May 19, 2000
Schedule Of Events

Time	Event	Location
9:30	Lagoon Park opens	
9:30 - 11:00	School & teacher registration	Main Gate
9:30 - 11:00	Contest registration & safety approval inspections	Davis Pavilion
11:00 - 1:30	**Colossus' Colossal G-Forces Contest**	
2:00	Entry forms due	Davis Pavilion
10:00 - 4:00	**Physics Bowl Competition**	
10:15 - 10:45	Preliminary Qualification Round	Davis Pavilion
11:00 - 12:30	Round of thirty-two	Davis Pavilion
1:00 - 2:00	Round of sixteen	Davis Pavilion
2:00 - 2:30	Quarter-final round	Davis Pavilion
2:30 - 3:00	Semi-final round	Davis Pavilion
3:00 - 3:30	Consolation round	Davis Pavilion
3:30 - 4:00	Championship round	Davis Pavilion
11:00 - 3:00	**Physics Demonstration** **Lagoon: 2001 Ride Design and Physics Day Logo Design Contests**	Davis Pavilion
10:00 - 3:00	**Student Workbook**	
3:30	Entry forms due	Davis Pavilion
12:00 - 1:00	Faculty and staff complimentary lunch	Canyon Terrace
3:30	All contest entry forms due at registration desk	Davis Pavilion
4:30	All rides close	
4:15 - 4:45	Awards and closing ceremony	Davis Pavilion
4:45	Park closes	

WIN FREE DAY PASSES AND SEASON PASSES TO LAGOON OR SPACE POSTERS!!!

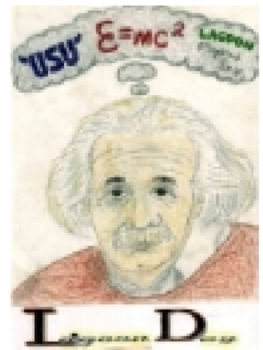
All students who turn in their workbook to the table at Davis Pavilion by 3:30 have a chance to win fabulous prizes by random drawing.

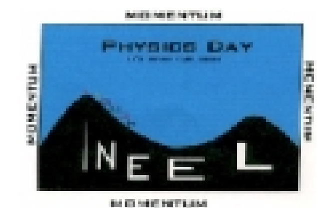
Workbooks must be turned in by 3:30!!

Utah State University

Middle/Junior High School Student Workbook

PHYSICS DAY AT LAGOON
May 19, 2000





ARTIST: Matt Ingles (Kaysville Jr. High School)
ADVISOR: Mark Tolman

ARTIST: Jordan Walker (Box Elder High School)
ADVISOR: Ron Cefalo

STUDENT ______________________

TEACHER ______________________

MIDDLE OR JR. HIGH SCHOOL ______________________

Lagoon

INEEL INSTITUTE

NASA IDAHO SPACE GRANT CONSORTIUM

ROCKY MOUNTAIN NASA SPACE GRANT CONSORTIUM

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 4000 physics students from more than 100 schools here to enjoy a fun day experiencing Amusement Park Physics first hand.

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

Student Workbook
Physics Bowl Contest
Colossus' Colossal G-Forces Contest
Physics Demonstration Design Contest
Lagoon: 2001 - A Ride Design Contest
Physics Day Logo Design Contest

The Physics Department at Utah State University, the NASA Rocky Mountain Space Grant Consortium, and the Idaho National Engineering and Environmental Laboratory are running today's activities. The contests are sponsored by Hansen Planetarium; Idaho National Engineering and Environmental Laboratory; Lagoon; Thiokol Corporation; NASA Rocky Mountain Space Grant Consortium; US Holographics, Logan; E-Systems, West Valley; Montgomery Watson Engineering, Salt Lake City; the USU College of Science, and the USU Office of School Relations.

If you have questions or would like to find out more about physics at Utah State University, stop by the Davis Pavilion.
We will be glad to see you!

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

Table of Contents

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

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.

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.

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} kw hr = 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 Calorie = 1 kcal = 1000 cl = 4186J	1 kg/liter H_2O = 8.35 lb/gal H_2O

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.

The Fermi Questions given below require information gathered for this workbook, estimation and some clever thinking. The additional questions provide hints for *one possible* way to figure out the answer.

