Schedule of Events

TIME	EVENT	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	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 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
2:30-3:45	Mindstorm Competitions	Maple Terrace
3:30	Awards Ceremony in Davis Pavilion	Davis Pavilion
4:30	All rides close	
4:45	Park closes	

Sky Drop Contest
10:00-11:30	Registration for the Sky Drop is open	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 will be announced as soon as the contest is judged.	Drop Site

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 (Bighorn Pavilion)
9:30 - 10:30	Contest registration	Bighorn Pavilion
10:30 – 11:00	Preliminary Qualification Round in	Bighorn Pavilion
11:00 - 11:45	Round of thirty-two	Bighorn Pavilion
1:15 - 1:45	Round of sixteen	Bighorn Pavilion
1:45 - 2:15	Quarter-final round	Bighorn Pavilion
2:15 - 2:45	Semi-final round	Bighorn Pavilion
2:45 - 3:00	Consolation round	Bighorn Pavilion
2:45 - 3:00	Championship round	Bighorn 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

ARDUSAT
10:00 - 2:00	Monitor G-Force wearing ARDUSAT's gear	Rocket

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

INL Idaho National Laboratory

Middle School Student Workbook

USU PHYSICS DAY

AT

Lagoon

May 15, 2015

G-FORCE PHYSICS

Lagoon   USU   INL

Artist— Sadie Jensen
South Cache Junior High School
Advisor— Mr. MacMurdo

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 Apogee, ARDUSAT, ASI, ATK Launch Systems, Boeing, Campbell Scientific, Eastern Idaho Regional Medical Center, Embry-Riddle, Exelis, Hill Air Force Base, Idaho Virtual Academy, IM Flash Technologies, Lagoon, Micron, Ophir-Spiricon, Parker Aerospace, 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, USU Admissions Office, Utah Virtual Academy, and WiTricity.

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 at Lagoon!

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 on a curve on Cannibal or on spinning rides, the riders feel an inward force known as _____ force.
4. To measure the acceleration throughout the Cannibal ride, riders can take an _____ on the ride.
5. The attractive force between two massive bodies, which causes Lagoon's roller coasters to run, is called _____.
6. Rides at Lagoon are all slowed down by this force: _____.
7. Riders on Cannibal experience _____ _____, a type of frictional force, due to our atmosphere.
8. Cannibal riders have the same _____ both here on Earth and on the Moon, but their _____ is less on the Moon.
9. A push or pull felt on the Cannibal ride is known as a _____.
10. _____ is felt when rapid changes in speed or direction occur.
11. If two Cannibal cars collide and the net external force acting on the cars is zero, the total momentum is _____.
12. _____ causes Cannibal riders to lean when going around a bend because their bodies resist changing direction.
13. As the Cannibal riders descend down the top of the hill, their _____ energy is rapidly converted to _____ energy.
14. The_____ on Cannibal cause riders to feel heavier than normal when they ride through the loops.
15. The _____ of _____ states that within the boundaries of a problem, _____ cannot be created nor destroyed, though it may change form.

FERMI QUESTIONS

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.

**Enrico Fermi
1901-1954**

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

1. Estimate the length of Cannibal and explain your reasoning.

2. What fraction of the weight of the moving parts (car and riders) of Cannibal do the passengers comprise? What fraction of the total weight of Cannibal do the riders account for?

   Hints: How many riders are there? What does an average person weigh? How many cars are there? How big (long, wide, and high) is each car? What fraction of each car is air and what fraction is the rest? What is the average density of the stuff the cars are made of (see page 5 for common densities)? Use the same logic for the cars on the whole Cannibal ride.

