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| ***IB PHYSICS-1*** |
| Name: ______________________ |
| Period: ________ Date: ______________ |

DEVIL PHYSICS
BADDEST CLASS ON CAMPUS

# IB Physics-1
# 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 "Advanced" 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:<br>☐ 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:<br>☐ too easy ☐ just about right ☐ too hard |
| In terms of helping you understand the material presented in class, this lab was:<br>☐ not helpful ☐ somewhat helpful ☐ very helpful |

**IMPROVEMENT: This lab can be improved by:**

# LOG FLUME: Advanced

## INSTRUMENTS REQUIRED
Stopwatch

## WHAT TO DO BEFORE COMING TO THE PARK
1. Problems:
   a. A log has an initial velocity of 15 m/s and slows down to 3 m/s in a distance of 20 meters. What is the G Force?
   b. A log has an initial velocity of 12 m/s and slows down to 2 m/s in a time of 5 seconds. What is the G Force?
   c. A log whose velocity at the top of the hill is 2 m/s comes down a hill of height 10 m and has a speed of 12 m/s at the bottom of the hill. What fraction of energy was converted to heat on the way downhill?
2. Predictions:
   a. What will be the percentage of energy lost (converted to heat) coming down the last hill?
   10% 20% 30% 40% 50%

## WHAT TO MEASURE OFF THE RIDE
1. Time the log from the beginning of the splash to the end. This will be during the period that the log is in the narrow portion of the trough at the end of the hill.
2. Measure the time that it takes the log to pass a point at the end of the trough.

DATA TABLE

| | #1 | #2 | #3 | Average Time |
|---|---|---|---|---|
| Time from beginning to end of splash | | | | |
| Time for the log to pass a point at the end of the trough | | | | |

## IF YOU DIDN'T RIDE THE LOG FLUME: BASIC
1. Measure the time on the last drop for a log to go between light pole A and the beginning of the splash B. (See picture on the front page of Log Flume: Basic)

| | | | | |
|---|---|---|---|---|
| Time from A to B | | | | Average Time |

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



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accelerometer testing of the amusement rides. In fact, the testing was done solely for the purpo
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## Problems

1. Find the energy converted to heat coming down the hill.
   Height of hill = 12.2 m    Speed at the top of hill = 1.2 m/s

   Speed at the bottom of the hill = _____________(use the value that you computed based on the time between A and B)

2. Compute the speed at the end of the splash. Length of log = 2.9 m

3. Find the deceleration of the log at the splash by using the speed before the splash, the speed after the splash, and the distance of the splash. (The distance of the splash is approximately equal to the length of the narrow portion of the trough, which is 14.5 meters.) What is the horizontal G Force indicated by this deceleration?

4. Find the deceleration of the log at the splash by using the speed before the splash, the speed after the splash, and the time of the splash. What is the horizontal G Force indicated by this deceleration?

5. How do these two G Forces (problems 3 and 4) compare with each other and with the value obtained by the G Force Meter in LOG FLUME: Basic (if measured)?



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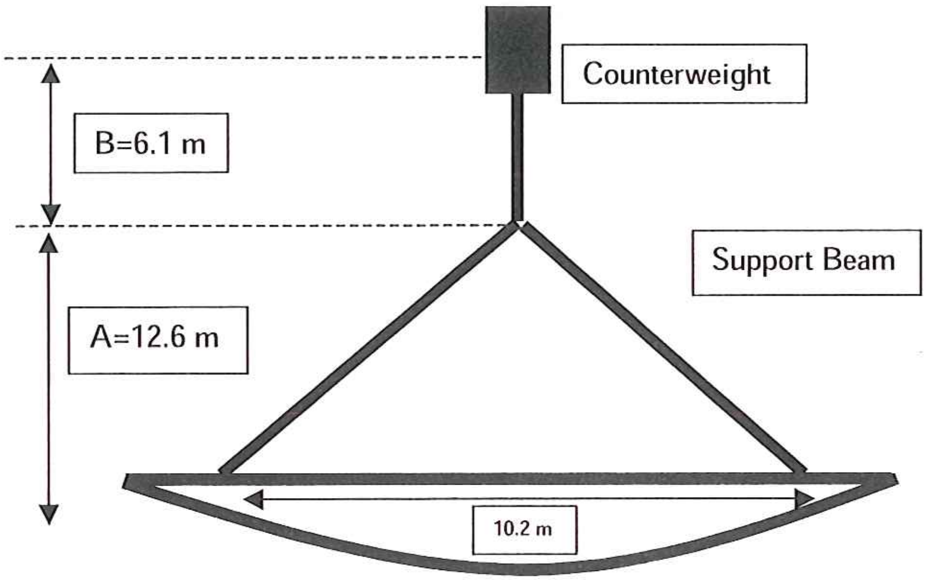
# PHOENIX: Advanced

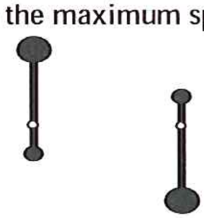



## INSTRUMENTS REQUIRED

Stopwatch (No instruments allowed on the ride!)

## WHAT TO DO BEFORE COMING TO THE PARK

1. Problems:
   a. Compute the maximum G Force on a pendulum whose length is 20 m and whose maximum speed is 15 m/s.
   b. An 8 m long rod which has a large mass on top and a smaller mass underneath is pivoted about a point 5 meters from the large mass. What is the maximum speed of the large mass as it swings down to the bottom?
   The large mass is 10 kg, and the small mass is 6 kg.



2. Predictions
   a. What is the maximum G Force experienced at the bottom of the swing?
   1 g    1.5 g's    2.0g's    2.5 g's    3.0g's
   b. Will you feel upside down at the top?    Yes    No

## WHAT TO NOTICE ON THE RIDE

1. Notice where the ride makes you feel heavy and where the ride makes you feel light.
2. When you are upside down, pay attention to your observations and feelings.
3. ***PHYSICS DAYS ONLY: Sit on the row in the middle of the boat and note the largest G Force, as indicated on the mounted G Force Meter. (Use your measurement and that of two friends) Record it below.

| | #1 | #2 | #3 | Average |
|---|---|---|---|---|
| G Force | | | | |



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## WHAT TO MEASURE OFF THE RIDE

1. Measure the time for the Phoenix to pass a point at the bottom of its swing. (Measure from one support beam to the other.)
2. Measure the drop time for the Phoenix. (Pick a cycle where the ride moves slow at the top but doesn't stop.)

DATA TABLE

| | Time #1 | Time #2 | Time #3 | Average Time |
|---|---|---|---|---|
| Time to pass at bottom | | | | |
| Drop time | | | | |

## Problems

In all of the problems, consider the zero reference level for the potential energy to be the bottom position of the center of gravity of the boat.

1. Using the principle of energy conservation, and assuming the counterweight to have no mass, compute the speed of the boat at the bottom of the swing.

2. Given that the mass of the counterweight is 12,500 kg, and that the mass of the boat is 8,250 kg, find the speed of the boat at the bottom of the swing. Assume that an average person has a mass of 68 kg, and the boat has 50 people (Hint: At any point, the velocity of the boat is about twice the velocity of the counterweight because of their distances from the rotational point.)

3. Compute the speed at the bottom of the swing using the time measurement for the boat to pass a point at the bottom (from one beam to the other, which is 10.2 m).



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4. Using the speed computed in Problem 3, compute the G Force as the bottom of the swing and compare it with the maximum G Force on the graph of G Force vs. Time. Compare it also with G Force from the mounted G Force Meter (if measured).

5. Does the period ever match the theory of a pendulum of length 12.6 m? Why does the period change? Period = 2*pi*Sqrt(L/g) where L is the Length, and g = 9.8 m/s$^2$.

## Questions

1. Name as many ways as you can to tell whether you are upside down. How is being upside down on the Kumba or Montu different than on the Phoenix?

2. Where did you feel the heaviest? Why? How did you feel when the Phoenix was dropping?

3. When the Phoenix is upside down, its center of gravity is about 25.2 m above its position when it is right side up. That's higher than the major hill on either the Scorpion. Why then is it much slower at the bottom than either of those two coasters?

4. How does the drop time compare with the drop time of the Scorpion? Why

5. Examine the G Force vs. Time graph; describe what the boat is doing at points A and B. When the graph crosses the 0 line, where is the boat?

