what location do you feel the least force on your body?

____

e. What is happening to the motion of your body at this location where you experience the least force?

____

7. What's in the shed?

a. Make a hypothesis before you ride Mystic Timbers. ______________________________

b. Record observations of what you see in the shed. ______________________________

c. Describe motions that you experience while in shed. ______________________________

Banshee®

Name:

Ride Data Bank

- Manufacturer: Bollinger & Mabillard (B&M)
- Ride Time: 3 minutes and 2 seconds
- Speed: 68 mph
- Height: 167 feet (lift hill)
- First Drop: 165' at 59.6-degree angle
- Track Length: 4,124.1 feet
- Year Opened: 2014
- Total Cost: $24 million dollars
- The first female-inspired thrill ride at a Cedar Fair Entertainment amusement park, Banshee® will send riders screaming through 4124.1 feet of track and seven mind-bending inversions at speeds up to 68 miles per hour! The ride layout is specially designed for Kings Island. Elements will include Curved Drop, Dive Loop, Looping interacting with the lift, Zero-G-Roll, Batwing, Outside Loop, Spiral, In-Line-Roll, and Carousel.

Activity Purpose

Examine graphs that describe The Banshee's first incline and decline.

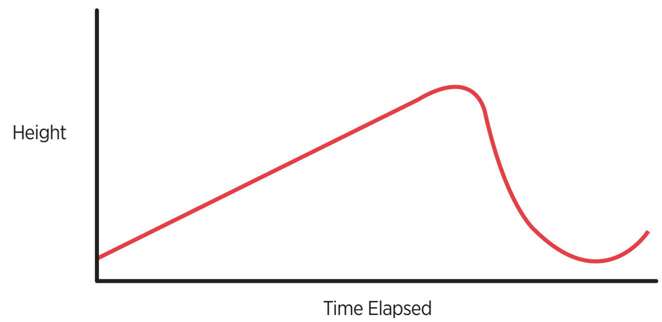
Materials ✓ Pencil or Pen ✓ Worksheet

Instructions

Before You Ride

Functions are the foundations of math and science; they provide a way to organize, represent and study information. A function is a rule describing a relationship between values. Each input value results with only one output value.

1. After observing the Banshee from the ground (or after riding it!), examine the "height function" of The Banshee's first incline and decline which is represented on the graph below.



____

____

   a. Where do you think the roller coaster train has the most potential energy? Identify the location by adding a "P" to the graph. Explain your reasoning.

____

____

____

   b. Where do you think the roller coaster train has the most kinetic energy? Identify the location by adding a "K" to the graph. Explain your reasoning.

____

____

____

   c. When or where do you think the roller coaster has the lowest speed? Why?

____

____

____

   d. When or where do you think the roller coaster has the greatest speed? Why?

____

____

____

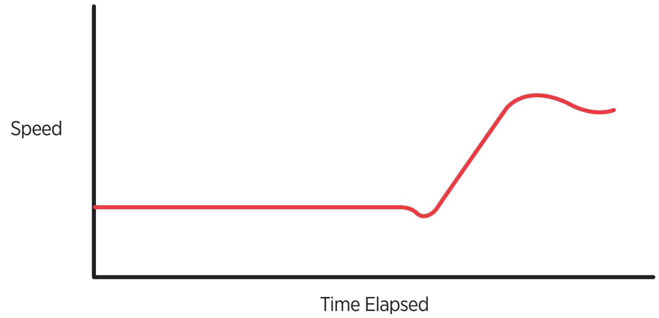
   e. Explain why the graph of the function never touches the x-axis (horizontal axis).

____

____

____

2. Next, examine the “speed function” of The Banshee’s first incline and decline which is represented on the graph below.



a. The speed of the train is constant as it makes its way up the incline; why do you think this occurs?

b. Explain what is happening to the train when the line of the graph dips down.

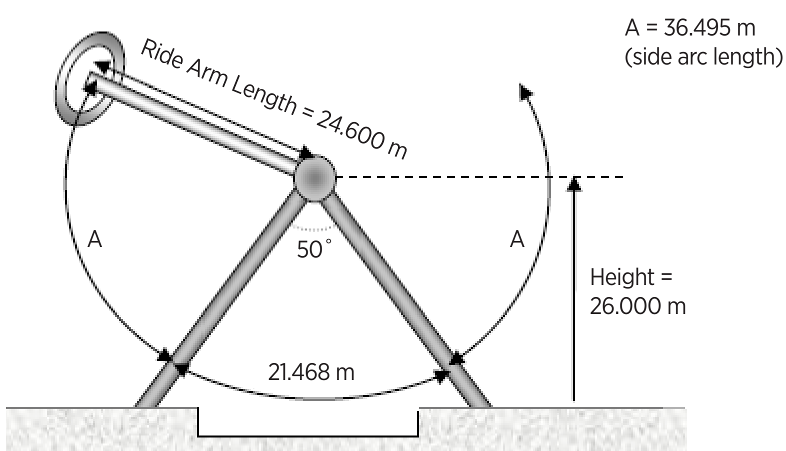
c. The train slows down after it reaches the bottom of the hill; why do you think this occurs?

