SCIENCE AND MATHEMATICS SERIES
STUDENT ACTIVITIES BOOK

WELCOME

Many requests for materials scaled to the needs of a more general mathematics and science program have been received. The Park Activities included here have been written or adapted to emphasize conceptual aspects, while still giving students an opportunity to use mathematical skills. It is suggested that you use the K'Nex Amusement Park Experience kit and the accompanying educational activities to help prepare the students for their visit to the amusement park. The concepts in those activities will serve as the foundation and framework for the experiences the students will engage in at the amusement park. The trip should serve as a capstone to the entire mathematics and science experience.

You can photocopy the entire Student Activities Book for your students to use or just choose a few activities that you want the whole class to do. Information on planning the trip and structuring the day at the park are available in the trip planning guide.

This is an updated edition of the first math and science workbook and we invite teachers who use it to provide feedback and offer suggestions for future editions. This updated edition is designed for a more general audience of mathematics and science students from middle school through high school. Together, we have an opportunity to make mathematics and science come to life in a very special way. Watch periodically for updates to current activities and new activities as well.

Acknowledgements:

New Activities and Editorial Updates to Other Lesson Plans
by Mike Long, Ed.D. Shippensburg University of Pennsylvania

Original Teacher Lesson Plans
by Barbara Wolff-Reichert

Other materials
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Education Series
written by Carole Escobar, Harold Lefcourt, Virginia Moore, and Barbara Wolff-Reichert.

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MIDDLE SCHOOL SCIENCE AND MATHEMATICS EDUCATION SERIES INTRODUCTION

The Middle School Mathematics and Science Education Series is a series of student activities that is intended to serve as a capstone mathematics and science experience for the students. It is expected that the students will arrive with a conceptual understanding of the mathematics and science with which they will be using to complete the activities which are part of this experience. The intent of these activities is not to introduce or teach new concepts, but instead they exist to provide a concrete connection to the concepts introduced and taught in the regular class as part of the curriculum. In some instances, these activities may stretch a concept covered in class, but that only enhances the students' learning.

The activities will mention connections to the K'Nex Amusement Park Experience. The activities in the K'Nex Amusement Park Experience are a great resource for introducing many of the concepts to the students if such experiences are not part of the current curriculum. Many of the concepts in the K'Nex Amusement Park Experience are the same as those that the students will encounter when using these activities at the park. Cross-references to the K'Nex Amusement Park Experience Activities are provided.

The activities in this updated edition are now arranged by concept. In many instances there is more than one ride which demonstrates the concept listed. Space is provided so the exercise can be performed for all of the rides which demonstrate the concept, perhaps for comparison purposes. It is not suggested that the students do the activities for all of the rides, especially when the rides associated with a particular concept are all dynamic.

A list of terms and formulas for the students to use is included. Students will have to select which formulas to use.

HELPFUL TERMS AND FORMULAS

Circumference of a Circle: $C = 2\pi r$ where r is the radius of the circle

Horsepower conversion: 1 horsepower = 746 watts

Kinetic Energy: $KE = \frac{1}{2}mv^2$ where m is the mass in kilograms and v is the velocity of the object in meters per second

Percent of Ideal: $\frac{|\text{ideal - experimental}|}{\text{ideal}} \times 100$

Period: time for one cycle of motion to be completed

Potential Energy: $PE = mgh$ where m is the mass in kilograms, g is the force of gravity $9.81 m/s^2$, and h is the height in meters

Proportion for Converting meters per second to miles per hour:

$$\frac{1\text{meter}}{\text{second}} = \frac{2.23\text{ miles}}{\text{hour}}$$

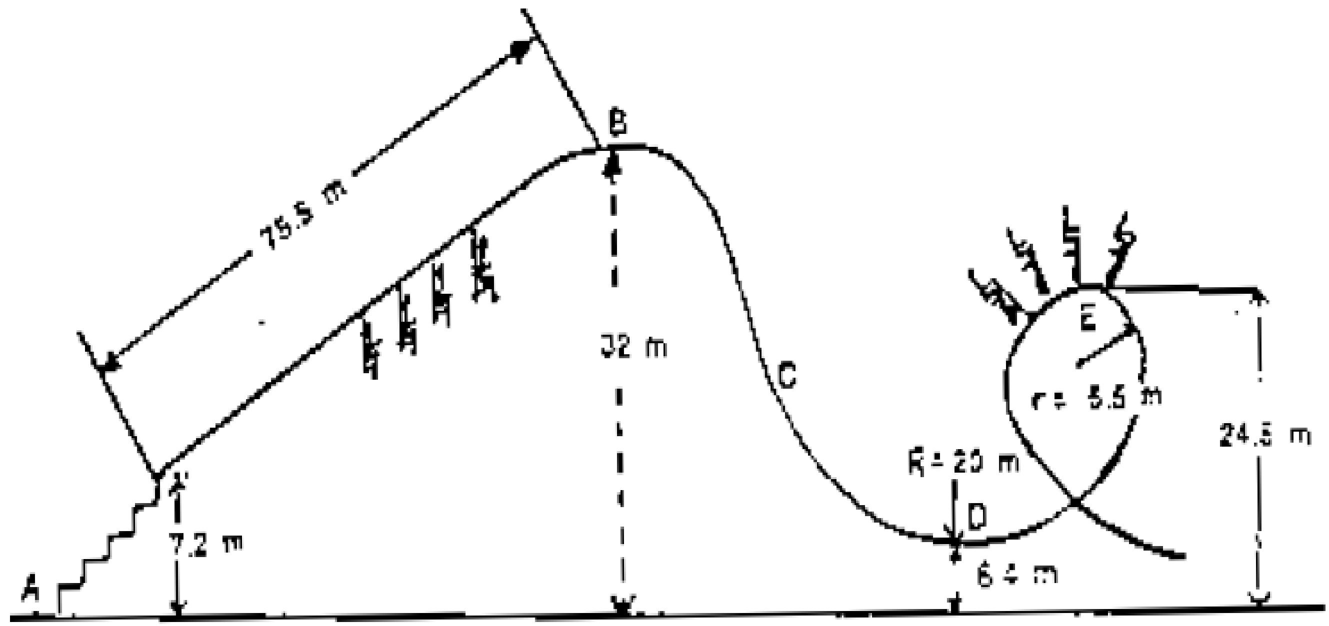
Speed: $\text{Speed} = \frac{\text{Distance}}{\text{Time}}$

Watts: is the number of joules of work the motor can do in one second.

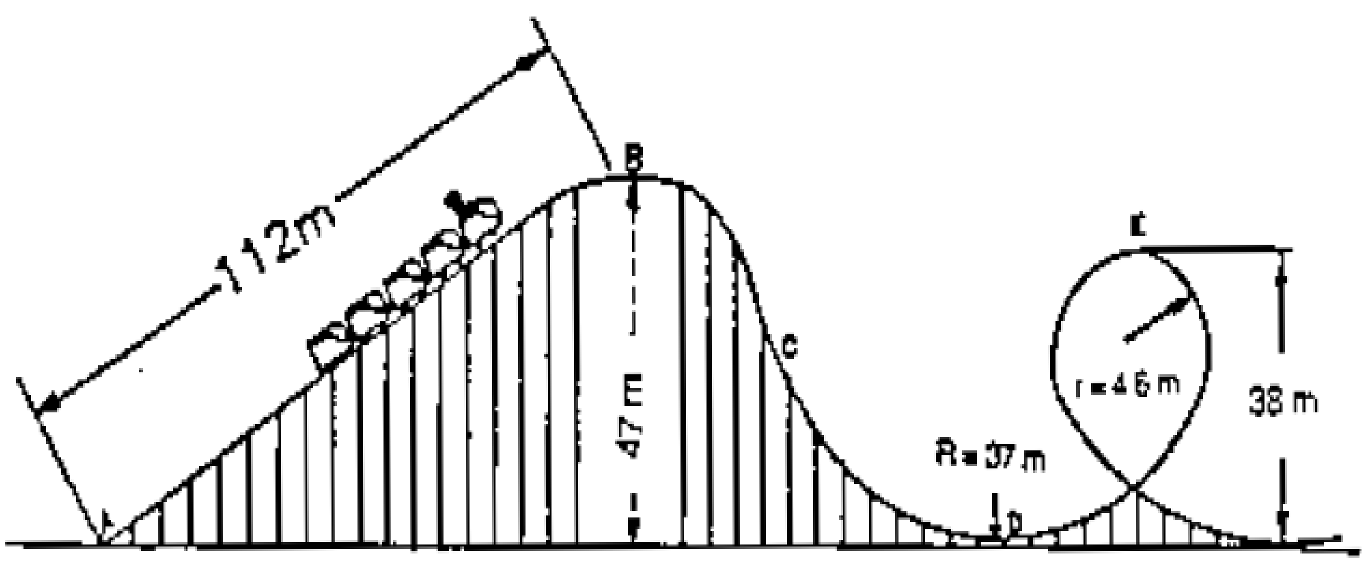
Work: Work = Force x Distance = Weight x Height

