Schedule of Events

TIME	EVENT LOCATION	LOCATION
8:45	Lagoon Autopark (parking lot) opens	
9:30	Lagoon Main Gates to rides opens	Main Gate
9:00 - 11:00	School & teacher registration	Main Gate
9:30 - 11:00	Contest registration & safety approval inspections	Davis Pavilion
10:00-11:00	Utah/Idaho FIRST Robotics Grudge Match—Semifinals	Davis Pavilion
10:00-2:00	Mindstorm Activities	Maple Terrace
10:00-2:00	Wind Energy Challenge MESA Contest Activities	Oak Terrace
12:00 - 1:00	Faculty and staff complimentary lunch	Canyon Terrace
2:30 - 3:30	Contest winners are posted in as judging is completed Prizes may be picked up then.	Davis Pavilion
2:00-2:45	Utah/Idaho FIRST Robotics Grudge Match—Finals	Davis Pavilion
2:45-3:15	Mindstorm Competition—Finals	Maple Terrace
3:30	Awards Ceremony for Physics Bowl, FIRST, Mindstorm and Wind Energy Challenge	Davis Pavilion
4:30	All rides close	
4:45	Park closes	

Sky Drop Contest

10:00-11:30	Registration for the Sky Drop	Drop Site
11:30-1:30	Eggs can be dropped from the Sky Coaster. Line will close at 1:00, or as soon as the line is finished.	Drop Site
2:30	Winners announced as soon as the contest is done.	Davis Pavilion

Colossus' Colossal G-Forces Contest

9:30-10:30	Contest registration & safety approval inspections	Davis Pavilion
10:30-12:30	Colossus open for measurements	Colossus
2:00	Entry forms due	Davis Pavilion

Physics Bowl Competition

9:30 - 10:30	Contest registration	BighornTerrace
10:30 – 11:00	Preliminary Qualification Round	BighornTerrace
11:00 - 11:45	Round of thirty-two	BighornTerrace
1:15 - 1:45	Round of sixteen	BighornTerrace
1:45 - 2:15	Quarter-final round	BighornTerrace
2:15 - 2:45	Semi-final round	BighornTerrace
2:45 - 3:00	Consolation round	Davis Pavilion
2:45 - 3:00	Championship round	Davis Pavilion
3:30	Scholarships and prizes awarded	Davis Pavilion

Physics Demonstration, Lagoon: Ride Design and Physics Day Logo Design Contests

9:30 - 11:00	Contest registration & safety approval inspections	Davis Pavilion
11:00 - 3:00	Judging	Davis Pavilion
11:00-2:00	Meet with Judges by appointment as arranged during registration	Davis Pavilion

Student Workbook

10:00 - 3:00	Workbooks Collected	Davis Pavilion
3:30	All entry forms due. Teachers can pick up solutions.	Davis Pavilion

All students who turn in their workbook to the table at Davis Pavilion by 3:30 can enter a random drawing to

Win Fabulous Prizes

UtahState University DEPARTMENT OF PHYSICS

Idaho National Laboratory

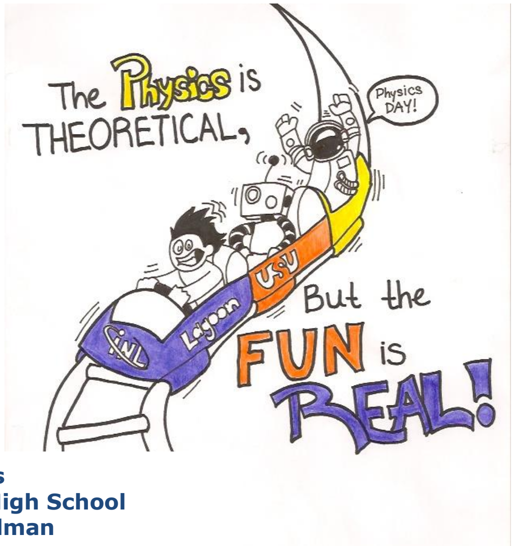
Middle School Student Workbook

USU PHYSICS DAY

AT

Lagoon

May 16, 2014



Artist— Emily Ellis
Kaysville Junior High School
Advisor— Alex Tolman

STUDENT ______________________

TEACHER ______________________

SCHOOL ______________________

WELCOME TO PHYSICS DAY AT LAGOON

Thank you for coming to Lagoon for a day of physics and fun!

You are one of more than 7000 physics students from more than 100 schools from five states here to enjoy a fun day experiencing Amusement Park Physics first hand.