Delirium

Name:

Ride Data Bank

- Hourly Capacity 600 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
- Location: Action Zone
- Manufacturer: Huss, Bremen, Germany



Materials

✓ Pencil or Pen ✓ Worksheet

Instructions

1. Answer the following questions based on observations you make while riding Delirium. You could also talk to a friend who has just ridden Delirium 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 how the speed of the ride is changing as the ride arm completes a full swing.

   ____
   ____
   ____

5. What force(s) acts to cause the ride arm to accelerate as it swings downward?

____

____

____

6. Write out the type(s) of energy that is associated with a rider at each of the locations shown below.

Position #1

____

____

Position #2

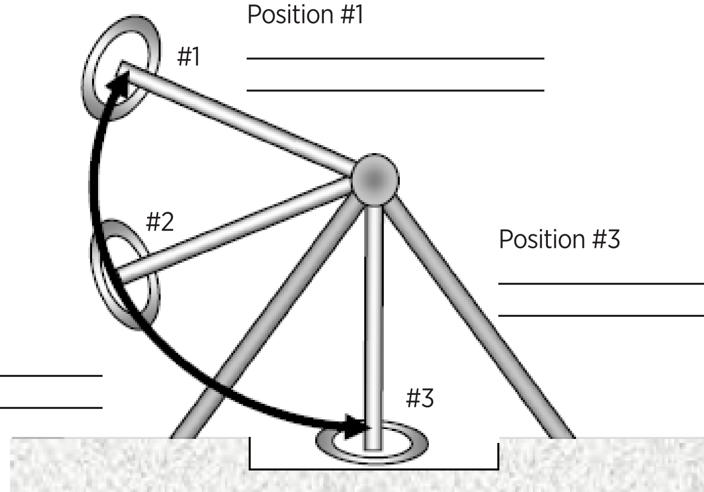
____

____

Position #3

____

____



7. Describe the types of energy associated with the gondola/riders and the energy transformations that take place in a single swing of the ride.

____

____

____

8. Considering only the spin of the gondola, answer the following questions:

   a. Measured or calculated time for one full rotation of the gondola = _______

   b. If a rider on the gondola travels 28.9 m in one full rotation, calculate the average speed of a rider due to the rotation of the gondola. ___________

Bumper Cars

Name:

Ride Data Bank

- Car length: 6 ft, 7 in
- Car width: 3 ft, 10.3 in
- Car height: 2 ft, 3 in
- Car height with arm: 8 ft, 1 in
- Car horsepower: 0.5
- Riding Area Facts
  - Inside diameter: 16 ft
  - Outside diameter: 89 ft

Activity Purpose

Going on this ride sometimes feels like being in the craziest parking lot on Earth with the worst drivers imaginable. Part of the fun is that half of the people seem to be trying to smash into each other, while the other half try to avoid all collisions. Which half are you in?

Materials

✓ Calculator ✓ Pencil or Pen ✓ Worksheet

Instructions

Before You Ride

1. When you are on this ride, it can seem as if there is no room to move your car. As you stand waiting to get on the ride, take a look at the space in which the cars can move. What percent of the driving space do you think is taken up by cars? Circle the percent that you think is closest to the actual answer.

   25%   50%   75%   100%

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

2. The total area covered by the ride.

   ____

   ____

3. The area of the center, where driving does not take place.

   ____

   ____

4. The driving area.

   ____

   ____

5. The base of a bumper car is shaped like a rectangle with rounded comers. Find the approximate area taken up by a bumper car.

   ____

   ____

6. When the ride has stopped and the cars are standing still, look at the floor to estimate the number of bumper cars there.

   ____

7. Use your answers to problems 5 and 6 to estimate the total floor space taken up by the cars.

   ____

   ____

8. Use your answers to problems 4 and 7 to estimate the percent of the driving area taken up by the cars.

   ____

   ____

9. How do your answers to problem 2 and 8 compare? If there is a big difference in the answers, can you explain why?

   ____

   ____

   ____

After You Ride

10. Bumper Cars resemble automobiles, except for their bumpers. How are their bumpers different?

   ____

   ____

   ____

11. When two cars collide, there is often a great deal of damage done to their bodies. When two bumper cars collide, there appears to be no damage done to the cars. Why do you think that is?

   ____

   ____

   ____

Carousel

Name:

Ride Data Bank

- Number of horses: 48
- Ride Facts
- Outside diameter: 34.16 m
- Height: 14.67 m

Activity Purpose

On a carousel, the horses are accelerating since their direction of motion, and therefore the velocity, changes. Among the scientific ideas students deal with in this activity is:

- speed vs. velocity
- acceleration due to a change in direction

Materials

✓ Stopwatch ✓ Calculator ✓ Pencil or Pen ✓ Worksheet

Instructions

Before You Ride

1. Calculate the distance a carousel horse located on the outside row of the carousel travels in one revolution.
   Remember the formula circumference = π x diameter (π = 3.14).

2. Time how long it takes for the carousel to complete one revolution.

3. Using the data from problems 1 and 2) calculate the speed of the carousel horse in problem 1.
   Remember the formula speed = distance/time.

