AP Physics
Name: ______________________
Period: ________ Date: ______________

DEVIL PHYSICS
BADDEST CLASS ON CAMPUS

AP Physics
PHYSICS DAY WORKBOOK

General Guidelines:

1. Completion of the lab is an individual effort.
2. Your signature at the end of your report affirms that the work on your report is your own. Any instances of cheating will be referred to the IB administrator for disciplinary action.
3. Referenced graphs are at the end of the workbook.
4. You will be answering the "Basic" questions and working problems for ***only the rides assigned to you, the ones you collected data for***. Remember to also do all the "What To Do Before Coming To The Park" activities.
5. Print and submit only those pages for the rides assigned to you and this cover page.

The answers on this exercise are a product of my own work and effort. Though I may have received some help in understanding the concepts and/or requirements, I did the work myself. ______________________________ **Student Signature**

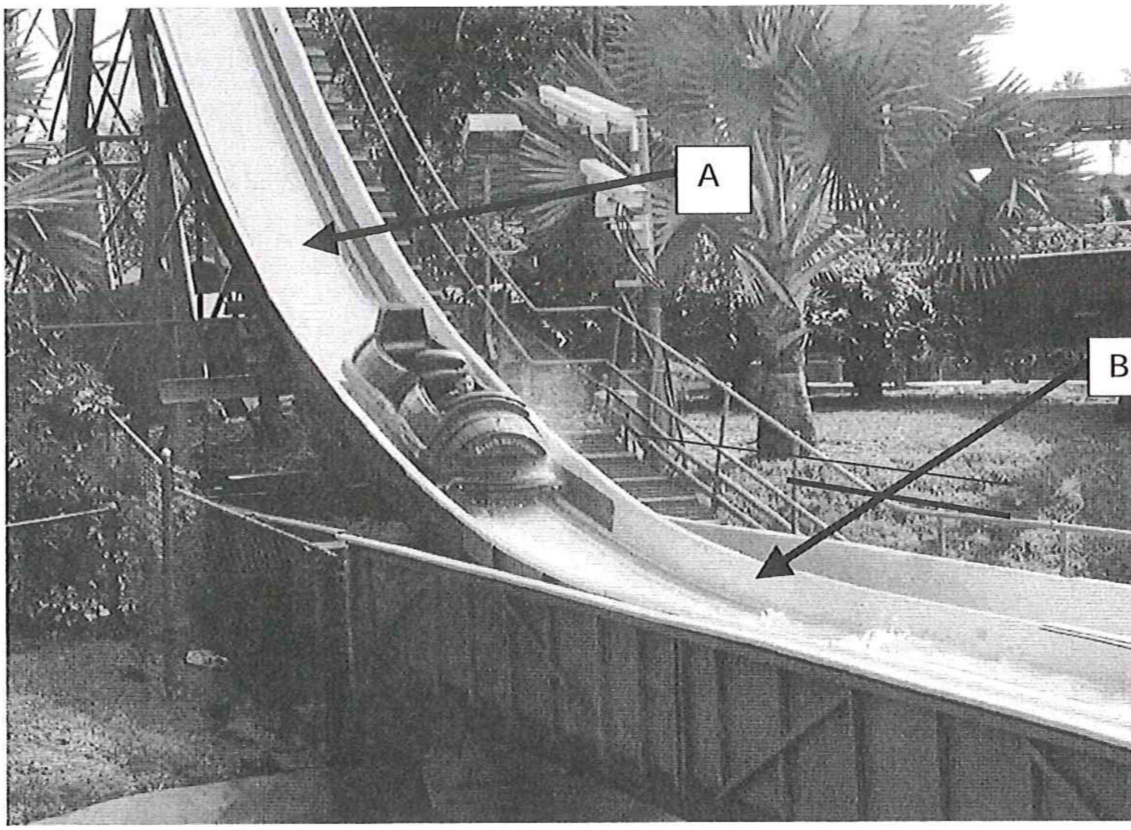
APPLICABILITY:

In terms of the material covered thus far, this lab was given: ☐ too early in the course ☐ at the right time in the course ☐ too late in the course
In terms of degree of difficulty, this lab was: ☐ too easy ☐ just about right ☐ too hard
In terms of helping you understand the material presented in class, this lab was: ☐ not helpful ☐ somewhat helpful ☐ very helpful

IMPROVEMENT: This lab can be improved by:

In Park Activities

LOG FLUME: Basic



INSTRUMENTS REQUIRED
Stopwatch, Horizontal G Force Meter

WHAT TO DO BEFORE COMING TO THE PARK
1. Construct Horizontal G-Force Meter with hand-strap.
2. Predictions
   a. At the bottom of the hill, when the log makes a big splash, will you:
feel pressed back into your seat; slide forward; neither

   b. Which makes a bigger splash:
an empty log; a log with two in the front; a log with two in the back; a log with four; all are the same

   c. Where will you feel close to weightless
coming down the big hill; at the bottom of the hill; nowhere

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WHAT TO MEASURE AND NOTICE ON THE RIDE

1. At the splash at the bottom of the last hill, note whether you feel pressed back into your seat or you slide forward. Pay attention to your feelings on the last drop.
2. With the Horizontal G Force Meter, measure the largest angle to which the BBs in the tube will rise at the splash at the bottom of the last hill. Hold the meter parallel to the log, and brace it against the side.

WHAT TO MEASURE OFF THE RIDE

1. Measure the time for the log to go between point A (the light pole) and point B (the beginning of the splash).
2. Observe the splash of several logs. Do they all make the same splash, or does it depend upon how many people are in the log and where they are seated?

Data Table

	#1	#2	#3	Average
Angle of the BBs In G Force meter				
Time from A to B				

Questions

1. Did you ever feel close to weightless? If so, where?

2. Did you feel thrown forward or backward at the splash at the bottom of the hill?

3. How does this drop compare with the drop on the Scorpion?

4. What loading of the log produces the maximum splash? Why?
   a) Two in front
   b) Two in back
   c) Four in log
   d) Empty log

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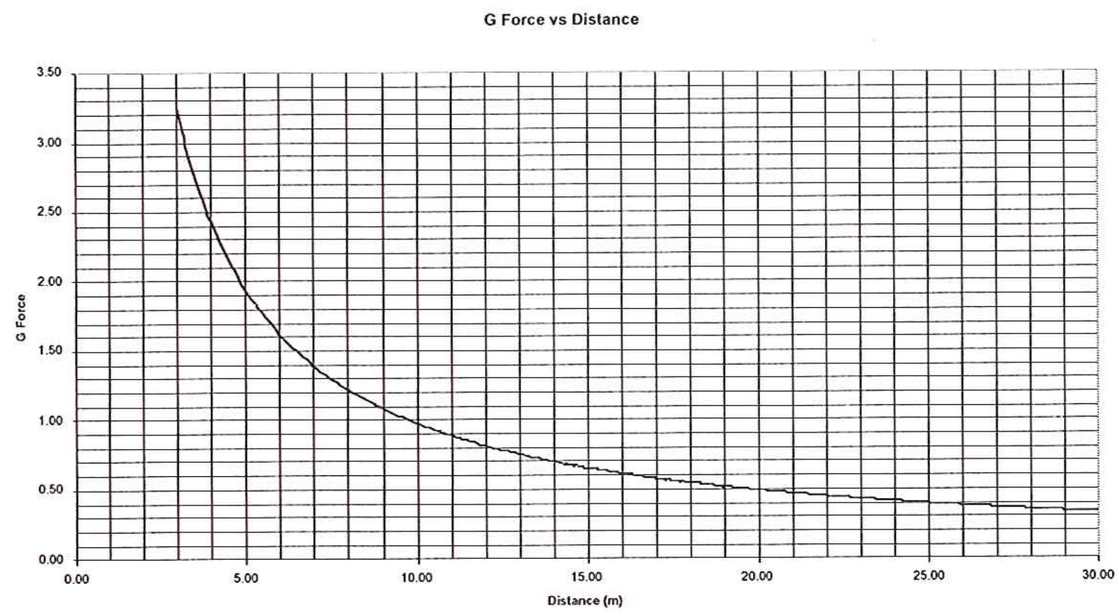
5. What was the horizontal G Force experienced at the splash? Use the chart below to convert from degrees to G Force.

Angle	10	15	20	25	30	35	40	45	50
G Force	0.2	0.3	0.4	0.5	0.6	0.7	0.8	1.0	1.2

Problems

1. Using your measured time from A to B, compute the speed at the bottom of the last hill. The distance from A to B is 11.6 m.

2. The chart below represents the relationship between the horizontal G Force at the splash and the distance of the splash. It assumes that the log has zero speed at the end of the splash.



a. Given that the narrow portion of the trough is 14.5 m, what should the G Force be? Why will this number be different than the actual G Force?

b. What is the minimum stopping distance that would be safe?

c. When the distance is doubled, what happens to the G Force?
Doubled   Stays the same   ½ as much   ⅓ as much
¼ as much   1/5 as much

d. What is the G Force at 60 meters?
e. Is it possible for the G Force to be equal to zero?

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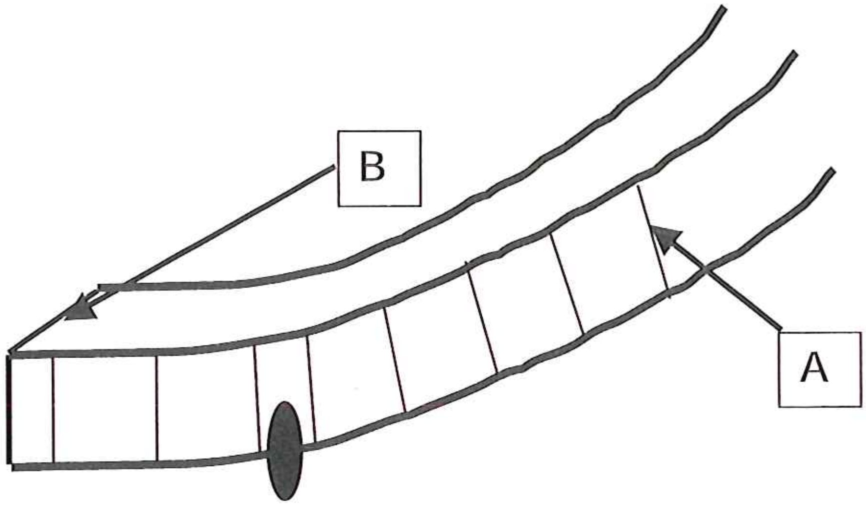
TIDAL WAVE: Basic



INSTRUMENTS NEEDED

Stopwatch; Horizontal G Force Meter

WHAT TO DO BEFORE COMING TO THE PARK

1. Build a Horizontal G Force Meter with hand-strap.
2. Predictions:
   a. What is the Horizontal G Force at the splash at the bottom of the hill:
      0.4g 0.6g 0.8g 1.0g 1.2g 1.4g 1.6 g 1.8 g
   b. Which boat makes the biggest splash?
      Fully loaded Empty Loaded in front only Loaded in back only
3. Problems:
   a. Compute the speed of a boat that goes between two points, 11 meters apart, in a time of 0.75 seconds.

WHAT TO DO ON THE RIDE

1. With the Horizontal G Force Meter, measure the largest angle to which the BBs in the tube will rise at the splash at the bottom. Make sure to aim the horizontal accelerometer parallel to the motion and brace it against the side of the boat.
2. Notice whether you feel thrown forward or pushed backward at the splash.

WHAT TO MEASURE OFF THE RIDE

1. Time the boat from A to B at the bottom of the drop.
2. Time the splash.
3. Observe several boats splash at the bottom, and make a note of what kind of mass distribution of the boat corresponds to what kind of splash.

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DATA TABLE

	#1	#2	#3	Average
Largest Angle of BBs in tube				
Time from A to B				
Time of the splash				

Questions

1. Did you feel thrown forward or pushed backward at the splash? Why?

2. Did all of the boats make the same size splash? If the splashes were different, describe which boat made the biggest splash and why?

Problems

1. Compute the speed at the bottom of the hill by using the time it takes the boat to go between point A and B. The distance from A to B is 10.9 meters.

2. Compute the G Force at the bottom of the hill by using the chart below to convert G Force Meter angular measurement to G Force.

Angle	25	30	35	40	45	50	55	60	65
G Force	0.5	0.6	0.7	0.8	0.1	1.2	1.4	1.7	2.1

How does this compare with the G Force experienced on the Bumper Cars or the Log Flume?

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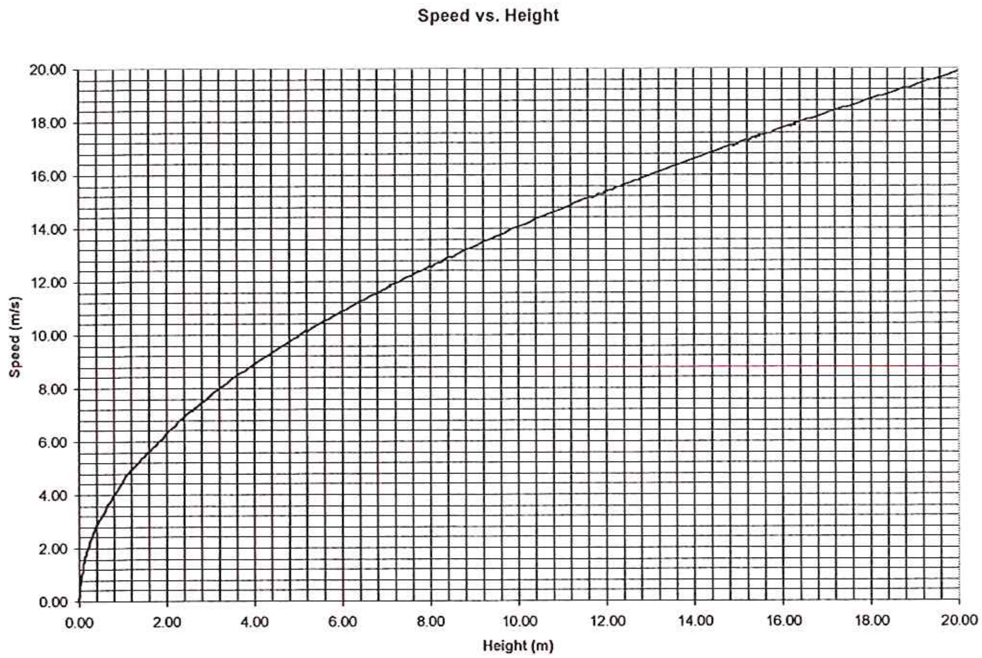
3. The graph below gives the speed at the bottom of a hill if there is no friction coming down the hill and a very small speed at the top.



a. The Tidal Wave hill is 15.2 m tall. What should be the speed at the bottom of the hill? How does this compare with the speed that you measured?

b. What size hill, without friction, would be required to produce a speed equal to the actual speed of the Tidal Wave that you computed in Problem #1?