HELPFUL RIDE DIAGRAMS

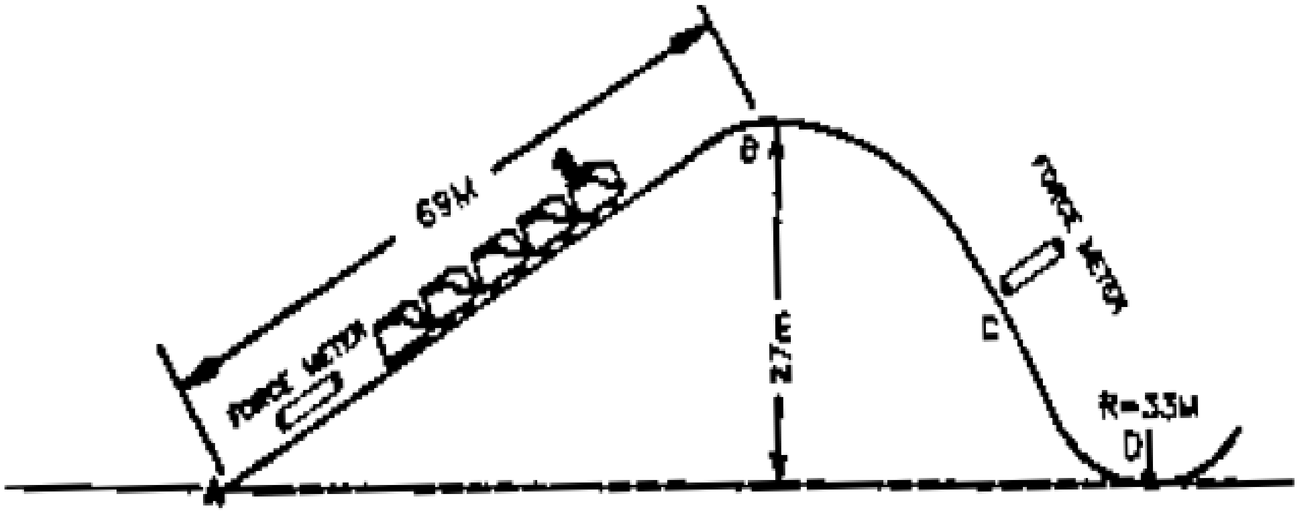
BATMAN THE RIDE



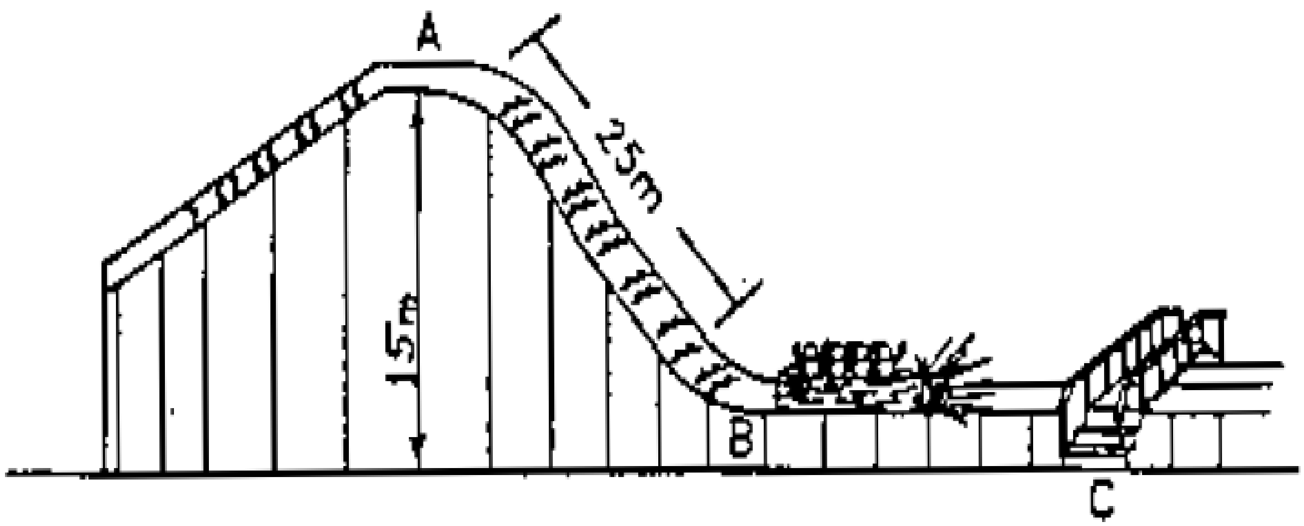
GREAT AMERICAN SCREAM MACHINE



ROLLING THUNDER



LOG FLUME

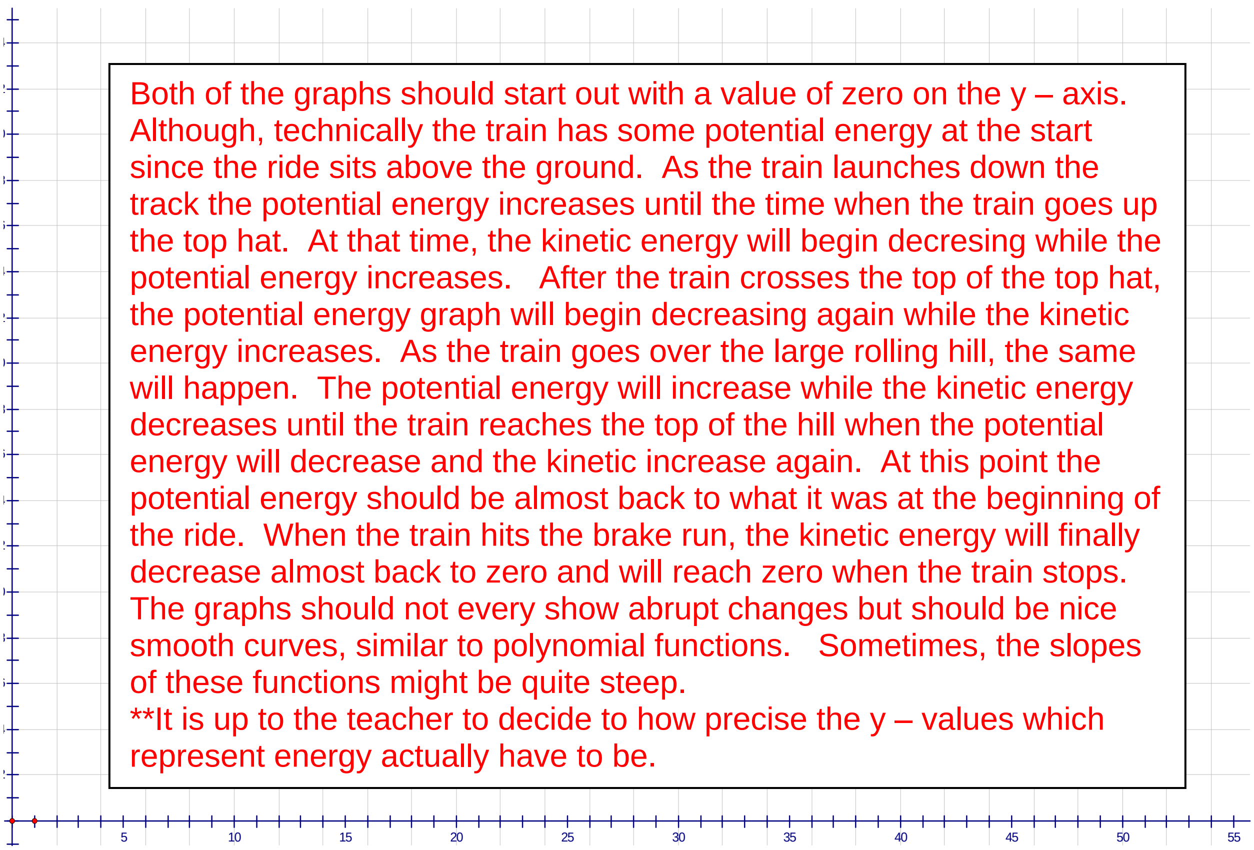


Activity One: Representing Potential and Kinetic Energy on Kingda Ka

- Connects with K'Nex Amusement Park Experience activities on the roller coaster, Ferris Wheel, and boom ride

Consider the new spectacular coaster, Kingda Ka. The ride launches from standing and then up over a top hat standing an astounding 425 feet tall. In this activity you are going to make sketches of two graphs on the same set of axes. The first is a potential energy versus time graph while the second is a kinetic energy versus time graph. Use a different type of line to show each graph (one solid and one dashed) and make sure to label your graphs.

Remember that potential energy is a function of the mass of the object, the height above the ground, and the force of gravity. Kinetic energy is a function of the mass of the object and its velocity.



Both of the graphs should start out with a value of zero on the y – axis. Although, technically the train has some potential energy at the start since the ride sits above the ground. As the train launches down the track the potential energy increases until the time when the train goes up the top hat. At that time, the kinetic energy will begin decresing while the potential energy increases. After the train crosses the top of the top hat, the potential energy graph will begin decreasing again while the kinetic energy increases. As the train goes over the large rolling hill, the same will happen. The potential energy will increase while the kinetic energy decreases until the train reaches the top of the hill when the potential energy will decrease and the kinetic increase again. At this point the potential energy should be almost back to what it was at the beginning of the ride. When the train hits the brake run, the kinetic energy will finally decrease almost back to zero and will reach zero when the train stops. The graphs should not every show abrupt changes but should be nice smooth curves, similar to polynomial functions. Sometimes, the slopes of these functions might be quite steep.