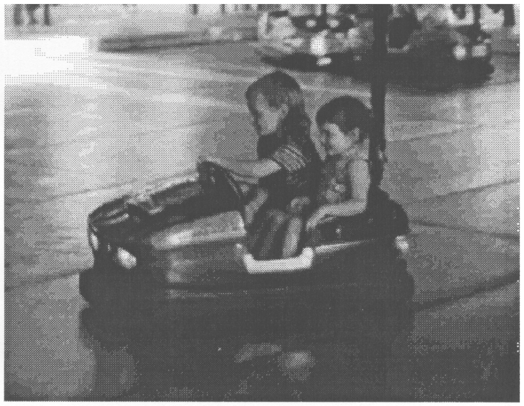
1. Lun-A-Beach
   In the year 2001, imagine an amusement park built on the Moon. On the Moon there are two important differences: (1) the acceleration due to gravity is only 15 % as that on Earth; and (2) there is no air resistance (or air!). Would you expect to be moving slower, faster, or the same speed at the bottom of the first hill on Colossus? Why? Does the lack of air cause you to move faster or slower? What about the change in gravity?

2. How many gallons of soft drinks will be drunk during Physics Day today at Lagoon?
   a. How much does the "average" person at Lagoon drink during the day? Estimate the number of soft drinks an average person drinks and their average size?

   b. Here is the tough part: How many people are here today? There are many ways to do this. For instance, you could check out the parking lot. Or you could estimate the number of rides, games, drink stands, and the number waiting at each of these. (Can you come up with a better way?)

   c. Does it take more power to turn the Ferris wheel or light it?

BUMPER CARS



1. What happens in a collision to each car when:

   a. one bumper car is not moving?

   b. a rear-end collision takes place?

   c. a head-on collision takes place?

   d. bumper car hits a stationary object, i.e. the wall?

   e. cars sideswipe each other?

2. What is the difference between two pieces of clay that collide and two marbles that collide? Do bumper cars behave more like clay or marbles?

3. When will a driver:

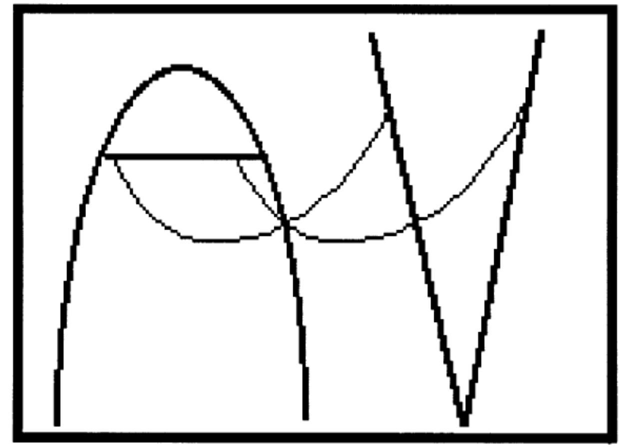
   a. feel the strongest jolt?

   b. be thrown forward?

   c. be thrown backward?

   d. be accelerated?

SKY COASTER



1. Measure the total time that the ride takes from the beginning, when the riders begin to be hoisted upwards, until the end when it comes to a stop.

2. Determine the number of swings for each ride.

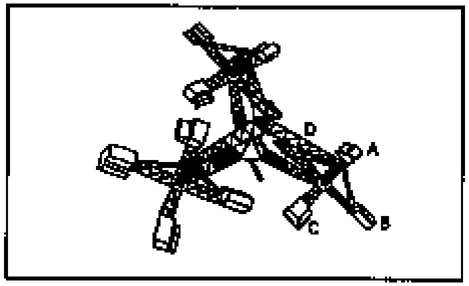
3. Determine the cost per swing for the ride for each person on the ride if there are four people riding.

4. Determine the expense of the ride in dollars per hour for each rider if there are four riders on board. How does this compare, in dollars per hour, with seeing a movie on Friday night?

   How does this compare with the expense of your trip to Lagoon in dollars per hour?

SCRAMBLER

Indicate the direction of rotation of the ride cars about the main and secondary axes on the adjacent figure.



Sketch the path of the ride car.

How many rotations does the rider make about each axis?

Main ___________

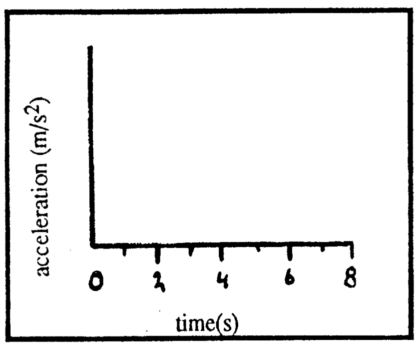
Secondary ___________

Ride Car Path

At which position (A, B, C, or D) was the speed (and force) of the ride car a maximum?

At which position (A, B, C, or D) was the speed (and force) of the ride car a minimum?

Calculate the total distance traveled by riding the Scrambler.



Graph the acceleration versus time for one main revolution of the Scrambler.