6. Looking at the graph, do you ever feel 'normal" or 1 g? What does a negative G Force mean?



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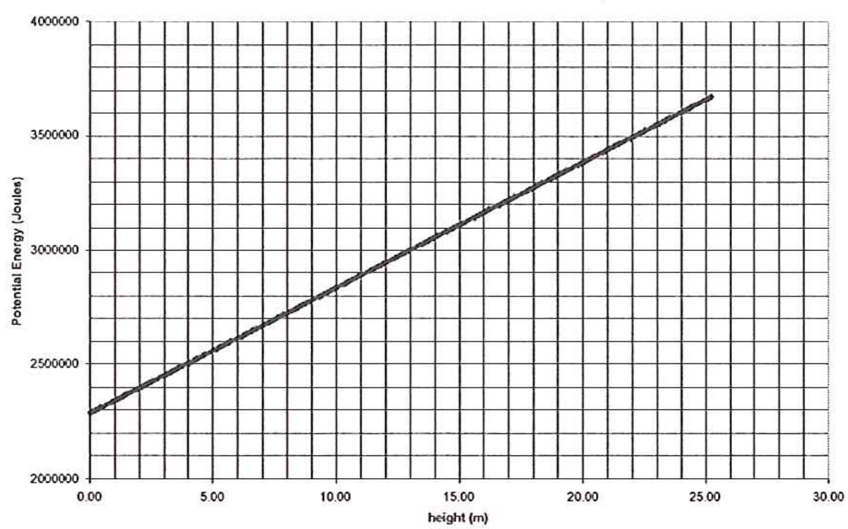
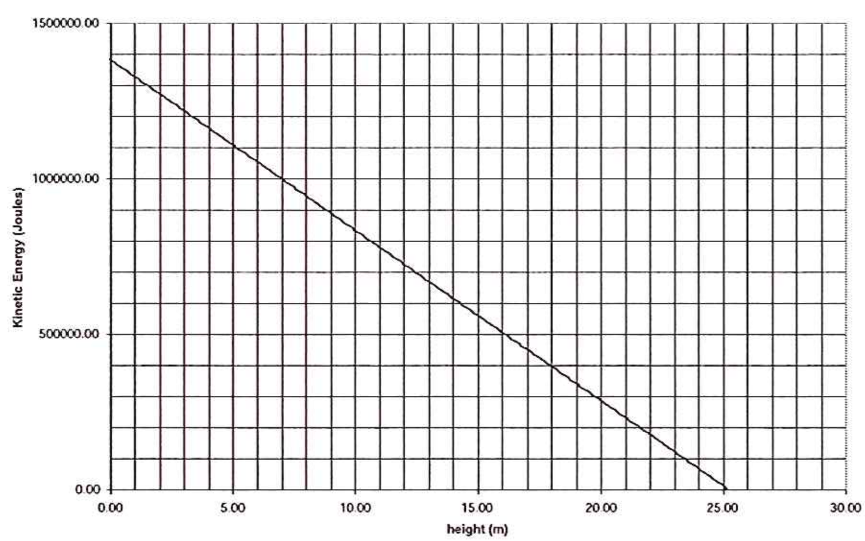
7. Where does the energy come from to get the boat up high?

8. Look at the Potential Energy vs. Time and the Kinetic Energy vs. Time graphs. The height measures the center of gravity of the boat.

**Potential Energy vs. Height**




**Kinetic Energy vs. Height**



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a. Why isn't the potential energy zero when the height of the center of mass of the boat is zero?

b. What is the total energy at h = 0? What is the total energy at h = 10 meters? What is the total energy at h = 25 m?

c. At what height is the Kinetic Energy equal to half the maximum Kinetic Energy?

d. How will the speed at the bottom compare with the speed at that point of half Kinetic Energy?

1. Four times as big
2. Two times as big
3. The square root of 2 times as big



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# TIDAL WAVE: Advanced

## INSTRUMENTS NEEDED
Stopwatch

## WHAT TO DO BEFORE COMING TO THE PARK
1. Problems:
   a. Given that a boat slows down from 10 m/s to 2 m/s in 15 meters, compute the acceleration of the boat and the horizontal G Force experienced.
   b. A boat comes down from a hill of height 12 meters and has a speed of 13 m/s at the bottom of the hill. What is the percentage energy loss?
2. Predictions
   a. How much energy will be lost (converted to heat) coming down the big drop?
   10% 20% 30% 40% 50%

## WHAT TO DO OFF THE RIDE
1. Measure the distance of the splash. (The posts in the water are 0.8 meters apart.)
2. Measure the time that it takes the boat to pass a fixed point after the splash is over.

DATA TABLE

| | #1 | #2 | #3 | Average |
|---|---|---|---|---|
| Distance of the splash | | | | |
| Time to pass a fixed point after the splash | | | | |

## IF YOU DIDN'T DO TIDAL WAVE: BASIC
1. Time the boat from A to B at the bottom of the drop. (See picture on front page of Tidal Wave: Basic.)

| | | | | |
|---|---|---|---|---|
| Time from A to B | | | | Average Time |

2. Given that the distance from A to B is 10.9 m, compute the speed of the boat at the bottom of the hill.

Speed at bottom of hill_____________

3. Ask someone for their Horizontal G Force Meter measurement.

Horizontal G Force _____________



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## Problems

1. Compute the speed of the boat after the splash. Length of the boat = 4.7 m

2. Compute the acceleration and G Force of the boat at the splash by using the speed before and after the splash and the distance of the splash.

3. How does the value of the G Force computed in Problem 2 compare with the G Force measured with the Horizontal G Force Meter? (If you didn't measure this yourself, you can get the measurement from someone who did.)

4. Given that the Tidal Wave hill is 15.2 m high, and the speed at the top is 1.5 m/s, compute the percentage of energy loss in the boat coming down the hill.

5. What would be the speed of the boat with no energy loss?



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# SCORPION: Advanced

## INSTRUMENTS REQUIRED

Horizontal G Force Meter; Stopwatch

## WHAT TO DO BEFORE COMING TO THE PARK

1. Problems:

a. Compute the percentage of energy loss experienced if the height of a coaster hill is 15.0 m and the velocity at the end of the ride is 8 m/s. Assume a zero speed at the top.

b. The top of the coaster appears at an elevation of 50 degrees. When you walk back an additional 15 meters, it is now at an elevation of 30 degrees. What is the height of the coaster

2. Predictions: How much energy will be lost (converted to heat) coming down the first hill? 10% 20% 30% 40% 50%

3. Construct a Horizontal G Force Meter with hand-strap.

## WHAT TO MEASURE OFF THE RIDE

1. Measure the time for the coaster to pass a point at the top of the vertical loop.
2. Measure the time for the coaster to pass a point on the top horizontal loop near the end of the ride.
3. Measure the angle of elevation of the top of the coaster hill; walk back a fixed distance and then measure the new angle of elevation

DATA TABLE

| | #1 | #2 | #3 | Average |
|---|---|---|---|---|
| Time to pass a point at the top of the loop | | | | |
| Time to pass a point on the top horizontal loop | | | | |
| Initial angle | | | | |
| Fixed Distance | | | | |
| Final angle | | | | |

## WHAT TO DO IF YOU DIDN'T DO SCORPION BASIC

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

| | | | | |
|---|---|---|---|---|
| Time to pass a point at the bottom of the hill | | | | Average Time |

2. Find the speed of the coaster at the bottom of the first hill given that the length of the coaster = 10.7 m



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## Problems

1. Compute the G Force at the bottom of the first hill. Radius of the hill bottom = 14.1m. Compare this number to that on the G Force vs. Time graph at the end of this workbook.

2. Compute the velocity of the coaster at the top of the vertical loop. Length of the coaster is 10.7 meters. Using this velocity, compute the G Force at the top of the vertical loop. Radius of the top of the loop = 5.4 m. Compare this number to that on the G Force vs. Time graph at the end of this workbook.

3. Compute the velocity in the horizontal loop. Compute the banking angle, and find the G Force in the horizontal loop, given that the radius of the loop is 8.1 m. Compare this value of the G Force to the value from the G Force vs. Time graph at the end of this workbook.

4. Compute the percentage of energy converted to heat coming down the first hill. The velocity at the top of the hill is approximately 1 m/s. Top of hill is 19.8 m above the ground. Lowest point is 0.8 meters above the ground.

5. Compute the percentage of energy converted to heat by the end of the ride, just before the brakes. The speed at this point is 11.8 m/s, and the track is .8 m off the ground.