This Student Workbook is for use in one of many activities that you can participate in today:

Student Workbook Physics Bowl Contest
Colossus' Colossal G-Forces Contest
Sky Drop (Egg Drop) Contest
Physics Demonstration Design Contest
Lagoon Ride Design Contest
Physics Day Logo Design Contest

The Physics Department at Utah State University and the Idaho National Laboratory are running today's activities.

The contests are sponsored by ATK Launch Systems, Boeing, Eastern Idaho Regional Medical Center, Hill Air Force Base, Lagoon, Micron, Portage Environment, Rocky Mountain NASA Space Grant Consortium, Space Dynamics Laboratory, US Navy, USU College of Science, USU Emma Eccles Jones College of Education & Human Resources, and USU Admissions Office.

More information about Physics Day is available at physicsday.usu.edu.
If you have questions or would like to find out more about physics at Utah State University (www.physics.usu.edu), please stop by the Davis Pavilion.
We will be glad to see you!

ABOVE ALL, HAVE A FUN AND SAFE DAY!!!

Table of Contents

GENERAL QUESTIONS

FILL IN THE BLANKS WITH THE TERMS IN THE GLOSSARY ON PAGES 4 & 5

1. When a roller coaster is at the top of a hill, it has the most __________________ energy?
2. ___________________ of an object refers to its speed and direction.
3. When riding a spinning ride, the riders feel an inward force known as ________________ force.
4. ____________________ is the number of repeated events per unit time.
5. Riders on the Sky Coaster feel a sense of ____________________ as they begin their swinging.
6. Rocket Re-Entry, Blast Off!, Tidal Wave, Sky Coaster and the Catapult all have what physics principle in common? ________________ ________________ ________________
7. Rides at Lagoon are all slowed down by this force ________________.
8. Most waves need a _________________ to travel through.
9. The Top Eliminator race cars have the same ____________ both here on Earth and on the Moon, but their ______________ is less on the moon.
10. The motors are performing _______________ on the Tidal Wave as the ride begins swinging.
11. Distance from crest to crest or trough to trough on a wave is known as the _________________.
12. _______________________ is felt when rapid changes in speed or direction occur.
13. If the net external force acting on a system of objects is zero, the total momentum of the system is ___________________.
14. When bumper cars hit into one another head on and bounce back, this is an ________________ collision.
15. As the roller coaster descends down the top of the hill, the ____________ energy is rapidly converted to _____________ energy?
16. ___________________ is the average force multiplied by its time interval of action.
17. Riders on the Colossus feel heavier than normal when they ride through the loops. This is known as the_______________.

FERMI QUESTIONS

Enrico Fermi
1901-1954

Enrico Fermi was one of this country's greatest physicists.. among his accomplishments were the 1938 Nobel Prize for nuclear and particle physics and the title "Father of the Atomic Age" for his role in building the first nuclear reactor. He had a rare talent as both a gifted theorist and experimentalist. One of his legacies is the "Fermi Question," an insightful question requiring both an understanding of physics principles and estimation skills.

The Fermi Questions given below requireinformation gathered for this workbook, estimation, and some clever thinking.