TURN OF THE CENTURY

Data Collection

(while on the ride)

1. How long did the ride last? ________s
2. How many times did you go around? ________s
3. When stationary, how far were you from the axis of the rotation? ________m
4. When moving, how far from the axis of rotation were you now? ________m
5. Does the distance from you to the chair in front increase or decrease as the ride speeds up? At maximum speed, what is that distance? ________, ________m

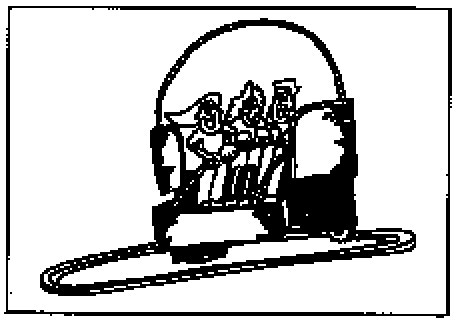
(while off the ride)

6. How many chairs are on the ride? ________
7. When stationary, how far apart are they? ________m

Questions

8. What is the circumference at the radius from which the chairs are hanging? ________m
9. Hence, what is the radius $C = 2\pi R$? R = ________m
10. Is this radius the same as you estimated in Q3?
11. Using information in Q1 and Q2 to get the time for a single turn and Q4, calculate the maximum speed you move.
    speed = $\frac{\text{circumference}}{\text{period of rotation}} = \frac{2\pi \text{Radius}}{\text{period}}$ = speed ________m/s
12. How many miles/hour does this speed correspond to? _______mph
    (1 mile = m and 1 hour = 3600 seconds)
13. Is this faster than your school bus coming to Lagoon?
14. As the ride speeds up, what happens to the passenger, her chair, and the chain supporting both?
15. What is the physics that leads to this effect called? Or how do you explain what you observe?

TILT-A-WHIRL -- CHAOS IN ACTION!!



When you hang a stone from a string, pull it aside, let go, and the stone swings back and forth in an almost exactly repeating way. These repetitions are so regular that you can keep pretty good time with such a simple toy. In fact, if you look inside a grandfather's clock, you'll see that the thing that "ticks" is a lot like a stone hanging from a string.

The repetitive swinging of a stone hanging from a string is very predictable. After you watch it for awhile, it gets kind of boring. There are many things in nature that repeat like a swinging stone. For example, the sun comes up every day, the moon is full every month, the temperature gets hot every summer, your heart beats about once every second (at least, if you are sitting still and not watching a horror movie). Those things, just like the swinging stone, are predictable.

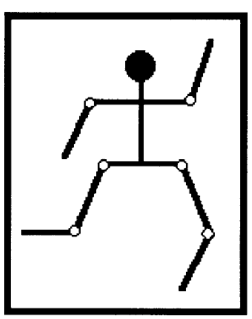
On the other hand, there are lots of other things that don't repeat in such a nice fashion and are very unpredictable. Some examples are the gurgling ripples in a rushing stream, the stretching and puffing of clouds blown by the wind, the flickering of a candle's flame, and the faces of a pair of dice that come up when you roll them.

Why do you suppose that some things are so regular and others so unruly? Maybe some parts of nature are governed by rules and are tame while other parts are run by luck and chance and are wild. Maybe.

But, hold on a second. If you make a gurgling stream slow down enough, the gurgles go away. And if you make the flame burn in just the right way, it becomes as smooth and regular as can be. Hmm.

But, the situation's more complicated still. The summer is hot every year, all right, but never quite the same — sometimes boiling, sometimes okay. And if you time your heartbeat very carefully you'll find it isn't regular either — sometimes it's a little fast, sometimes a little slow.

There are good reasons to believe that tame and wild behaviors are both governed by rules — they are opposite sides of the same coin. People are beginning to realize that some things that appear to be run by chance and to be unpredictable (streams and flames and hearts are all examples) actually march to the same kind of rules as the swinging stone. We call such unruliness "chaos."



You may have seen a toy like the one pictured in the box. Its arms are free to flail about, as are its legs. The whole body rotates around a pivot in its chest. When you give the toy a good spin around its pivot, the arms and legs go every which way without any seeming rhyme or reason. If you give it a gentle spin, the arms and legs swing back and forth in a regular, repetitive manner. In both cases, the arms and legs go where rigid rules tell them to go. The wild, unpredictable behavior in this toy isn't due to chance. It's chaos.

The Tilt-a-Whirl ride at Lagoon is similar to this toy. Notice how unpredictable the ride feels. Pick a spot on the ground. Every time you pass that spot, jot down (if you can) which way you're facing. Later, after you can think straight again, look at your record. Does it seem repetitive or irregular? The irregularity of the Tilt-a-Whirl is not due to some genie playing chance with you. This ride obeys rigid rules. The unexpected whips and turns you just experienced are chaos.

(So here's an interesting question for you to ponder when you have nothing better to do: When you have an accident or you have a little good luck or it rains when it isn't supposed to or you decide to eat a hot dog instead of a piece of pizza, is that because of chance, or are you doing a chaotic dance just like the toy?)

