## Schedule of Events

<table>
<thead>
<tr>
<th>TIME</th>
<th>EVENT LOCATION</th>
<th>LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:45</td>
<td>Lagoon Autopark (parking lot) opens</td>
<td>Main Gate</td>
</tr>
<tr>
<td>9:30</td>
<td>Lagoon Main Gates to rides opens</td>
<td>Main Gate</td>
</tr>
<tr>
<td>9:00 - 11:00</td>
<td>School &amp; teacher registration</td>
<td>Main Gate</td>
</tr>
<tr>
<td>9:30 - 11:00</td>
<td>Contest registration &amp; safety approval inspections</td>
<td>Davis Pavilion</td>
</tr>
<tr>
<td>10:00 - 11:00</td>
<td>Utah/Idaho FIRST Robotics Grudge Match—Seminars</td>
<td>Davis Pavilion</td>
</tr>
<tr>
<td>10:00 - 2:00</td>
<td>Wind Energy Challenge MESA Contest Activities</td>
<td>Oak Terrace</td>
</tr>
<tr>
<td>12:00 - 1:00</td>
<td>Faculty and staff complimentary lunch</td>
<td>Canyon Terrace</td>
</tr>
<tr>
<td>2:30 - 3:30</td>
<td>Contest winners are posted in as judging is completed</td>
<td>Davis Pavilion</td>
</tr>
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### 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 (Bighorn Terrace)
- **10:30 – 11:00** Preliminary Qualification Round (Bighorn Terrace)
- **11:00 – 11:45** Round of thirty-two (Bighorn Terrace)
- **1:15 - 1:45** Round of sixteen (Bighorn Terrace)
- **1:45 - 2:15** Quarter-final round (Bighorn Terrace)
- **2:15 - 2:45** Semi-final round (Bighorn Terrace)
- **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)

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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**

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**USU PHYSICS DAY**

**AT Lagoon**

**May 16, 2014**

**Artists—Naomi Hilton**

**Skyline High School Advisor—Mrs. Smith**

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**STUDENT**

___________________________

**TEACHER**

___________________________

**SCHOOL**

___________________________
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!!!

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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 _________________.
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 require information gathered for this workbook, estimation, and some clever thinking.

1. How many gallons of water flow in Rattlesnake Rapids to produce the waves for the riders? The ride is 1,625 feet long and lasts 5-6 minutes. 
   \[\text{Hint: } 1 \text{ ft}^3 = 7.5 \text{ gallons}\]

2. How tall would the Rocket need to be for the riders to experience weightlessness for a full 10 sec?

3. What diameter would the carousel need to be to fit everyone attending Physics Day at Lagoon on the ride at one time?

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

**FRICITION:** 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 \((g = 9.8 \text{ m/s}^2)\).

**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 COLLISION:** 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.

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**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.

**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.
Waves are the repeated motion of a medium carrying energy. An example you can witness every day is sound. Sound is a wave traveling through the air as its medium. Harmonic motion is a closely related type of motion. Lagoon’s Rocket Blast Off! is an example of damped simple harmonic motion. If Rocket Blast Off! was moving past you on a big cart horizontally, it would resemble a wave. Likewise, if you were moving past Rocket Blast Off! on a moving sidewalk, its motion would look like a wave. While waiting in line, see if you can understand how simple harmonic motion and relative motion relate to waves through the following activities.

Useful Equations

\[ \lambda = \frac{v}{f} \quad f = \frac{1}{T} \quad v = \frac{d}{t} \]

Ride Facts

Height of ride: 60 meters (approximately 200 feet)
Force initially: 4.5 g upward and 2 g downward

Use the “Vernier Video Physics” iPhone or iPod application, stand next to Boomerang and record a group riding Blast Off! 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. Watch the ride a second time and use the “Stopwatch Analog+Digital” iPhone or iPod application to time the ride. This worksheet can also be completed using the Android “StopWatch and Timer” application, simply bypass question three.

Questions

1. Using the iPhone or iPod “Stopwatch Analog+Digital” application or Android “StopWatch and Timer” application, how long does it take the ride to first reach the top of the ride in seconds?