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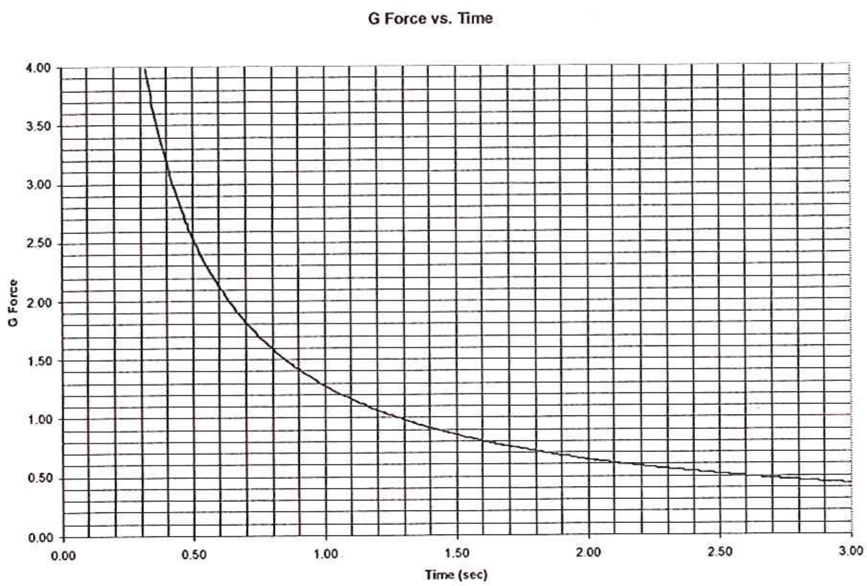
4. The graph below represents the approximate G Force experienced at the bottom of the Tidal Wave, depending on the time of the splash.



a. What is the G Force predicted by your splash time? How does this compare with the G Force that you measured?

b. How would the ride be different if the splash took 3 seconds?

c. What is the shortest splash that you think would be safe? (Remember that this is a horizontal G Force.)

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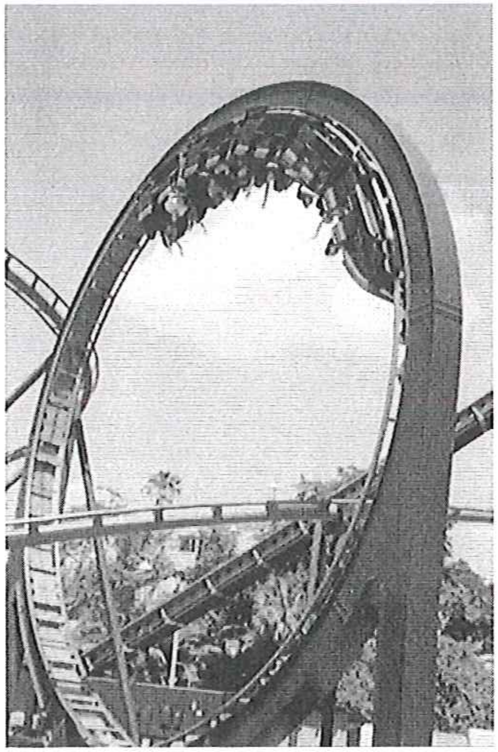
SCORPION: Basic



INSTRUMENTS REQUIRED
Vertical G Force Meter; Stopwatch

WHAT TO DO BEFORE COMING TO THE PARK
1. Construct a vertical G Force meter with hand-strap.
2. Problem: If a coaster train of length 15 m passes a point at the bottom of the hill in .75 seconds, how fast is the coaster moving?
3. Predictions:
   a. The Scorpion hill is about half the height of the Montu hill. If the Montu achieves a speed of 60 mph, what will be the approximate speed of the Scorpion?
      20 mph 30 mph 40 mph 50 mph 60 mph
   b. What will be the maximum G Force experienced on the Scorpion?
      2 g's 2.5 g's 3.0 g's 3.5 g's 4.0 g's

WHAT TO MEASURE ON THE RIDE
1. Measure the G Force at the bottom of the first hill.
2. Measure the G Force at the top of the vertical loop.
3. Measure the G Force while moving through the top horizontal loop.
4. Notice whether you ever felt upside down.
5. Estimate the banking angle in the two horizontal loops near the end of the ride.
(Use your estimate along with estimates of two friends)
6. Do you feel pushed to the side in the two horizontal loops? If so, which way?

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WHAT TO MEASURE OFF THE RIDE

1. Measure the time for the coaster to pass a point at the bottom of the first hill

DATA TABLE

	#1	#2	#3	Average
G Force at bottom of first hill				
G Force at the top of the vertical loop				
G Force in the top horizontal loop				
Time to pass a point at the bottom of the hill				
Banking angle				

Questions

1. The speed of Scorpion at the bottom of its first drop is about 10 m/s (22mph) slower than the speed of Kumba at the bottom of its first drop, but their G Forces at this point are very similar. Why?

2. As the coaster goes into the banked turns, do you feel pressed up against the sides of car or do you feel you're sitting upright? If you do feel pressed up against the sides, indicate whether you're pressed against the inside or outside of the car. Why is the banking angle so critical?

Problems

1. Using the measurement of the time to pass a point at the bottom of the hill, compute the speed of the coaster at the bottom of the hill. The length of the coaster is 10.7 meters.

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2. The graphs on the next page indicate the banking angle of the carrousel (the horizontal circles near the end of the Scorpion), and the G Force experienced there. These graphs are based upon the actual speed of the coaster in those turns.
   a. The actual radius of the carrousel is 8.1 meters. According to the graphs, what should the banking angle be? How close does this come to your estimate of the banking angle?

   b. What is the G Force associated with this radius of 8.1 meters? How does that compare with your measured value of G? How does it compare with the value from the graph of G Force vs. Time found a the end of the workbook?

   c. If the radius is doubled to 16.2 m, what happens to the banking angle and G Force?

   d. If the radius is cut in half, to 4 m, what happens to the banking angle and G Force?

   e. What banking angle corresponds to a G Force of 5?

   f. What is the smallest radius of curvature that would be safe?

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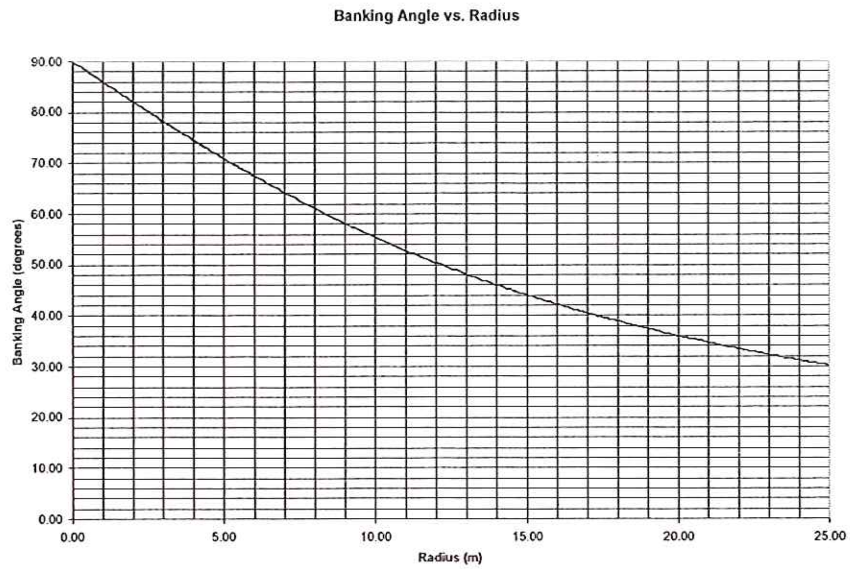

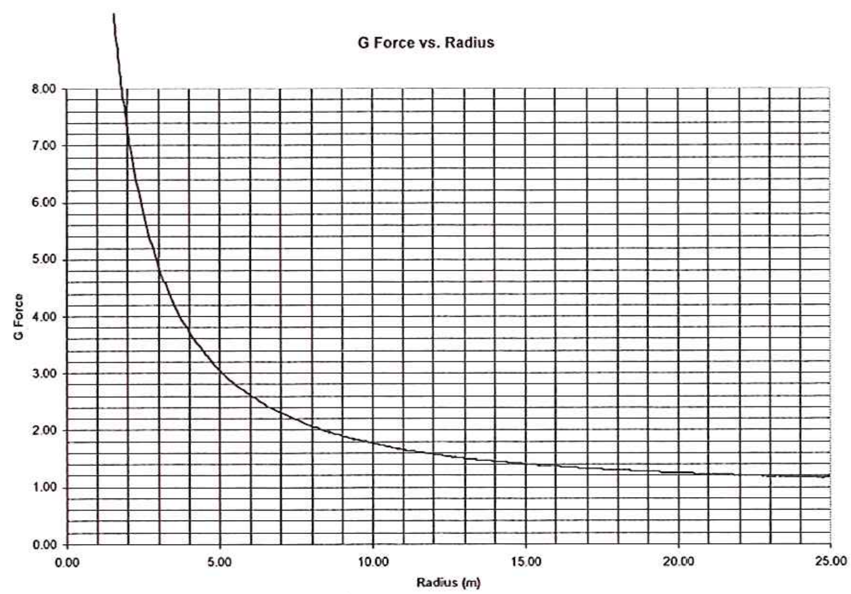

3. The graph of G Force vs. Time at the end of this workbook was produced with a CBL and TI-83 calculator and a Low-g accelerometer probe.
   a. How do your G Force readings for the bottom of the first hill and the top of the vertical loop compare to the graph?

   b. How long does the graph indicate that you felt heavy (greater than 2 g's) in the carrousel?

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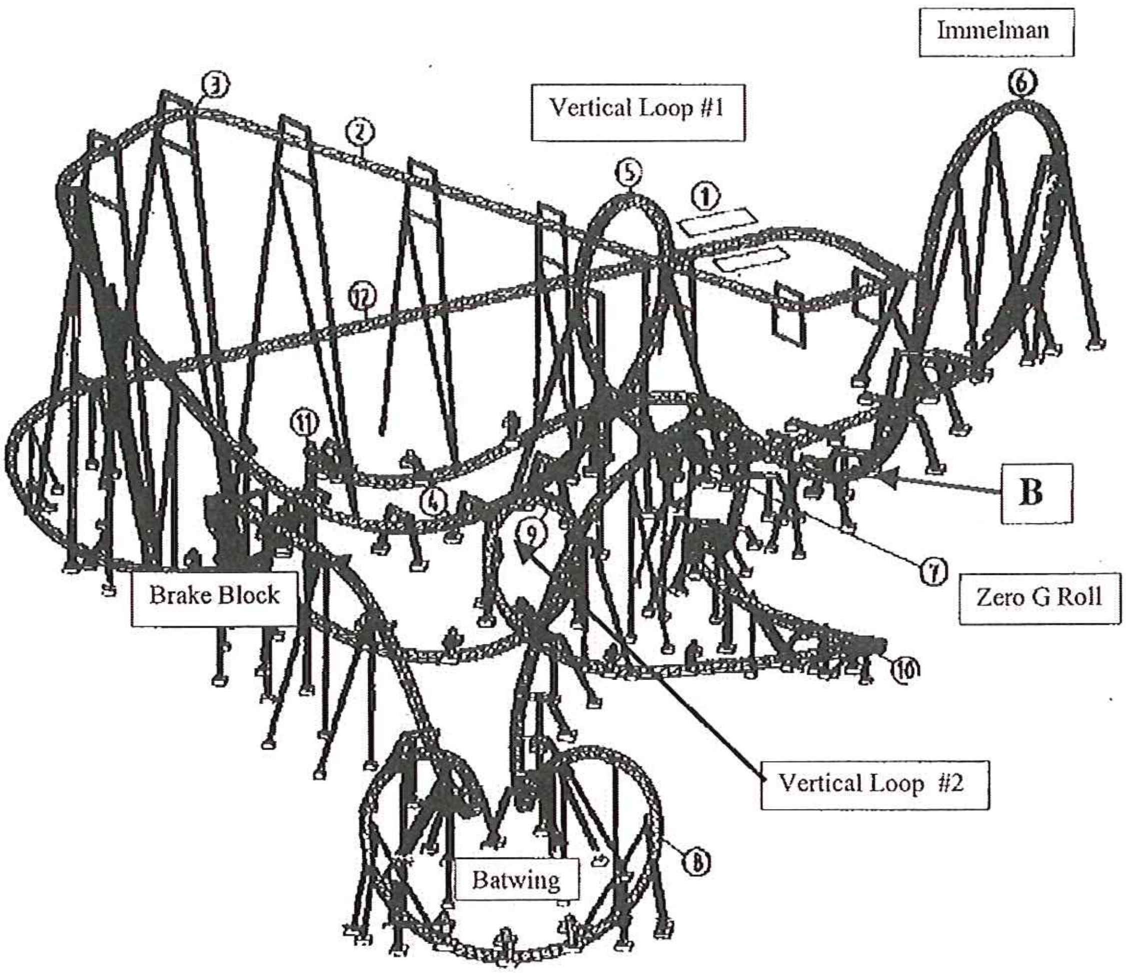
MONTU: Basic



The Montu is known as an inverted roller coaster. It features a 40.0 m first drop; seven inversions; a maximum g force of about 4, and approximately seven occasions where the g force exceeds 3; and a zero g roll, where passengers come close to weightlessness. In the 27 m tall Immelman, named after a German stunt pilot, the riders start over the top of the loop in an inverted position and then are rotated 180 degrees to an upright position as they come down the loop. In the Batwing, riders go over the top of both loops upside down, disappearing underground in the middle. With maximum speeds over 60 miles per hour, one of the largest-ever vertical loops on an inverted coaster (32 m), ¾ mile of track, and the whole experience being spent seated under the track with your feet dangling, the Montu is an intense experience.

INSTRUMENTS REQUIRED

Stopwatch (No instruments allowed on the ride!)

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WHAT TO DO BEFORE COMING TO THE PARK

1. Predictions:
   a. Will you ever leave your seat when you are upside down? Yes No
   a. Where will the heaviest feeling on the ride be experienced?
      Top of the Vertical Loops Top of the Immelman Zero-G Roll
      Middle of the Batwing Bottom of the First Hill Brake Block
2. Problems: Given that the coaster is 11.6 m long, find its speed if it takes .75 second to pass a post.

WHAT TO NOTICE ON THE RIDE

1. Pay attention to your feelings when you are upside down. Do you ever leave your seat? Do you feel upside down?
2. Where on the ride do you feel the heaviest? Given that you experience approximately 3.5 g's at the bottom of the first hill, make an estimate of the g force at the heaviest point. Record your estimate and that of two friends. (On Physics Days only, sit in the second row, and check the G Force Meter to find the heaviest point. Record the actual G Force instead of just an estimate.)
3. Where on the ride do you feel heavy for the longest period of time? Where on the ride did you feel normal?
4. Ride once near the front of the coaster and once near the rear. Notice differences.

On the Ride Estimate

	#1	#2	#3	Average
Maximum G Force				

WHAT TO DO OFF THE RIDE

1. Measure the time for the coaster to pass the top of the second vertical loop (#9). (Start the stopwatch when the front of the front car reaches the top of the loop, and stop the stopwatch when the back of the last car reaches the top of the loop.)

DATA TABLE

	#1	#2	#3	Average Time
Time for the coaster to pass the top of the loop (#9)				Sec

Questions

1. Describe the places on the ride where you felt normal and explain why. Where did you feel the heaviest? Where did you feel the lightest?

2. Explain your experiences in the inversions. Which of them felt light? Did you ever leave your seat?

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3 At the bottom of the first drop, the speed is 27 m/s. Just before the flat spin at the end of the ride, the speed is 18 m/s. The force factor at both places is 3.4. How can the force be so strong at the end of the ride when the speed is much slower?