**It is up to the teacher to decide to how precise the y – values which represent energy actually have to be.

QUESTIONS TO ANSWER FOR KINGDA KA

1. Kingda Ka's train is launched by using a fly wheel attached to a sled which pulls the train down the track. When the fly wheel starts turning energy is transferred to the train. What type of energy increases when this happens and how do you know this?

Kinetic Energy increases in this case. You know this because the velocity of the train is increasing and Kinetic Energy is a function of velocity $KE = \frac{1}{2}mv^2$

2. When Kingda Ka goes up the top hat the state of energy is changed. Your graph actually shows this. How is the energy changed when this happens and how do you know this?

The Kinetic Energy is changed to Potential Energy. Potential energy increases because the height of the train above the ground increases as the train travels up the top hat. Potential Energy is a function of the height $PE = mgh$.

3. As Kingda Ka travels its path each time, some energy seems to be lost from kinetic and potential energy. Name some forces that contribute to this energy loss and how they impact the train.

On any roller coaster wind resistance is very important as it slows down the trains. Some coasters actually have to cease operation when the wind speed is too high. Probably the most important factor is the friction of the wheels on the track. A great deal of energy on a roller coaster is lost due to friction.

4. When Kingda Ka is slowed at the end of the ride by the brakes, energy is transferred again. Brakes create friction which creates energy loss. What type of energy is lost on the brake run and how do you know this?

Kinetic Energy is lost on the brake run. This is the case because the train is slowed down by the brakes and recall that Kinetic Energy is a function of the velocity $KE = \frac{1}{2}mv^2$.

Activity Two: Circular Motion on Flying Wave, Carousel, Musik Express, and Big Wheel

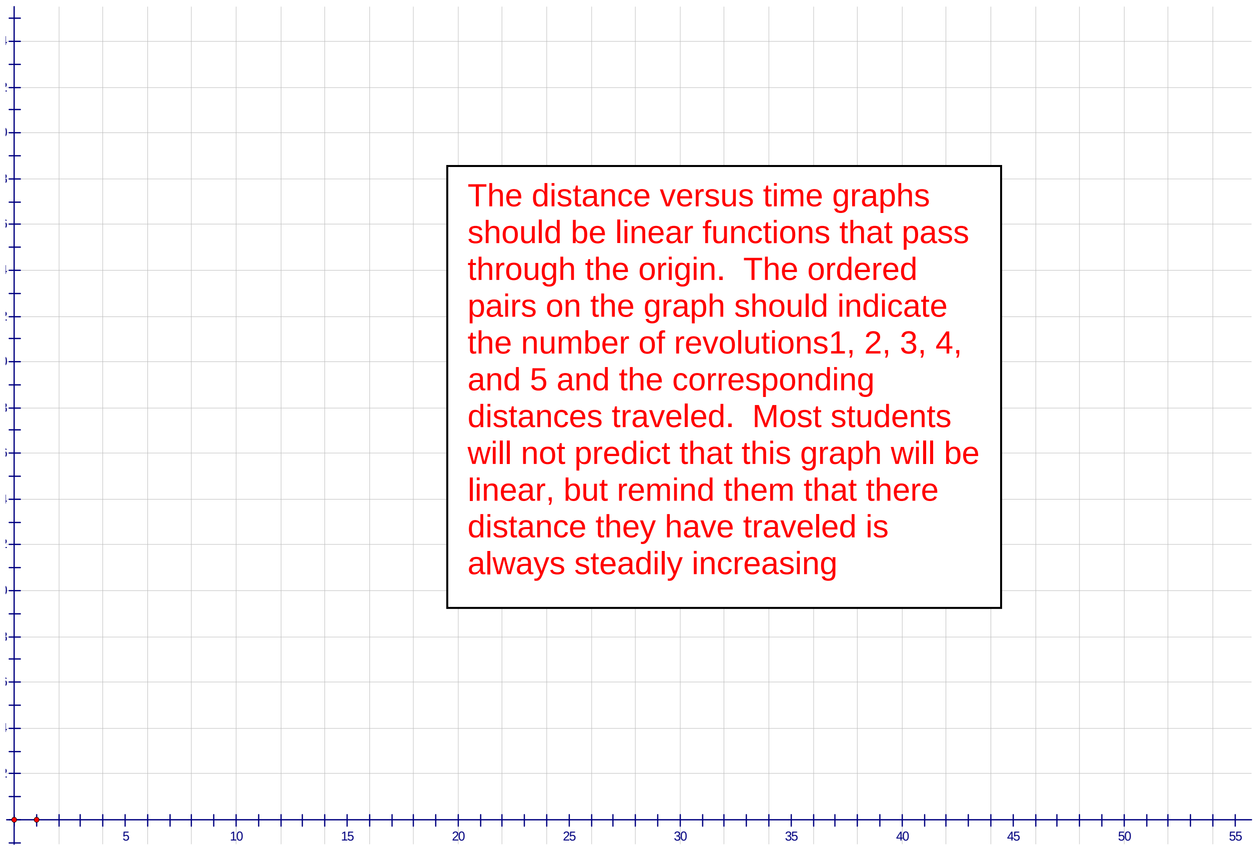
- Connects with K'Nex Amusement Park Experience activities on the carousel, swings, Ferris Wheel, and boom ride