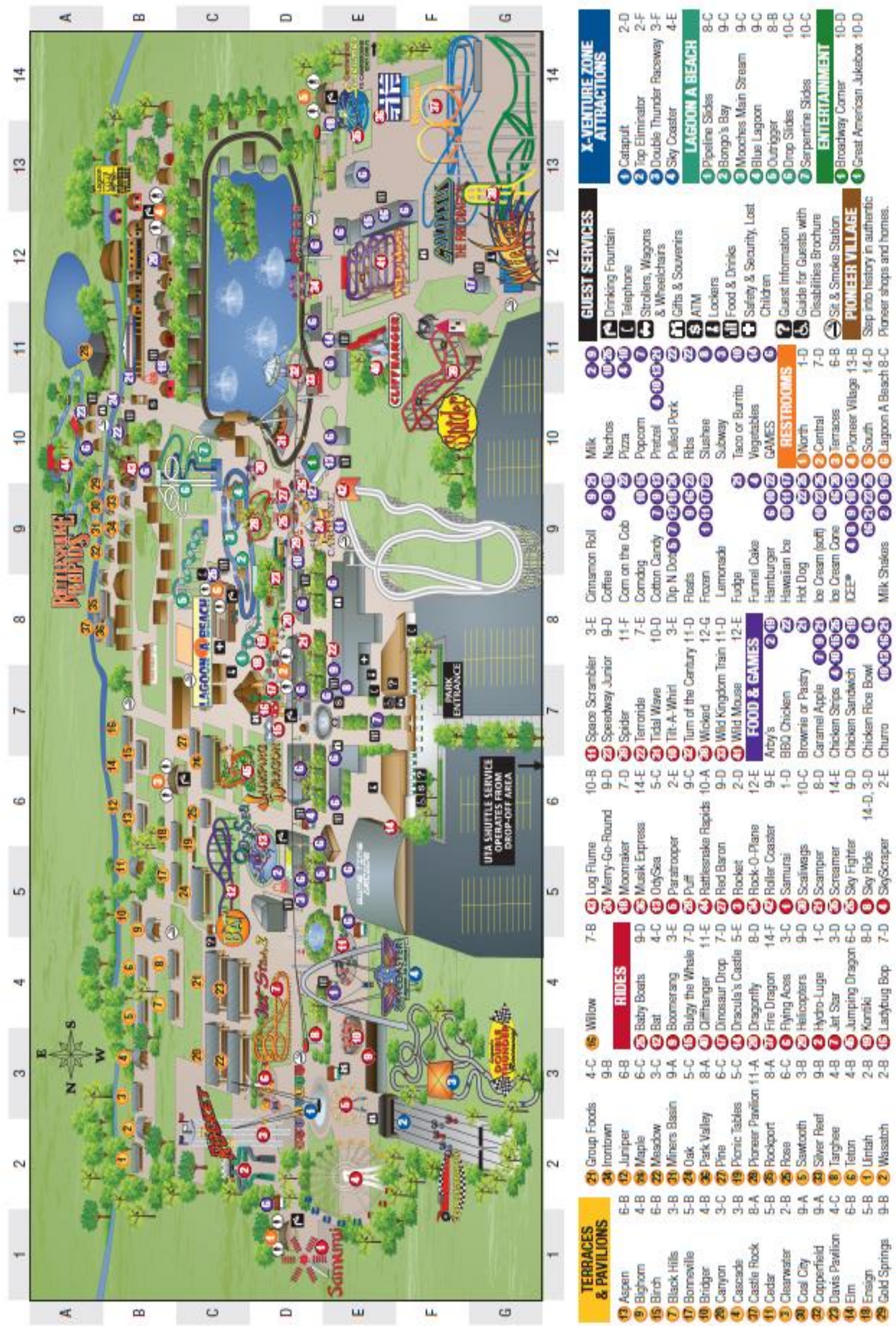
1. How many water balloons would it take to fill all 36 gondolas on the Sky Scraper?

2. What is the total mass in kilograms of everyone attending Physics Day at Lagoon?

3. How many revolutions did one school bus wheel make to get to Lagoon from your school?

4. How many meters of metal is the Colossus constructed with?

LAGOON PARK MAP



AMUSEMENT PARK PHYSICS GLOSSARY

Here are some physics concepts that you will encounter today. Most of them should be familiar to you after the exciting physics class you've been in this year.

ACCELERATION: Time rate of change of velocity (either speed or direction) of motion.

ACCELEROMETER: A device to measure acceleration.

AIR RESISTANCE: Force resisting motion of a body through air due to the frictional forces between the air and body.

AMPLITUDE: The maximum height of the wave above or below zero level.

ANGULAR ACCELERATION: Time rate of change of angular velocity.

ANGULAR VELOCITY: Time rate of change of angular position.

CENTRIPETAL FORCE: A force on an object pulling or pushing the object towards the center of its curved path.

CONSERVATION OF ENERGY: Basic tenet of physics stating that energy can neither be created nor destroyed in any process, though it may change form.

CONSERVATION OF MOMENTUM: The total momentum of a system is constant whenever the net external force on the system is zero.

ELASTIC COLLISION: A collision in which kinetic energy is the same before and after the collision.

FORCE: A push or pull. The time rate of change (direction and magnitude) of momentum.

FREQUENCY: The number of waves that pass a particular point in one second.

FRICTION: A retarding force that resists the motion of a body.

G-FORCE: Ratio of the magnitude of acceleration on a body to the acceleration of gravity at sea level on Earth ($g = 9.8\ m/s^2$).

GRAVITY: Attractive force between two bodies, proportional to their masses.

IMPULSE: Product of the magnitude of a force on a body times the time over which the force acts on the body.

INELASTIC COLLISON: A collision in which kinetic energy decrease as a result of the collision.

INERTIA: Tendency of a body to remain at rest or in uniform motion in a straight line.