As You Ride

4. In what direction do you feel yourself being pushed?

5. Face straight ahead as you go around. Does the direction you are facing change? Explain.

6. What evidence do you have that can help you decide whether or not the velocity of the horse is constant?

After You Ride

7. Was the speed of the horse constant once the carousel reached its top speed? Explain.

8. Was the velocity of the horse constant once the carousel reached its top speed? Explain.

9. When you whirl a mass around in a circle on the end of a string, is the mass moving at a constant velocity? Explain.

Drop Tower

Name:

Ride Data Bank

- Height of Tower: 315 ft.
- Height of rider at beginning of fall: 264 ft.
- Ride Length: 88 seconds
- Maximum Speed: 67mph

Activity Purpose

Talk about quick thrills. On this ride, you climb slowly to the top, only to be dropped from the sky. It is all over very quickly, but you may find yourself back in line again!

Materials

✓ Stopwatch ✓ Calculator ✓ Pencil or Pen ✓ Worksheet

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. Look how high riders climb before they are dropped. Suppose a building were that tall. Estimate how many floors it would have. Explain your reasoning.

2. The first part of the ride down, before the brakes are applied, is called free fall. Using the same approach as in problem 1, estimate how many stories you drop during free fall and how many stories you have left to stop falling.

As You Ride

3. Estimate how many seconds the climb up on the lift lasted.

4. As the ride stops or immediately after it ends, estimate how many seconds free fall lasted.

After You Ride

5. Look back at the ride and use a stopwatch to time how long it takes to climb to the top of the ride.

6. Compare your answers to problems 3 and 5. If there is a significant difference, can you suggest a reason why?

7. How fast in miles per hour did the climb feel?

8. Estimate the climb speed in miles per hour using Data Bank information and your answer to problem 5. Convert your answer to miles per hour using the fact that there are 60 seconds in 1 minute, 60 minutes in 1 hour, and 5,280 feet in 1 mile.

9. Compare your answers to problems 7 and 8. If there is a significant difference, can you suggest a reason why?

10. The time spent in free fall can be roughly approximated using the formula $\sqrt{d}/4$, where d = the distance traveled during free fall. Using information from the Data Bank, estimate the time spent in free fall.

11. Compare your answers to problems 4 and 10. If there is a significant difference, can you suggest a reason for it?

12. How fast did it feel like you were moving during free fall?

13. Compare your answer to problem 12 with the maximum speed during free fall listed in the Data Bank. If there is a significant difference, can you suggest a reason why?

Drop Tower

Name:

Ride Data Bank

- Height of Tower: 315 ft.
- Height of rider at beginning of fall: 264 ft.
- Ride Length: 88 seconds
- Maximum Speed: 67mph

Activity Purpose

Some amusement park rides rely on complex machines or computers to thrill you. This ride thrills you by dropping you out of the sky without a parachute.

Materials ✓ Calculator ✓ Pencil or Pen ✓ Worksheet

Instructions

Before You Ride

According to Newton's first law of motion, an object will remain at rest or move at constant velocity if no net force acts on it. For example, if two teams are playing tug-of-war, and the rope they are pulling on is not moving, then the net force on the rope is zero. This is true even though both teams are pulling with all their might! Why? The forces add up to zero because the two teams are pulling with equal force in opposite directions.

1. The Drop Tower car slowly climbs a lift powered by a motor. Soon after the car starts moving upward, it moves with constant speed. At this point, what is the net force acting on the car? (HINT: Remember Newton's first law.)

2. After reaching the top, the Drop Tower car is released. What force causes the car to fall?

3. Does gravity act on the Drop Tower car only while it is falling? Explain.

4. Suppose the force of gravity acting on the Drop Tower car is 2,000 pounds. In other words, the weight of the car and its passengers is 2,000 pounds. How much force do you think the motor exerts on the car as it moves upward at constant velocity? (HINT: The net force on the Drop Tower car equals the upward force exerted by the lift motor minus the downward force of gravity.)

5. While you are waiting in line, observe the velocity of the Drop Tower car as it falls. Record your observations carefully. What can you conclude about the net force acting on the car while it is falling?

As You Ride

6. On the way up, pay attention to the force with which the floor is pushing up against your feet. Are there times when the force is smaller or greater than usual? How does this compare to an ordinary elevator ride?

7. On your way down, notice how the floor pushes up against your feet. Are there times when the force is smaller or greater than usual? Were you surprised by any of your observations?

After You Ride

According to Newton's second law of motion, force = mass x acceleration*. The direction of the acceleration will be the same as the direction of the net force.*

8. The moment the Drop Tower car starts to fall, you are left behind for an instant, and the "floor falls out from under you." Explain what happens next, in terms of your motion and the forces acting on you.

9. If you were standing on a weight scale during free fall, approximately what would you expect the scale to read? Explain.

10. The force applied by the brakes to stop the Drop Tower car must be greater than the weight of the car. Explain.

11. When the brakes start to slow down the car, you can feel the force of the floor pushing up on your feet. Explain why the force feels greater than the force you experience when standing on the ground. If you were standing on a scale during braking, what would you expect the scale to read?

