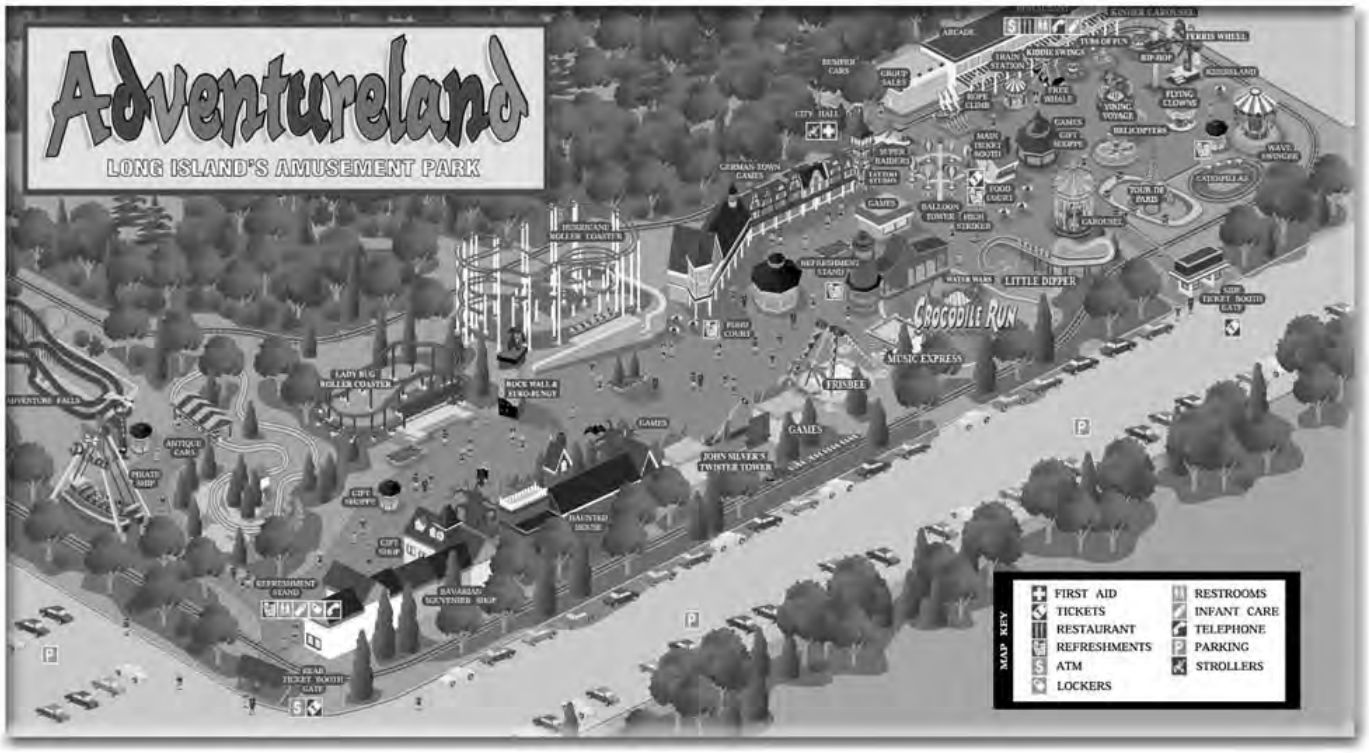
Amusement Park Physics at Adventureland



Your Name: _____

Partners' Names: _____

_____

_____

_____

Useful Information

Determining the period

The period is the time for a ride to return to its starting position. For a circular ride, it is the time to complete one revolution and for a swinging ride it's the time to complete one cycle (a full back and forth motion).

You should measure the total time of several cycles or revolutions and then divide by the number of revolutions to get an average period for the ride.

Determining lengths

To determine lengths from paces, determine the distance you move in 10 paces and divide by 10 to find the average length per pace.

Suggested equipment: Stopwatch, accelerometer, sighting protractor, target, bean bag, tethered tennis ball

Freebody diagrams

Label each force vector with an appropriate symbol or name.

For any information that you calculate, be sure to include the formula, substitution into equations and answer with the appropriate unit.

Conceptual questions must be answered in complete and coherent sentences.

If a ride is not in operation, you are to omit that section of the lab.