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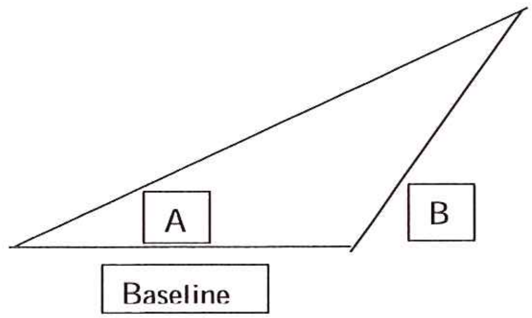
6. Find the height of the top of the first hill using your angle measurements.

H= (baseline)*sin (B)*sin(A)/(sin(B-A))




7. The radius of the top of the vertical loop is 5.4 m, and the radius of the bottom of the loop is 14.1 m. Compute the G Force at the bottom of the vertical loop if the loop were a circle of radius 5.4 meters, instead of the teardrop or clothoid that it is.



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# MONTU: Advanced

## INSTRUMENTS REQUIRED

Stopwatch (No instruments allowed on the ride!)

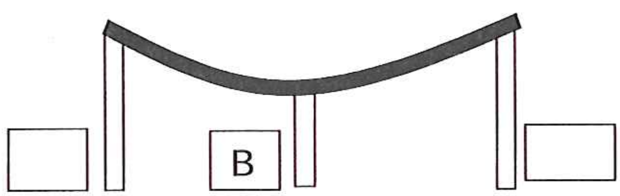
## WHAT TO DO BEFORE COMING TO THE PARK

1. Problems:
   a. Compute the G Force experienced by passengers at the top of a vertical loop of radius 6 m, where the velocity is 10 m/s.
   b. Compute the G Force experienced by passengers at the bottom of a hill where the radius is 30.0 m and the speed is 25 m/s.
   c. A roller coaster descends a hill of height 30.0 m. If its speed at the top is small, and its speed at the bottom is 22 m/s, what is the percentage energy loss?

2. Prediction: What will be the energy loss of the coaster just prior to the braking at the end of the ride? 30% 40% 50% 60% 70% 80%

## WHAT TO DO OFF THE RIDE

1. Measure the time for the coaster to pass between post A and post C at the hill bottom following the Immelman, where Post A is the second post in the grass and post B is the lowest point of the track. (Start your stopwatch when the front car passes post A, and stop it when the front car passes post C).




| | | | | |
|---|---|---|---|---|
| Time to pass between A and C | | | | Average Time |

## WHAT TO DO IF YOU DIDN'T RIDE MONTU: BASIC

1. Measure the time for the coaster to pass the top of the second vertical loop (#9).

| | | | | |
|---|---|---|---|---|
| Time to pass the top of the vertical loop | | | | Average Time |

2. Given that the length of the coaster is 11.6 m, find the speed of the coaster at the top of the loop.



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## WHAT TO DO ON THE RIDE (Physics Days Only)

1. Sit in the second row where you can see the mounted accelerometer, and note the G Force at the bottom of the hill following the Immelman and at the top of the second loop. Take three readings yourself or use your reading and that of two friends.

DATA TABLE

| | #1 | #2 | #3 | Average |
|---|---|---|---|---|
| Bottom of hill | | | | |
| Top of loop | | | | |

## Problems

1. Find the speed of the coaster at point B, just after the Immelman. Use the time to go between posts A and C, and the fact that the distance between posts A and C is 22.0 m.

2. Compute the G Force at the bottom of the hill following the Immelman. Use your computed speed and a radius of 30.0 meters. Compare your answer with the value obtained from the G Force vs. Time graph at the end of the workbook and to the G Force Meter reading (if measured).

| Computed value of G Force | Value from graph | Average G Force reading (if measured) |
|---|---|---|
| | | |



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3. Compute the G Force at the top of the second loop. Use your computed speed and a radius of 5.5 meters. Compare your answer with the value obtained from the G Force vs. Time graph and to the accelerometer reading (if obtained).

| Computed value of G Force | Value from graph | Average G Force reading |
|---|---|---|
| | | |

4. The first hill is 39.9 m above the ground level. Near the end of the ride, where the coaster is near ground level, the speed of the coaster is 16 m/s. What has been the percentage energy loss (converted to heat) at this point?



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# KUMBA: Advanced

## INSTRUMENTS REQUIRED

Stopwatch (No instruments allowed on the ride!)

## WHAT TO DO BEFORE COMING TO THE PARK

1. Problems:
   a. Compute the G Force acting on a rider who is upside down at the top of a loop of radius 10 m whose speed is 12 m/s.
   b. Compute the G Force acting on a rider who is at the bottom of a hill of radius 40 m whose speed is 30 m/s.

## WHAT TO DO ON THE RIDE

1. Ride the coaster near the front and then again near the back. Notice the differences at the tops and bottoms of the hills, especially in the Cobra Roll and in the Vertical Loop.
2. On Physics Days Only: Sit in the second row, in view of the mounted G Force Meter, and record the G Force at the following locations: bottom of the first hill; top of the vertical loop; top of the first corkscrew; carrousel.
   Record three readings if possible (or use yours and those of two friends) and find the average.

## WHAT TO MEASURE OFF THE RIDE

1. Time the descent of the first car from the top of the Cobra Roll to the lowest point. Then do the same thing for the last car. (This is most easily done on the bridge to the Congo)
2. Measure the time it takes the coaster to pass the top of the vertical loop. (Start the stopwatch when the front of the first 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 of descent of first car | | | | |
| Time of descent of last car | | | | |
| Time to pass the top of the vertical loop | | | | |



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# Physics Day Only Ride Data

| | #1 | #2 | #3 | Average |
|---|---|---|---|---|
| Bottom of first hill | | | | |
| Top of vertical loop | | | | |
| Top of first corkscrew | | | | |
| carrousel | | | | |

## WHAT TO DO IF YOU DIDN'T DO KUMBA: BASIC

1. Measure the time it takes the coaster to pass the top of the first corkscrew.

| | | | | |
|---|---|---|---|---|
| Time to pass the top of the corkscrew | | | | Average time |

2. Compute the speed at the top of the corkscrew using the measurement of the time it takes to pass the top of the corkscrew. Length of the coaster = 13.1 m

3. Looking at the Banking Angle vs. Speed graph in Kumba: Basic, determine the banking angle for a speed of 15 m/s. Then use the G Force vs. Banking Angle graph to determine the G Force. These graphs are based upon the radius of curvature of the carrousel, which is the horizontal loop near the end of the Kumba.

Banking angle =__________ G Force = ____________

## Questions

1. How was riding in the front car different from riding in the back car?

2. Why are the two descent times measured on the Cobra Roll so different? Is the descent time also different for the first and last cars on the other hills (Dive Loop, First Drop, etc.)?



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## Problems

1. Compute the banking angle and the G Force in the carrousel based upon a speed of 15 m/s and a radius of curvature of 8.5 m. Compare your calculated values with the values obtained from the G Force vs. Banking Angle and the Banking Angle vs. Speed graphs in Kumba: Basic. How do your G Force calculations compare with the G Force vs. Time graph at the end of the workbook and the value from the G Force Meter ( if measured)?

| | Calculated | Two graphs in Kumba: Basic | G Force vs. Time graph | G Force from the G Force Meter |
|---|---|---|---|---|
| G Force | | | | |
| Banking Angle | | | XXXXXXX XXXXXXX XXXX | XXXXXXX XXXXXXX XXXX |

2. Compute the speed of the coaster at the top of the vertical loop. The length of the coaster is 13.1 m

3. Using the just-computed speed of the coaster at the top of the vertical loop , compute the G Force at the top of the vertical loop. The radius of curvature at the top is 7.2 m.

4. Using the speed at the top of the corkscrew, compute the G Force at the top of the corkscrew, given a radius of curvature of 7.6 m.



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5. Compute the G Force at the bottom of the first hill. The velocity at this point is 27.5 m/s, and the radius of the curvature of the track is 29 m.

6. Find the percentage of energy converted to heat by the time the coaster reaches the top of the vertical loop. Elevation of the first hill above lowest point = 40.8 m

   Elevation of the Vertical Loop above lowest point = 30.9 m
   Speed up the incline = Speed at top of first hill = 2.3 m/s.

7. The vertical loop is called a clothoid. It has a variable radius, with the radius large at the bottom and small at the top. To investigate what would happen if the loop were a circle, assume that the loop has the same height (30.9 m), but also that it had a constant radius (r = 15.5 m). The velocity at the top would still be the same as you measured earlier, and the velocity at the bottom would also be the same as at the bottom of the first hill (27.5 m/s). Based on this information, explain why vertical loops are not circles. (Hint: Compute the G Force at the bottom and at the top.)