Flight of Fear

Name:

Ride Data Bank

- Number of trains running at once: 3
- Cars per train: 5
- Passengers per train: 20
- Hourly capacity: 1,000
- Length of track: 2,705 ft
- Velocity at end of tunnel: 54 mph
- Ride time: 60 seconds
- Launch time from station to end of tunnel: 4 seconds

Activity Purpose

Flight of Fear 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. Describe the way a traditional roller coaster begins its ride.

2. In the 19^{th} 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 the way this ride begins with the way a traditional roller coaster begins.

After You Ride

A traditional roller coaster uses a lift hill at the beginning of the ride to raise its cars to the highest point on the track. Gravity then takes over, driving the roller coaster through its ups, downs, twists, and turns.

Gravity has been driving roller coasters for more than 100 years. Flight of Fear uses a very different approach. Using the power of magnetism and electricity, this ride is able to drive its trains without a lift hill, achieving high velocities almost immediately after the ride begins.

Look at the Data Bank. The statement "Flight of Fear goes from O to 54 mph in 4 seconds" is one way of expressing acceleration. Acceleration is a measure of a change in velocity over a period of time.

4. In which of the following roller coasters would you experience a greater sense of acceleration: one that goes from O to 60 mph in 6 seconds or one that goes from O to 75 mph in 24 seconds? Explain your reasoning.

5. The Flight of Fear data stated velocity at the end of the tunnel in terms of miles per hour. Convert that figure 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. (HINT: 54 mph is also written as 54 m/h .)

6. Use the acceleration formula to calculate the acceleration of Flight of Fear in the first 4 seconds. Your answer should be expressed in ft/s^2.

7. To understand the acceleration of Flight of Fear, compare it to a sports car that accelerates from 0 to 60 mph in 6.0 seconds.

The acceleration due to gravity causes a falling object to move toward Earth with its velocity increasing by 32 feet per second every second.

8. Compare the acceleration on Flight of Fear with the acceleration of gravity. Which is greater?

9. Compared to a sports car, how long would a traditional roller coaster take to reach a speed of 60 mph on its first hill? (Assume that gravity is the only force acting on the roller coaster.)

Viking Fury

Name:

Ride Data Bank

- Max. height at full swing: 25 meters
- Length of ship: 16 meters
- Width of ship: 2.5 meters

Activity Purpose

The Viking Fury 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

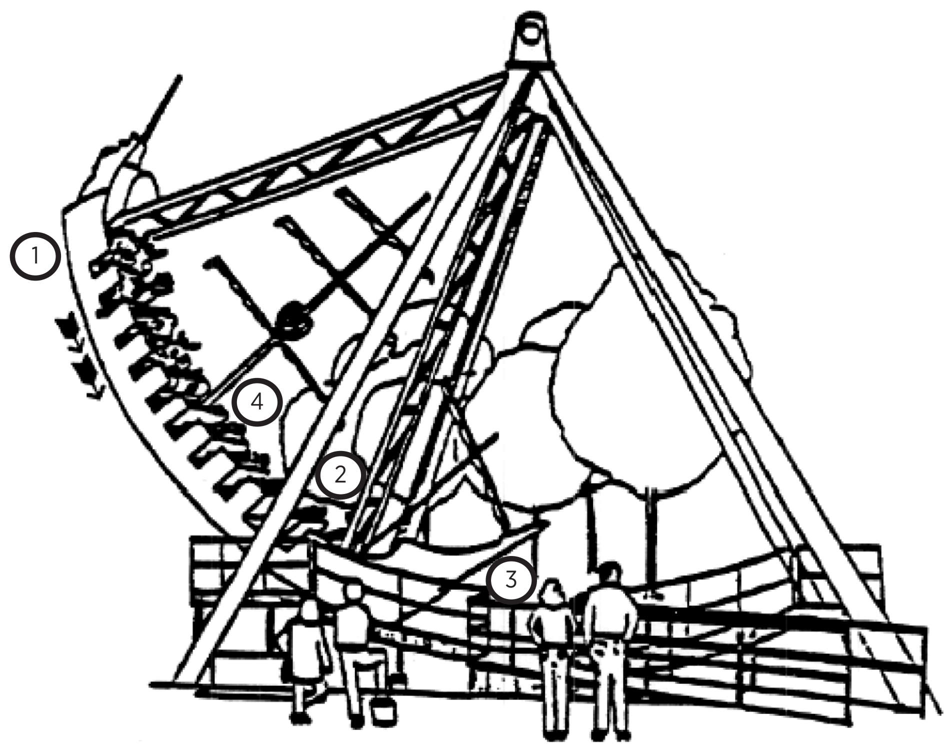
E. Maximum acceleration

F. Maximum velocity

G. Minimum velocity

H. Equilibrium point

I. Maximum centripetal force



Firehawk

Name:

Ride Data Bank

- Track length: 1018 m (3340 ft.)
- 1st Hill Height above ground: 35.05 m (115 ft)
- 1st Hill Drop: 19.20 m (63 ft)
- Vertical Loop Height (above bottom track): 20.73 m (68 ft)
- Angle of descent: 33˚
- Hourly capacity: 600 guests per train
- Riders: 24 (6 four-passenger rows per train - 2 trains)
- Ride length: 2:55 minutes
- Height requirement: 54"

Activity Purpose

Calculate the speed that Firehawk travels across a section of track.