Stand outside of the gate of Flying Wave, Carousel, Musik Express, and the Big Wheel to take the measurements that you will need to complete this activity. Record the time that it takes for two revolutions of each of the rides in the data table. Then complete the data table

	Wave Motion	Carousel Inner Circle	Carousel Outer Circle	Musik Express	Big Wheel
Radius of A Rider At Full Speed	7.6 meters	3.4 meters	5 meters	5.6 meters	20.5 meters
Period	7.2 seconds	5.75 seconds	5.75 seconds	6 seconds	This will vary with each student
Distance Traveled By A Rider In One Revolution	47.75 meters	21.36 meters	31.42 meters	35.19 meters	128.81 meters
Calculate The Speed Of A Rider At Maximum Speed	$= \frac{\text{distance}}{\text{period}}$	$= \frac{\text{distance}}{\text{period}}$	$= \frac{\text{distance}}{\text{period}}$	$= \frac{\text{distance}}{\text{period}}$	$= \frac{\text{distance}}{\text{period}}$
Distance Traveled By A Rider In Two Revolutions	95.50 meters	42.73 meters	62.83 meters	70.37 meters	257.61 meters
Distance Traveled By A Rider In Three Revolutions	143.26 meters	64.09 meters	94.25 meters	105.56 meters	386.42 meters
Distance Traveled By A Rider In Four Revolutions	191.01 meters	85.45 meters	125.66 meters	140.74 meters	515.22 meters

Distance Traveled By A Rider In Five Revolutions	238.76 meters	106.81 meters	157.08 meters	175.93 meters	644.03 meters

On the coordinate axis below, make a distance versus time graph for the one of the rides when it is up to full speed. The x-axis should represent the time in seconds that has elapsed and the y-axis the distance traveled by a rider. After you have plotted as much data as will fit on the graph, make a line of best fit for the data.



The distance versus time graphs should be linear functions that pass through the origin. The ordered pairs on the graph should indicate the number of revolutions1, 2, 3, 4, and 5 and the corresponding distances traveled. Most students will not predict that this graph will be linear, but remind them that there distance they have traveled is always steadily increasing

EXTENSIONS:

Determine the equations of each of the lines that represent the data.

The equations will vary based on the data. Simply find the slope of the line by using two of the ordered pairs. Then use the slope and one of the ordered pairs (revolutions, distance traveled) to complete the equation of the line..

What does the slope of each of the lines indicate?

The slopes will give the speed of the ride when the ride is at full speed.

QUESTIONS TO ANSWER FOR THE FLYING WAVE

1. Sketch what happens to the swings as the ride speeds up.

Start Slow Fast

At the start, the swings are perpendicular to the ground. As the ride begins, the swings begin to swing out away from the center. When the ride is up to speed, the swings should be swinging out about 30 degrees form their original position.

2. How do you feel as the ride speeds up?

As the ride speeds up, you feel as if you are being pushed away from the center of the ride and into the seat most and more as the ride speeds up. As the wave motion begins, you will feel lighter or as if you are floating when you are at the highest point (at the top of a wave) and feel pushed into the seat more at the lowest point (at the bottom of a wave).

3. In words, compare the angle of the chain with an empty swing to the angle of a chain holding an occupied swing.

The angles of the chairs should almost be the same.

4. If you have a force meter, how does the force meter reading relate to how you feel on the ride?

The force meter reads higher at the bottom of the wave, when you feel pushed into the seat. The force meter reads less at the top of the wave, when you feel lighter or as if you are floating.

5. Describe the change in the motion of the swings after the ride is up to full speed and the top tilts.

The swings make waves in the air.

QUESTIONS TO ANSWER FOR THE CAROUSEL

1. Sketch the motion of the horses as the ride speeds up?

The motion will look like a wave.

2. How do you feel as the ride speeds up?

As the ride speeds up, you feel pushed more and more away from the center of the ride.

3. In words, describe how do you feel just before the horse begins to fall after having climbed?

You feel as if you are lighter or floating just before the horse begins to fall.

4. If you have a force meter, how does the force meter reading relate to how you feel on the ride?

The force meter reads less just before the horse begins to fall after having climbed.

5. Describe the change in the motion of the horses after the ride is up to full speed.

The horses move up and down in a circular motion.

QUESTIONS TO ANSWER FOR THE MUSIK EXPRESS

1. What happens to the people in the seats as the ride speeds up?

As the ride speeds up, the people in the seat are pushed toward the outside of the seat.

2. How do you feel as the ride speeds up?

You feel like you are riding in a car going over hills and valleys while being pushed to one side in your seat.

3. In words, describe how you feel in your seat when you cross the hills on the Musik Express.

When you go over the hills, it feels as if you are floating in your seat for a moment.

4. If you have a force meter, how does the force meter reading relate to how you feel on the ride?

At that point, the g-forces will go down and may actually be negative g-forces.

5. Describe the motion of the seats after the ride is up to full speed.

The seats go up and down traveling the path of the track.

Activity Three: Number Theory On The Big Wheel

At the present time…there is not an answer key for this activity…

While observing the Big Wheel…answer the following questions…

1. On the Big Wheel, the cars are painted different colors. What are these colors?

2. How many different colors are there?

3. How many cars of each color are there?

4. Use multiplication to find the number of cars that are on the ride. Show your work below.

5. Each year at the end of the season, the seats are removed and put back in place at the beginning of the next season. As the ride technicians begin putting the seats back on the ride, they know that they have to use one of every color before using the color of the first seat they put in place again. The technicians then repeat the same pattern again. How many different arrangements can there be for the seats on the Big Wheel?

6. For each of the following questions, determine the fraction of cars that are in the group.
   a. The fraction of the cars painted red

   b. The fraction of the cars painted in the primary colors, red, blue or yellow

   c. The fraction of the cars painted black

   d. Red and green are a pair of complementary colors. The fraction of cars that make up this complementary pair is

7. Lighting the wheel

   a. Determine the total lights that you can see on the outside rim of the Big Wheel

   b. Count the number of lights on the rim between two adjacent (neighboring) cars

   c. Number of lights on the rim between cars

   d. The total number of spaces between the cars is

   e. The total number of lights that you can see on the outside rim of the Big Wheel is

   f. The total number of lights on both sides of the outside rim of the Big Wheel is

   g. If each light is a 60-watt bulb, what is the total wattage of all the bulbs on both sides of the outside rim of the Big Wheel?

   h. How many kilowatts would this be?

   i. If the lights are on for 5 hours a night, how many kilowatt-hours of electrical energy are used?

8. On a Saturday in July, all the cars had riders in them. The average number of riders per car was three. How many people were riding on the Big Wheel at that time?

9. While waiting in line to get on the Big Wheel, have one member of your team count the number of people getting on the ride. Have a second member of your team count the number of cars filled.

a. Total number of riders = Total number of cars used =

b. Calculate the average number of riders per car. Show your work below.

10. On some days, when the park is not crowded, the attendants load only a fraction of the cars. For each case below, state the fraction of the total cars that are loaded.