USEFUL PHYSICS FORMULAS

Kinematic Equations

$$\Delta d = d_f - d_i \qquad v = \frac{d_f - d_i}{t} \qquad a = \frac{v_f - v_i}{t} \qquad v = v_i + at$$

$$d = v_i t + \frac{1}{2}at^2 \qquad d = \frac{1}{2}t(v_f + v_i) \qquad v_f^2 = v_i^2 + 2ad$$

Translational (Straight Line) Motion

Newton's Second Law: $F_{NET} = \Sigma F = ma$ Force of Friction: $F_f = \mu F_N$

Work = Fd = ΔKE Kinetic Energy = KE = ½ mv^2 Power = P = E / Δt

Gravitational Potential Energy = PE = mgh

Total Energy of a System = PE + KE = ½ mv^2 + mgh

Linear Momentum of an object = p = mv Impulse = I = FΔt = Δp = mΔv

Rotational (Circular) Motion

Circumference = C = 2πr Diameter = D = 2r

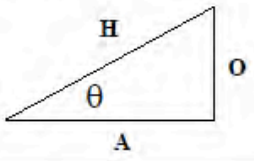
Period = T Frequency = f $T = \frac{1}{f}$

Velocity = $v = \frac{2\pi r}{T}$ Centripetal Acceleration = $a_C = \frac{v^2}{r}$ Centripetal Force = $F_C = ma_C = m\frac{v^2}{r}$

Newton's 2nd Law for Rotational Motion: $F_{NET} = \Sigma F_R = \frac{mv^2}{r}$

Right Angle Trigonometry

$$\sin\theta = \frac{O}{H} \qquad \cos\theta = \frac{A}{H} \qquad \tan\theta = \frac{O}{A} \qquad a^2 + b^2 = c^2$$



The Bus Ride

Data

Record the following data for the bus ride to the park. A helium balloon will be used for observations

Odometer reading of bus at departure from school	
Time of departure from school	
Time of arrival at Adventureland	
Odometer reading of bus at arrival at Adventureland	

Questions and Calculations

1. Whenever the bus starts from rest and moves forward, which way do you feel your body move?

2. Whenever the bus starts from rest and moves forward, which way do you see the helium balloon move?

3. When the bus slows down, which way do you feel that your body is being moved?

4. Look at the helium balloon when the bus slows down. Which way does the helium balloon move?

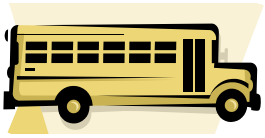
5. When the bus makes a right turn, which way do you feel your body is being moved?

6. Watch the helium balloon when the bus makes a turn. If the bus makes a right turn, which way does the helium balloon move?

7. When the bus is on the highway and moving at *constant velocity*, do you feel any forces pushing or pulling on your body?

8. How does the helium balloon react when the bus is moving at constant velocity?

9. Draw a freebody diagram labeling all the forces acting on the bus when it is moving at constant velocity.



10. When the bus is moving on a straight road at constant speed, **carefully** toss a coin **straight** up into the air. Do this several times. Where does the coin land?

11. Look out the window when the bus is moving fairly fast. In what direction does the scenery "move"? Explain this apparent motion.

12. Draw a freebody diagram of the forces acting on the bus when the bus is slowing down.

Conclusion Questions

13. Based on the data recorded, determine the average speed of the bus. Be sure to show formula, substitution with units, and answer with units in the space below.

14. Explain why your body reacted differently to changes in the bus' motion than the helium balloon.

Bumper Cars

Questions and Observations

Some of these questions can be answered while waiting on line and looking at the field of cars as they move.

1. If a car is hit head on by another car, what happens to its speed? What is the direction of its acceleration?

2. Look around at the field of cars and their drivers. Which cars are able to accelerate more, heavier mass cars or lighter mass cars?

3. If a car is hit head on by another car, what do you think will determine whether that car continues to move forward or goes backward after the collision?

4. If a car hits another car on the side, at right angles to its direction of motion, what immediately happens to the direction of the other car upon impact?

Conclusion Questions

5. Describe a situation in which each of the following conditions would occur
   a. The driver is thrown forward.

   b. The driver is thrown backward.

   c. The car will accelerate (forward) upon impact.

   d. The car will decelerate upon impact.

   e. The car will change direction upon impact.