Materials

✓ Calculator ✓ Pencil or Pen ✓ Worksheet

Instructions

1. How is the experience of riding Firehawk different from other looping roller coasters?

   ____

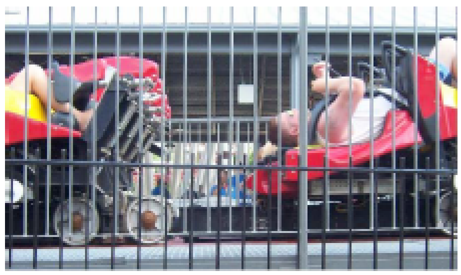
   ____

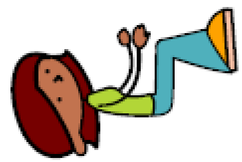
2. Describe the forces exerted on your body by the seat/restraints. What direction are the forces more commonly applied to your body during the ride? Are the forces typically stronger or weaker than the forces you experience on other looping roller coasters?

   ____

   ____

3. On the following page you will see pictures of different parts of the ride. Next to each picture is a person that is positioned approximately how he or she would be on that part of the ride. Draw arrows on the person to represent the different major forces that are acting on the person at each of those locations—the stronger the force, the longer the arrow should be. Write a brief statement next to each arrow describing what is applying the force.





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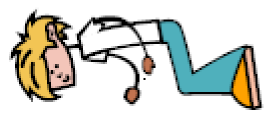

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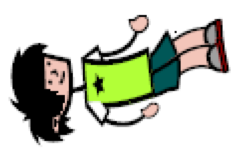

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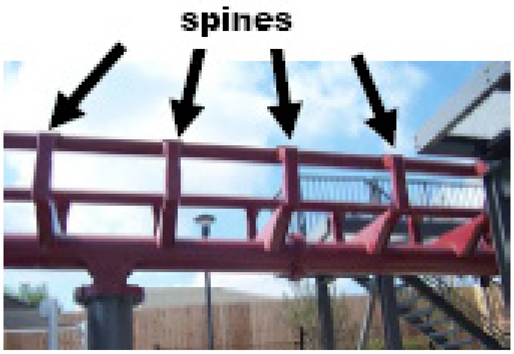
4. Make observations of the track itself.

   a. In traditional roller coasters, the train rides on the top of the track and the track is then supported from the bottom. This is not always possible for the Firehawk. Look over the track and find two sections where the train is either below the track or on the side of the track. Diagram and describe how the track is supported.

b. As pictured below, the track consists of two rails that the train rides on and then many cross supports called spines. Make observations regarding the spines…approximately what angle do they make to the two parallel rails? Is the angle always the same or does it vary for different parts of the ride? How does the space between the spines vary between different parts of the ride?



5. Predict: At what location in the ride is the train traveling the fastest?

a. Pick the three locations where you think the train is moving the fastest. For each location, identify a section of track and count a number of spines in that location. Measure the time it takes from when the front of the train passes the first identified spine to the last identified spine. Calculate the speed of the train in each section in units of spines per second.

Describe Track Location	**# of Spines**	**Time**	**Average Speed** (spines/sec)

b. What conclusion can you draw about where the train is traveling the fastest? What assumptions are you making in drawing this conclusion?

c. Calculate the speeds of the train at the following locations in spines/second. An approximate median spacing between the spines is 0.914 m (3 feet)—adjust this distance up or down if you feel it necessary based on differences in spine spacing at different parts of the track. Calculate the speed of the train in feet/second also.

Track Location	**Speed** (spines/sec)	**Speed** (m/sec)
Top of First Hill (after curve)		
Bottom of first hill drop		
Top of loop		
Bottom of loop		

d. In general, where do you see the train travel the slowest? …the fastest? What force(s) is acting on the train to cause it accelerate or decelerate at different locations on the track? Explain.

Diamondback

Name:

Ride Data Bank

- Manufacturer: Bollinger and Mabillard (B&M)
- Ride Time: 3 min.
- Speed: 80 mph
- Height: 230 ft
- First Drop: 215 ft at 74-degree angle
- Track Length: 5,282 ft
- Year Opened: 2009
- Total Cost: $22 Million

Diamondback officially opened April 18, 2009. Through a first rider auction, more than $107,000 was raised for the charity A Kid Again, a non-profit organization dedicated to providing fun-filled adventures for children suffering from life threatening illnesses and their families.

On July 20, 2009, Jim McDonel from Buffalo, NY was the 1,000,000th rider on Diamondback. A little over a month later, on August 23, Cedar Fair platinum season passholder Gary Coleman became the first park guest to accrue 1,000 rides on Diamondback. The Monford Heights, OH native has since surpassed the 4,000 ride mark on the tallest, fastest and meanest roller coaster to ever strike Kings Island.

Diamondback has given 3,627,573 rides since 2009, the 39th–most in park history. Its record year was 2009, when 1,852,831 rides were given.

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 Diamondback 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 stairs, 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 Diamondback, a steel coaster, compare to other steel or wooden coasters?