2. Draw a graph of the riders’ position versus time. Identify the period, \( T \), on the graph.

3. Using the “Vernier Video Physics” application, 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?

4. Using the “Stopwatch Analog+Digital” application, how long does it take the ride to complete one oscillation (one time to the top and back down)? This is the period, \( T \). Assume you are skateboarding past the ride at 1 m/s. Using this information, calculate the wavelength of the first oscillation in meters.
A wave is a disturbance that carries energy through a medium. Lagoon is full of screaming participants enjoying themselves on the rides. 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 at the same rate as the screamer’s vocal chords. In physics terms, it is acoustic energy transmitted as pressure waves through the air.

Acoustic energy is one form of energy that waves travel in. 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 type of energy being transferred, the energy source, the form energy is transferred in, and the medium in which the energy travels.

<table>
<thead>
<tr>
<th>Ride or Activity</th>
<th>Type of Energy Transferred</th>
<th>Energy Source</th>
<th>Form the Energy is Transferred In</th>
<th>Medium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screaming</td>
<td>Acoustic (Sound)</td>
<td>Screamer’s Vocal Chords</td>
<td>Air Pressure Waves</td>
<td>Air</td>
</tr>
<tr>
<td>Log Flume</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rattlesnake Rapids</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rocket</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flashing Lights</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turn-of-the-Century</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sky Scraper</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vibrations of a Motor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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?
When motion is neither driven or damped, it is referred to as simple harmonic motion. This motion is periodic and oscillates about an equilibrium position in a sinusoidal pattern. Each oscillation is identical and therefore the period, frequency, and amplitude are the same. In most oscillating occasions, friction causes the motion to slow down. This is known as damping. On a ride, if the initial displacement is zero, the displacement, $x$, at any given time, $t$, of the damped harmonic motion is defined as the following:

$$x(t) = Ae^{-at} \cos(2\pi t + \phi).$$

Using The Rocket Blast-Off!, investigate and identify each component of the equation.

Questions
1. Measure how long does it take the ride to reach the top of the ride in seconds?
2. Draw the wave graph with respect to the riders’ position versus time?
3. Looking at the graph, which parts represent $A$, $a$, and $\phi$ from the equation?
4. Now investigate what causes the different constants identified on the graph to occur?
5. Why does the graph gradually come to a stop rather that continually repeating the same motion? What is this known as?
The Sky Coaster gives riders that exciting sensation of skydiving or hang gliding as the ride reaches speeds up to 50 miles per hour. The falling, then climbing of the ride repeats as it swings riders back and forth just like a swinging pendulum. Watch riders on the Sky Coaster to best answer the following questions and to better understand simple pendulum motion.

**Useful Equations**

\[ T = 2\pi \sqrt{\frac{L}{g}} \quad g = 9.8 \text{ m/s}^2 \]

**Questions**

1. Using the iPhone or iPod “Stopwatch Analog+Digital” or the Android “StopWatch and Timer” application, measure the period of the first full swing starting immediately after the riders are released. Measure this for three sets of riders, then calculate the average.

   \[ T_1 = \_\_\_\_\_\_\_\_\_s \quad T_2 = \_\_\_\_\_\_\_\_\_s \quad T_3 = \_\_\_\_\_\_\_\_\_s \quad T_{avg} = \_\_\_\_\_\_\_\_\_s \]

2. Does the period depend on the mass of the riders? Explain why or why not.

3. Based on the average period (found in question one), for one oscillation of the Sky Coaster riders, calculate the length of the Sky Coaster cables.

4. Measure the angle of the rider’s using the iPhone or iPod “Multi Protractor” or Android “Advanced Protractor” application. Align the protractor point of rotation with the fulcrum of the ride. Then, using the length of the cables found above and assuming the riders hang 5 meters above the ground when at rest, determine how high off the ground, “h,” the riders are at the point “P” (right before the riders fall back from the initial swing to the starting point) below.

5. What happens when you are not 90 degrees from the ride when measuring the angle with the inclinometer?

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This swinging boat ride is a great example of an everyday pendulum. 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 pendulum 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.