6. What is the purpose for wearing the seatbelt?

Pirate Ship

Data

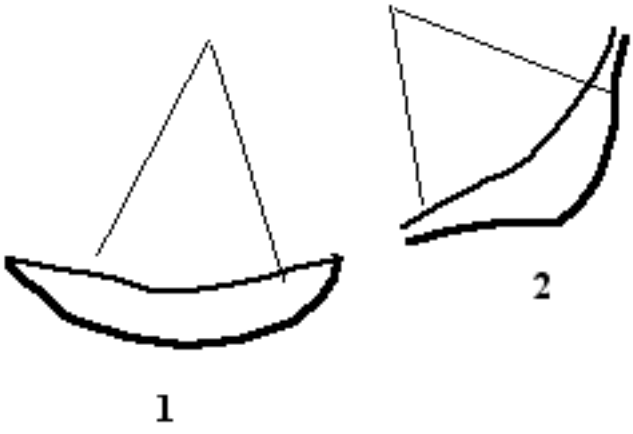
While waiting, calculate the average period of this ride when the ride is first starting up, using five cycles. Repeat when the ride is at maximum amplitude. The period is the time for the ride to swing back and forth once.

Period at beginning (s)	
Period at maximum amplitude (s)	

Using your vertical accelerometer, record its maximum and minimum reading.

	Accelerometer reading (g's)
Maximum Reading	
Minimum Reading	

Indicate on the drawing below where the masimum and minimum readings occurred.



Questions and Observations

1. As you sit on the ride when it is swinging back and forth, where in the cycle do you feel the seat applies the most pressure to you?

2. As you sit on the ride when it is swinging back and forth, where in the cycle do you feel the seat applies the least pressure to you?

3. What is the relationship between your vertical accelerometer reading and the pressure that the seat applies to you.

4. Tires are used to make the Pirate Ship swing back and forth. Look down at them when you are on the top part of the ride. How do the tires apply a force to the Pirate Ship to accelerate it?

5. How are the tires used to slow down the ride at the end?

6. Does the period significantly differ from the beginning of the ride to the maximum amplitude?

7. What factors determine the period of the Pirate Ship ride?

8. Based on your understanding of pendulum motion, does this the Pirate Ship behave like a pendulum?

The Frisbee

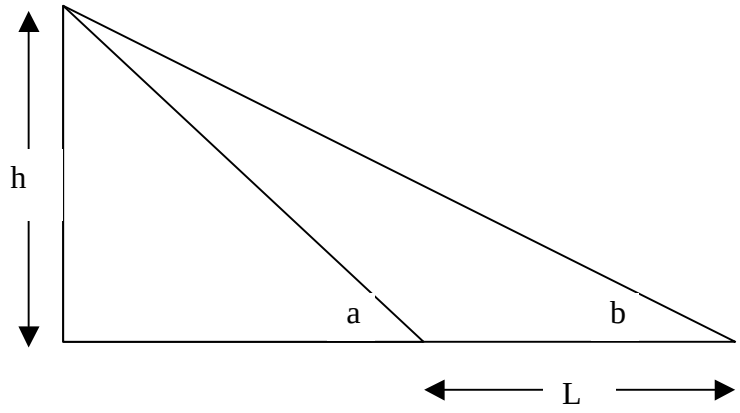
Data and Calculations

While waiting, calculate the average period of this ride when the ride is first starting up, using five cycles. Repeat when the ride is at full speed. The period is the time for the ride to swing back and forth once.

Period at beginning (s)	
Period at full speed (s)	

Calculate the height of the ride using triangulation and the law of sines.
Sight the angle from position *a* then pace backwards (counting your paces) to position *b* and sight this angle, using your sighting protractor. Record the information below.

1 pace = _____ m (to be done in class)



angle a = _____
angle b = _____
length L = _____ paces
length L in meters:

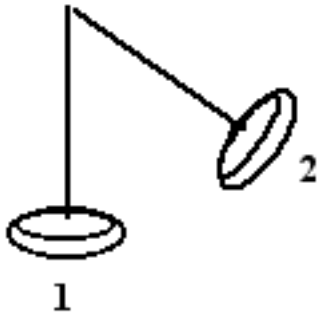
h = (sin a)*(sin b)*L/(sin(a-b))

h = _____m

Using your vertical accelerometer, record its maximum and minumum readings.

	Accelerometer reading (g's)
Maximum Reading	
Minimum Reading	

Indicate on the drawing to the right where the maximum and minimum readings occurred.



Questions and Calculations

1. As you sit on the ride when it is swinging back and forth, where in the cycle do you feel the seat applies the least pressure to you?