-14-

LAGOON PARK MAP

LEGEND

DRINKING FOUNTAINS	SAFETY & SECURITY / LOST CHILDREN	
PUBLIC PHONES	INFORMATION	
ATMS	FOOD & DRINKS	
STROLLER, WAGON & WHEELCHAIR RENTALS	SIT & SMOKE STATION	
GIFTS & SOUVENIRS	GUIDE FOR GUESTS WITH DISABILITIES (available)	
RESTROOMS	ENTERTAINMENT - CAROUSEL THEATRE	
LOCKERS		

TERRACES & PAVILIONS

13 ASPEN	6-B	3 CLEARWATER	3-B	22 MEADOW	3-C
9 BIGHORN	5-B	30 COAL CITY	9-A	31 MINERS BASIN	9-A
15 BIRCH	7-B	32 COPPERFIELD	9-A	24 OAK	5-C
7 BLACK HILLS	4-B	23 DAVIS PAVILION	4-C	36 PARK VALLEY	8-A
17 BONNEVILLE	5-B	14 ELM	6-B	27 PINE	7-C
10 BRIDGER	5-B	1B ENSIGN	6-B	19 PICNIC TABLES	6-C
20 CANYON	3-C	29 GOLD SPRINGS	9-A	11A PIONEER PAVILION	11-A
4 CASCADE	3-B	34 IRONTOWN	9-B	35 ROCKPORT	8-A
37 CASTLE ROCK	8-A	12 JUNIPER	6-B	25 ROSE	6-C
11 CEDAR	5-B	26 MAPLE	6-C	5 SAWTOOTH	4-B
				33 SILVER REEF	3-C
				8 TARGHEE	9-A
				6 TETON	5-C
				1 UINTAH	8-A
				2 WASATCH	7-C
				16 WILLOW	6-C

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.

iOS

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

Coaster Physics – 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 Generator – Produce a wide range of tones for fun or to test the hearing of those around.

Vernier Video Physics ($4.99) – 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.

Sound Meter – 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.

G-FORCES WITH ARDUSAT

This year, one of our sponsors is providing you with The opportunity to make measurements in real time – riding on the Rocket!! ARDUSAT provides these interactive opportunities for students to get this hands on experience. Visit the ARDUSAT table by the Rocket sometime between 10:00 and 2:00 to put numbers to those feelings in the pit of your stomach!

For your chance to wear their gear, answer the following questions!

1. What is the size and weight of a cubesat satellite?

2. What is the acceleration of gravity?

Now that you have the answers to these questions, step up and strap in! Answer the question below when you get back from space for a chance to enter the ARDUSAT drawing!

3. What is maximum G force on the ride The Rocket? How does compare to the force astronauts experience in a launch to the International Space Station?

4. What is the minimum G force on The Rocket? How does this compare to the force USU Get Away Special students experienced during their experiments on the NASA Vomit Comet? (Talk to the GAS Team members in Davis Pavilion for more information!)

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.

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

POWER: Rate of work done per unit time.

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	Common Densities (g/cm3)	
1 m = 3.28 ft	air	0.001
1 hr = 3600 sec	water	1
1 m/s = 3.6 km/hr = 2.24 mi/hr	aluminum	2.7
1 g = 9.8 m/s2 = 32 ft/s2	iron	7.9
1 fortnight = 1.728 x 10^6 sec	lead	11
1 league = 3.45 miles	plastic	0.9
1 fathom = 6 feet	wood	0.9

DISTANCE WITH TRIANGLES

The height of the first hill of a roller coaster is very important. Roller coasters use the acceleration due to gravity to complete its course. Thus, the height of the beginning of the coaster determines the _____ energy and therefore the kinetic energy and _____ of the roller coaster. Thus, the height of the Cannibal tower is critical to rest of the ride!

Useful Information

Height of Cannibal track as it exits the tower (h): 63 m

Questions

1. Fill in the blanks of the above statement.
   a. _____ b. _____

2. A right isosceles triangle has a right angle and two 45° angles (see the picture below). This means that leg h (the height of the Cannibal track as it exits the tower) is _____ to the leg d (your distance from the base of the tower).
   a. greater than
   b. equal to
   c. less than

3. Using your answer to Question 2, find a location at which you are at a 45° angle to where the track exits the top of the Cannibal tower. Where is this location?