____

____

____

____

____

Roller Coaster Data Banks

Adventure Express

- Cars/Train: 5
- Train Capacity: 30
- Hourly Capacity: 1600
- Train Mass: 2380 lbs/car
- Incline Length: 34.7 m
- Incline Height: 16.8 m
- Decent Angle: 26°
- Track Length: 888.8 m

The Beast®

- Cars/Train: 6
- Train Capacity: 36
- Hourly Capacity: 1200
- Train Mass: 2300 lbs/car
- Incline Length: 159.1 m
- Incline Height: 41.1 m
- Decent Angle: 45°
- Track Length: 2255.5 m

Vortex®

- Cars/Train: 7
- Train Capacity: 28
- Hourly Capacity: 1500
- Train Mass: 1200 lbs/car
- Incline Length: 116.9 m
- Incline Height: 46 m
- Decent Angle: 55°
- Track Length: 907 m
- 1st Loop Height: 89 ft

Racer

- Cars/Train: 5
- Train Capacity: 30
- Hourly Capacity: 2640
- Train Mass: 2200 lbs/car
- Incline Length: 132.7 m
- Incline Height: 26.8 m
- Decent Angle: 50°
- Track Length: 2081.8 m

Roller Coasters Part One

Name:

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

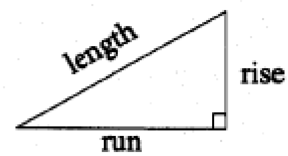
As you wait for the ride to begin, use the information in the Data Bank to compute and record each of the following.

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.

Roller Coasters Part Two

Name:

Purpose

What happens when you hurtle down a hill at 60 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.

Additional Questions:

1. Which roller coaster have you chosen on which to answer the questions? Answer:

2. Make the following time measurements:
   a. time to go up the first incline:
   b. time to go down the first hill:
   c. time for the entire ride:

3. What is the average speed of the entire ride (in m/s)? Answer:

4. What is the average speed going down the first hill? Answer:

5. How much work is done in pulling the train up the first incline? (Assume there is no friction and that the total mass includes the mass of the train plus -passengers [count them!] having an average mass of50 kg each.) Answer:

6. How much power is expended in pulling the train up the first incline? (use the same assumptions as in #5.) Answer:

7. Assuming there is no friction and that the train passes over the top of the first hill traveling 2 m/s, what is the kinetic energy of the train (and passengers) at the bottom of the first hill? Answer:

8. What is the velocity of the train at the bottom of the first hill? Answer:

Additional problems for the more advanced students of physics!

9. For roller coasters with a vertical loop:
   a. Make (or find in the data table) the following measurements: Time to complete the vertical loop = Average radius of the vertical loop = Height of the loop = Your mass in kilograms = (1 kg of mass has a weight of 2.2 lbs)
   b. Calculate the average speed of the train in the loop. Answer:
   c. Calculate the gravitational potential energy that you have at the top of the loop Answer:
   d. Calculate the centripetal force applied to you at the top of the loop. Answer:
   e. The centripetal force in part d) is a combination of two other forces-name them. Answer:
   f. Calculate the force with which you are pressed against the roller coaster seat when you are at the highest point in the loop. Answer:

Careers at the Park

Who works at an amusement park?

You see the men and women operating the rides and the concessions, and you notice other workers on the park grounds. Now consider the fact that hundreds of thousands of people visit the park each month. Making an amusement park run smoothly and safely for so many visitors requires many employees with different skills.

In this activity, you explore the amusement park to find out more about careers and the jobs people perform. Your teacher will discuss with the class which of the investigations you will be performing. Each is designed to be completed by a group of students working together.

Investigation 1

Operating an amusement park is very complex. Below is a list of questions a person might have about how an amusement park works. Divide the list among your group and investigate to find answers to the questions. For each, find out and record who provides the service being asked about. In some cases, your answer may be simple; in other cases, you may need to explain how a group of people working together is responsible.

- Suppose a child gets sick on a ride. Is someone available to provide first aid?
- Roller coasters are supposed to be safe. Does anyone test them on a regular basis?
- How does the amusement park know how much popcorn to buy each week?
- Some of those rides must be causing pollution. Does anyone keep an eye on that?
- How does the amusement park get rid of its garbage at the end of a day?
- How does the amusement park determine how much to charge for admission?
- How does the amusement park determine how much to charge for a hot dog?
- How do advertisements for the amusement park get into newspapers and magazines?

Investigation 2

To find out about careers at the amusement park, you have to go behind the scenes! To do that, assign each member of your group the task of interviewing and collecting information from three people who perform different jobs at the amusement park.

1. Each student in your group should first write the questions below on a pad of paper. Then he or she should record the answers while conducting the interviews. Have each person interviewed:
    - provide his or her job title
    - describe his or her job
    - explain how his or her job makes the park run better
    - estimate how many people work at the amusement park
2. After everyone in your group is finished, gather together all the information that was collected and present it as a single report.