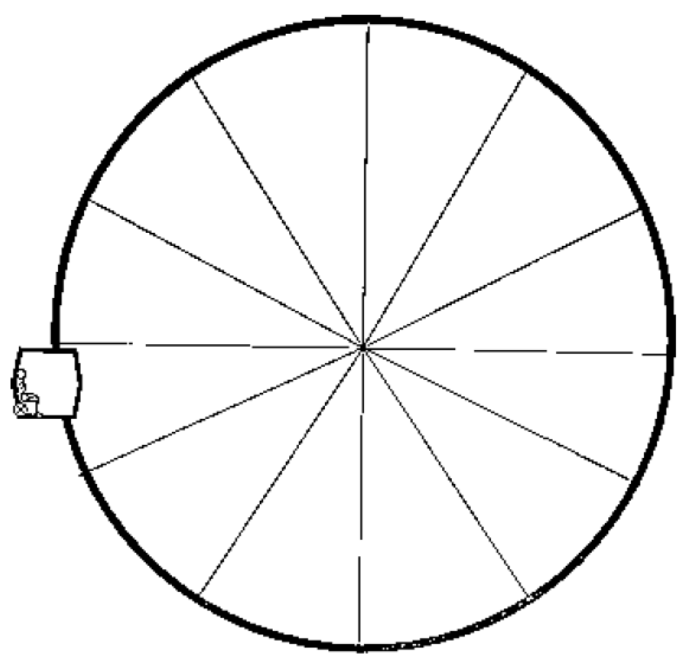
a. Only four cars of each color are loaded. The total number of cars used is . The fraction of total cars used is .

b. Only three colors of cars are used and all the cars of that color are loaded. The fraction of total cars used is .

c. Only three colors of cars are used and only four cars of each color are loaded. The fraction of total cars used is .

11. On the diagram at right, there is one representative car on the Big Wheel. On this car there is a circle with an "x" in it just under the seat. Observe the motion of an actual car on the Big Wheel when it is moving. Place an "x" near the end of each of the twelve lines drawn to show where the seat would be when the car was in each of these positions. Does the rider go in a circle?

The Big Wheel



Is the circle made by the rider's seat larger, smaller, or the same size as the circle made by the outside rim of the Big Wheel?

Activity Four: Geometry and Waves…the Big Wheel, Musik Express, and the Space Shuttle

- Connects with K'Nex Amusement Park Experience activities on the carousel, swings, Ferris Wheel, and boom ride

The Geometry Part

Answer the questions in the table while observing the Big Wheel and the Musik Express.

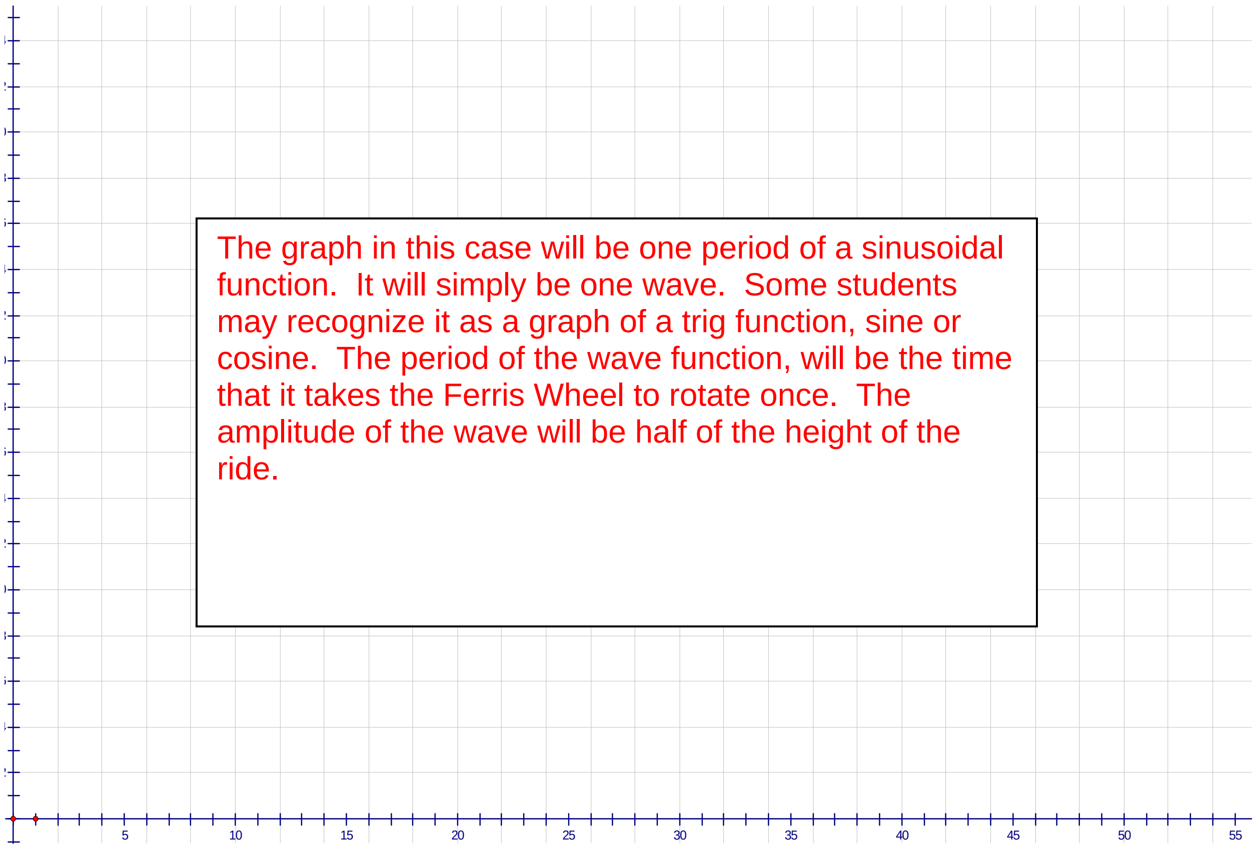
	Big Wheel	Musik Express
Look at two adjacent seats on the rides. The beams holding the seats all connect to a center spool. What is the angle measure between the beams holding the adjacent seats?	15 seconds	18 degrees
If you go half of the way around on either of the rides how many degrees will you travel?	180 degrees	180 degrees
If you go one fourth of the way around on either of the rides how many degrees will you travel?	90 degrees	90 degrees
If you go on third of the way around on either of the rides how many degrees will you travel?	120 degrees	120 degrees
If you go one twelfth of the way around on either of the rides how many degrees will you travel?	30 degrees	30 degrees

The Waves Part

Complete the following table when the ride is at full speed…traveling in only one direction

	Big Wheel Radius: 20.5 meters		Space Shuttle Radius:	
Angle traveled by a rider	Time to travel the given angle	Height above the loading height	Time to travel the given angle	Height above the loading height
0 degrees	0 seconds	0 meters		
45 degrees	2 seconds	20.5 meters		
90 degrees	4 seconds	41 meters		
135 degrees	6 seconds	61.5 meters		
180 degrees	8 seconds	82 meters		
225 degrees	10 seconds	61.5 meters		
270 degrees	12 seconds	41 meters		
315 degrees	14 seconds	20.5 meters		
360 degrees	16 seconds	0 meters		
405 degrees	18 seconds	20.5 meters		
450 degrees	20 seconds	41 meters		
495 degrees	22 seconds	61.5 meters		
540 degrees	24 seconds	82 meters		

Now make a graph of the data you collected. Plot both sets of data on the same coordinate plane. Use two different types of lines, either changing the type of line, solid and dashed, or changing the color of the line. Plot the time on the x-axis and the height on the y-axis.



The graph in this case will be one period of a sinusoidal function. It will simply be one wave. Some students may recognize it as a graph of a trig function, sine or cosine. The period of the wave function, will be the time that it takes the Ferris Wheel to rotate once. The amplitude of the wave will be half of the height of the ride.

Activity Five: Making Predictions with El Toro, Medusa, and Nitro

PREDICTION 1 The data here is a sample of what a set of data for this activity will look like. The data for this activity will vary with each student.

In this activity you are going to estimate how many people actually ride El Toro, Medusa, and Nitro in an hour. In order to do this, there are two pieces of information, the time between trains and the average number of riders per train. You can use the table below to keep track of the information.