4. Why is the second vertical loop much smaller than the first vertical loop?

5. How is riding in the front car different from riding in the last?

Problems

1. Using the average time for the coaster to pass the top of the vertical loop, compute the speed at the top of the second Loop (#9). The coaster length is 11.6 meters.

2. The graphs on the next page represent the top of the second vertical loop (#9). The graph to the right indicates how the force factor at the top of the loop depends upon the velocity at the top with a fixed radius of 5.5 m. The graph to the left indicates how the speed at the top of the loop depends upon the height of the loop above the ground level. (The actual loop is 13 meters above the ground level, with the base of the loop in a trench 6 meters deep.)

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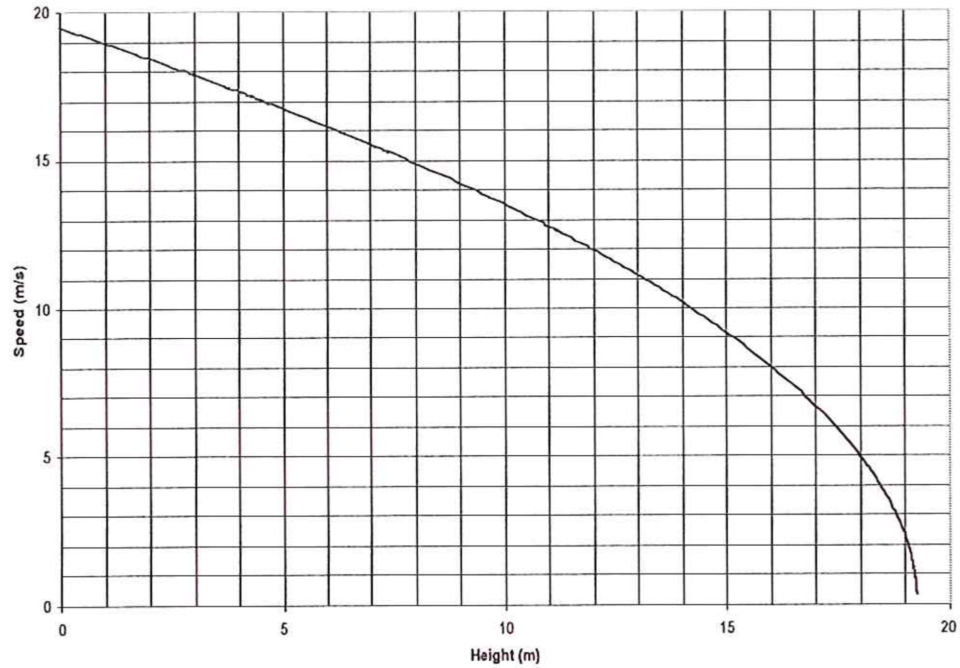
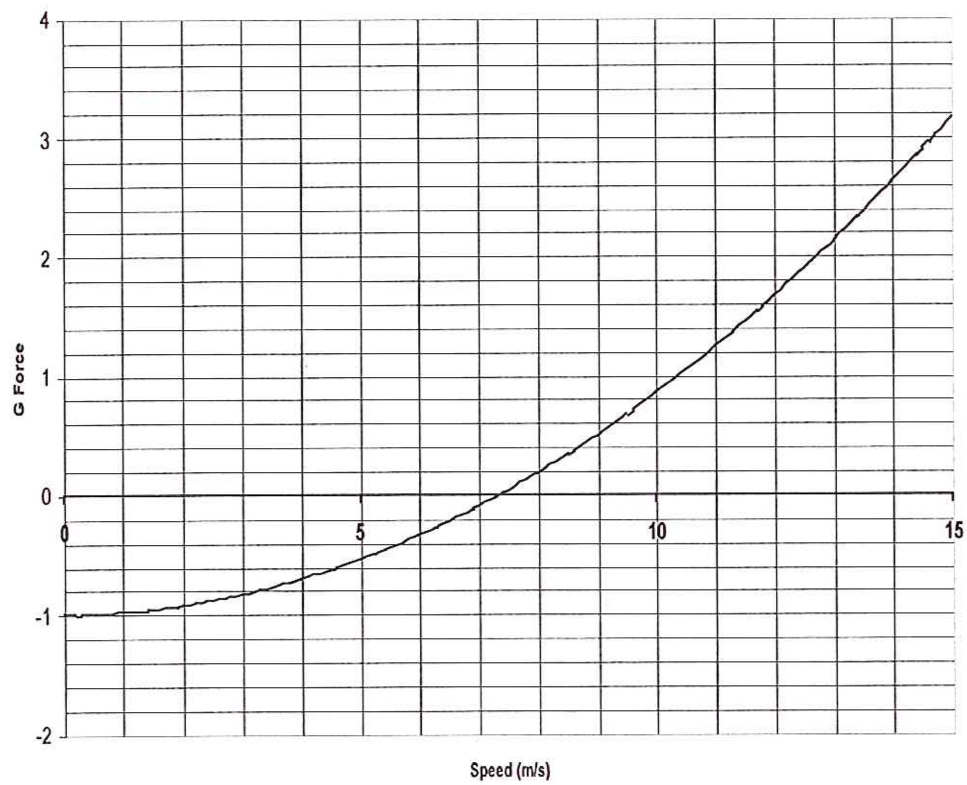
Speed vs Height



G Force vs Speed



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a. What range of velocities would produce a light feeling at the top of the loop (g force less than 1 and greater than 0)?

b. What is the minimum velocity required to get the coaster through the loop without it falling off? (In reality, the coaster has wheels underneath the track and the passengers have safety harnesses, so neither the car nor the passengers could fall out even if the G Force were negative.)

c. Find the height of a loop for which this minimum value of velocity is obtained.

d. What height of the loop would prevent the coaster from reaching the top?

e. A coaster designer has proposed to redesign the loop with a height of 8 meters. What would be the velocity at the top and the resulting g force at the top?

3. Answer the following questions based on the graph of G Force vs. Time at the end of the workbook. (This graph was obtained with a CBL, TI-83 Calculator and a Low-g accelerometer)

a. Where on the ride will you feel normal?

b. Which points on the ride have the greatest g forces? Where is the g force the greatest, and how does this compare with your guess?

c. On which upside-down point do you experience the lowest g forces?

d. On which upside-down points do you feel heavier than normal?

e. How do these graphical readings compare to your experiences

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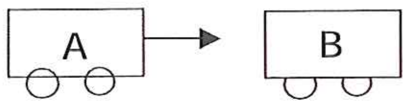
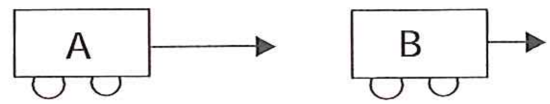
UBANGA-BANGA BUMPER CARS: Basic



Stationary collision



Moving collision

INSTRUMENTS REQUIRED

Horizontal G Force Meter; Stopwatch

WHAT TO DO BEFORE COMING TO THE PARK

1. Predictions:
   a. When you strike a car from the rear, you feel pushed:
   forward backward left right
   b. When you are struck from the rear, you feel pushed:
   forward backward left right
   c. When you are struck on the left side, you feel pushed:
   forward backward left right
   d. When you strike a car on its side, you feel pushed:
   forward backward left right
   e. A stationary collision will have a (larger or smaller) G Force than a moving collision.
   f. What is the maximum speed of the bumper cars?
   3 mph 5 mph 7mph 9mph
2. Construct a Horizontal G Force Meter with hand-strap.

WHAT TO MEASURE ON THE RIDE

1. Using the Horizontal G Force Meter, measure the maximum angle to which the balls roll in a stationary collision. (Hold the Horizontal G Force Meter parallel to your direction of motion.) Note both the magnitude and direction of the motion of the balls in the tube. Pay attention to striking and also to being struck.
2. Using the Horizontal G Force Meter, measure the maximum angle to which the balls roll in a moving collision. (Hold the Horizontal G Force Meter parallel to your direction of motion.) Note both the magnitude and direction of the motion of the balls in the tube. Pay attention to striking and also to being struck
3. Pay attention to the motion of the balls when you are struck from the side. In that situation, you will need to hold your G Force Meter perpendicular to your car's original motion.

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WHAT TO MEASURE OFF THE RIDE

1. Measure the time that it takes the cars going full speed to pass between two posts.

DATA TABLE

	#1	#2	#3	Average
Stationary collision angle				
Moving collision angle				
Time between posts				

Questions

1. Using the chart below, determine the Horizontal G Force in a stationary and a moving collision. How do these forces compare to the Tidal Wave and the Log Flume?

Angle	20	25	30	35	40	45	50	55	60
G Force	0.4	0.5	0.6	0.7	0.8	1.0	1.2	1.4	1.7

2. How does the force of being hit compare with the force of hitting?

3. Answer the following:

a. When you strike a car from the rear, you feel pushed: forward backward left right

b. When you are struck from the rear, you feel pushed: forward backward left right

c. When you are struck on the left side, you feel pushed: forward backward left right

d. When you strike a car on its side, you feel pushed: forward backward left right

4. Which of the following conditions would produce greater forces?(circle all that apply)

Harder bumpers Softer bumpers Higher Speeds Lower Speeds

Problems

1. Using the time between posts, compute the speed of the bumper cars in m/s. In addition, compute the speed in miles/hour by multiplying the m/s speed by 2.24. The posts are 7.6 m apart.

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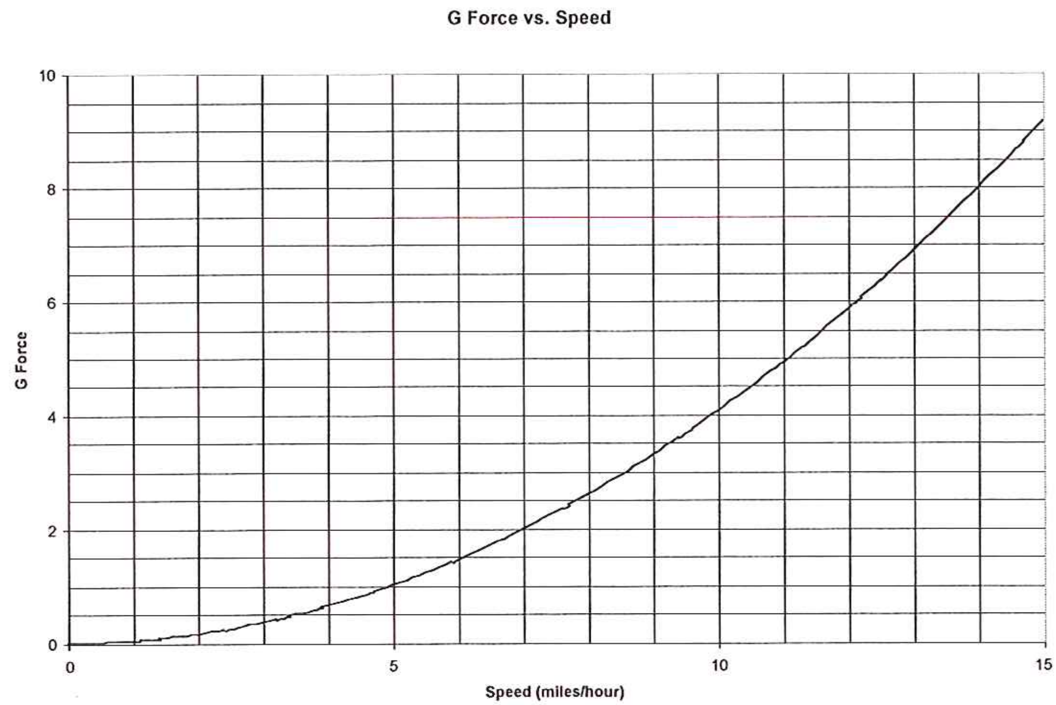
2. The graph below indicates the relationship between the G Force in a stationary collision between bumper cars and the speed of the collision. This graph assumes that the final speed is zero.



a. What happens to the force of the collision when the speed is doubled?

b. What happens to the force of a collision when the speed is quadrupled?

c. What would be the maximum safe speed in a bumper car collision?

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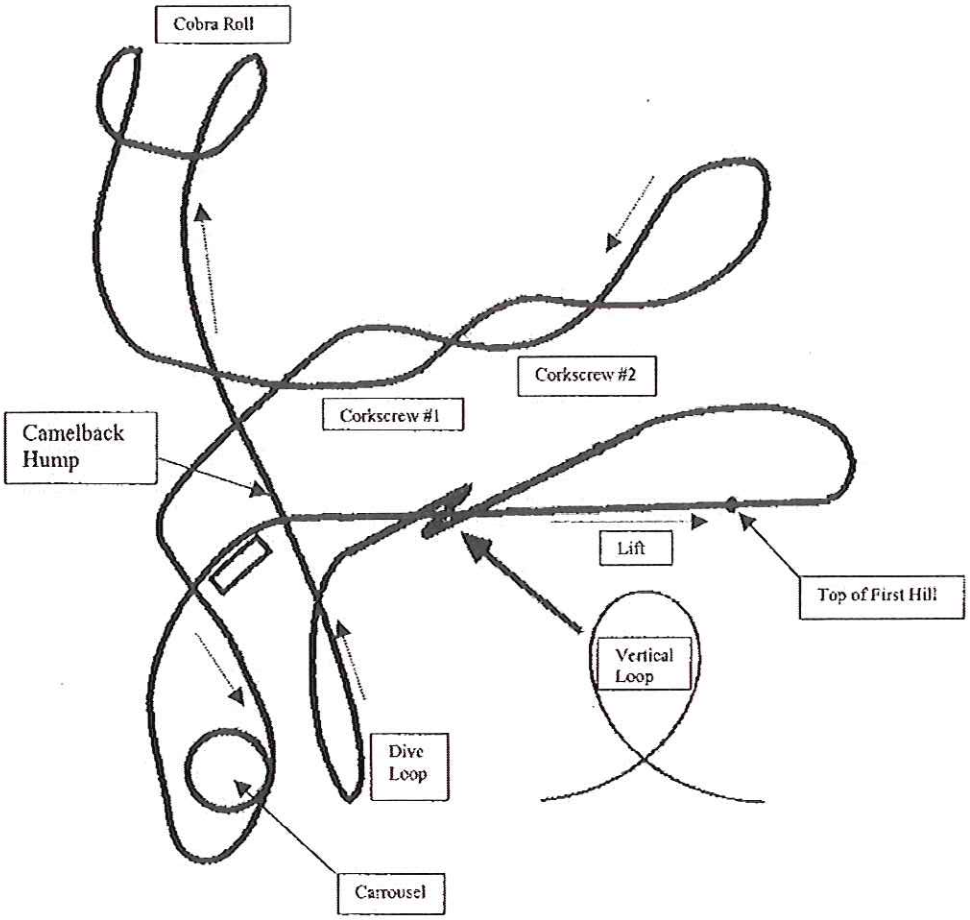
KUMBA: Basic



The Kumba features a double corkscrew; a Cobra Roll; a 33 m tall Vertical Loop that takes the ride around the original lift hill; a Dive Loop that mimics a stunt plane's maneuver; and a 42.9 m drop on the first hill. In addition, the Kumba has a highly banked circular turn called the carrousel, which produces heaviness for several seconds, and a Camelback Hump that does just the opposite, giving the riders a few seconds of near weightlessness. The coaster has three wheels: a Road Wheel above the track to ride on; a Guide Wheel beside the track to keep the train from rocking side to side; and an Uplift Wheel beneath the track to ensure that the train stays on the track through all its twists and turns. With maximum speeds of up to 62 miles/hour, seven inversions, and multiple opportunities to experience forces of greater than 3 g's, the Kumba is an awesome physics experience

INSTRUMENTS REQUIRED

Stopwatch (No instruments allowed on the ride!)