8. Compare your calculations for the G Forces at the top of the vertical loop, at the top of the first corkscrew, and at the bottom of the first hill with the values indicated on the G Force vs. Time graph and with the mounted G Force Meter (if obtained). Why are the values different? (The graph was made with a CBL, Low G accelerometer and a TI 83 Calculator on the Kumba in the first car.)

| | G force at bottom of first hill | G force at top of vertical loop | G force at the top of the first corkscrew |
|---|---|---|---|
| From calculation | | | |
| From graph | | | |
| From mounted G Force Meter | | | |



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# SHEIKRA: Advanced

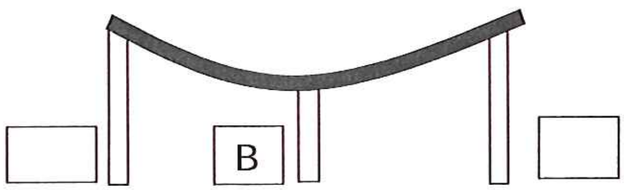
## INSTRUMENTS REQUIRED
Stopwatch (No instruments allowed on the ride!)

## WHAT TO DO BEFORE COMING TO THE PARK
1. Predictions:
   a. What will the G Force be at the bottom of the hill? 2 3 4
   b. What is the maximum speed of SheiKra? 50 mph 60 mph 70 mph

2. Problems:
   a. What is the G Force experienced when a coaster is at the bottom of a hill of radius 10 m, with a speed of 20 m/s?
   b. What is the percentage energy loss when the coaster decreases its speed from 30 m/s to 15 m/s?

## WHAT TO NOTICE ON THE RIDE
1. Notice your feelings as the coaster "splashes" through the water.
2. Pay attention to which point on the ride has the most intense G Forces.

## WHAT TO NOTICE OFF THE RIDE
1. Time the coaster at the bottom of the first hill between posts A and C.




2. After the coaster goes underwater, time it between the two blue posts at its highest point.
3. Time the splash of the water brake.

DATA TABLE

| | #1 | #2 | #3 | Average |
|---|---|---|---|---|
| Between A and C | | | | |
| Between two blue posts | | | | |
| Water brake | | | | |



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## Questions

1. The speed at the bottom of the hill of the Immelman (26.5 m/s) is less than the speed at the bottom of the drop after the brake block (28 m/s). Why?

2. Referring to the SheiKra G Force graph at the end of the workbook, why is the G Force at the middle of the water brake close to 1 G?

3. Referring to the SheiKra G Force graph, which of the high G Force portions of the ride — the bottom of the first hill or coming out of the Immelman — is the most intense? Which lasts the longest at high G Force? How does this compare with your experience?

## Problems

1. Compute the velocity at the bottom of the first hill. The distance between posts A and C is 20.7 meters.

2. Compute the G Force at the bottom of the first hill. The radius of curvature is 38.1 m. How does your computed G Force compare with the G Force indicated on the SheiKra G Force graph?

3. Compute the velocity at the top of the hill after going underwater. The distance between posts is 15 meters.



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4. Compute the energy loss at this point, compared with at the top of the first hill. At the top of the first hill, the velocity is zero and the height is 61 m. At the point measured at the top of the hill after going underwater, the height is 23.1 m.

5. In the water brake, the speed decreases from approximately 24 m/s to 22 m/s. How much of the remaining energy is lost?

6. Using your time of splash, what is the Horizontal G Force experienced in the water brake? Did you feel a significant force during the water brake?



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# CHEETAH HUNT: Advanced

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.

RF1 (Right Front seat of the 1st coaster car in the four car train)
RR4 (Right Rear seat of the 4th coaster car in the four car train)

INSTRUMENTS
Stopwatch

WHAT TO DO BEFORE COMING TO THE PARK
**Problems**

a. If the speed of a coaster car is 18 m/s, and the radius of curvature at the bottom of a hill is 20 m, what is the g force experienced by the riders?
b. If a coaster car has a speed of 12 m/s at the top of the hill, what will the speed be at the bottom of the hill that is 10 m lower?
c. If a coaster car has a speed of 15 m/s at the top of an airtime hill (parabolic) with a radius of curvature of 25 m, what would be the g force experienced by the passengers?

**Predictions**

a. Which coaster car will experience the most g's as the coaster train begins to go up the tower?

1st Car 4th Car

b. Coming down the tower, which coaster car will experience the most g's as the train pulls out of the dive?

1st Car 4th Car

c. What is the longest time that you will feel heavy (more than 2 g's) on the ride?

1.3 seconds 1.8 seconds 2.4 seconds 3.1 seconds



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## WHAT TO DO AND NOTICE ON THE RIDE

1. Ride in the first car of the train and the last car of the train. Notice any differences in where you feel the heaviest on the ride.
2. There are two trains loaded at a time. Ride in the front train, and later ride in the second train. Notice any differences on the first launch.

## WHAT TO MEASURE OFF THE RIDE

1. Time the coaster train between the highest two posts off the Outbound Twister (this is just after you come down from the tower). Make three measurements and compute the average.
2. Measure the front to back time of the coaster train as it passes the first post at the top of the tower.

**Data**

| | #1 | #2 | #3 | Average |
|---|---|---|---|---|
| Time between posts of the Outbound Twister | | | | |
| Front to back time a the top of the tower | | | | |

# Questions

1. a. The element of the track that seems to have the highest g's for the longest time is at the bottom of the tower coming down. Looking at the graph at the top of the next page, list the maximum g's and estimate how long you felt heavy (heavy> 2.0 g's).

   b. Looking at the Cheetah Hunt Vertical G Force (RR4) graph, which other three elements have more than 2 g's for the greatest time? How does this compare with your experiences on the ride? List the name of the element, the g force and the time that it was greater than 2 g's.

| Name of Element | G Force | Time |
|---|---|---|
| ______________________ | ________ | ________ |
| ______________________ | ________ | ________ |
| ______________________ | ________ | ________ |