KINETIC ENERGY: The energy of a body associated with its motion.

BORED? PHYSICS ON YOUR PHONE physicsday.usu.edu

iOS

Angry Birds – Projectile motion, acceleration, force, and many more fun physics principles tested with this series of games.

Coaster Physics ($0.99) – Build and ride your own roller coaster. See real-time potential and kinetic energy, speed and acceleration, and the g-forces felt during the ride.

Convert Units for Free – Feet to meters, miles per hour to kilometers per hour? Convert many units with this application.

Flashcards+ – Build your own flashcards or use premade decks to keep on top of your physics game.

Footsteps – Pedometer Free – Use this to measure your own velocity or get velocity of rides using distance per unit time.

IBPhysics Definitions – Test your physics definitions using the innovative flashcard style application.

Roller Coaster RushFREE– Use the accelerometer to gain speed, get points, and master each level.

Paper Toss – Throwing paper into the trash has never been so fun especially with a blowing fan and other obstacles.

SPARKvue – Acceleration data application. Measure and log each x, y, or z axis individually or all three at the same time.

TONE: The Ultimate Tone Generator – Produce a wide range of tones for fun or to test the hearing of those around.

Vernier Video Physics ($2.99) – Real-time video analysis of motion. Plot and chart the positions as well as determine the velocity.

android

Angry Birds – Projectile motion, acceleration, force, and many more fun physics principles tested with this series of games.

Angular Velocity – Up for a challenge? Try this app to test your physics reasoning abilities. Tilt the phone to control gravity and to swing your way through each level.

Audalyzer – Walk around Lagoon and determine the loudest locations. Displays waveform and frequency spectrum.

Cardio Trainer – Use this to measure your own velocity or get velocity of rides using distance per unit time.

Unit Converter – ConvertPad – Feet to meters, miles per hour to kilometers per hour? Convert many units with this application.

Flash Cards – Build your own flashcards or use premade decks to keep on top of your physics game.

Grav-O-Meter – Measures real-time acceleration felt and logs the maximum.

Instant Heart Rate – What is your heart rate before and after the ride? Test it out to see!

Paper Toss – Throwing paper into the trash has never been so fun especially with a blowing fan and other obstacles.

Smart Measure – Use the built in camera to measure the distance and height of objects.

Surveyor – Use the built in camera to measure the distance of objects.

True Tone – Produce a wide range of tones. Test this out with the Audalyzer application to see what cool designs can be generated.

WICKED

Wicked uses strong electromagnets to quickly accelerate riders up the steep, 110-foot tower at speeds close to 41 miles per hour. Throughout the ride, Wicked travels through steep valleys, high-banked turns, a half pipe, roll inversion, and other exciting features. Using the iPhone or iPod "Mobile Science – Acceleration 1.0" application or Android "Grav-O-Meter" application, fill out the following information as you enjoy the ride.

Questions

1. How would you estimate the length of the ride?

2. Before riding Wicked, look at the drawing below and identify where a rider feels the maximum amount of acceleration. Why?

3. Using the "Mobile Science - Acceleration 1.0" iPhone or iPod application, turn the collection rate to 60 samples/second, hit the green "start" icon. Start collecting the data before you get on the ride, safely secure the device, and collect data during the ride. Hit the red "stop" icon to stop recording data once the ride is complete. Using the application data, identify the maximum acceleration felt in each axis. (**Note:** *The data from "Mobile Science - Acceleration 1.0" cannot be saved unless e-mailed. In order to save the data, take a screenshot of the iPhone or iPod device. To do so, hold the "home" and "power" button down at the same time. The screenshot will be saved in the "Photos" folder on the device).*
   Using the Android "Grav-O-Meter" application, start the application and allow it to run during the duration of the ride. Once the ride is over, hit the "menu" button and you can see the maximum acceleration felt.
   - x-axis:
   - y-axis:
   - z-axis:
4. Using the data from question three, identify on the map in question two where the maximum acceleration was felt. Does it match up to your initial thoughts? Why or why not?

AMUSEMENT PARK PHYSICS GLOSSARY

LONGITUDINAL WAVE: A wave that vibrates or oscillates in the same direction that the wave pattern is moving (example: sound wave).

MASS: The amount of material a body contains. A quantitative measure of the inertia of a body.

MEDIUM: stuff that a wave travels through (i.e. air, water)

MOMENTUM: The product of mass times velocity.

NEWTON'S LAWS OF MOTION: Physical laws governing the motion of bodies (at speed much less than the speed of light) expressed in terms of force, mass, and acceleration.