Train Number	Time Since Last Train El Toro	Number of Riders on El Toro	Time Since Last Train Medusa	Number of Riders on Medusa	Time Since Last Train Nitro	Number of Riders on Nitro
1	0 seconds	28 people	0 seconds	32 people	0 seconds	32 people
2	45 seconds	56 people	45 seconds	64 people	45 seconds	64 people
3	90 seconds	84 people	90 seconds	96 people	90 seconds	96 people
4	135 seconds	112 people	135 seconds	128 people	135 seconds	128 people
5	180 seconds	140 people	180 seconds	160 people	180 seconds	160 people
6	225 seconds	168 people	225 seconds	192 people	225 seconds	192 people
7	270 seconds	196 people	270 seconds	224 people	270 seconds	224 people
8	315 seconds	224 people	315 seconds	256 people	315 seconds	256 people
9	360 seconds	252 people	360 seconds	288 seconds	360 seconds	288 seconds
10	405 seconds	280 people	405 seconds	320 people	405 seconds	320 people

Use the information in the table to compute the average time between trains for each coaster: Sample included for El Toro. Please note that there are a number of different ways to compute the average time between trains. This is simply one method:

$$= \frac{(45-0)+(90-45)+(135-90)+(180-135)+(225-180)+(270-225)+(315-270)+(360-315)+(405-360)}{10}$$

$$= 45$$

Use this information to determine the number of trains that will dispatch in one hour for each coaster. Sample included for El Toro. A train leaves the station ever forty five seconds. There are 3600 seconds in an hour. To determine the number of trains that leave the station every hour, divide 3600 by 45. The answer would be 80. So 80 trains an hour dispatch.

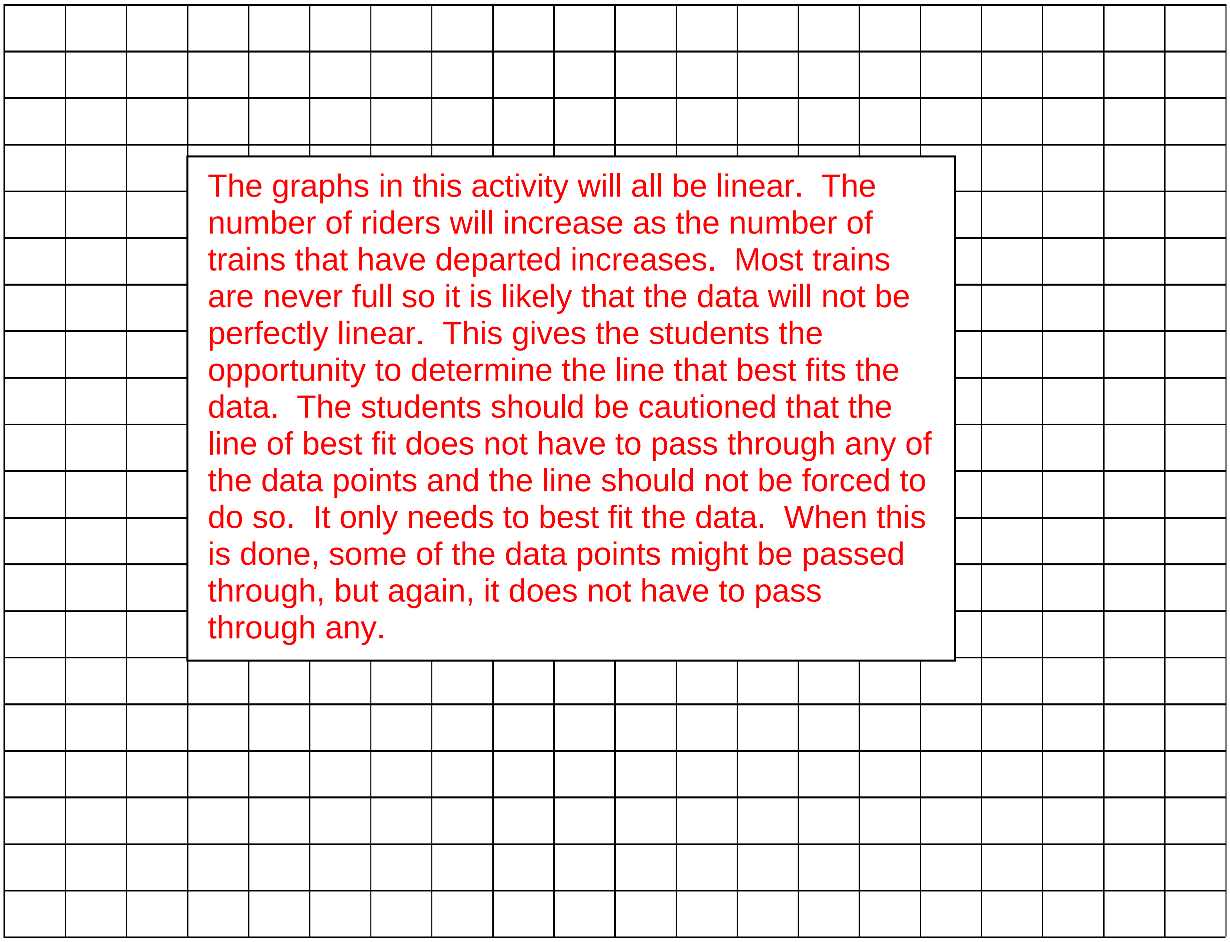
Use the information in the table to determine the average number of riders in each train for each coaster. Sample included for El Toro.

$$= \frac{28+(56-28)+(84-56)+(112-84)+(140-112)+(168-140)+(196-168)+(224-196)+(252-224)+(280-252)}{10}$$

$$= 28$$

Use all of the information to determine the average number of riders that can ride El Toro in one hour. Sample included for El Toro. A train dispatches every 45 seconds or four trains every three minutes. That means that 80 trains dispatch per hour. If 80 trains dispatch per hour with an average of 28 riders per train, 2240 people can ride El Toro per hour.

On the graph below make a sketch of a TOTAL number of riders versus trains dispatched graph. On the x-axis, plot the number of trains that have been dispatched. On the y-axis, plot the corresponding TOTAL number of people that have been dispatched.



The graphs in this activity will all be linear. The number of riders will increase as the number of trains that have departed increases. Most trains are never full so it is likely that the data will not be perfectly linear. This gives the students the opportunity to determine the line that best fits the data. The students should be cautioned that the line of best fit does not have to pass through any of the data points and the line should not be forced to do so. It only needs to best fit the data. When this is done, some of the data points might be passed through, but again, it does not have to pass through any.

EXTENSIONS:

After adding the line of best fit for each set of data, determine the equations of each of the lines that represent the data.

The equations will vary based on the data. Simply find the slope of the line by using two of the ordered pairs that are on the line. These may not be actual data points. Then use the slope and one of the ordered pairs to complete the equation of the line.

What does the slope of each of the lines indicate? The slope indicates the average number of riders dispatched in each train or the average number of additional people that ride the coaster each time a train leaves the station.

Prediction 2:

Predict the number of times the wheels on each coaster turn during one complete trip on the coaster.

El Toro: Answers vary **Medusa:**Answers vary **Nitro:** Answers vary

Why did you make the predictions that you did:

Given the information below, determine how many times the wheels on each of the coasters turn during one complete trip:

	Track Length	Radius of Wheels	Number of Times the Wheels Go Around During One Complete Trip
El Toro	4400 feet or 52800 inches	7.1 inches	7436.62 times
Medusa	3095 feet or 37140 inches	6.3 inches	5895.24 times
Nitro	5394 feet or 64728 inches	6.3 inches	10274.29 times

Activity Six: The Basics of Speed on the Log Flume, Batman The Ride, The Great American Scream Machine, and Rolling Thunder

With this activity…the answers for student will vary. The answers here are simply an example to demonstrate the concepts.