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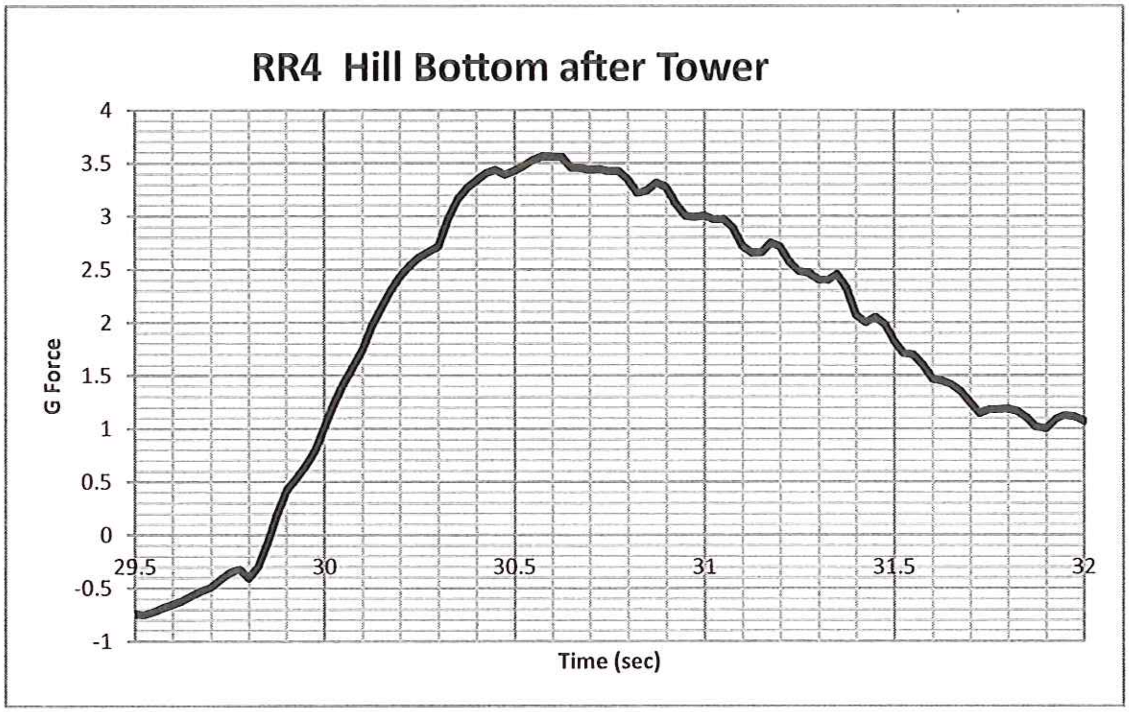
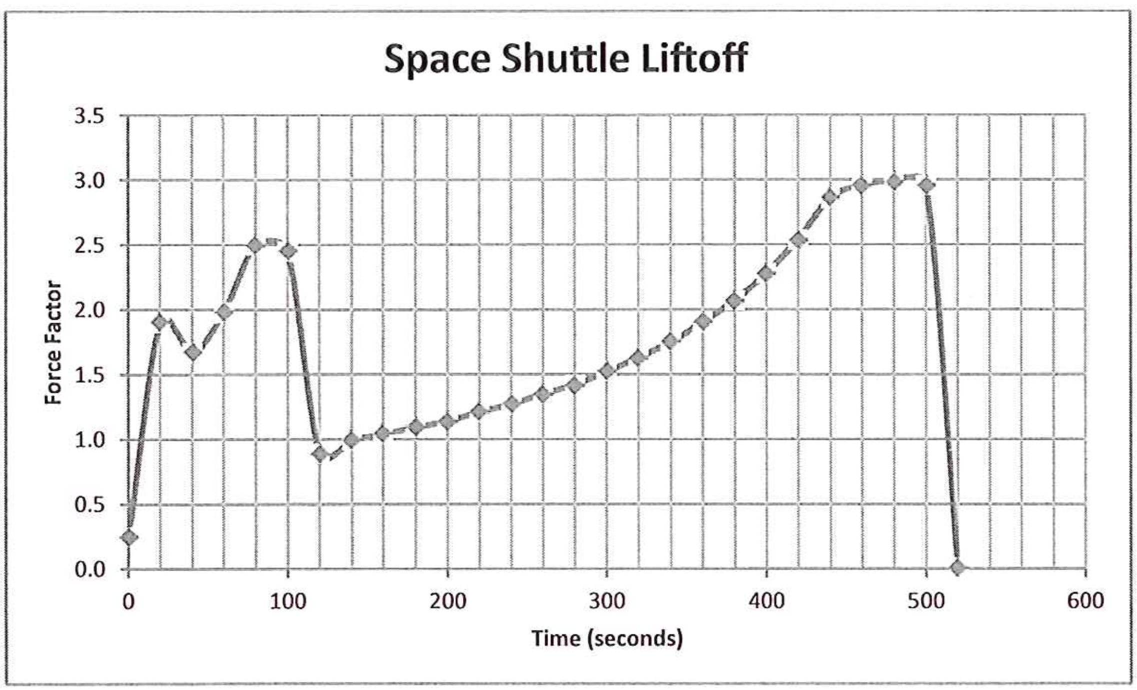



c. Compare your heavy experiences on the Cheetah Hunt with the lift off of the Space Shuttle, illustrated below.



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2. The Cheetah Hunt is a Linear Synchronous Motor Coaster. There is a friction wheel system to get the coaster into and out of the station, but otherwise it is electromagnetically accelerated. There are permanent rare earth magnets mounted on the coaster, and three launch areas that contain powerful electromagnets. There is no physical contact between the permanent and electromagnets, thus no wear and tear on the system. These magnets operate at 400 V and thousands of amps. The system uses computer systems with sensors to keep the Cheetah Hunt exceptionally consistent. For example, we timed five launches just before the Tower with the aid of a radar gun. Each train had different loads, and yet three of the launches were exactly the same, and the other two were only 0.1 mph faster or slower than the other two.

   a. The system is set up so that if a car does not succeed in getting up the hill after the launch, the coaster will roll back into the launch area to be re-launched. Obviously the re-launches for launch 2 and 3 will need to be more powerful, since it will be starting from zero, as opposed to already moving when it comes into the launch area. (Note: Re-launches are very rare.) Why do copper plates pop up in the middle of the track after the coaster has cleared the launch area? Also, why are there copper plates at the end of the ride?

   b. Why is it necessary to have a third launch, when the Air Time hill after the third launch is lower than the tower.

   c. Why is there a strap on the back of the last car that seems to drag along?



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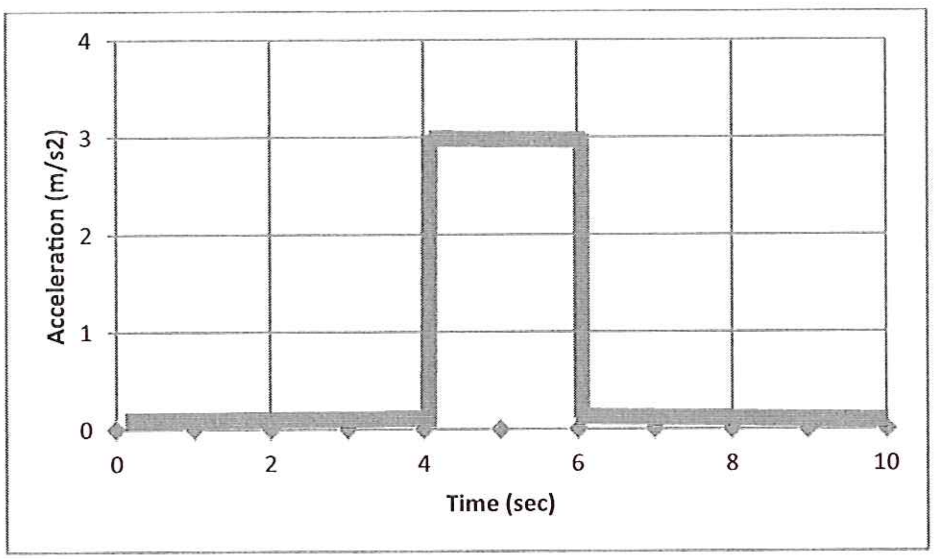
## Problems

1. Two trains line up and load in the station at the same time. On the next page you will find the acceleration graphs of the 1st launch of the first train, and the 1st launch of the second train.

   a. How would you describe the differences in these two launches? Does this match your experiences of the first and second trains?

   b. Why do these two launches need to be different?

   c. Look at the graph below of acceleration versus time.




This object has an acceleration of 3 $m/s^2$ for 2 seconds. The equation v=at produces a velocity of 6 m/s. If you look at the rectangle on the graph (formed between 4 and 6 seconds) it has an area (length x width) of 6 m/s. It turns out that the velocity change indicated on any acceleration versus time graph is the area under the curve, even when it is not a regular shape.

The graphs on the next page are of the 1st launches of the first train and the second train. You can approximate the area under the curve by counting the number of squares under each curve. You can also count partial squares to add up to the total. Each square is .1 sec by .5 m/s2 , which equals 0.05 m/s. (i.e. If there were 120 squares under the curve then the change in velocity would be 6 m/s.

$\Delta$V (first train) = ________ squares= ____________ m/s

$\Delta$V (second train)= ________squares=____________m/s



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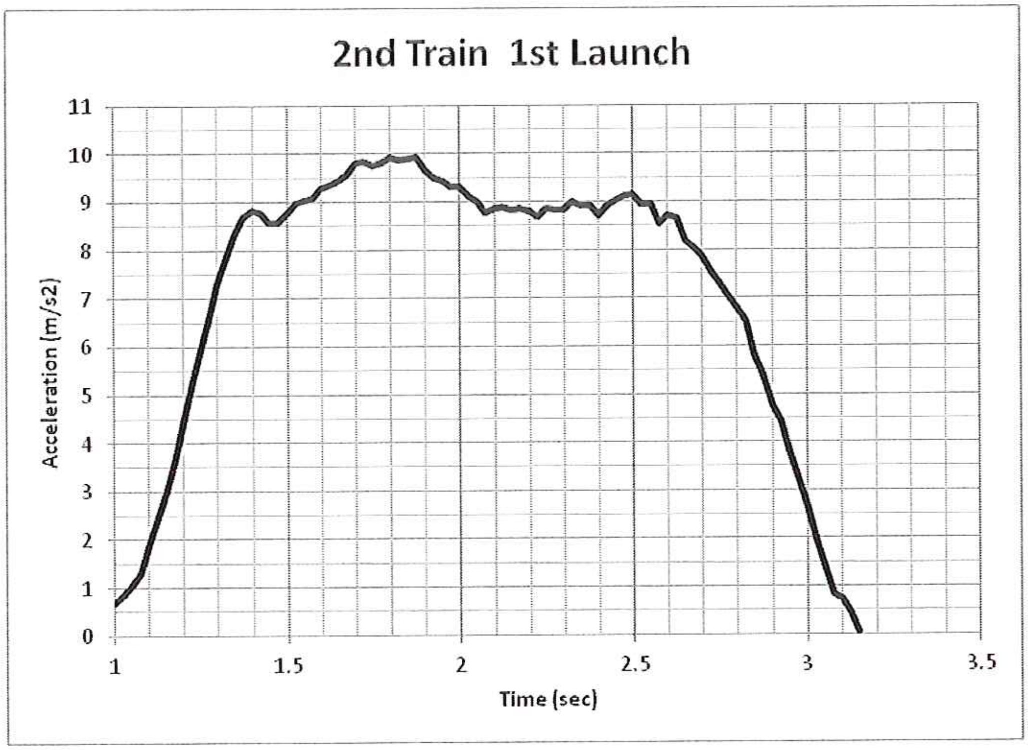