PERIOD: The amount of time for one complete wave oscillation to pass a point in space.

POTENTIAL ENERGY: Energy of a body associated with its position.

POWER: Rate of work done per unit time.

SIMPLE HARMONIC MOTION: Repetitive vibration about an equilibrium position in which a restoring force is proportional to the displacement from equilibrium (example: pendulum, oscillating spring).

SPEED: The magnitude of velocity.

TRANSVERSE WAVE: A wave in which the vibration or oscillation is perpendicular to the direction that the wave pattern is moving (example: stadium wave football cheer).

VELOCITY: The magnitude and direction of the time rate of change of position.

WAVELENGTH: The distance between successive crests or troughs of a wave.

WEIGHT: A force proportional to the mass of a body. Measurement of the gravitational attraction of a body to the Earth.

WEIGHTLESSNESS: A condition under which a body feels no net force proportional to its mass.

WORK: Product of the magnitude of force on a body times the distance through which the force acts.

Useful Conversion Factors

1 in = 2.54 cm	1 J = 2.78 x 10-7 kwhr = 9.5 x 10^{-4} BTU
1 km = 0.621 miles	1 W = 1J/s = 1.3 x 10^{-3} horsepower
1 liter = 0.264 gal	1 W = 1.3 x 10^{-3} horsepower
1 hr = 3600 sec	1 g = 9.8 m/s^2 = 32 ft/s^2
1 fortnight = 1.728 x 10^6 sec	1 N = 0.225 lbf
1 m/s = 3.6 km/hr = 2.24 mi/hr	1 atm = 1 x 10^5 Pa = 14.7 lb/in^2
1 Cal = 1 kcal = 1000 cal = 4186J	1 kg/liter H_2O = 8.35 lb/gal H_2O

WHICH DIRECTION IS THE ENERGY WAVE TRAVELING?

A wave is a repeated disturbance that carries energy as it travels through stuff (a medium). Lagoon is full of screaming participants enjoying themselves on the rides and full of waves. When a rider screams, their vocal chords vibrate causing alternating high and low pressure to emanate from their mouth. Those high and low pressure bursts cause energy to travel through the air (the medium) to your ear and you hear the scream. When the pressure waves reach your ear, it causes your eardrum to move back and forth just like the screamer's vocal chords. Energy is transferred from the vocal chords to the ear drums through the air. In physics terms, it is acoustic energy transmitted as pressure waves through the air. Acoustic energy is just one form of energy that waves can transmit. There are many other forms of energy that produce waves. Lagoon is full of examples. Let's go on a scavenger hunt and discover the energy of waves all around us.

Fill in the following table with the medium the wave travels through, the direction of the wave motion, the type of wave, and the kind of energy they transmit. *Hint:* Define the three types of mechanical waves below. Does the stuff in the medium move in the direction the wave travels, perpendicular to the wave travel, or both?

Transverse____

____

Longitudinal____

____

Surface____

____

Ride or Activity	Medium (What's Moving)	Direction of Medium Motion	Type of Wave	Type of Energy Transferred
Screaming	Air	Perpendicular	Transverse	Acoustic (Sound)
Sky Coaster	Ride or Car			
Catapult				
Rattlesnake Rapids				
Turn-of-the-Century				
Log Flume				
Tidal Wave				
Music playing at Lagoon				

DAMPED HARMONIC MOTION

When a periodic or oscillating motion is slowed down by a force, often friction, it is known as damped harmonic motion. The motion can either be damped out quickly, slowly, or hardly at all. Everyday we see damping occurring. Walk around Lagoon and identify at least two examples each of underdamping, critical damping, and overdamping. Define each term and draw the graph of each scenario as well.

Underdamping

Definition:____

____

Examples Graph

Critical Damping

Definition:____

____

Examples Graph

Overdamping

Definition:____

____

Examples Graph

FREQ OUT!

Lagoon is full of rides that exhibit repetitive motions, each with similar characteristics. One particular type of motion is wave-like motion. Waves have characteristics and properties that oscillate with time at a certain speed. The period is the time it takes for a wave to repeat itself. The number of complete oscillations per unit time is the wave frequency. Waves are often described as being transverse or longitudinal. Use the worksheet below to identify the various characteristics and similarities between the waves and better develop your own understanding of how to describe wave-like motion.