FLYING ACES

MEASUREMENTS:

1. What is the time for a single revolution at top speed? _________ s/rev

2. What are the maximum and minimum radii of the planes and their angles with respect to vertical?

   Maximum: ________ m________ °   Minimum:________ m________ °

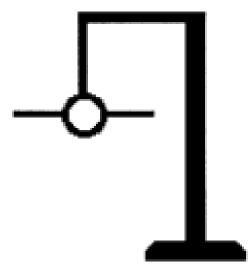
QUESTIONS

1. Planes move (toward, away from) the middle as they turn faster.

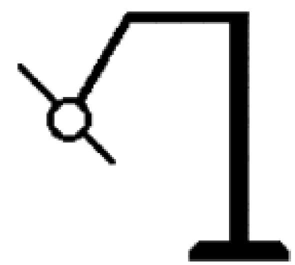
2. What causes this to happen?

3. Although the center hub rotates at a constant rate, it does not feel that way. Why?

4. Diagram vector forces acting on the planes shown below.



Plane at Rest



Plane in motion at maximum angle from vertical

5. Calculate the speed of the planes in the two figures above.

   _________m/s   _________m/s

SIMPLE MACHINES

The following is a list of simple machines:

(1) Lever

(2) Inclined plane

(3) Screw (includes propeller)

(4) Wedge

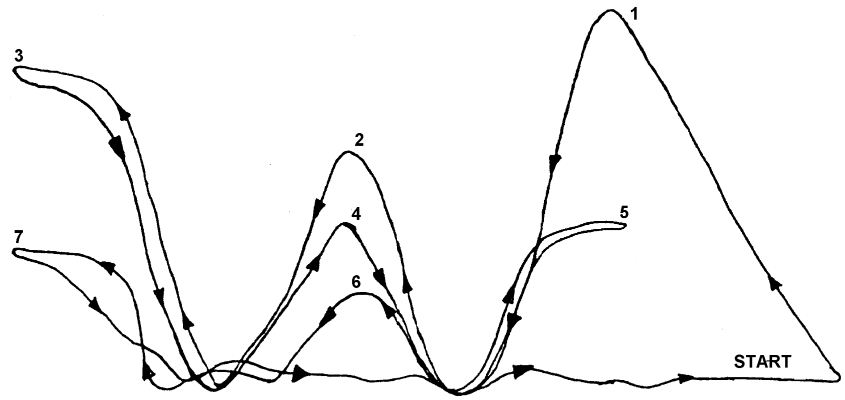
(5) Pulley

(6) Rollers

(7) Wheel and Axle

FOR EACH SIMPLE MACHINE LISTED ABOVE, FIND AT LEAST 4 EXAMPLES SOMEWHERE AT LAGOON.

WOODEN ROLLER COASTER



Numbers identify peaks in order
Length of Track 805 m

Arrows show direction
Maximum Height 18.5 m

1. Determine the angles of ascent and descent of the first hill.

2. Identify at least 3 sources of friction in this ride.

3. Complete the diagram by putting in the proper labels. Label the following, minimum potential energy, G; maximum potential energy, X; maximum kinetic energy, K; minimum kinetic energy, M; weightless sensation, W; heavy sensation, H.

4. What is the average speed from the beginning to the end of the ride?

GENERAL QUESTIONS

FILL IN THE BLANKS WITH THE WORDS IN THE GLOSSARY ON PAGE 3

1. As a roller coaster drops, it ______________________________.
2. At the top of a roller coaster hill, you have the most _________ energy.
3. The ______________ of a car from Flying Aces is the same on Earth and the Moon; the ___________________ is much less on the Moon.
4. The force that slows down all rides is__________________________.
5. The force that makes a roller coaster roll is______________________.
6. A miniature golf ball hitting a hard wooden rail is an example of an________________________ collision.
7. At the top of the Colossus loop, you experience negative ___________ is a friction force experienced to some degree on all rides, especially the fast ones.

11. Spinning riders feel a _______________________ force.
12. As you go through the Colossus loop, you experience _____________.
13. Because of your speed at the bottom of a roller coaster hill, you have enough ____________________ to climb to the top of the next hill.
14. As you revolve, your _______________ is the same at the top and bottom of the Skyscraper Ferris Wheel; your ____________________ is in opposite directions at the top and bottom.
15. As the roller coaster is pulled up the first hill, the motors do________.
16. If 3 crests of a wave pass by in one second, that wave has a _____________ of 3/sec and a _________________ of 1/3 second.
17. A water wave, in which water moves up and down vertically and the crests move horizontally, is a ___________________ wave.
18. The _________SP____________ of a wave is its highest point above or below zero, and the _________________ of a wave is the distance from one crest to the next.

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.