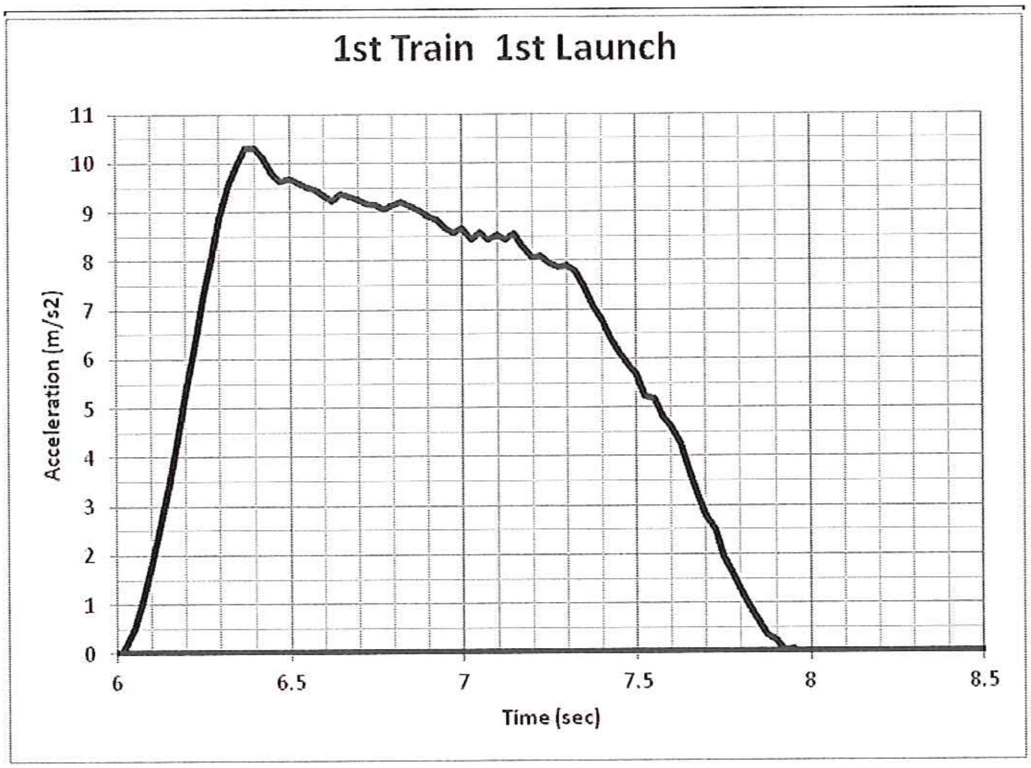




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2. a. . Compute the g force in the first coaster car as it begins to go up the tower following the second launch.

   v= 25.9 m/s    radius of the turn = 24.4 m

   b. Compute the g force in the last coaster car as it begins to go up the tower following the second launch.

   v=21.9 m/s    radius of the turn =24.4 m

   c. Why is the last coaster car moving at a slower speed than the first coaster car when it arrives at the tower?

   d. At the bottom of the tower coming down, each car should experience a high g force. Look at the g force graphs for the 1st Car (Cheetah Hunt Vertical G Force (RF1)) and the 4th Car (Cheetah Hunt Vertical G Force (RR4)) and record the g force of each car. These graphs are found at the end of the workbook. Which is higher and why?

   1st Car________    4th Car__________

   e. Now examine the differences in the G force for the 1st Car and the 4th Car at the following points:

| | 1st Car | 4th Car |
|---|---|---|
| Entering Launch 2 | _______ | _______ |
| Leaving Launch 3 | _______ | _______ |

   Does this match your explanation for both going up and coming to the bottom of the tower?

   Does this also match your experiences on the coaster?



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3.a. Compute the velocity at the top of the Outbound Twister (this element is just after coming down the tower). The posts are 18 meters apart.

V= 18 m/ (            sec) = ________________ m/s

b. Given that the radius of curvature at the top of the hill is 34.0 m, compute the g force at the top of the hill. $(1\text{-}v^2/rg)$

c. Compare this to the g force on the (RF1) G force graph. How does it compare to your feelings on the twister?

4. a .Compute the speed of the coaster train at the top of the tower, by using the front to back time as it passes the first post at the top. The length of the train is 10.25 m.

V= 10.25 m/ (            sec)= ________________ m/s

Using conservation of energy (KE at bottom=KE +PE at top) compute what the speed should be at the top. The speed at the bottom of the hill 25.9 m/s, and that the height of the tower is 31.9 meters above the Launch 2.

b. Using conservation of energy, explain why the coaster train is faster at the bottom of the tower going down, than after the second launch.



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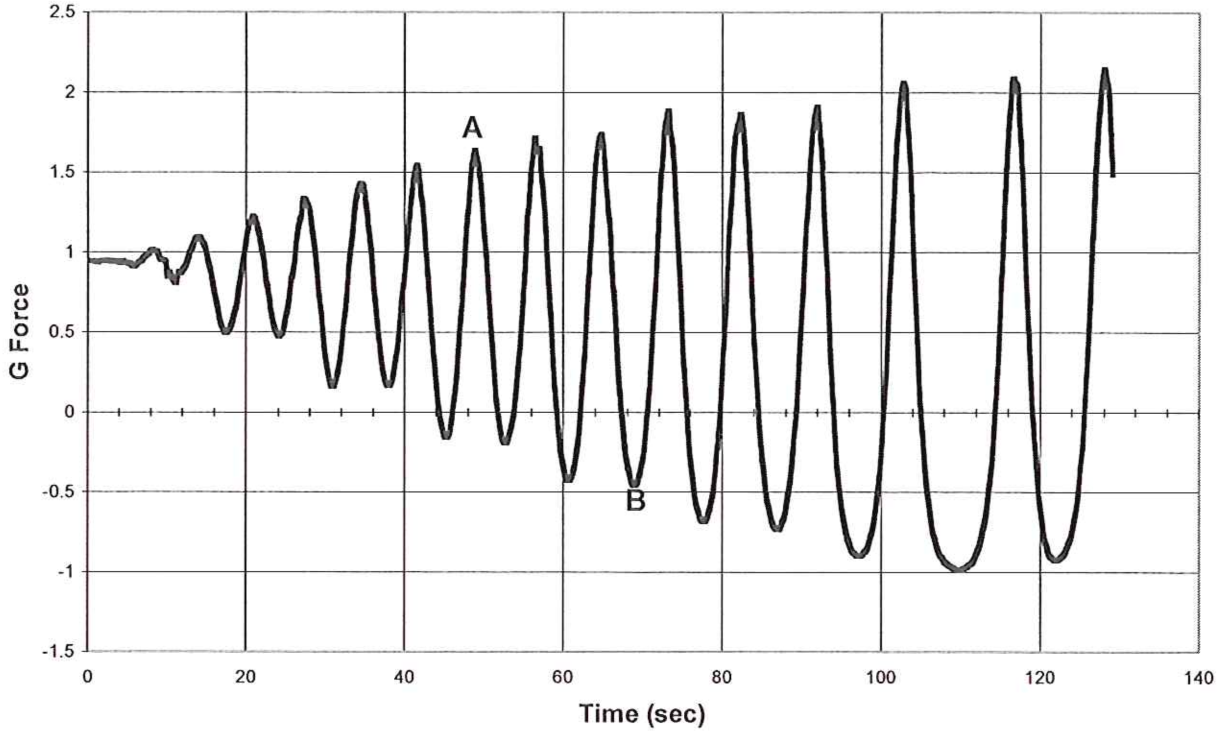
## Phoenix