2. Use your calculated height to determine the maximum potential energy that you reach.

3. What is the maximum kinetic energy that you reach because of the potential energy?

4. Calculate the maximum speed that is reached.

5. How is this ride similar to the Pirate Ship?

6. Does the period of the Frisbee differ from the period of the Pirate Ship? Why are they different/the same?

7. Now consider the spinning motion of this ride. In what direction does your body feel a force as a result of the spinning?

8. As the ride spins faster, how does this affect the force that you experience?

Hurricane Roller Coaster

Data

Time for one complete ride (s)	
Time for train to ascend the incline (s)	
Approximate length of one car (m)	
Approximate length of 3 cars (m)	

Time for 3 cars to pass a fixed point going up a the first hill (s)	

Record the vertical accelerometer readings at the following locations:

	Accelerometer reading (g's)
Descending the first hill	
Ascending the second hill	

As you fall down the second hill, turn the accelerometer into a horizontal positon. Observe the maximum acceleration reached as you go around the remaining curves.

maximum horizontal acceleration= _____g's

Questions and Calculations

1. What is the approximate magnitude of your resultant displacement at the end of the trip?

2. Describe the changes in velocity and force on you going down the first hill.

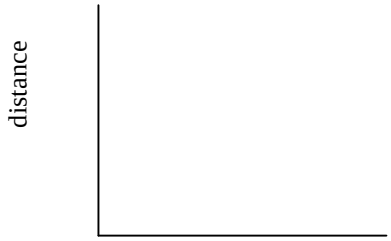
3. Do the same as you go up the second hill.

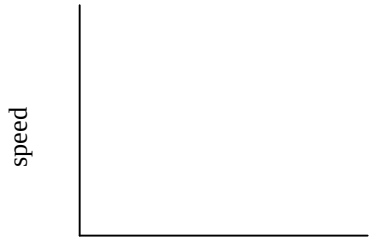
4. As you ride the roller coaster, where along the ride do you feel you were going the fastest?

5. At what point(s) did you feel the greatest force upon you?

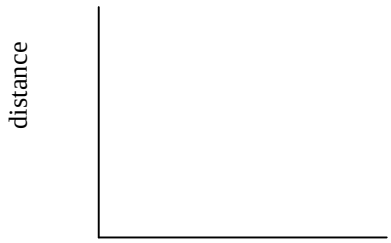
6. Calculate your average speed going up the first hill? Give formula, substitution with units and answer with unit.

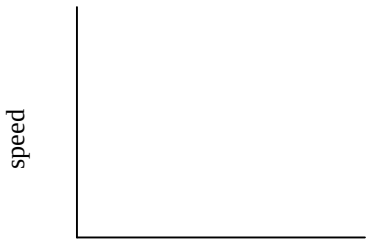
7. Sketch a graph of the distance vs. time and speed vs. time for the train as it goes up the incline.



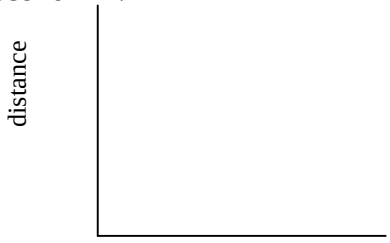


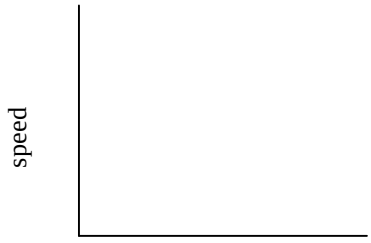
8. Sketch a graph of the distance vs. time and speed vs. time for the train as it goes down the first hill.





9. Sketch a graph of the distance vs. time and speed vs. time for the train as it goes up the second hill.





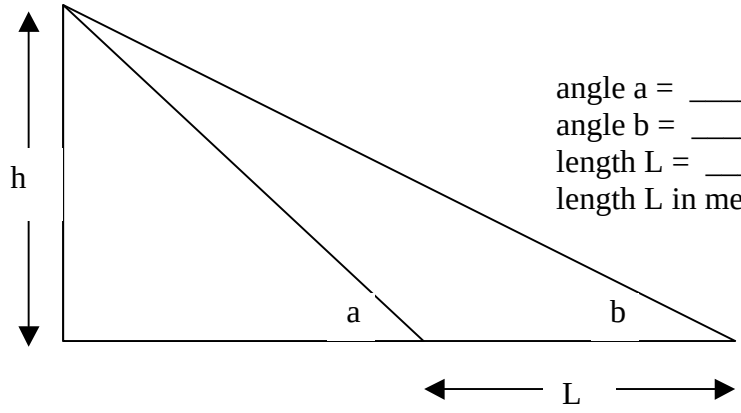
10. Did you feel as if you were lifted off the ride at any point? If so, where along the ride did this happen? What did the vertical accelerometer read during this time?