Investigation 3

Here are twelve careers with which you are familiar:

- Accountant
- Cook
- Nurse
- Advertising Writer
- Costume Designer
- Scientist
- Bus Driver
- Engineer
- Security Officer
- Carpenter
- Office Manager
- Receptionist

1. Divide the list among your group.
2. For each career, find out whether someone at the amusement park performs that role. Then provide some details of what that person does in carrying out the job.
3. After everyone in your group is finished, gather together all the information that was collected and present it as a single report.

Geometry Around the Park

Every ride in an amusement park shows a great deal of geometry in its design. It may be circles, lines, rectangles, or more complicated geometric figures. The amusement park as a whole also reveals a geometric design. In this activity, you explore the amusement park and its rides to find out more about the geometry behind them. Your teacher will discuss with the class which of the investigations below you will be performing. Each is designed to be completed by students working together.

Investigation 1

Here you uncover the geometry behind two different rides. Work with a partner on the investigation.

First agree with your partner on two rides to investigate. Then complete the following tasks for each:

1. Examine the ride from as many different sides as possible.
2. Construct a drawing of the ride, making clear its geometry. You do not need to create a fancy piece of art here; instead, use lines and curves to express geometric ideas.
3. Beneath your drawing or on a second page, explain how the ride operates and what geometric ideas are involved in its operation.

Among the ideas you may want to include in your discussion of a ride are the following:

- lines and circles
- rectangles and squares
- parallel, perpendicular, and intersecting lines
- congruent shapes
- concentric circles

Investigation 2

Here you uncover the geometry behind the design of the amusement park. Work with a group of students on the investigation:

1. Starting from a common point, divide a portion of the amusement park into as many sections as there are group members. For example, shown below are two ways to divide a rectangle into four sections from a common point at its center.

2. Assign one section to each student.
3. Have each student walk through his or her section, drawing a map of that region of the park.
4. After everyone in your group is finished, meet again at the common point. Gather together all maps and form a single map. At this point, you will have to agree on how to combine the different methods group members used in drawing their maps. If time permits, you may want to go back and redraw some portions before completing the final maps.

Investigation 3

Work with a partner to create a scale drawing:

1. Select a ride or an amusement that you and your partner would like to draw.
2. Perform and record all necessary measurements and estimations. Among the tools you may need are a calculator, tape measure, and protractor.
3. Complete your drawing.
4. On your completed work, include explanations of the geometric features of the structure you have drawn.

Life Around the Park

As you get ready to visit an amusement park, you probably think about all the rides you will go on. But there is a lot more happening there than just rides.

In this activity, you explore the life of an amusement park. Your teacher will discuss with the class which of the investigations below you will be performing. Each is designed to be completed by students working together.

Investigation 1

Someone at the amusement park has to figure out how many hot dogs to order every week. If too few are ordered, customers are disappointed and may leave the park with a bad taste in their mouths. If too many are ordered, some may spoil and money will be lost. Suppose your job were to order one week's worth of hot dogs for the amusement park. Your assignment is to write a group report in which you:

- First explain in detail how you would determine how many hot dogs to order. You will need to make some estimates here, since data are not provided, and
- Then try to find out how the park actually determines its hot dog order. Include anything you find out in your report.

Investigation 2

People at the amusement park spend a day there, but go home at night after the park closes. But there are some that call the amusement park their home. For example, trees and plants grow around you as you walk the park grounds. In addition, as any gardener knows, where there is soil, weeds grow and take up permanent residence.

- Work with a partner studying the different plants that you find around the amusement park. Draw sketches of plants, leaves, and fruits. Also, try to judge whether a plant occurs in a great number of places in the park or whether it seems to grow only in a particular area.

Investigation 3

The men and women who operate the amusement park must predict how many people will attend each day so the park can operate smoothly and safely. Working with a group,

- Discuss what you think some of the factors are in determining whether park attendance is high or low on a given day. Have one member of your group keep notes of the discussion, and
- Use the notes from your group discussion to write a report that lists the key factors used in determining park attendance.

Investigation 4

In addition to predicting daily attendance, amusement park operators need to have a sense of what people do when they are at the park and whether they are enjoying themselves. You can help out by conducting a survey at the end of your visit to the park.
Ask 25 people the following questions:

- About how many rides did you go on? What was your favorite ride?
- About how much money did you spend on food?
- Was there any ride at which you felt the wait was too long? If so, what was it?
- Were there enough different types of activities available for you?
- Would you recommend this amusement park to a friend? Why or why not?

After you complete your survey, combine your group's data to form a report.

Linear Thinking Student Worksheet

Name:

Activity Purpose

We want you to have a continuous learning experience even while visiting Kings Island. Therefore, we have developed a few questions that can be completed while they wait in line for a ride.

Materials

✓ Calculator ✓ Pencil or Pen ✓ Worksheet

Instructions

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

Drop Tower:

1. A person on this ride will drop 264 feet. How many times would you have to ride this ride to travel a mile?

 ____

 ____

2. The height from which a rider drops is 264 feet. There is 5280 feet in a mile. What is the length of the fall expressed in miles?

 ____

 ____

Invertigo

1. The park runs this ride for 13 hours a day. The ride lasts 1 minute 30 seconds. If you and a friend rode this ride continuously, with no stops, how many times would you "Face off" with your partner?