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WHAT TO DO BEFORE COMING TO THE PARK

1. Problems:
   Find the speed of a coaster train whose length is 20 m and which takes .75 seconds to past a post.
2. Predictions:
   a. As the coaster goes around the carrousel near the end of the ride, will you feel:
      pushed to the outside   pushed to the inside   not pushed to the left or the right
   b. As the coaster goes around the carrousel, you will feel:
      Heavy   Light   Normal
   c. When the coaster cars are inverted, you will feel:
      Heavy   Light   Like you are falling
      Sometimes Heavy and Sometimes Light
   d. What is the average speed of the coaster, expressed in miles/hour?
      15   20   25   30   35   40   45   50   55
   e. What is the highest G Force on the ride?
      3.0   3.2   3.4   3.6   3.8   4.0   4.2
   f. How many times does the coaster ride exceed 3 G's?
      2   3   4   5   6   7   8   9

WHAT TO NOTICE ON THE RIDE

1. Pay attention to your feelings during the carrousel section of the ride, near the end. Estimate how heavy you feel and whether you feel pushed to the left or right. Can you get your feet off the floor?
2. You will be inverted seven times. Pay attention to the similarities and differences in these inversions, i.e., do you feel heavy or light; do you ever leave your seat; etc.
3. The G Force at the bottom of the first hill is about 3.4. Where on the ride is the G Force greater than this? Where is the G Force the greatest, and what is that value? What is the value of the G Force in the carrousel?

On Physics Days only, sit in the second row in view of the mounted G Force Meter. Record the measured value instead of estimates.

WHAT TO MEASURE AND NOTICE OFF THE RIDE

1. Time the coaster from the point where the middle car passes the top of the first hill until the middle car reaches the top of the second corkscrew.
2. Measure the time for the coaster to pass the top of the first corkscrew. (Start the stopwatch when the front of the first car reaches the top of the corkscrew, and stop the stopwatch when the back of the last car reaches the top of the corkscrew.)
3. Watch the ride from the beginning to the end to determine where it moves the fastest and where it moves the slowest.

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DATA TABLE

	Time #1	Time #2	Time #3	Average Time
Time it takes the coaster to go from the top of the first hill to the top of the second corkscrew				
Time it takes the coaster to pass the top of the first corkscrew				

On the Ride Estimates

	#1	#2	#3	Average
Heaviest point				
carrousel				

Questions

1. Describe the differences in the times that you were upside down. Did you ever leave your seat? Which time did you feel the lightest?

2. Where did you feel the heaviest during the ride? Where you able to pick up your feet in the carrousel? Were you thrown to the left or right or were you upright in the carrousel?

3. The Kumba has so many twists and turns that it can be disorienting. It is hard to tell where you are or whether you are upside down or not. This is especially true because your eyes will tell you that you are upside down, but you may not feel upside down. You also go from being light to being heavy many times. Where were your senses the most confused?

4. Give a general explanation for where on the ride you go fast and where slow.

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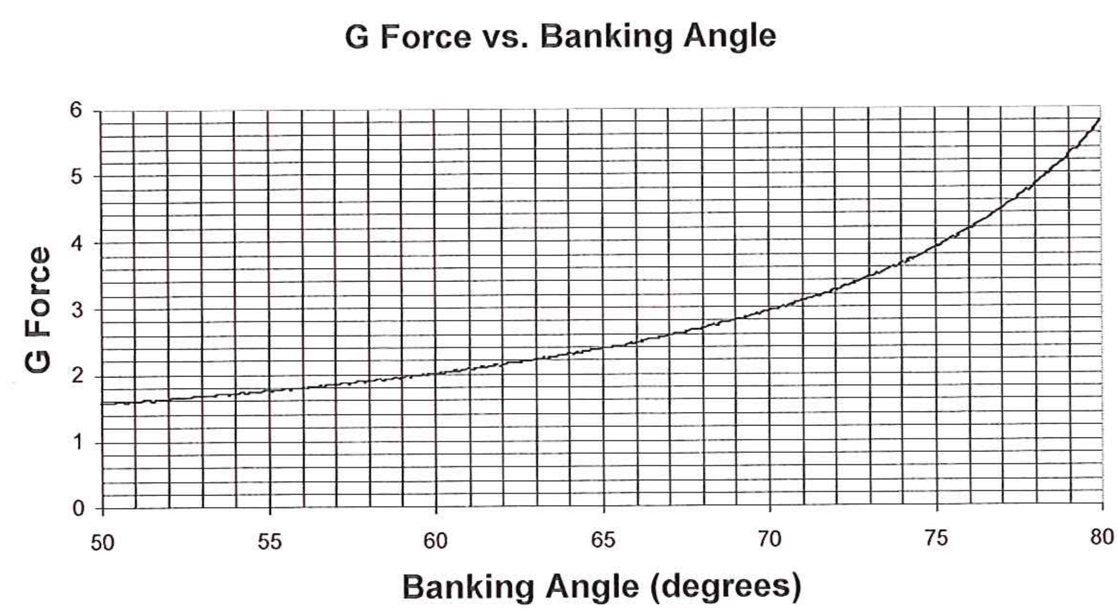
5. Generally speaking, where do you feel heavy and where do you feel light — at the tops of hills, at the bottoms, on the curves, going down hills, being upside down, etc.?

Problems

1. The graphs below are based on the carrousel, which is the horizontal circle near the end of the coaster ride.



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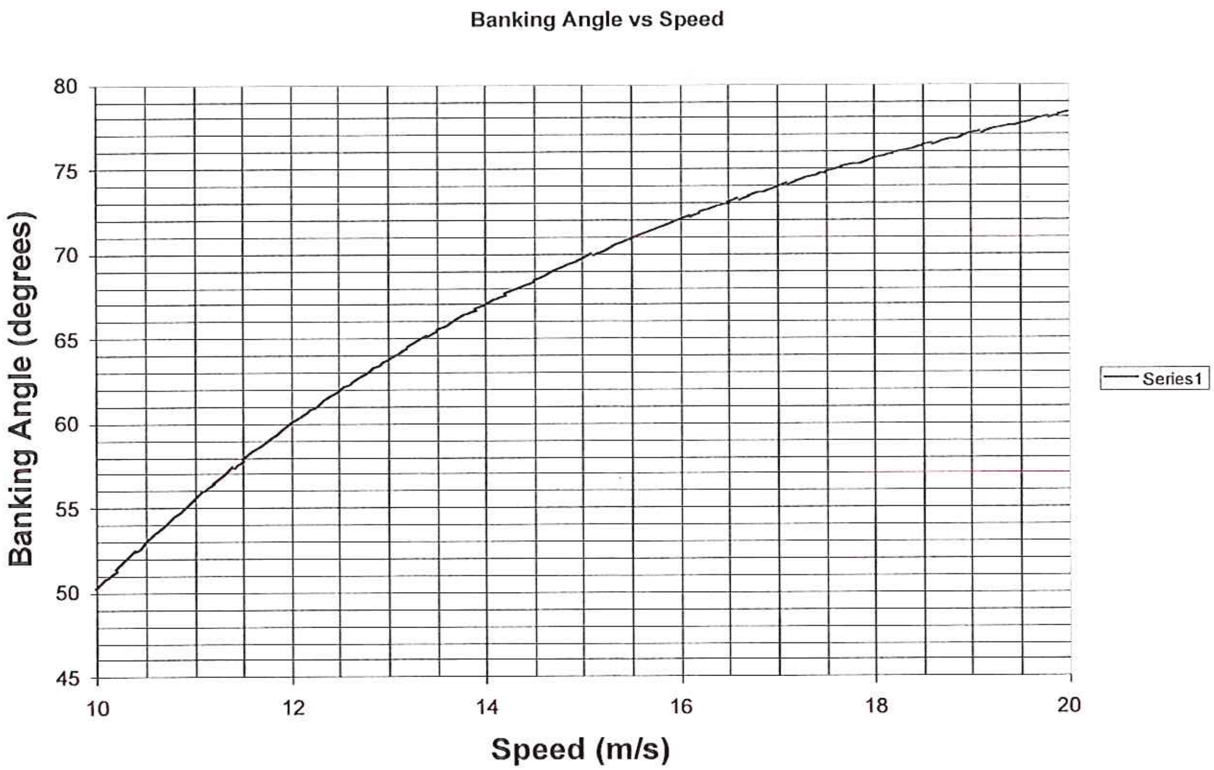

a. The velocity in the carrousel is 15 m/s. What is the banking angle?

b. What is the G Force that corresponds to this banking angle? How does this compare with your estimate (or measurement) of the G Force in the carrousel?

c. If you wanted to design a coaster that experienced 2 g's in the carrousel, what would the speed of the coaster need to be?

d. What is the maximum safe banking angle? Why did you pick this angle?

1. Using the time it takes the coaster to pass a point at the top of the corkscrew, compute the speed of the coaster at the top of the corkscrew. Coaster length = 13.1 meters

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2. Using the time for the coaster train to go from the top of the first hill to the top of the second corkscrew, compute the average speed of the coaster. The distance between those two points is 770 meters. Find the average speed in miles/hour by multiplying m/s by 2.24.

3. List the G Forces on the inversions as obtained by the G Force vs. Time graph at the end of the workbook. This graph was produced with a CBL, TI-83 calculator and a Low-G Accelerometer. How does this compare with your feelings on the ride?

Top of Vertical Loop	Top of Immelman	Camelback Hump	Cobra Roll Inversion #1	Cobra Roll Inversion #2	First Corkscrew	Second Corkscrew

4. List the maximum forces at the bottoms of the hills. How do these figures compare with your estimations (or your measurements with the G Force Meter) of where the force was the greatest?

Vertical Loop bottom	Going into Dive Loop	Going into Camelback	Going into Cobra Roll	Middle of Cobra Roll	Coming out of Cobra Roll	Corkscrew Bottom #1	Corkscrew Bottom #2	carrousel

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SandSerpent : Basic

INSTRUMENTS NEEDED
Horizontal and Vertical G Force Meters

WHAT TO DO BEFORE COMING TO THE PARK
1. Construct a Vertical and a Horizontal G Force Meter with hand-straps.
2. Predictions:
a. Will the horizontal forces in the turns increase, decrease or stay the same as you go around the six sharp turns on the top level? **Increase** **Decrease** **Stay the Same**
b. Will the greatest forces on the ride be horizontal or vertical?
Horizontal **Vertical**
c. Where should someone sit in the car to avoid having their seatmate push against them in the turns?
Left side of the car **Right side of the car** **You can't avoid being pushed**

WHAT TO MEASURE AND NOTICE ON THE RIDE
1. With the Horizontal G Force Meter, measure the largest angle to which the BBs in the tube will rise on the third and fourth turns on the top level. Also note the direction that the BBs move. Indicate which seat you sat in: right or left. .NOTE: You must hold the accelerometer perpendicular to the motion.
2. With the Vertical G Force Meter, measure the maximum G Force experienced in the dips. Hold the Force Meter parallel to your spine.

	#1	#2	#3	Average
Angle: Turn 3				Direction: R or L
Angle: Turn 4				Direction: R or L
G Force: Dip				

Note: Ride the ride three times or get data from a friend.

Questions
1. Compute the G Force in the two turns using the average angle and the following chart:

Degrees	33	35	37	39	41	43	45	47	49	51	53	55	57	59
G Force	.6	.7	.8	.8	.9	.9	1.0	1.1	1.2	1.2	1.3	1.4	1.5	1.7

G Force (measured) Turn #3 __________ BBs to (left, right)

Turn #4 __________BBs to (left, right)

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2. What are the values of the G Force obtained from the G Force vs. Time graph at the end of the workbook. How close are your values to that of the graph?

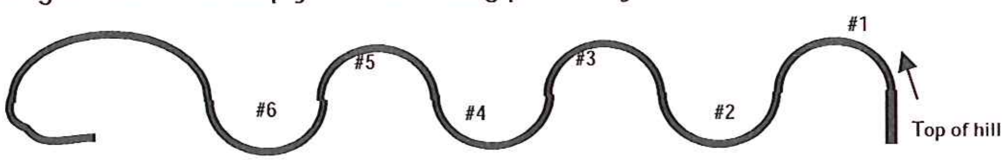
G Force Graph Turn #3 ________ Turn #4 ___________

3. What is the largest vertical G Force obtained from the CBL graph? How does it compare with your measured value? How does this compare with the G Forces experienced on the Montu and Kumba? How can the G Force be so large when the speed is small?

G Force (G Force Graph) _________ G Force (Measured) __________

4. From your experience on the ride, how did the horizontal forces in the six sharp turns on the top level compare with each other? Were they about the same, steadily increasing, steadily decreasing or randomly changing? How does this compare with what the graph indicates?

5. The direction of the force is opposite the direction that the BBs slide. Indicate the direction of the force on the passengers in the six turns illustrated below. (Use arrows.) Does sitting in either seat help you avoid being pushed by a seatmate?



6 (Advanced)*. The radius of each of the turns is the same. R = 2.36 m. Taking the average Horizontal G Force in each of the turns from the G Force graph, compute the speed of the coaster car. $F=mv^2/r$, where F = (G Force) * mg

7. Did the car seem to speed up, slow down, or remain at about the same speed throughout the six turns? The track on the top level slopes downward gradually. Why?

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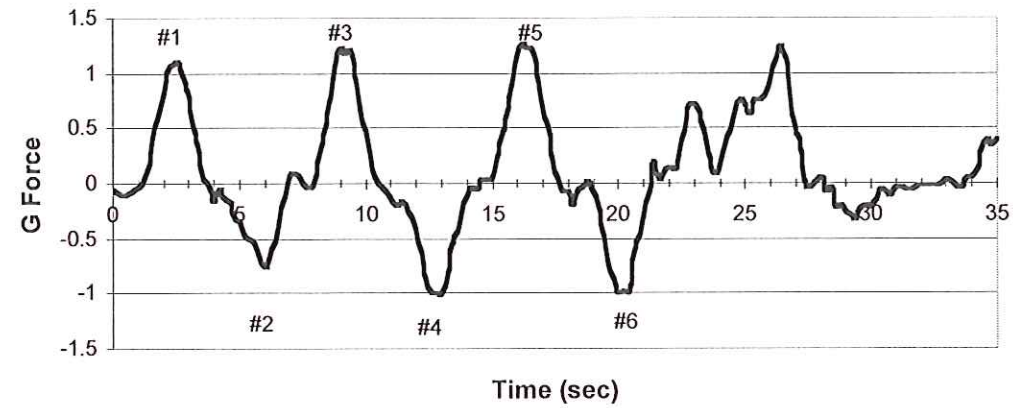
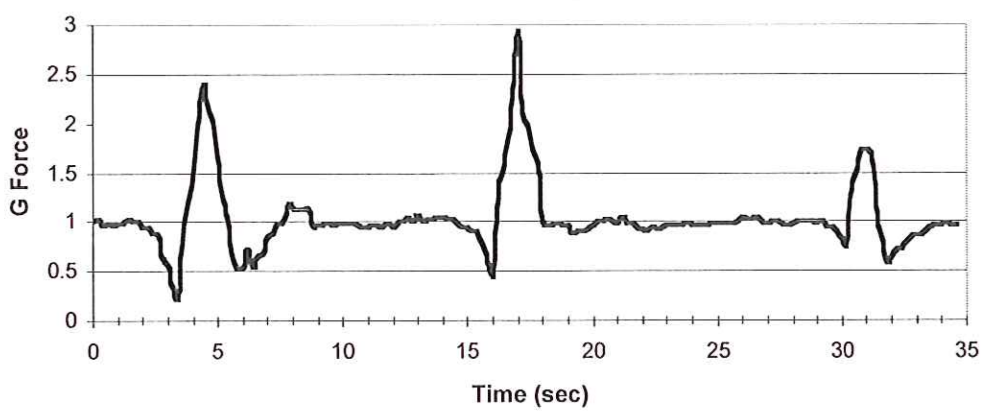
8 (Advanced)*. Because the turns are not banked, there is a considerable sideways force. If the track were banked at an appropriate angle, then the passengers would feel heavy in the turns but would not feel pushed to the side. Based upon your answer to question No. 6, what should this banking angle be, to avoid sideways forces? Tan (angle) = v^2/rg

9 (Advanced)* In your experience, was a greater force experienced by the person on the outside of the turn or the inside, or are they both the same? What do the graphs indicate? (The accelerometer that produced the graphs was in the right-hand seat.)