The Ferris Wheel

Data and Calculations

Measure the height of the ride using triangulation and the law of sines. Sight the angle from position *a* then pace backwards (counting your paces) to position *b* and sight this angle using your sighting protractor. Record the information below.

1 pace = _____ m (to be done in class)



angle a = _____
angle b = _____
length L = _____ paces
length L in meters: _____

h = (sin a)*(sin b)*L/(sin(a-b))

h = _____m

Measure the period of the ride.

Period = _____ s

Questions and Calculations

1. Did you feel that the speed was constant during the ride? If not, tell where you felt the ride was going fastest and slowest?

2. Calculate the circumference of the ride. {Hint: The height of the ride is the approximate diameter of the ride.} Show work.

4. Calculate the average speed of the Ferris wheel. Show work.

The Carousel

Data

Circumference for inner horses (m)	
Circumference outer horses (m)	
Period (s)	

Questions and Calculations

1. Look at the horses when the ride is in motion. Do the horses on the outer ring appear to be going faster, slower or at the same speed as the horses on the inner ring?

2 Determine the circumference of the outer ring of horses. Describe the method and measurements you used to determine the circumference.

3. Determine the circumference of the inner ring of horses. Describe the method and measurements you used to determine the circumference, if different from #2.

4. Calculate the average speed of the outer ring of horses. Show work.

5. Calculate the average speed of the inner ring of horses. Show work.

6. Which horses have the greater speed, the inner or the outer ring? How does this calculated answer compare to your answer in question #1 ?

7. Calculate the centripetal acceleration of the ride for the ring that you rode in (inner or outer ring) .

8. Using your mass, find the centripetal force acting on you for the ring that you rode in (inner or outer ring).

9. What physical force is responsible for the centripetal force?

10. Determine the minimum coefficient of friction needed to keep you from sliding off the ride if you are standing.

11. Observe the motion of the horses on the ride. Imagine making a mark on a piece of paper while you ride. Notice that the horse's body moves like a wave as you go up, down and around.
    a) Approximately how many degrees does the ride rotate for the horse to complete one cycle.

    b) Determine the wavelength of the path of the horse.

12. Take a tennis ball on a tether.
    a) While you are riding, gently toss the ball to a classmate and observe its path.
    b) Now, leave the ride and watch the ball as two students toss it to each other on the carousel. How does the path of the ball look different? Why?

13. Obtain permission to go to the 2nd story of the carousel. Drop a tennis ball from the 2nd story to the base. Where does the ball land relative to where you dropped it?

14. Suggested Activity: Place a target on the ground beside the carousel. From the carousel try to throw a bean bag at the target. What problems do you encounter?

Music Express

Data

Determine the period of the ride.

Period = _____ s

Using your vertical accelerometer, record its maximum and minimum readings and where these readings occurred.

	Accelerometer reading (g's)
Maximum reading	
Minimum reading	

Hold the accelerometer horizontally when the ride reaches full speed. Record your reading.

Horizontal accelerometer reading = _____ g's

Questions and Calculations

1. Describe the way your body's position changes as it goes around the circle.

2. Did you feel like you were going faster at the higher points (the crests) or the lower points (the troughs) of the ride?

3. Describe the forces that you feel are acting on you when the ride is moving at full speed. How do these forces cause your position to change?

4. As the ride slows down, what would you expect to happen to the reading on the horizontal accelerometer? What about if you were holding it vertically? Why?

Wave Swing

Data

Determine the period of the ride.

Period = _____ seconds

Using your vertical accelerometer, record the maximum and mininum values and where they occurred.

	Accelerometer reading (g's)	Location on ride
Maximum reading		
Minimum reading		

Holding the accelerometer horizontally, record the reading when the ride reaches full speed.

Horizontal accelerometer reading = _____ g's

Questions and Observations

1. As you ride the swings, does the swing move inward or outward?

2. What happens to the position of the swing as it speeds up?

3. Look at empty swings on the ride. Does an empty one swing higher, lower or the same as a swing with a person in it?

4. Draw a freebody diagram showing all the forces acting on a person on the swing when it is in "full swing".

5. As the ride slows down, what happens to the reading on the horizontal accelerometer?