## Schedule of Events

<table>
<thead>
<tr>
<th>TIME</th>
<th>EVENT</th>
<th>LOCATION</th>
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<tr>
<td>8:45</td>
<td>Lagoon Autopark (parking lot) opens</td>
<td></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 Main Gate</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—Semifinals</td>
<td>Davis Pavilion</td>
</tr>
<tr>
<td>10:00 - 2:00</td>
<td>Mindstorm Activities</td>
<td>Maple Terrace</td>
</tr>
<tr>
<td>10:00 - 2:00</td>
<td>Wind Energy Challenge MESA Contest Activities</td>
<td>Oak Terrace</td>
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<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 as judging is completed</td>
<td>Davis Pavilion</td>
</tr>
<tr>
<td></td>
<td>Prizes may be picked up then.</td>
<td></td>
</tr>
<tr>
<td>2:00-2:45</td>
<td>Utah/Idaho FIRST Robotics Grudge Match—Finals</td>
<td>Davis Pavilion</td>
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<tr>
<td>2:30-3:45</td>
<td>Mindstorm Competitions</td>
<td>Maple Terrace</td>
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<tr>
<td>3:30</td>
<td>Awards Ceremony in Davis Pavilion</td>
<td>Davis Pavilion</td>
</tr>
<tr>
<td>4:30</td>
<td>All rides close</td>
<td></td>
</tr>
<tr>
<td>4:45</td>
<td>Park closes</td>
<td></td>
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**Sky Drop Contest**

10:00 - 11:30 Registration for the Sky Drop is open
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.
2:30 Winners will be announced as soon as the contest is judged.

**Colossus’ Colossal G-Forces Contest**

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

**Physics Bowl Competition (Bighorn Pavilion)**

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

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

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

**USU Physics Day Photo Contest**

2:00 All photo entries due with #USUPhysicsDay
3:00 Contest winners posted @USUAggies

**Student Workbook**

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

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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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STUDENT

TEACHER

SCHOOL

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

You are one of more than 8000 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:

Twitter/Instagram Photo Contest
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 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!

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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 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.
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. 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.
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 ($g = 9.8 \text{ m/s}^2$).

**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.
USU PHYSICS DAY PHOTO CONTEST

START THOSE SELFIES!

This year, we are starting a new contest…a Physics Day Photo Contest! Students are asked to submit original photographs of physics activities during USU Physics Day at Lagoon using Twitter, Instagram or Facebook. Be sure to use both the #USUPhysicsDay and one of the four categories below when posting your picture!

Entries can be viewed www.USU.edu/PhysicsDay.

CATEGORIES
DefyGravity
ColossalKinetics
ItIsRocketScience
WickedWork

All photos must be posted by 2:00 pm to win. Winners in each category will be posted @USUAggies by 3:00 pm.

Be creative. The more unique and “physics-y” your picture, the better your chances of winning!
So, keep it clean! Keep it fun! And keep it PHYSICS!!!!

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

<table>
<thead>
<tr>
<th>Conversion</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 m = 3.28 ft</td>
<td></td>
</tr>
<tr>
<td>1 hr = 3600 sec</td>
<td></td>
</tr>
<tr>
<td>1 m/s = 3.6 km/hr = 2.24 mi/hr</td>
<td></td>
</tr>
<tr>
<td>1 g = 9.8 m/s² = 32 ft/s²</td>
<td></td>
</tr>
<tr>
<td>1 fortnight = 1.728 x 10⁶ sec</td>
<td></td>
</tr>
<tr>
<td>1 league = 3.45 miles</td>
<td></td>
</tr>
<tr>
<td>1 fathom = 6 feet</td>
<td></td>
</tr>
</tbody>
</table>

Common Densities (g/cm³)

<table>
<thead>
<tr>
<th>Substance</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>air</td>
<td>0.001</td>
</tr>
<tr>
<td>water</td>
<td>1</td>
</tr>
<tr>
<td>aluminum</td>
<td>2.7</td>
</tr>
<tr>
<td>iron</td>
<td>7.9</td>
</tr>
<tr>
<td>lead</td>
<td>11</td>
</tr>
<tr>
<td>plastic</td>
<td>0.9</td>
</tr>
<tr>
<td>wood</td>
<td>0.9</td>
</tr>
</tbody>
</table>
The height of the first hill of a roller coaster is very important. Roller
costers 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.
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.

<table>
<thead>
<tr>
<th>Location on Cannibal</th>
<th>d (m)</th>
<th>h (m)</th>
<th>PE (J)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

\[ PE = m \times g \times h \]

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?
SPEED IS KEY

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

‘\(v_{\text{final}}\)’ is the velocity at the bottom of the tower  
‘\(g\)’ is the acceleration due to gravity  
‘\(t_{\text{avg}}\)’ 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)

\[
v_{\text{final}} = g \times t_{\text{avg}} \quad KE = \frac{1}{2} m \times v^2
\]

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 \hspace{1cm} \(t_2=\)_______s \hspace{1cm} \(t_3=\)_______s \hspace{1cm} \(t_{\text{avg}}=\)_______s

2. Now that ‘\(t_{\text{avg}}\)’ is known, calculate the velocity of the car at the bottom of the tower?

\(v_{\text{final}} = \)_______m/s

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

USEFUL UNITS

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

\[\text{Value in } A \text{ units} = \text{Value in } B \text{ units} \times (A \text{ units}/B \text{ units})\]

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.