4. With your knowledge of right isosceles triangles, how far are you from the base of the Cannibal tower?

   d = _____ m

Hint: You can use the iPhone or iPod "Multi Protractor" or Android "Advanced Protractor app (see p 13) to measure angle. Alternately, you could use this workbook itself as a low-tech tool to measure a 45° angle. Open the workbbook with the back pages flat and the front page vertical at right angles; then sight along the edges of the pages to view a 45° angle.
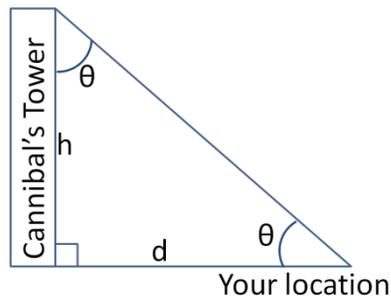
PHYSICS DAY CROSSWORD
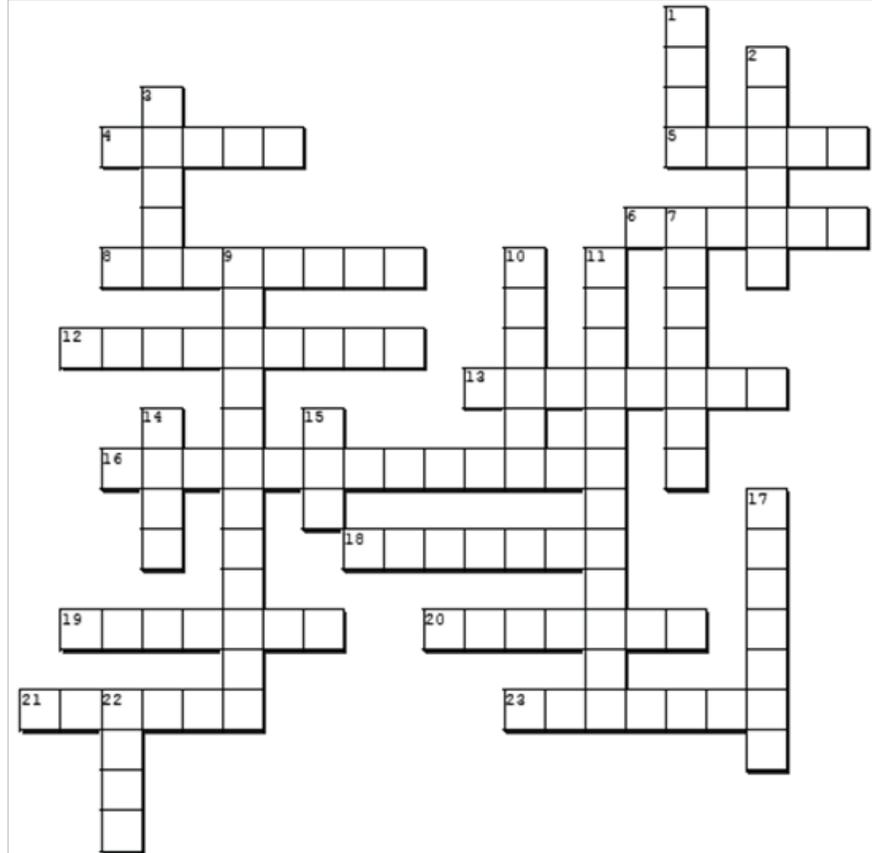
Created on TheTeachersCorner.net Crossword Maker

Across
4. The push or pull felt when riding a roller coaster.
5. The magnitude of the velocity of a Cannibal car.
6. Measurement of the gravitational pull on a Cannibal rider.
8. A force that resists the motion of the Cannibal cars.
12. The energy at the top of the Cannibal tower.
13. Mass times velocity.
16. The frictional force that a Cannibal car and rider experience due to air.
18. The tedency of a body to continue in the direction of motion it's currently in.
19. The science behind the Cannibal coaster.
20. The force that makes the Cannibal work!
21. The unit used to measure the force on a Cannibal rider.
23. The energy a rider has at the bottom of the Cannibal tower.

Down
1. A measurement of the amount of material a body contains.
2. Kinetic and Potential are a type of this.
3. Rate of work done per unit time.
7. A collision in which the kinetic energy is the same before and after.
9. This says that energy is neither created nor destroyed.
10. Amusement park where physics is learned!
11. Time rate of change of velocity.
14. Each of these uses physics concepts to work. They are the reason we go to amusement parks!
15. The university behind Physics Day!
17. An acceleration ratio to the acceleration of gravity.
22. The force on a body times the distance the force is acting.

GOING TO NEW HEIGHTS

There are many more things we can measure and calculate with respect to this new ride, Cannibal. Using the things you learned and calculated on the previous pages, complete this worksheet to learn more about Cannibal.