 ____

 ____

The Beast®

1. The Beast is 7,400 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 the Beast'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 2 million slices of pizza. If we sold just 2 million 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 131 days a year. We will use 1,000 gallons of liquid soap in the restrooms. About how many gallons do we use per day?

 ____

 ____

Up and Over

Description: Predict and observe what will happen when a container of water is subjected to circular motion.

Keywords: Centrifugal Force, Gravity

Concepts: Circular motion can counter the force of gravity.

Materials: Container of Water (Cup)

Instructions:

Using the container with water in it; move it around so participants can see it is water. Ask the participants to predict what would happen if you slowly turned this container upside down?

Start twirling the container of water around in a circle. Does anyone know why the water doesn't fly out of this container? Explain that the water would go in a straight line if it were not for your arm forcing it into a curved path.

Has anyone ever whirled a yo-yo around on its string? Do you remember the tension you could feel on your finger or hand when you did that? You probably were told to stop doing that by an adult, because they realized that if the yo-yo came off the string, or the string came off your finger, it would continue in a straight line, and probably crash into something.

There are two things at work here. One is inertia, and the other is called centripetal force. Can anyone tell me what inertia is, or how it affects matter? (Try to draw out a few answers from the participants.) Inertia, the tendency of matter to stay at rest unless acted upon by an outside force, presses the contents of this container outward against the bottom of the container, while the centripetal force, provided by my arm, is continually changing the direction of the container and keeping it from flying off in a straight line.

Can anyone tell me where you have seen inertia and centripetal forces at work? Many rides at amusement parks, the spin dry cycle on washing machines, banked exit ramps on highways, skateboard ramps.

Now, if we remove the centripetal force, what will happen? That's right; the contents of this container will continue to move in a straight line. (At this point, pretend to throw water out over the audience!)

Possible Interactive Questions:

- How did spinning the container with water in the cup feel? Did you get wet? Could you stop it slowly enough to not spill any water?
- What will happen if you suddenly stop the action? Why does this happen?
- What amusement park rides remind you of the cup and water? (Answers may include the loop on a roller coaster, the boat pendulum ride that goes 360 degrees, etc.)

What's Going On?

In this experiment, the force of the circular motion is greater than the force of gravity so when the container is twirling quickly the water doesn't spill out of the container.

There are two things at work here. One is inertia, and the other is called centripetal force. Inertia, the tendency of matter to stay at rest unless acted upon by an outside force, presses the contents of this container outward against the bottom of the container, while the centripetal force, provided by my arm, is continually changing the direction of the container and keeping it from flying off in a straight line. If we remove the centripetal force, the contents of this container will continue to move in a straight line.

Remember that a moving object will keep going straight until a force acts upon it. A force that causes the acceleration needed to make an object move in a circular path is called centripetal force. Acceleration, to a scientist, can mean either a change in speed of an object or a change in direction in which the object is traveling. In this case, our arm attached to the container caused the centripetal force which kept the water moving in a circular path.

FYI: Centripetal force can be compared to "a center seeking force", while centrifugal force can be compared to "a center fleeing force."

Friction

Description: Experiment with potential and kinetic energy and their relation to opposing forces such as friction.

Keywords: Friction, Lubricant

Concepts: Friction is the force that opposes the relative motion or tendency of such motion of two surfaces in contact.

Materials: Hands, Lotion/Powder (optional)

Instructions:

I'd like to take a brief opportunity to talk to you a little about opposing forces of motion. Let's begin by rubbing their hands together... slowly at first...and then...faster....faster....FASTER! What do you feel? Your hands get warm because of friction. Friction is a force that resists the motion of an object.

If I were to roll a ball across the floor does it keep going forever? No, friction gradually slows the ball until it stops. What could we do to make the ball roll further without adding more force/energy? (Decrease the opposing force of friction.)

Let see if we can decrease friction. Does anyone have any ideas as to how to decrease friction?
(Take a variety of hypotheses from the participants.)

All of those are great examples of how to decrease friction between objects. Let's revisit our first experiment and try a hypothesis. This time, instead of just rubbing our hands together, I am going to sprinkle powder/lotion on each of your hands, and have you rub your hands together again.

(Give the participants sufficient time to experience the experiment.) What is different, now that you have talcum powder/lotion between your hands? Do you feel less heat?

Possible Interactive Questions:

- Can you think of some sporting activities that involve friction or the lack of? What affects does friction have on the sport?
- How does friction create a challenge for roller coaster design? Are there advantages to friction that amusement park rides utilize?

What's Going On?

When something moves, it will keep moving unless something slows it down. Friction is a force that slows things down. It is formed when two or more objects rub together. It can be thought of as a resistance to movement.

In this experiment, the powder acts as a lubricant; therefore, it reduces the friction between the participants' hands and the production of heat. Oil and petroleum products are often used as lubricants. There are other uses for lubricants. On a bicycle chain, on door hinges, on skateboard wheels, on roller coaster tracks, in a frying pan, anywhere individuals want something to glide smoothly across the surface.

Further Exploration:

- Use a variety of lubricants to decrease the friction between various objects. Are certain lubricants more effective than others? Why?