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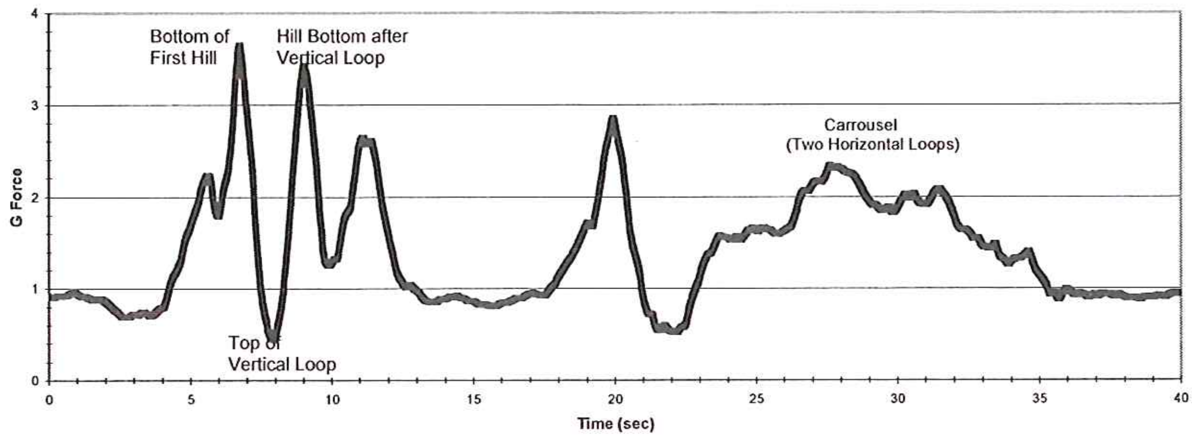




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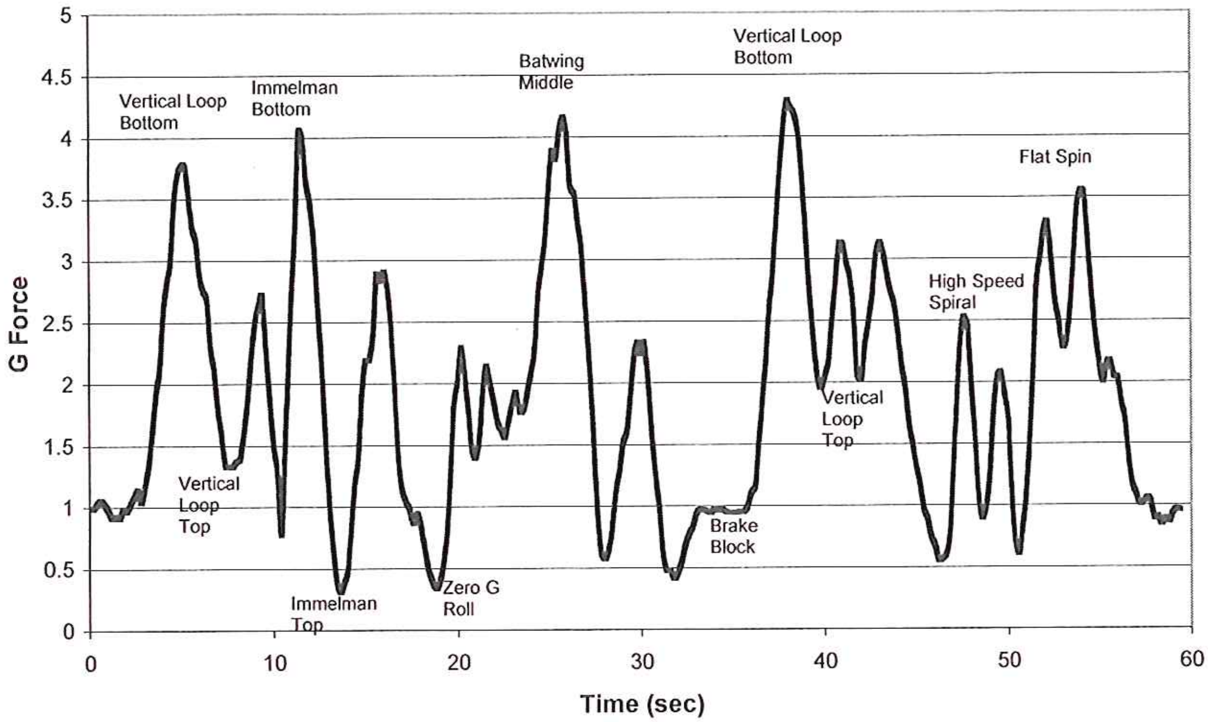




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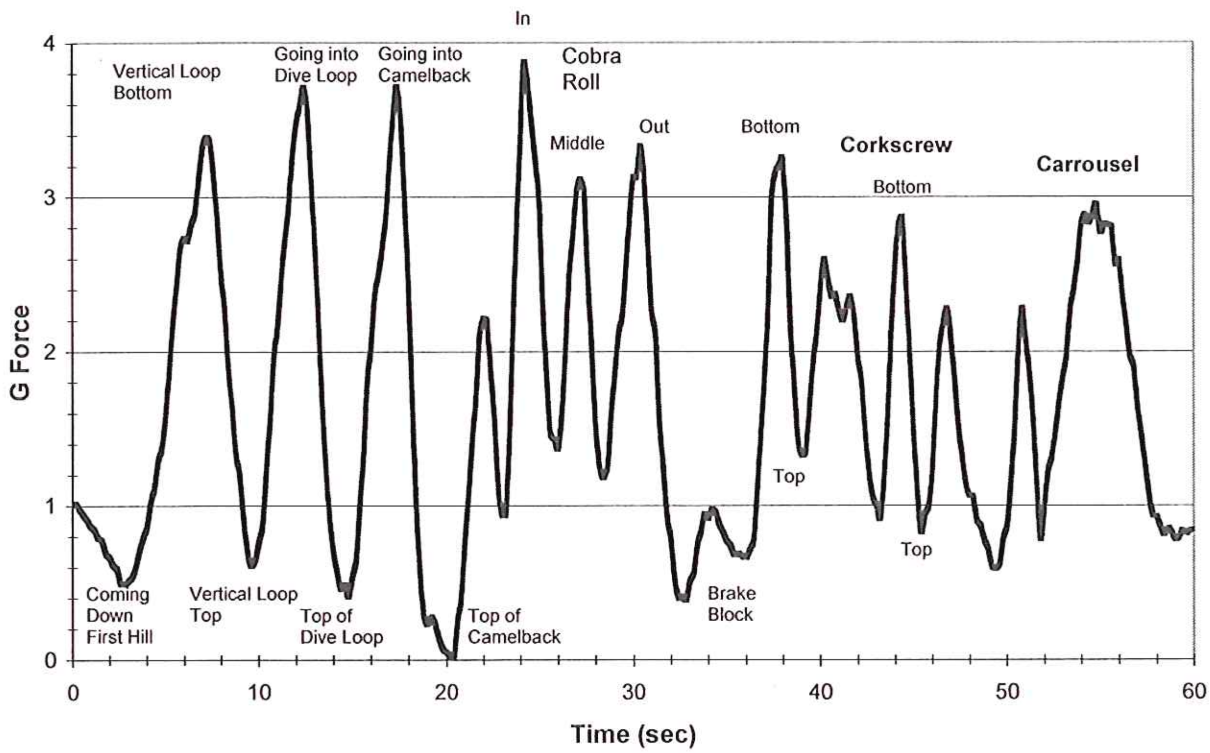
# Kumba