Questions
1. Fill out the table using the same technique from page 6. This time, estimate d in order to find h. Then calculate the PE for each position as you did on page 7.

Location on Cannibal	d (m)	h (m)	PE (J)
A			
B			
C			
D			
E			
F			
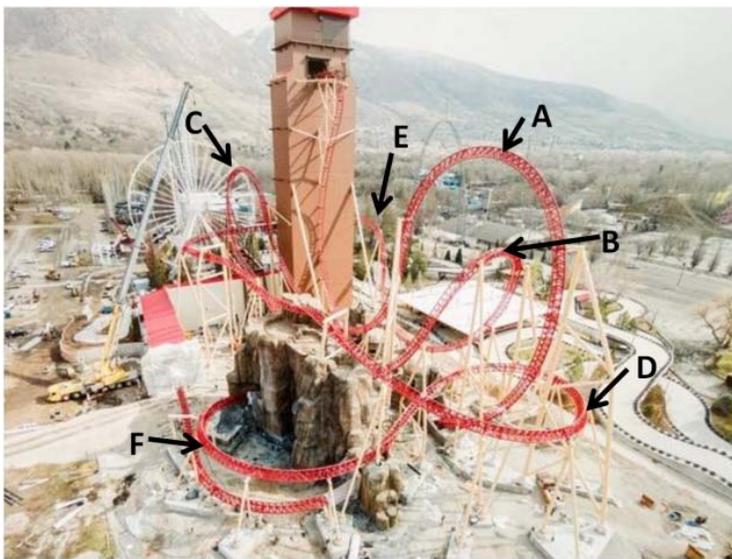
GRAVITY'S NUDGE

When you get in the Cannibal roller coaster car, an elevator lifts the car to the top of the tower . From here, the car exits the tower and begins the thrilling ride.

Useful Equations

'h' is the height of the track, found on page 6
'm' is the mass (assume 1000 kg for the mass of the car)
'g' is the acceleration due to gravity
'PE' is the potential energy

$$PE = m * g * h$$

Questions
1. What provides the potential energy for Cannibal?

2. What is the potential energy of a Cannibal car where track actually exits the tower?

3. What is the potential energy at the bottom of the tower?

You survived the first drop of Cannibal and are well on your way to the end of the ride. This ride is a great example of kinetic energy, which you will be calculating below. Here, we assume that the initial velocity is zero and it's a frictionless coaster.

Useful Equations

'v_{final}' is the velocity at the bottom of the tower
'g' is the acceleration due to gravity
't_{avg}' is time in seconds to reach bottom of tower
'KE' is the kinetic energy
'm' is the mass (assume 1000 kg for the mass of the car)

$$v_{final} = g * t_{avg} \qquad KE = \frac{1}{2}m * v^2$$

Questions

1. Watch Cannibal run 3 times. Using the iPhone or iPod "Stopwatch Analog+Digital" or the Android "StopWatch and Timer" application, measure the time it takes for the car to travel from the top of the tower to the bottom for each of those runs. Determine the average time.

   $t_1=$_____s $t_2=$_____s $t_3=$_____s $t_{avg}=$_____s

2. Now that 't_{avg}' is known, calculate the velocity of the car at the bottom of the tower?

   $v_{final} =$ _____m/s

3. Use the velocity found in Question 2 to calculate the kinetic energy of the car at the base of the tower.

It is very useful to know how to convert from one unit to another. That's why, in this exercise, you're going to practice this. Have fun as you convert these useful units into some not-so-useful ones (except perhaps for Captain Nemo from Jules Verne's *20,000 Leagues Under the Sea.*!
Hint: A simple way to do unit conversions has the form
$$Value\ in\ A\ units = Value\ in\ B\ units * (A\ units/B\ units)$$
The term in parentheses comes from simple unit conversions like those listed on page 5.

Questions

1. From page 6, how many leagues from the Cannibal tower are you standing?

2. On page 7, you used 9.8 m/s^2 for the acceleration of gravity. What is the acceleration of gravity in fathoms/hr^2?

3. You know how fast the Cannibal car is traveling in m/s from page 8. Now, find the final velocity in feet/fortnight.