SandSerpent (Horizontal Force)



SandSerpent (Vertical Force)



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SHEIKRA: Basic

INSTRUMENTS REQUIRED
Stopwatch (No instruments allowed on the ride!).

WHAT TO DO BEFORE COMING TO THE PARK:
1. Predictions:
   a. How long will you feel "weightless" on the big drop? .5 sec. 2.5 sec. 5 sec.
   b. Will you ever feel weightless when you are upside down? Yes No

2. Problems: Given that the coaster takes .75 seconds to go from post A to post B, which are 20 meters apart, what is the speed of the coaster?

WHAT TO NOTICE ON THE RIDE
1. Estimate the time that you are "weightless" on the big drop. Estimate to the nearest ½ second. (Practice counting: One thousand one, one thousand two, etc., or one-Mississippi, two-Mississippi, etc.) Use your count and that of two friends.

	#1	#2	#3	Average
Estimated time of big drop				

2. There are at least two other places on the ride where you feel weightless. Where are they?

WHAT TO DO OFF THE RIDE
1. Measure the time for the coaster to "free fall" down the first hill. Start your stopwatch at the instant the coaster begins to fall (it will hang at the edge for approximately 4 seconds before falling), and stop your stopwatch when the coaster arrives at the top of the blue post that supports the track. The track begins to curve after this point.

DATA TABLE

	#1	#2	#3	Average time
Time of fall				

Questions
1. How does the time you estimated on the ride compare with the time you measured?

2. On the G Force graph below, estimate the time of weightlessness by finding the time spent with a G Force of less than 1 G.

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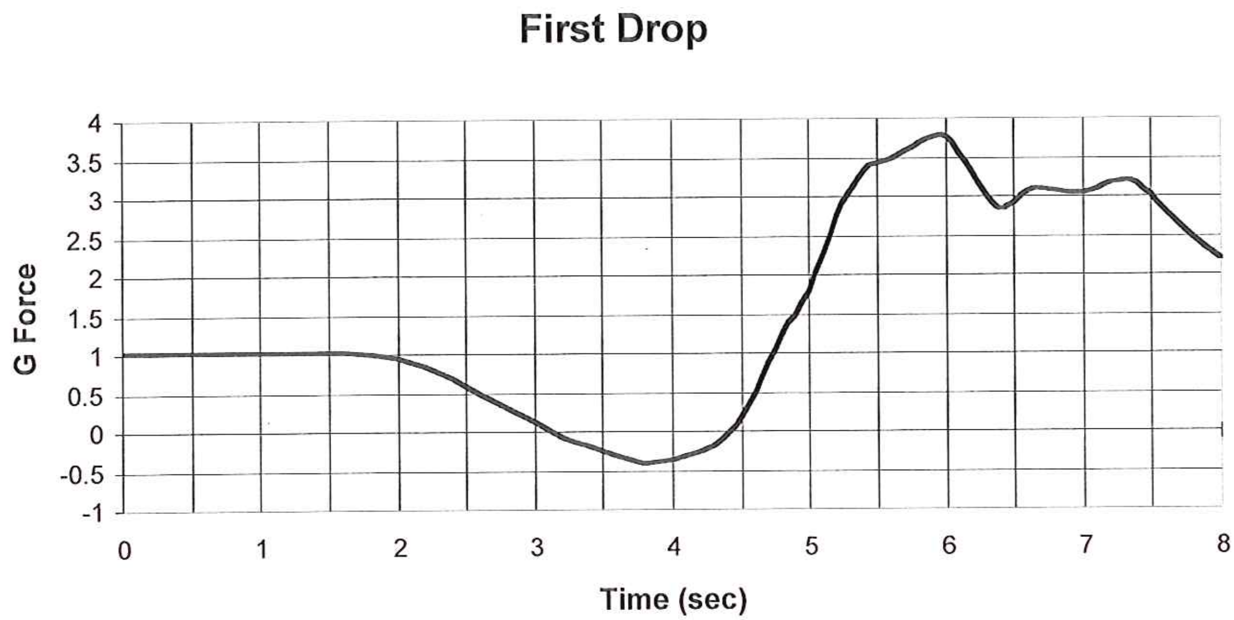
3. How long does it take for the G Force to increase from 1 to its highest level?



4a. From the Drop Distance vs. Time graph on the next page, determine how far the coaster dropped in the time measured with the stopwatch.

b. If the coaster dropped the entire 61 meters to the ground, how long would the falling time be? (In reality, such a drop is not possible, because the coaster track must begin curving before it reaches the ground.)

c. Using the Drop Distance graph, what should the "free fall" time be? (It is 32.7 meters from the top of the hill to the blue post.)

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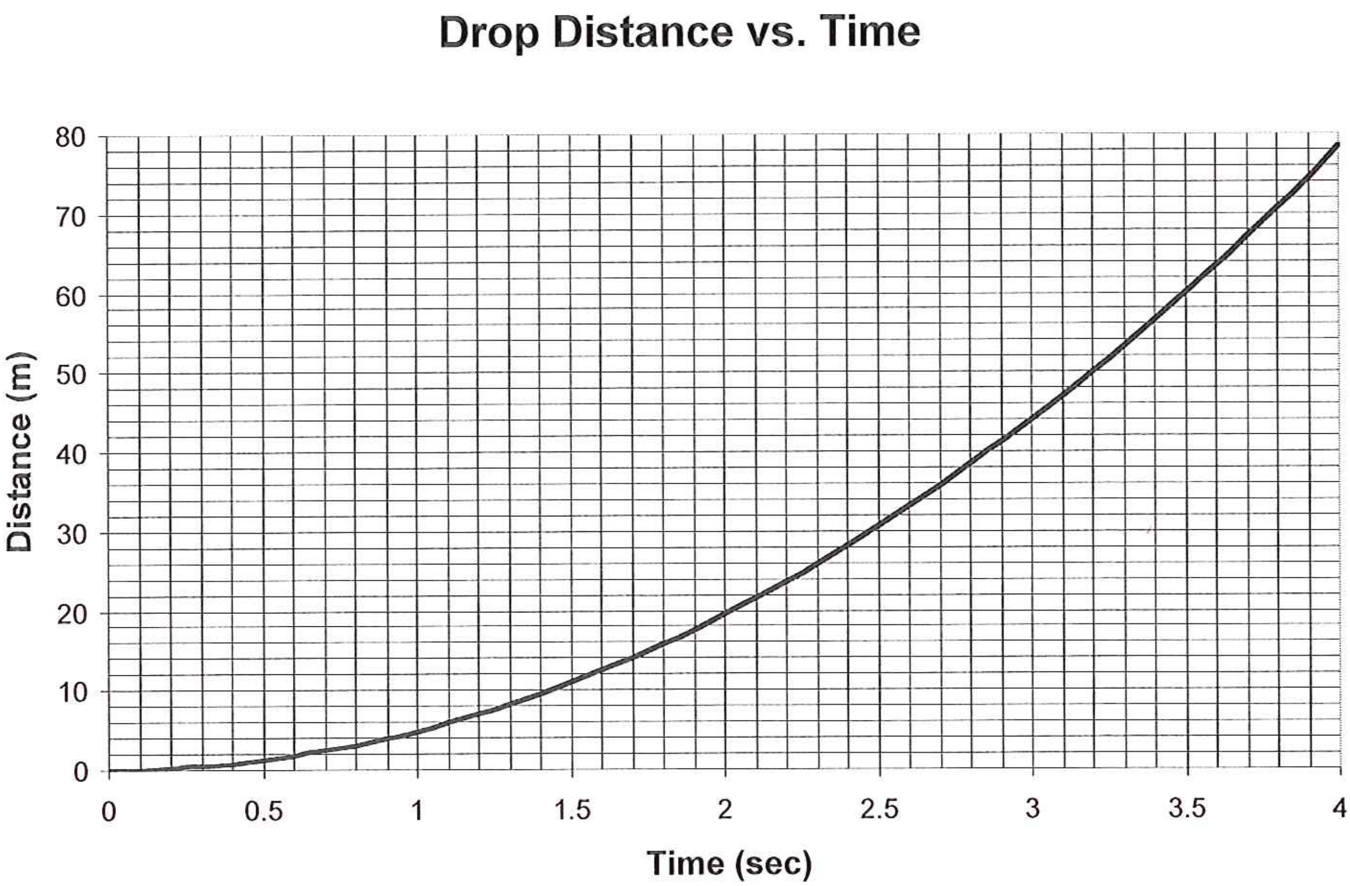
5. From the complete SheiKra G Force graph at the end of the workbook, find where else on the ride you are weightless. Which weightless period is the longest? How does this graph compare with your observations?



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CHEETAH HUNT: Basic

ELEMENTS OF THE RIDE:

1st Launch:	Acceleration in the Station
Overbanked Turn:	Immediately after 1st launch. Big looping turn.
2nd Launch:	Acceleration before the Tower
Tower:	You'll come down the tower and into a trench
Outbound Twister :	Parabolic Hill with a twist up top. You're going over the skyride.
Heartline Roll:	Upside down with the heart line as the pivot
Brake Block:	Relatively flat, where the coaster can be stopped if needed
Serpentine turns:	Like a snake, undulating back and forth
3rd Launch:	Acceleration before Air Time Hill
Air Time Hill:	Parabolic Hill with a weightless sensation
Inbound Twister:	Sometimes called the over and under

Train Track Hill, and then **Sharp Left Turn** into the brakes at the end.

INSTRUMENTS

Stopwatch

WHAT TO DO BEFORE COMING TO THE PARK

Problems

a. If the Cheetah hunt takes 1.5 seconds to pass between two posts that are 20 meters apart, how fast is the coaster train moving?
b. What is the acceleration of a car that goes from 0 to 20 meters per second in 4 seconds? (Assume a constant acceleration)

Predictions

a. If you are in a car making a hard turn to the right, which direction do you feel pushed? (Note: This is because of a lateral or sideways acceleration.)

   Right   Left

b. There are three launches on the coaster. Which do you think will be the most intense?

   First (at station)   Second (before the Tower)   Third (near the end of the ride)

WHAT TO DO AND NOTICE ON THE RIDE

1. Note where you are when you feel pushed to the side. One easy way is to pay attention to your legs, especially if they are slightly raised off the ground.
2. Pay attention to where you feel the greatest periods of weightlessness.
3. Notice where on the ride you feel the heaviest.

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WHAT TO MEASURE OFF THE RIDE

1. Time the coaster train between the highest two posts on the Air Time Hill. (This is just after the third launch and is easily visible behind the Pit Stop near the entrance to Rhino Rally.) Make thre measurements and compute the average.
2. Watch the Cheetah Hunt coaster do its "serpentine" turns down the canyon.
3. Draw a sketch of the Air time hill, including the locations of the posts at the top.

AIR TIME HILL

	#1	#2	#3	Average
Time between Posts of Airtime Hill				

Questions

1. Look at the Cheetah Hunt RR4 Vertical G Force (RR4) graph (RR4=Right Rear seat of the fourth coaster car) at the end of the workbook. This lists the Vertical G forces on the ride.
   a. List four elements with the largest g force with their respective g force. Indicate whether the high g's occurred entering the element or leaving it. (i.e Leaving Launch 4, Entering Air Tin Hill, etc.

Element	g's
______________________________	________
______________________________	________
______________________________	________
______________________________	________

   b. Do the highest g forces correspond to where you felt the heaviest?

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2. a. From the same RR4 graph, list which elements had the longest "air time". Air time might be defined as when you experience less than 1 g. (Consider only those elements whose lowest g force value was zero or beyond.) Air time usually occurs at the top of a hill, or coming down a steep slope. Be as specific as you can in describing where the events happened.

Element	Approximate Time
______________________________	_________
______________________________	_________
______________________________	_________
______________________________	_________

b. Do these measurements from the graph correspond to your experiences on the ride? Which element did you feel had the "best" airtime?

3. a. There are three types of acceleration on the Cheetah Hunt: ***Vertical Acceleration*** which results in heaviness or lightness; ***Lateral Acceleration*** which is left/right. ***Forward/Backward Acceleration*** which includes launches and braking. Looking at the Cheetah Hunt Lateral G Force (RR4) graph at the end of the workbook, list the three most intense events that produce lateral g force, and list the magnitude of the g force. Note that these G forces are much less than the vertical g forces. Make a note of whether these forces are positive or negative.

	G force
1.______________________________	_________
2.______________________________	_________
3.______________________________	_________
4.______________________________	_________

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b. As you leave the station and make a hard left turn, you will note that the acceleration indicated on the graph is negative. Right turns should therefore be positive accelerations, as you can see from the right turn at the top of the tower that occurs at 20 seconds. Turning to the left should produce a feeling of being pushed to the right and vice versa. (Think about being in a car making a sharp turn). Do these four events listed above compare with your observations on the ride (i.e., were your feet "pushed" to the left with positive accelerations, did your most intense sideways feelings come when the graph indicated it, did positive accelerations correspond to right turns, etc.)?

c. The region where the serpentine turns occur is filled with lateral accelerations. From your observations of these turns, why is this the case?

Problems

1. Cheetahs are the world's fastest land animal. At Busch Gardens, the cheetahs have been timed at a speed of 36 mph. Maximum speed of cheetahs in the wild is 70 mph, but cannot be reached at Busch Gardens due to limited running space.

   a. A Cheetah can accelerate from 0 to 62 miles per hour (27.7 m/s) in just three seconds. Compare this to a Ferrari Enzo (660 Horsepower and $670,000), which requires 3.5 seconds. What is the acceleration of a Cheetah in m/s^2?

   b. Express this acceleration in "g's" by dividing by 9.8 m/s^2.

2. Look at the launch graphs on the next page. These measurements were made on the third or fourth coaster car in the three launches of the Cheetah Hunt.

   a. Which of the three launches is for the longest amount of time? Which is for the shortest amount of time?

   b. Which of the launches is the most intense, with the highest acceleration? Which is the least intense? Compute the maximum "g'" of these three launches by dividing the maximum acceleration by 9.8 m/s^2. Compare these accelerations to that of the Cheetah.

   c. Describe the three launches in terms of whether they have high accelerations in the beginning or the end.