Useful Equations

$$v = \frac{d}{t} \qquad f = \frac{1}{T} \qquad \lambda = \frac{v}{f} \qquad C = 2\pi r$$

Ride	**Top Speed (m/s)**	**Period (s)**	**Frequency (Hz)**	**Wavelength (m)**	**Wave-like Motion**
Carousel					
Catapult					
Paratrooper					
Centennial Screamer					
Musik Express					

Hint to find speed: Estimate the height of the ride or the diameter (radius) to find the distance traveled in one period, *d*. Then count how long it takes to arrive to the top point or to complete one rotation, *t*. Finally, calculate the average speed, *v*, using the equation $v = \frac{d}{t}$.

1. Which ride has the largest frequency and why?

2. What is the most common wave-like motion exhibited in the rides above?

3. How does the circular motion impact the speed?

4. Does the mass of the occupants change the ride's frequency? Explain.

TIDAL WAVE

This swinging boat ride is a great example of an everyday pendelum. It swings back and forth reaching a maximum height of 20 meters (approximately 66 feet) allowing the riders to feel a sense of weightlessness. While waiting in line, find out the relationship between this pendelum action, simple harmonic motion, and waves.

Questions

1. Face the side of the boat and draw a graph of the position action.

2. Continue facing the side of the boat and draw another graph of the position action but this time add time. Keep your drawing hand stationary and with the other hand pull the paper perpendicular to your drawing hand's motion. Do this for the first four complete swings.

3. Now face the front of the boat and draw a graph of its position action.

4. Continue facing the front of the boat and draw another graph of its position action but this time add time. Keep your drawing hand stationary and with the other hand pull the paper perpendicular to your drawing hand's motion. Draw the last five swings of the ride.

5. How do the graphs of questions one and three compare and differ? (b) How do the graphs of questions two and four compare and differ? (c) What type(s) of motion does each graph represent? (d) If the ride took approximately 20 seconds, label the period, amplitude, wavelength, and frequency on the graph of question four with the correct symbols.

AMP IT UP

Lagoon is full of rides that exhibit wave motions. Those waves all have certain characteristics. For example, they oscillate in time at a certain rate and move through a medium at a certain speed, *v*. The time it takes for a wave to repeat itself is known as its period, *T*. The number of complete oscillations per unit time is the wave frequency, *f*. Use the worksheet below to identify the various characteristics and similarities betweenKiddieland and the adult rides. If the Kiddieland rides are not running, use your imagination and best estimates.

Useful Equations

$$v = \frac{d}{t} \qquad f = \frac{1}{T} \qquad \lambda = \frac{v}{f} \qquad C = 2\pi r$$

Ride	**Average Speed (m/s)**	**Period or time per oscillation (s)**	**Frequency or oscillations per second (Hz)**	**Wavelength or distance per period (m)**
Tidal Wave				
Kontiki				
Turn-of-the-Century				
Dragonfly				

Hint to find speed: Estimate the height of the ride or the diameter (radius) to find the distance traveled in one period, *d*. Then count how long it takes to arrive to the top point or to complete one rotation, *t*. Finally, calculate the average speed, *v*, using the equation $v = \frac{d}{t}$.

1. How do the size and speeds of the Kiddieland rides compare to the adult rides in general?
2. What makes the difference between the Kiddieland and adult rides?
3. What characteristic(s) gives the adult rides their thrill?
4. Which ride has the highest frequency and why?

RE-ENTRY

Waves are disturbances in a medium that transfer energy. An example we witness every day is sound. Sound is a wave traveling through the air as its medium. Lagoon's Rocket Re-Entry is an example of damped simple harmonic motion. If the ride were moving past you horizontally on a cart, it would resemble a wave. While waiting in line, investigate how simple harmonic motion and waves relate through the following activities.

Ride Facts
Number of riders: 12
Height of ride: 60 meters (approximately 200 feet)
Force initially: 4.5 g

Questions

1. What are the forces that cause the riders to slow down?
2. Using the iPhone or iPod "Stopwatch Analog+Digital" application or the Android "StopWatch and Timer" application, measure how long it takes to complete the first free-fall.
3. Draw a graph of the riders' position over time. Identify the period, *T*, on the graph.
4. What is meant by experiencing 4.5 g's on this ride?
5. Use the "Vernier Video Physics" iPhone or iPod application, stand next to Boomerang and record a group riding Re-Entry from beginning to end. Be sure that you can see the entire ride in the video screen, do not pan the video, and keep the device as steady as possible. Follow the directions in the application and analyze the ride video. In the top right corner, hit the graph icon and compare the distance versus time graphs to your graph. How are they similar and different?