- Connects with K'Nex Amusement Park Experience activities on the carousel, swings, Ferris Wheel, boom ride, and roller coaster

Check the Diagrams at the Front of the Activities for Select Measurements

You will need to determine a few pieces of information before starting out…

	Log Flume	**Batman**	**Great American Scream Machine**	**Rolling Thunder**
Time to Come down the slide or the largest hill	5 seconds	3 seconds	3 seconds	3 seconds
Length of hill of slide:	Length of hill: 25 meters	Length of hill: 75.2 meters	Length of hill: 112 meters	Length of hill: 69 meters
Determine the average speed for the boats or trains as they travel down the largest hill or slide	5 meters per second	23.3 meters per second	37.3 meters per second	23 meters per second
Explain how you might determine the speed at the bottom of the largest hill or slide from the average speed	The speed at the top of the hill is essentially zero. So the speed at the bottom must be twice the average in order for the average to work out. Zero plus twice the average at the end would mathematically equal the overall average. The boats or trains are actually moving at the average speed when they are half way down the hill or slide.			
Using your explanation, what is the speed of the trains or boats at the bottom of the largest hill or slide.	10 meters per second	46.6 meters per second	74.6 meters per second	46 meters per second
Use a proportion to convert your calculation of the speed at the bottom to miles per hour.	22.3 miles per hour	103.918 miles per hour	166.358 miles per hour	102.58 miles per hour

OBSERVATIONS AND QUESTIONS TO ANSWER FOR THE LOG FLUME

1. Why is there water on the slide and not just at the bottom?

   There is water on the slide to lower the friction.

2. If there is a lot of mass up front, is the splash larger or smaller? Explain why this is so.

   The splash is larger if there is a lot of mass up front. There is more mass in the front pushing down into the water which is slowing down the log.

3. Does the distribution of mass influence how long the splash lasts? Describe your observation.

   The distribution of mass does determine how long the splash lasts. If there is a great deal of mass, there is a much longer splash needed to slow down the log.

4. Where on the ride do the riders lunge forward? Explain why this happens.

   The riders lunge forward at the bottom of the hill when the splash begins. This is because the water moving against the logs, creating the splash, is abruptly slowing the logs down.

Activity Seven: Energy to the Top of Batman, The Great American Scream Machine, and Rolling Thunder

The data here is a sample of what a set of data for this activity will look like. The data for this activity will vary with each student.

Check the Diagrams at the Front of the Activities for Select Measurements

	Batman	**Great American Scream Machine**	**Rolling Thunder**
Your Mass	70 kilograms	70 kilograms	70 kilograms
Time for the Car to Reach the Top of the First Hill	30 seconds	30 seconds	30 seconds

	Batman	**Great American Scream Machine**	**Rolling Thunder**
Find the work the motors do pulling *you* from the platform to the top of the hill.	$= 9.81 * 70 * (32 - 7.2)$ =17030 Joules	$= 9.81 * 70 * (47 - 0)$ =32274 Joules	$= 9.81 * 70 * (27 - 0)$ =18540 Joules
Determine the power the ride used to get you to the top of the lift hill.	$= 17030 / 30$ 567.67 Watts	$= 32274 / 30$ 1075.8 Watts	$= 18540 / 30$ 618 Watts
Convert the power in watts to horsepower.	$= 567.67 * (550 / 746)$ =418.5 Horsepower	$= 1075.8 * (550 / 746)$ =793.1 Horsepower	$= 618 * (550 / 746)$ =455.6 Horsepower

QUESTIONS TO ANSWER FOR BATMAN (also linked with Activity Six)

1. What is the advantage to the park of having you walk up the first 7.2 meters to get on? The motors are required to do less work to move you to the top of the ride. The park saves energy.

2. On which type of hill does a motor have to exert more force, a steep hill or a shallow one? How does this explain why the first hill of this ride is not very steep? Motors have to exert more force on steep hills so having a shallow hill means the park uses a smaller motor.

3. The power of a motor indicates how much work it can do per second. If the time to go uphill were shorter, what would happen to the power of the motor that was needed? If the time uphill were shorter, more power would be needed.

4. Where on this ride do you have the most Potential Energy? Riders have the most potential energy at the top of the first hill.

5. Where on this ride are you going the fastest? Riders are moving the fastest at the bottom of the first drop.

6. Where on this ride do you have the most Kinetic Energy?
   At the bottom of the first drop riders have the most kinetic energy, since kinetic energy is the energy of motion.

7. Describe what happens to your Potential Energy, Kinetic Energy and speed as you go through the ride. When do you first have a Kinetic Energy of 0? Do you ever have 0 Kinetic Energy again? As the ride progresses, energy keeps shifting from potential to kinetic energy as the ride goes down a hill and then back to potential from kinetic as the ride goes up hills. It is partly kinetic energy and partly potential energy at the top of the loop.

8. Why is the first hill of a roller coaster always the highest?
   The height of the first hill determines the total energy of the ride in terms of maximum potential energy. It is lost because energy is lost to friction as the ride progresses so the total mechanical energy continually shrinks. The coaster can never get as high again.

QUESTIONS TO ANSWER FOR THE GREAT AMERICAN SCREAM MACHINE (also linked with Activity Six)

1. On which type of hill does a motor have to exert more force, a steep hill or a shallow one? In terms of forces, explain why most rides use a long, shallow first incline. Long shallow first incline means less force to pull uphill so they can use smaller motors.

2. The power of a motor indicates how much work it can do per second. If the time to go uphill were shorter, what would happen to the power needed? Shorter time uphill requires more power.

3. Why do some people think it makes a ride more exciting to have a long first hill? Long hills give you more time to anticipate the ride and make it feel even higher.

4. Where on the ride do you have the most Gravitational Potential Energy? The greatest potential energy is at the top of the first hill.

5. Where on the ride are you going the fastest? You are going fastest at the bottom of the first hill.

6. Where on the ride do you have the most Kinetic Energy? The most kinetic energy is also at the bottom of the first hill.

7. Describe the way potential and kinetic energy are exchanged as the ride progresses. As the ride progresses, the potential energy of the first hill first becomes all kinetic energy at the bottom of that hill. Then some kinetic energy is traded for potential energy to get up to the top of the next hill. The kinetic energy is never zero again because the trains always have some speed as they go over the later hills.

8. Why is the first hill always the highest? The first hill is highest because, as the ride progresses, energy is lost to friction, which creates heat so the total mechanical energy to be potential and kinetic energy shrinks. The coaster can never get as high again.

9. Did you ever feel as if you were lifting out of your seat? Where? Why? Going over the tops of some hills the coaster goes so fast that the "natural trajectory" is larger than the hill's radius. The car is pulled out from under the rider.

10. Did you ever feel upside down? Where? The rider never feels upside down. At no point does the rider leave the seat or harness weight support.

QUESTIONS TO ANSWER FOR ROLLING THUNDER (also linked with Activity Six)

1. On which type of hill does a motor have to exert more force, a steep hill or a shallow one? In terms of forces, explain why most rides use a long shallow first incline. Long shallow first incline means less force to pull uphill so they can use smaller motors.

2. The power of a motor indicates how much work it can do per second. If the time to go uphill were shorter, what would happen to the power needed? Shorter time uphill requires more power.

3. Why do some people think it makes a ride more exciting to have a long first hill? Long hills give you more time to anticipate the ride and make it feel even higher.

4. Where on the ride do you have the most Gravitational Potential Energy? The greatest potential energy is at the top of the first hill.

5. Where on the ride are you going the fastest? You are going fastest at the bottom of the first hill.

6. Where on the ride do you have the most Kinetic Energy? The most kinetic energy is also at the bottom of the first hill.

7. Describe the way potential and kinetic energy are exchanged as the ride progresses. As the ride progresses, the potential energy of the first hill first becomes all kinetic energy at the bottom of that hill. Then some kinetic energy is traded for potential energy to get up to the top of the next hill. The kinetic energy is never zero again because the trains always have some speed as they go over the later hills.

8. Why is the first hill always the highest? The first hill is highest because, as the ride progresses, energy is lost to friction, which creates heat so the total mechanical energy to be potential and kinetic energy shrinks. The coaster can never get as high again.

9. Did you ever feel as if you were lifting out of your seat? Where? Why? Going over the tops of some hills the coaster goes so fast that the “natural trajectory” is larger than the hill’s radius. The car is pulled out from under the rider.