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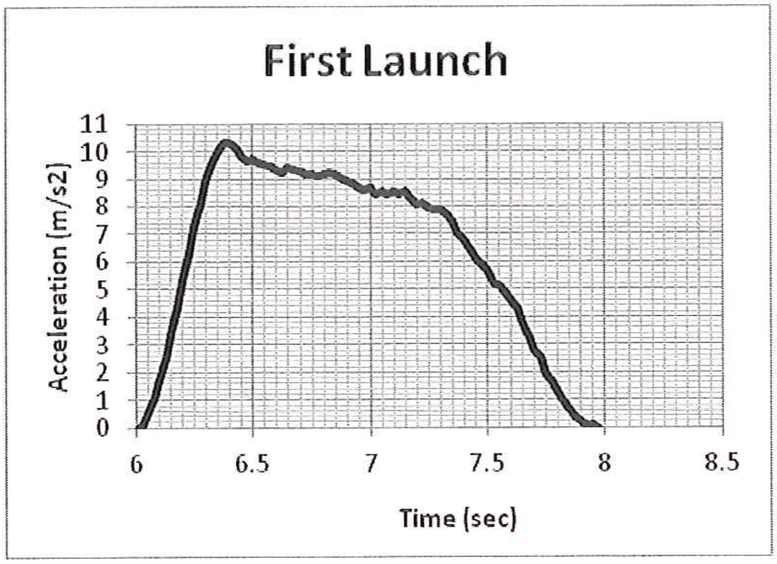

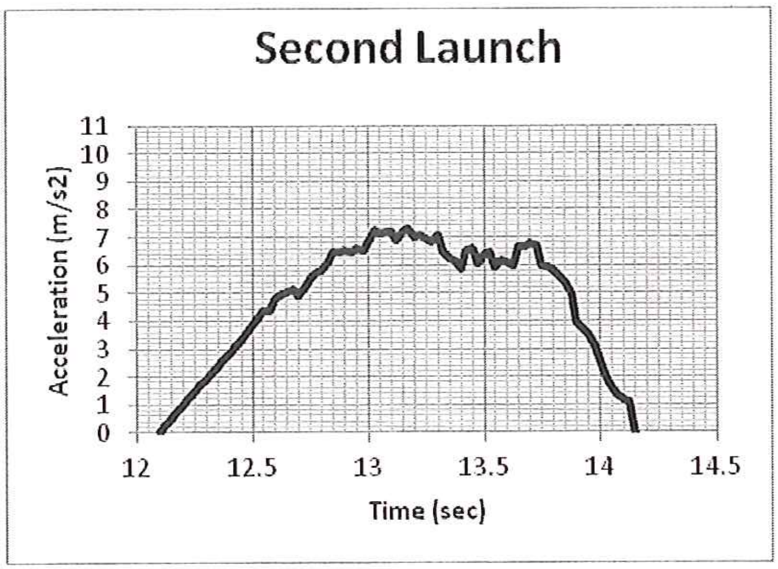

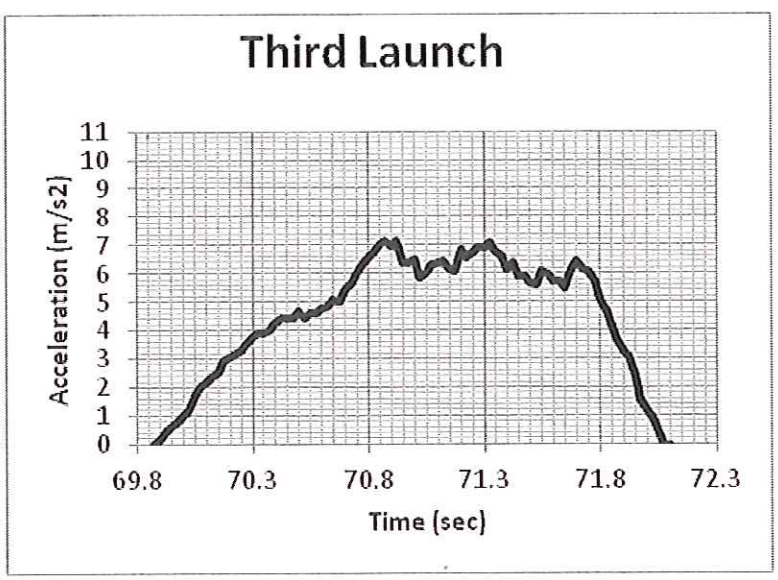

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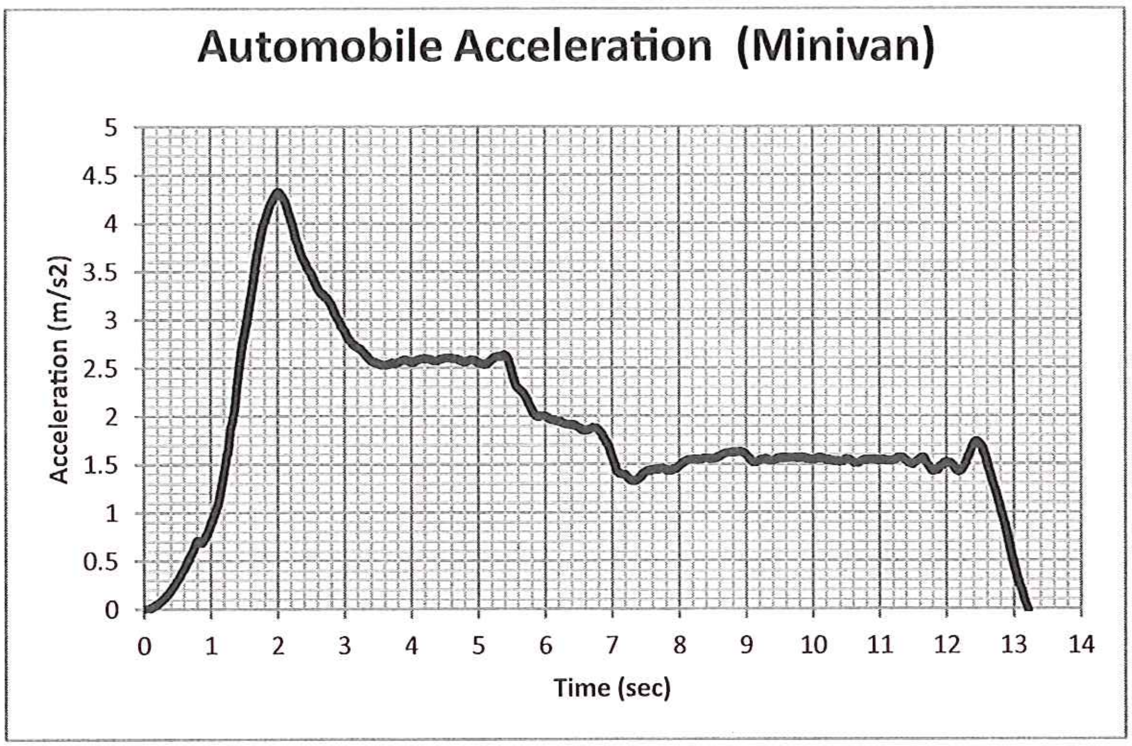
d. Which of the accelerations would you guess produces the greatest change in the velocity?

e. How do these graphs compare to how you felt in these three launches?

f. The acceleration below is of minivan accelerating between 0 and 55 mph. Indicate how it is similar and how it is different to the first launch.



3.a. Using the time between posts that you measured, compute the speed of the coaster train on the Air Time Hill (just after Launch 3). The distance between posts is 15.0 meters.

Velocity=distance/time=

b. Using the graph below, compute how long you feel weightless in the Air Time hill. To do this, assume that weightlessness is experienced when the g force is less than 1 g.

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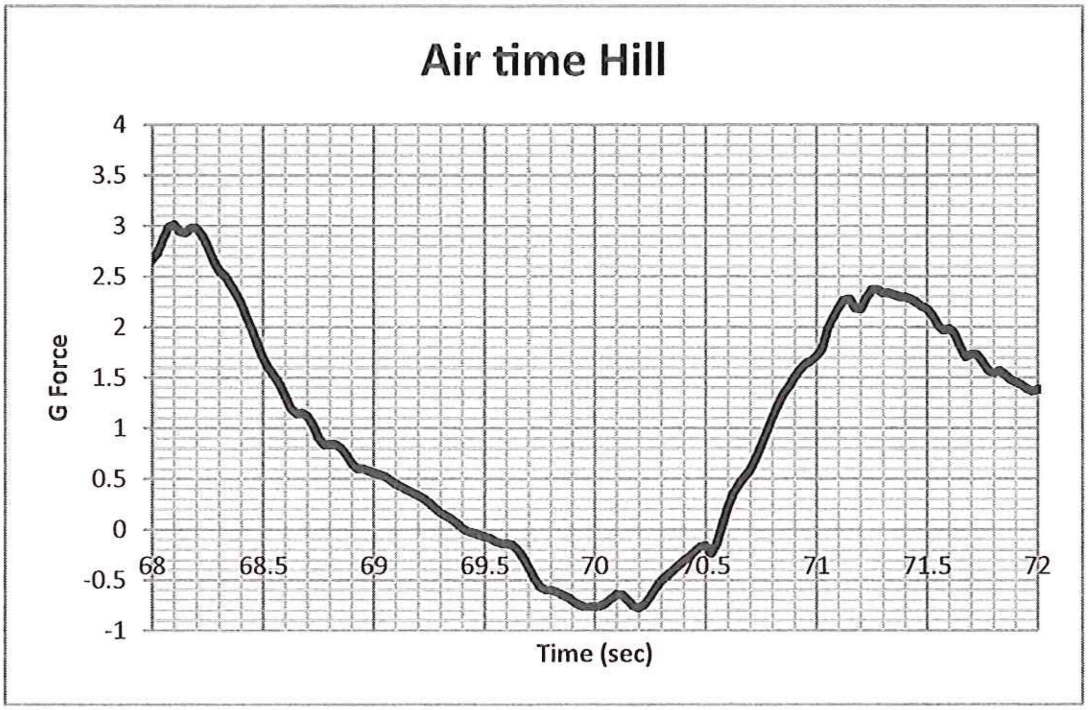
Weightless time = ____________ second



Draw a sketch below of what the Air Time Hill looks like. Include the posts in your sketch. What mathematical shape does it appear to be?

Is the weightless feeling experienced on the way up the hill, on the way down, or both?

What fraction of the "weightlessness" (<1g) occurs during the time between the two posts? The coaster is at zero g's or less for how long? What fraction of this sensation occurs between the posts?

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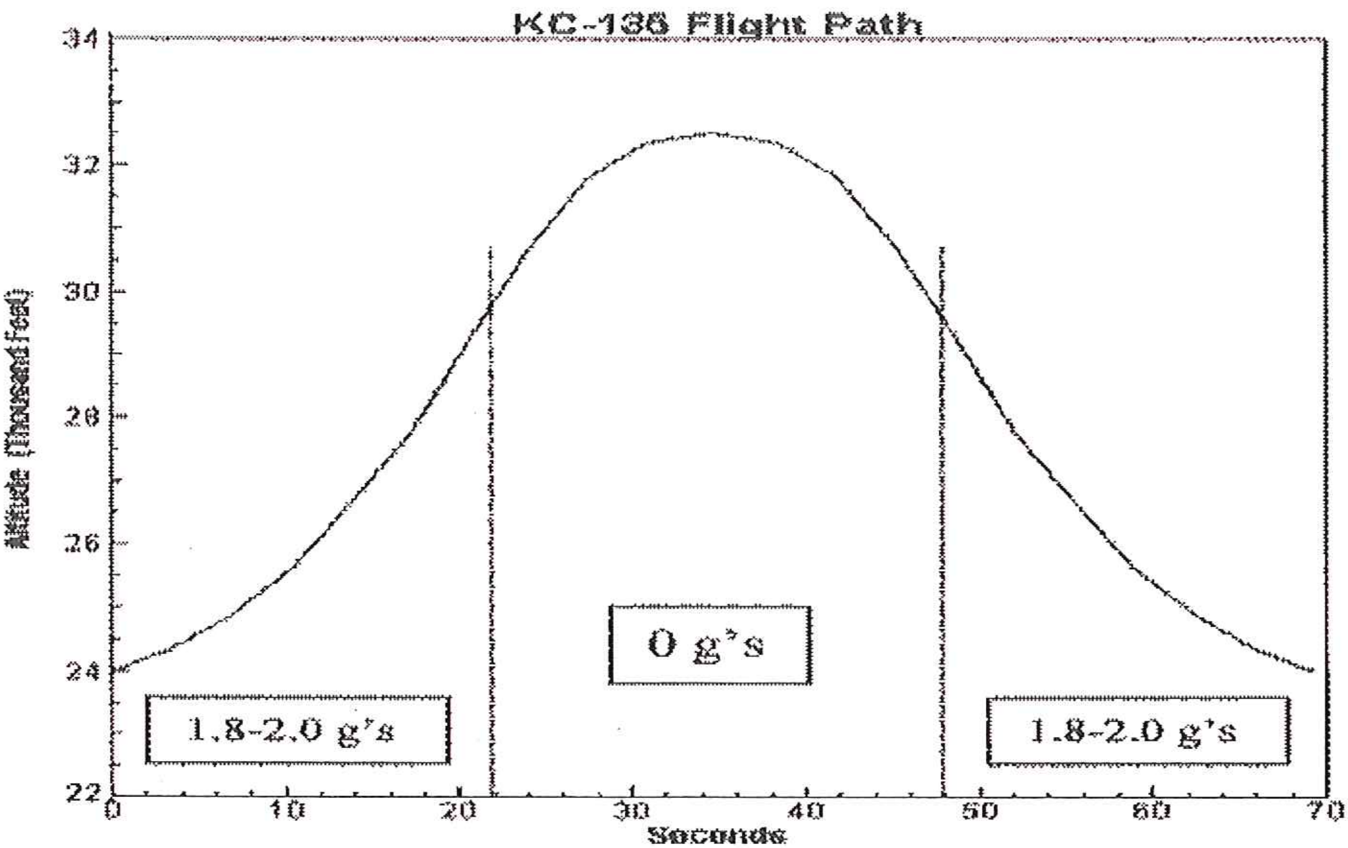
f. When the astronauts train for space travel, they fly in an Air Force plane, KC135, that flies in a trajectory, as illustrated below. The plane is dubbed the "Vomit Comet". According to the graph, how long a period of weightlessness is achieved in the Vomit Comet? How does the shape of the Air Time Hill and its weightless period compare to the Vomit Comet?



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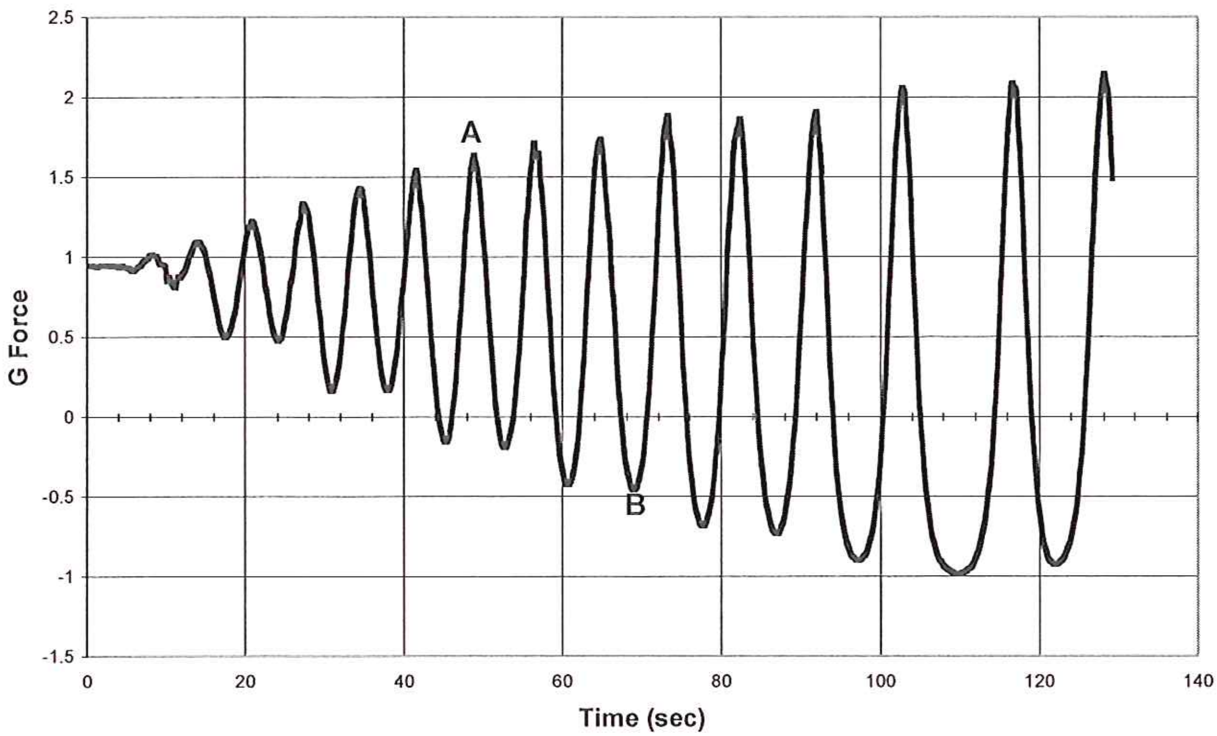
Phoenix



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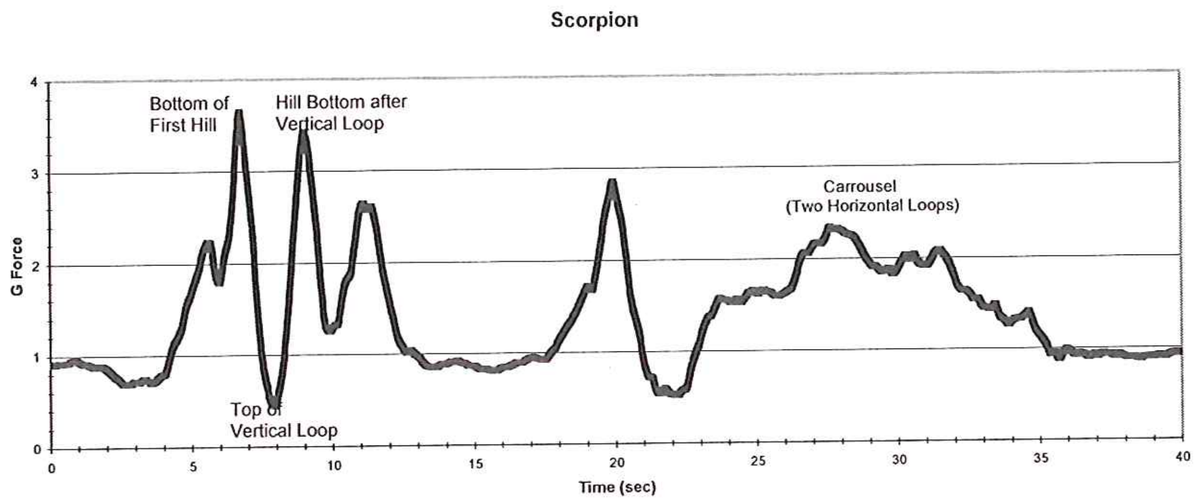

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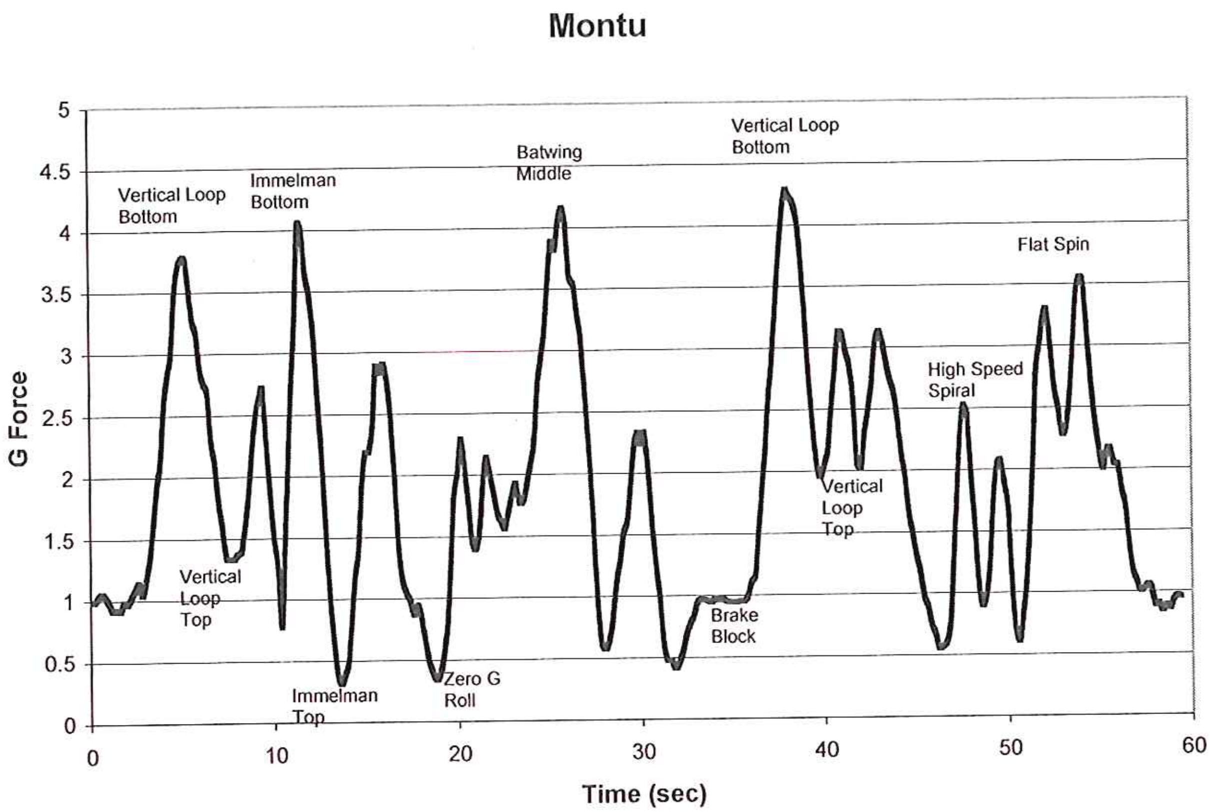

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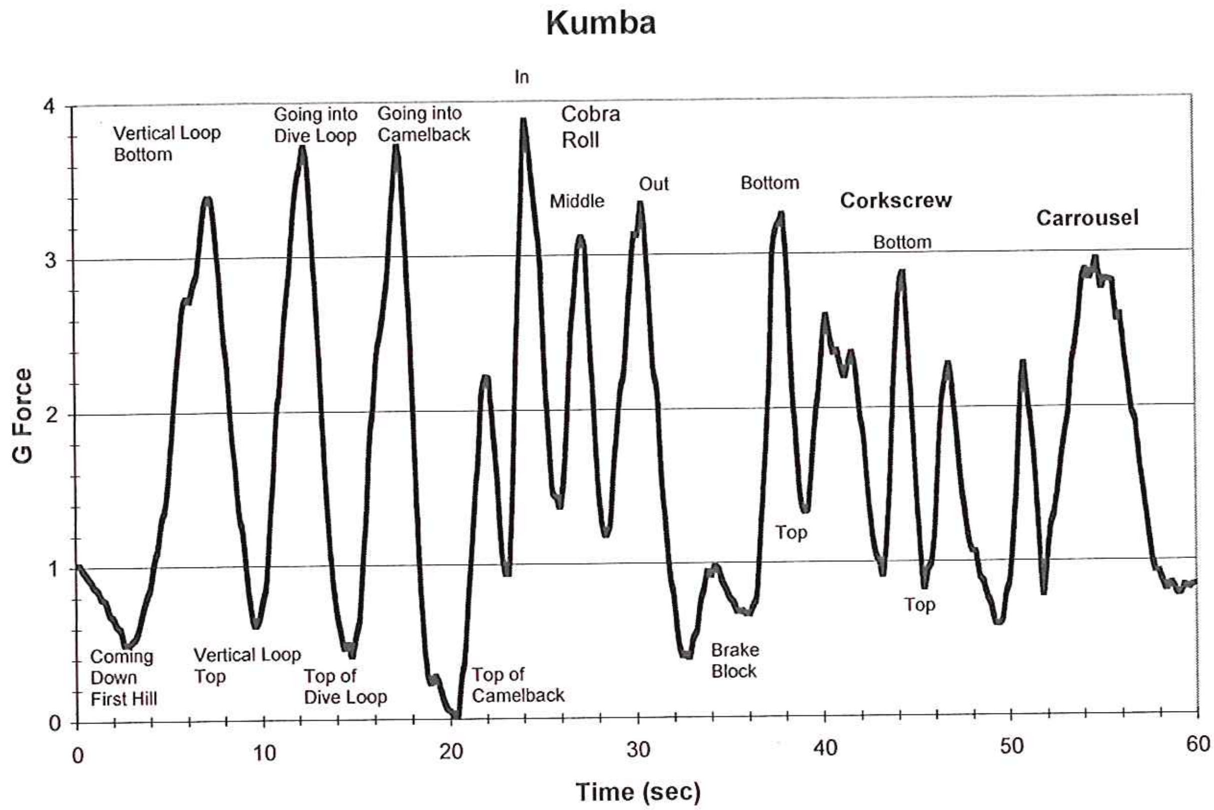

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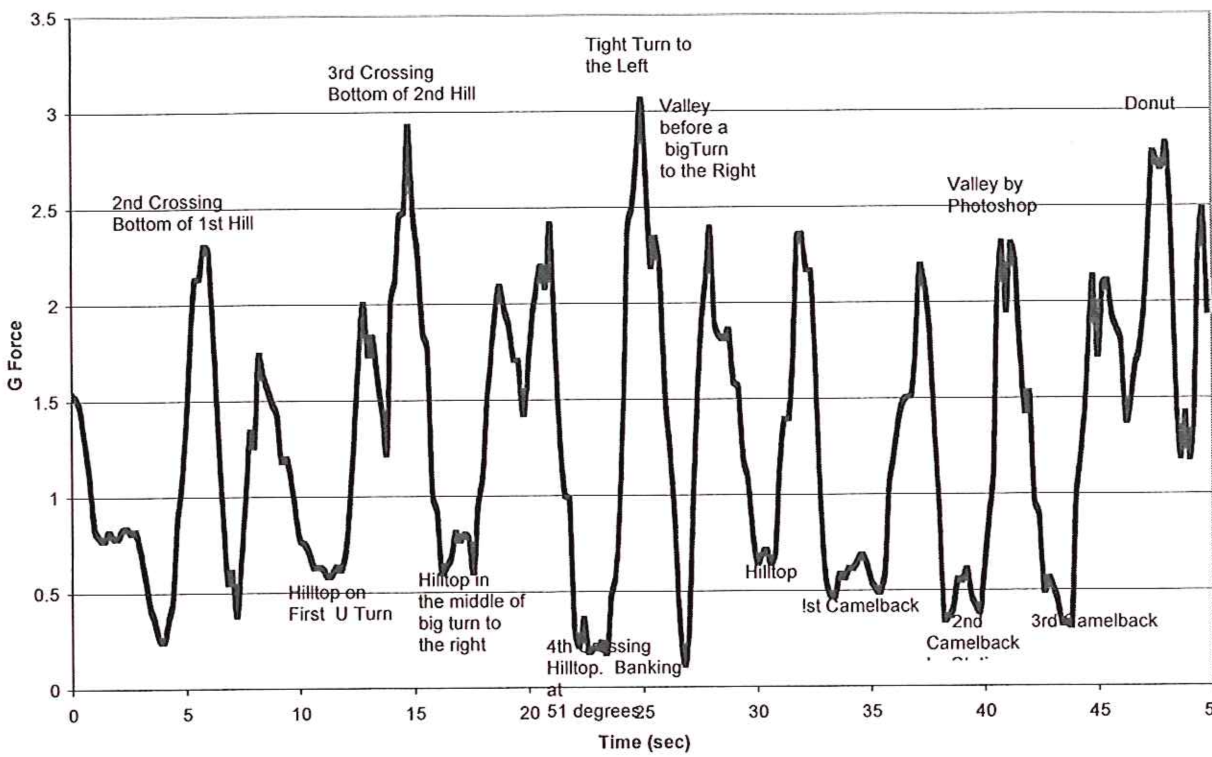
Gwazi Lion Middle Car



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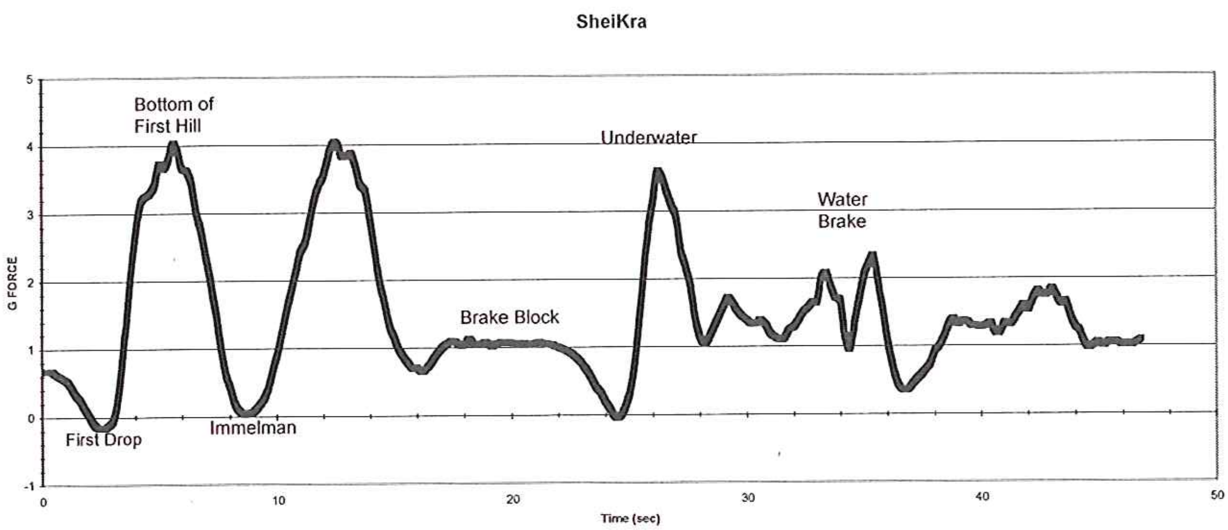