Activity Eight: Loop the Loop with Batman The Ride and The Great American Scream Machine

The data here is a sample of what a set of data for this activity will look like. The data for this activity will vary with each student.

- Connects with K'Nex Amusement Park Experience activities on the carousel, swings, and roller coaster

	Batman The Ride	Great American Scream Machine
Time to pass the point at the top of the loop.	2 seconds	2 seconds
Length of the train	10 meters	10 meters
If there is no loss of energy to friction, the speed of a roller coaster depends only on how far it is below its highest position. How high is the coaster above the ground at its highest point?	18.1 meters	38 meters
Speed is distance divided by time. You know the length of the train and the time it took for that length to pass point E at the top of the loop. Calculate your EXPERIMENTAL speed by dividing the length of the train by the time it took to pass E, at the top of the loop.	5 meters per second	5 meters per second
Describe why the Theoretical Speed may be more than the Experimental Speed. Consider the forces acting on the ride.	Experimental speed will consider friction.	Experimental speed will consider friction.

OBSERVATIONS AND QUESTIONS TO ANSWER FOR BATMAN

1. Describe how you would feel if someone strapped you into a chair and put you upside down. Would you feel any force from the seat? How would your stomach feel? What would your hair be doing? Strapped into a chair and hanging upside down there would be no force from the seat. Stomach would feel like it was in your throat. Hair would hang down away from your head.

2. Watch the hair of the people going through the upside down part of the first loop. How does it look? The hair of the people in the loop does not hang down.

3. Did people who went on Batman the Ride ever feel upside down as they went through the first loop? What made the riders feel the way they did? The rider never feels upside down. Riders feel pressed into the seat. Hair stays in normal position. The rider is moving so fast that if he / she were free to follow a “natural” trajectory it would be far larger than the small upper loop. Therefore, in the upper loop the seat exerts a large force on the person to force the rider into a curved path. Any force between seat and rider implies gravity pushing down into the seat so the rider is fooled into feeling right side up.

4. Near the end of this ride, you swing out as you go around a curve. What other rides have this kind of motion? The ride called the Flying Wave has cars which swing out just like the end of Batman, but you are not going as fast.

5. On what part of your body did you feel forces being exerted as you rounded the curve? Most of the force was on the rider’s seat coming around the turn.

6. Sketch what would happen to the angle of the train if it were moving faster. If the train went faster the ride would swing out further.

7. Even though the train was at such a great angle as it came around the curve, did you ever feel as if you were falling out? Explain. Riders never feel as if they are falling out because the large force on their seat makes them feel very secure. They feel pressed into the seat.

OBSERVATIONS AND QUESTIONS TO ANSWER GREAT AMERICAN SCREAM MACHINE

1. Describe how you would feel if someone strapped you into a chair and put you upside down. Would you feel any force from the seat? How would your stomach feel? What would your hair be doing? Strapped into a chair and hanging upside down there would be no force from the seat. Stomach would feel like it was in your throat. Hair would hang down away from your head.

2. Watch the hair of the people going through the upside down part of the first loop. How does it look? The hair of people in the loop does not hang.

3. Did people who went on The Great American Scream Machine ever feel upside down as they went through the first loop? What made the riders feel the way they did? The rider never feels upside down. Riders feel pressed into the seat. Hair stays in "normal" position.

Activity Nine: Bumper Cars

Questions to Answer for the Bumper Cars

Most of these questions can be answered just by watching.
Ask a rider about the questions with the **.

1. What kind of energy is converted into kinetic energy in this ride?

   Mechanical energy is converted to kinetic energy.

2. How does the energy get to the cars? (Look up)

   Energy is transferred to the cars in the overhead metal device that drags against the ceiling.

3. The bumper cars can only work when you have a closed circuit. **How do you close the circuit in the Bumper Cars?

   The circuit is closed when the rider steps on the pedal to make the car go.

4. **Can you control the speed of your car? If so, explain how you do this?

   You can control the speed by pressing the pedal and leaving off. If the pedal is depressed constantly, the speed will eventually reach a constant.

5. Describe what happens if you rear-end a car that is standing still. Try to choose a car with someone of almost equal mass.
   a. What happens to the moving car?

   The moving car either slows down or stops.

   b. What happens to the car standing still?

   The car standing still begins to move.

6. Describe what happens when you are rear-ended by a faster moving car.
   a. What happens to your slower moving car?

   Your car will speed up.

   b. What happens to the faster moving car that hit you?

   The faster moving cars will slow down.

National Council of Teachers of Mathematics Standards Alignment

	Activity								
NCTM Standards	1	2	3	4	5	6	7	8	9
Understand numbers, ways of representing number, relationships among numbers, and number systems.		X	X		X	X	X	X	
Understand meanings of operations and how they relate to one another.		X	X			X	X	X	
Compute fluently and make reasonable estimates.		X	X	X	X	X	X	X	
Understand patterns relations and functions.	X	X	X	X	X	X		X	
Represent and analyze mathematical situations and structures using algebraic symbols.		X	X	X	X	X	X	X	
Use mathematical models to represent and understand quantitative relationships.	X	X		X	X	X	X	X	
Analyze change in various contexts.	X	X		X	X	X	X	X	X
Analyze characteristics and properties of two and three dimensional geometric shapes and develop mathematical arguments about geometric relationships.		X		X				X	X
Specify locations and describe spatial relationships using coordinate geometry and other representational systems.	X	X		X	X	X			
Apply transformations and use symmetry to analyze mathematical situations.				X					
Use visualizations, spatial reasoning, and geometric modeling to solve problems.		X		X	X	X		X	X
Understand measurable attributes of objects and the units, systems, and processes of measurement.	X	X	X	X	X	X	X	X	
Apply algorithmic techniques, tools, and formulas to determine measurements.	X	X	X	X	X	X	X	X	X
Formulate questions that can be addressed with data, and collect, organize, and display relevant data to answer them.	X	X		X	X	X	X	X	
Select and use appropriate statistical methods to analyze data.	X	X	X	X	X	X			
Develop and evaluate inferences and predictions that are based on data.			X		X	X			
Understand and apply basic concepts of probability.			X		X				
Build new mathematical knowledge through problem solving.	X	X	X	X	X	X	X	X	X
Solve problems that arise in mathematics and in other contexts.	X	X	X	X	X	X	X	X	X
Apply and adapt a variety of appropriate strategies to solve problems.	X	X	X	X	X	X	X	X	X
Monitor and reflect on the process of mathematical problem solving.	X	X	X	X	X	X	X	X	X
Recognize reasoning and proof as fundamental aspects of mathematics.									
Make and investigate mathematical conjectures.	X	X	X	X	X	X	X	X	X
Develop and evaluate mathematical arguments and proofs.	X	X	X	X	X	X	X	X	X
Select and use various types of reasoning and methods of proof.	X	X	X	X	X	X	X	X	X
Organize and consolidate their mathematical thinking through communication.	X	X	X	X	X	X	X	X	X
Communicate their mathematical thinking coherently and clearly to peers, teachers, and others.	X	X	X	X	X	X	X	X	X
Analyze and evaluate the mathematical thinking and strategies of others.	X	X	X	X	X	X	X	X	X
Use the language of mathematics to express mathematical ideas precisely.	X	X	X	X	X	X	X	X	X
Recognize and use connections among mathematical ideas.	X	X	X	X	X	X	X	X	X
Understand how mathematical ideas interconnect and build on one another to produce a coherent whole.	X	X	X	X	X	X	X	X	X
Recognize and apply mathematics in contexts outside of mathematics.	X	X	X	X	X	X	X	X	X
Create and use representations to organize, record, and communicate mathematical ideas.	X	X	X	X	X	X	X	X	X
Select, apply, and translate most mathematical representations to solve problems.	X	X	X	X	X	X	X	X	X
Use representations to model and interpret physical, social, and mathematical phenomena.	X	X	X	X	X	X	X	X	X