The information from the Physics Day program collateral is not based on any scientifically acc
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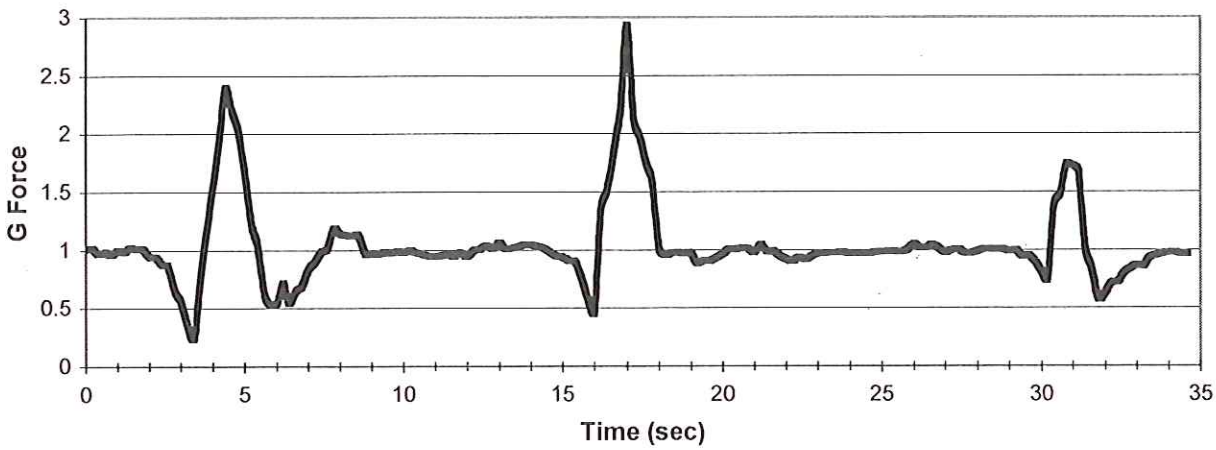
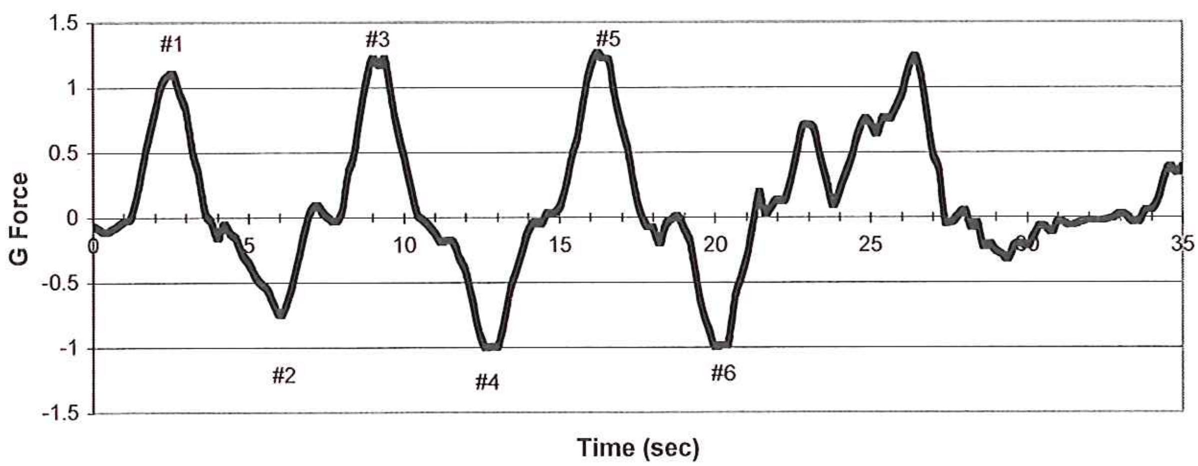
SandSerpent (Vertical Force)



SandSerpent (Horizontal Force)



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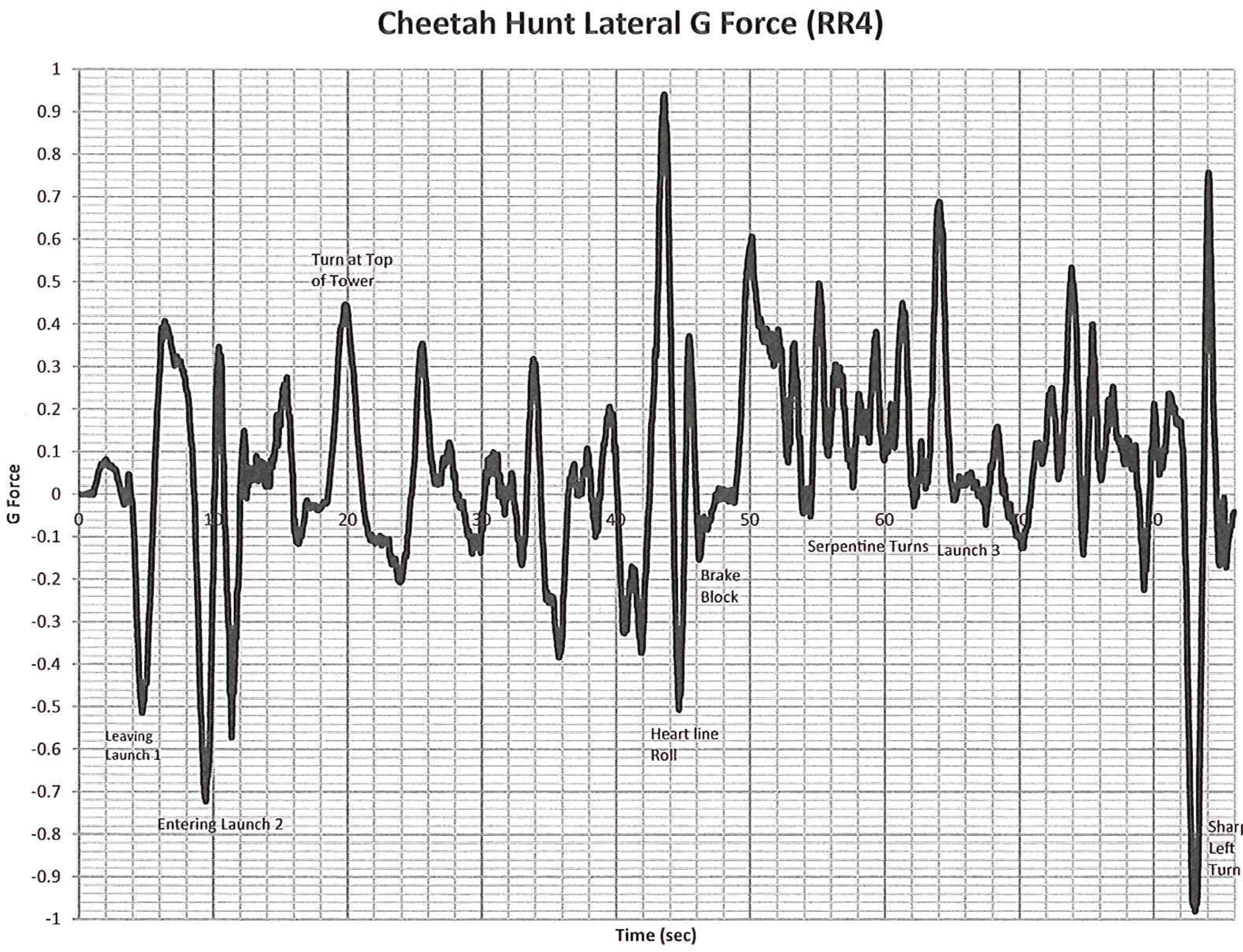

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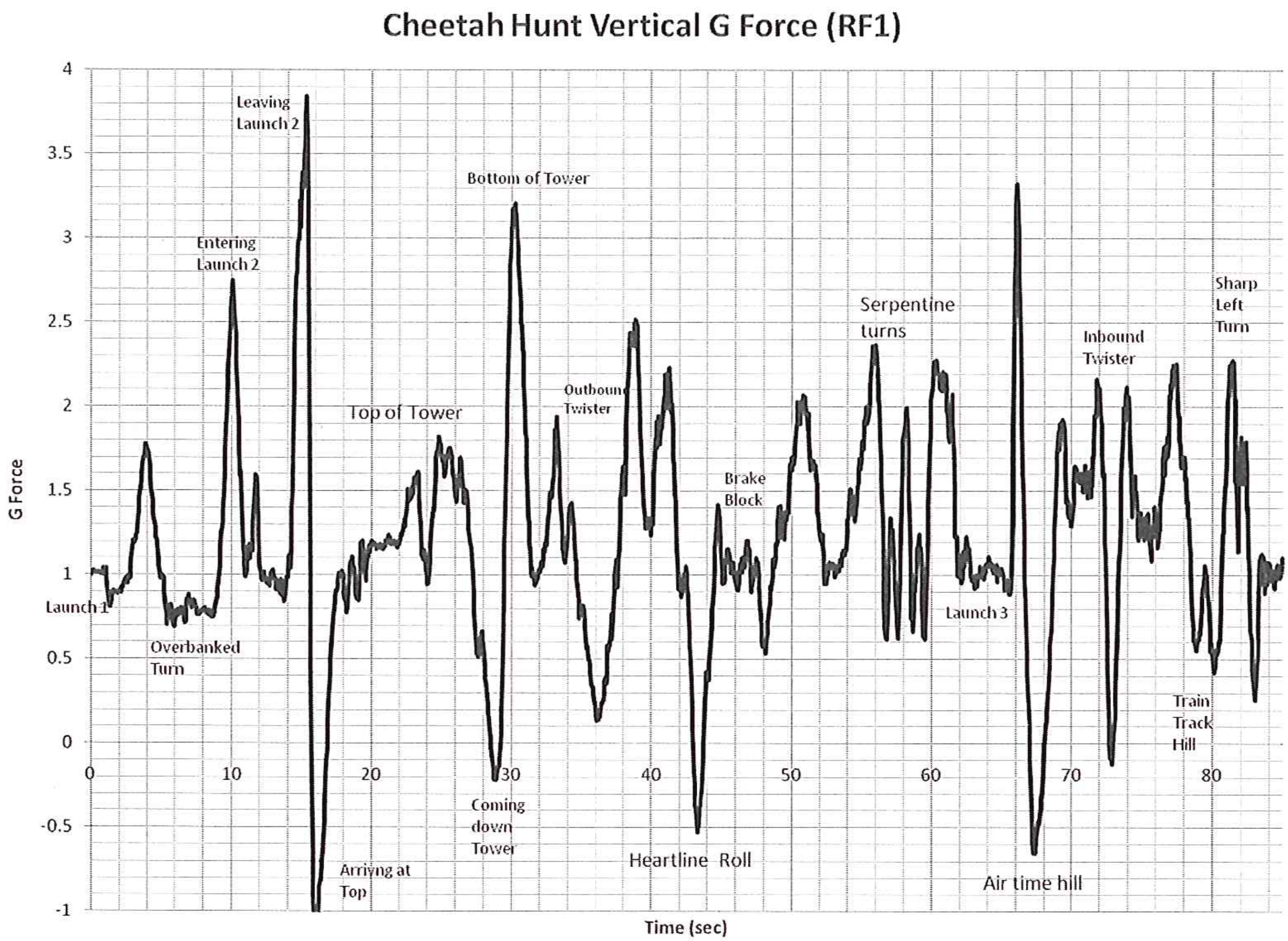

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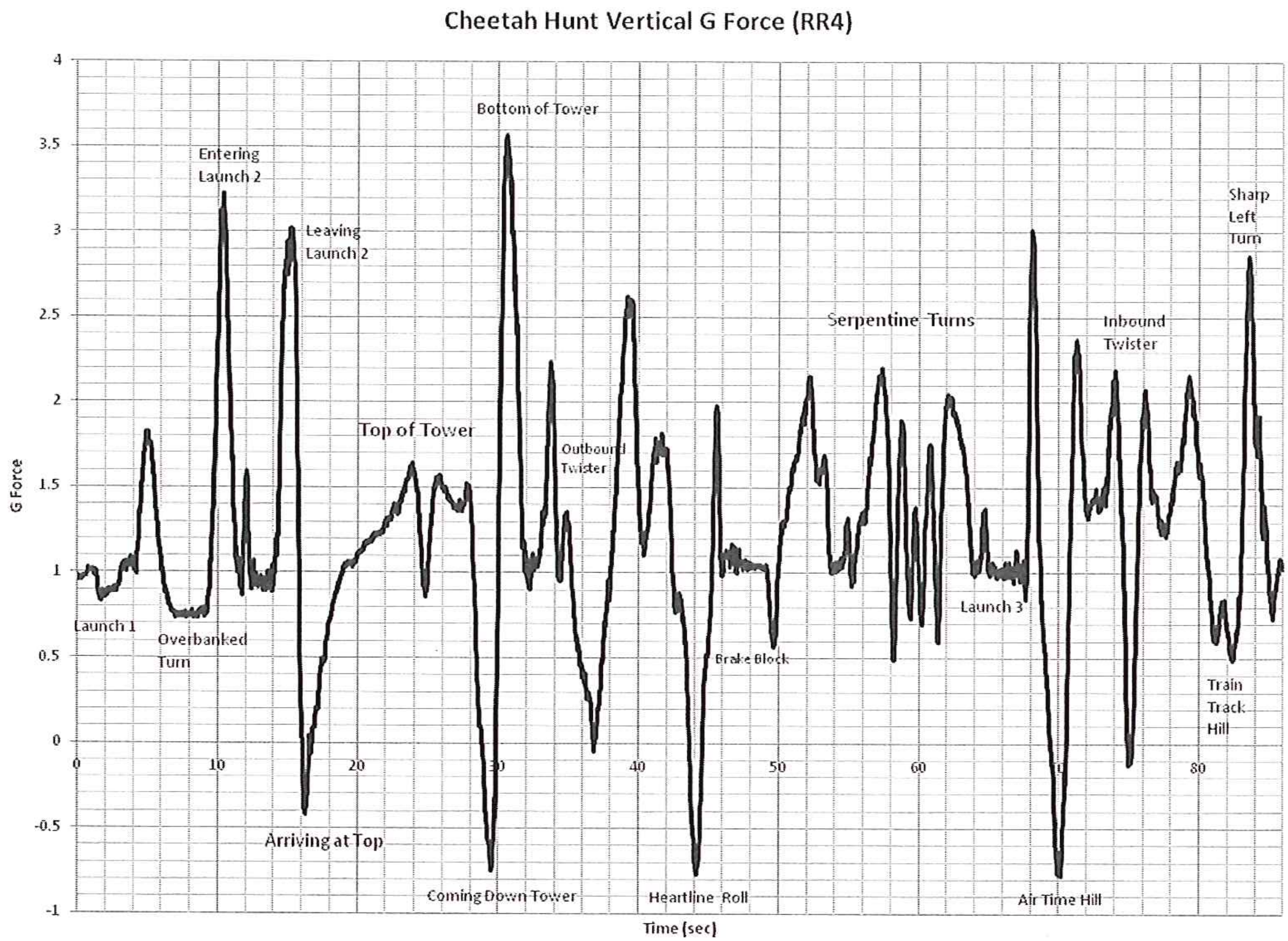

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