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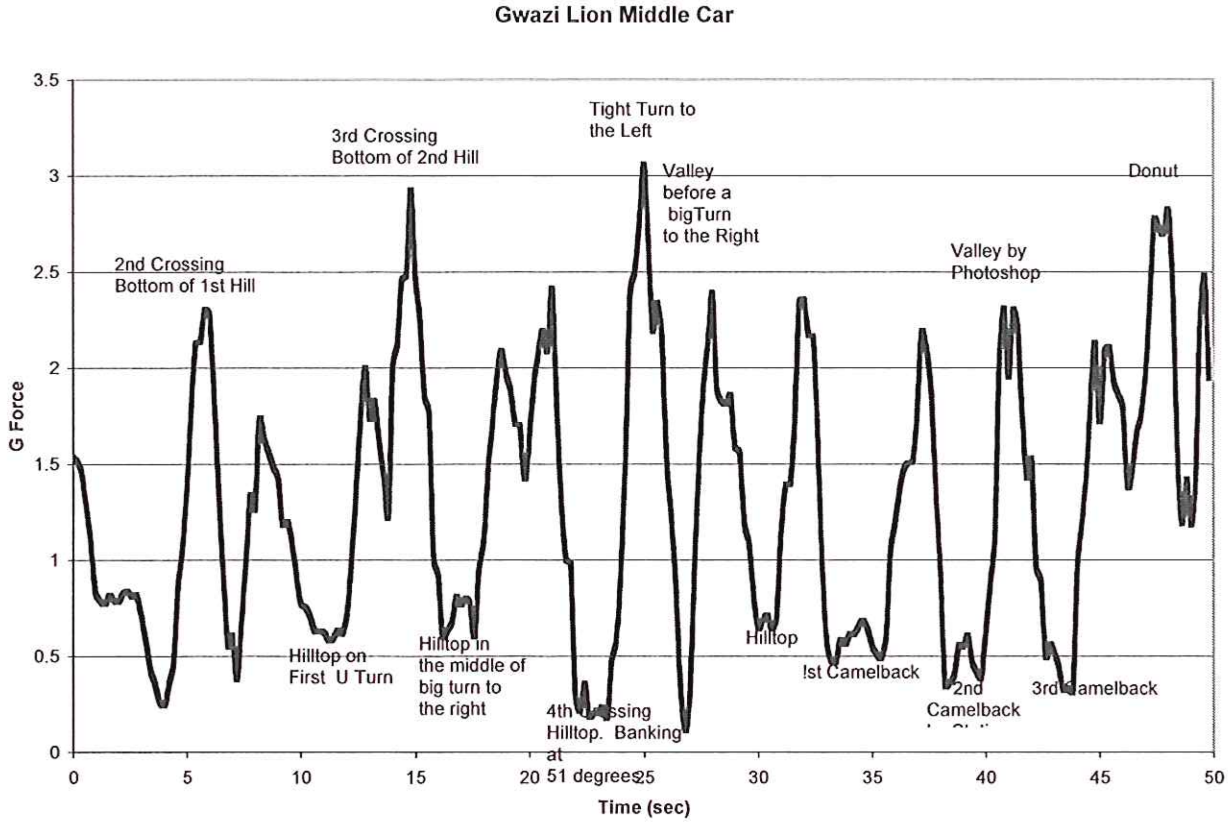




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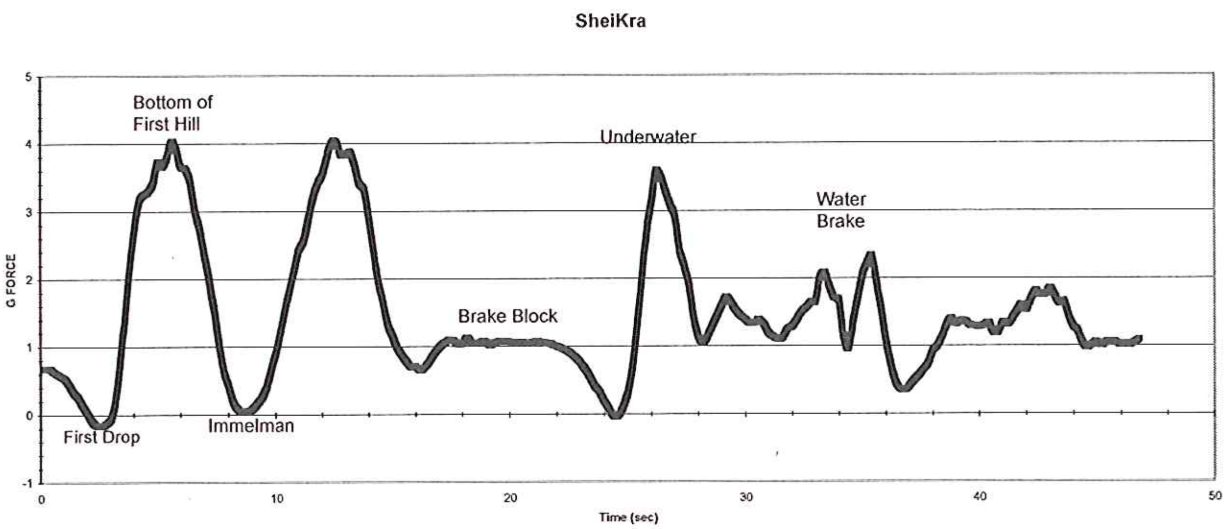




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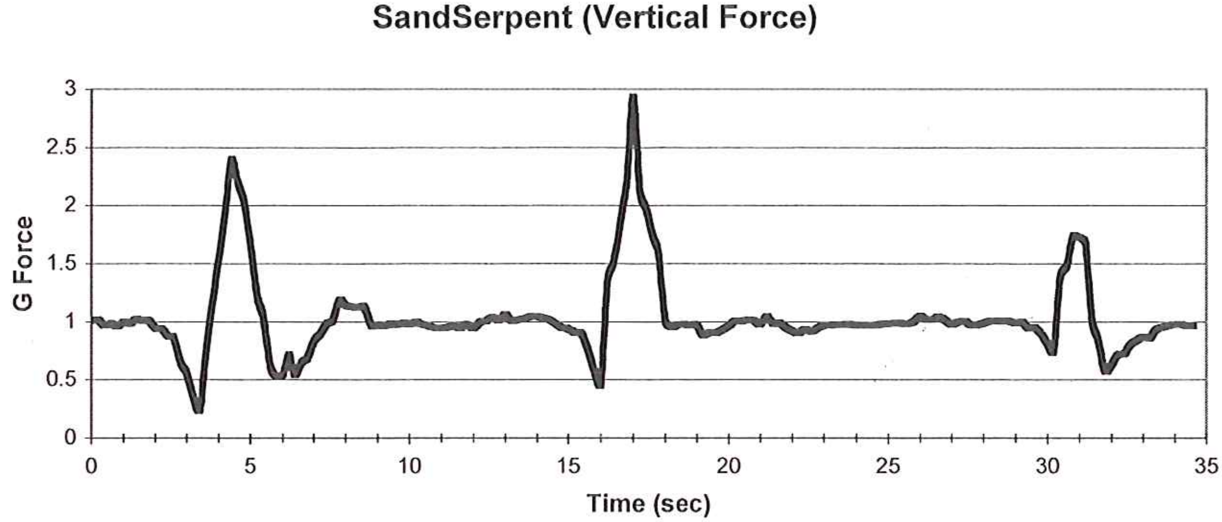


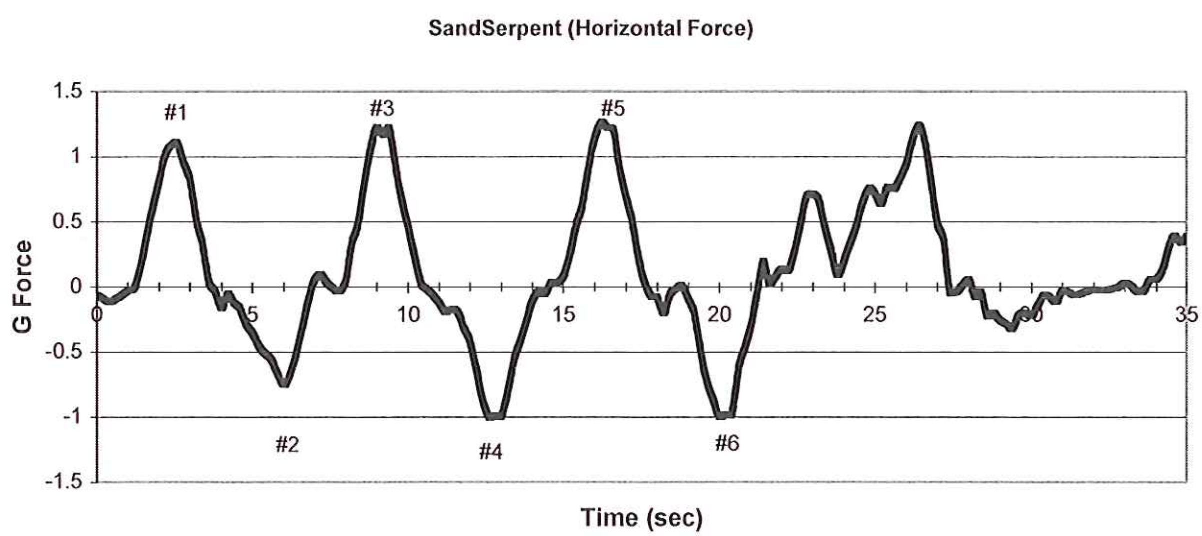




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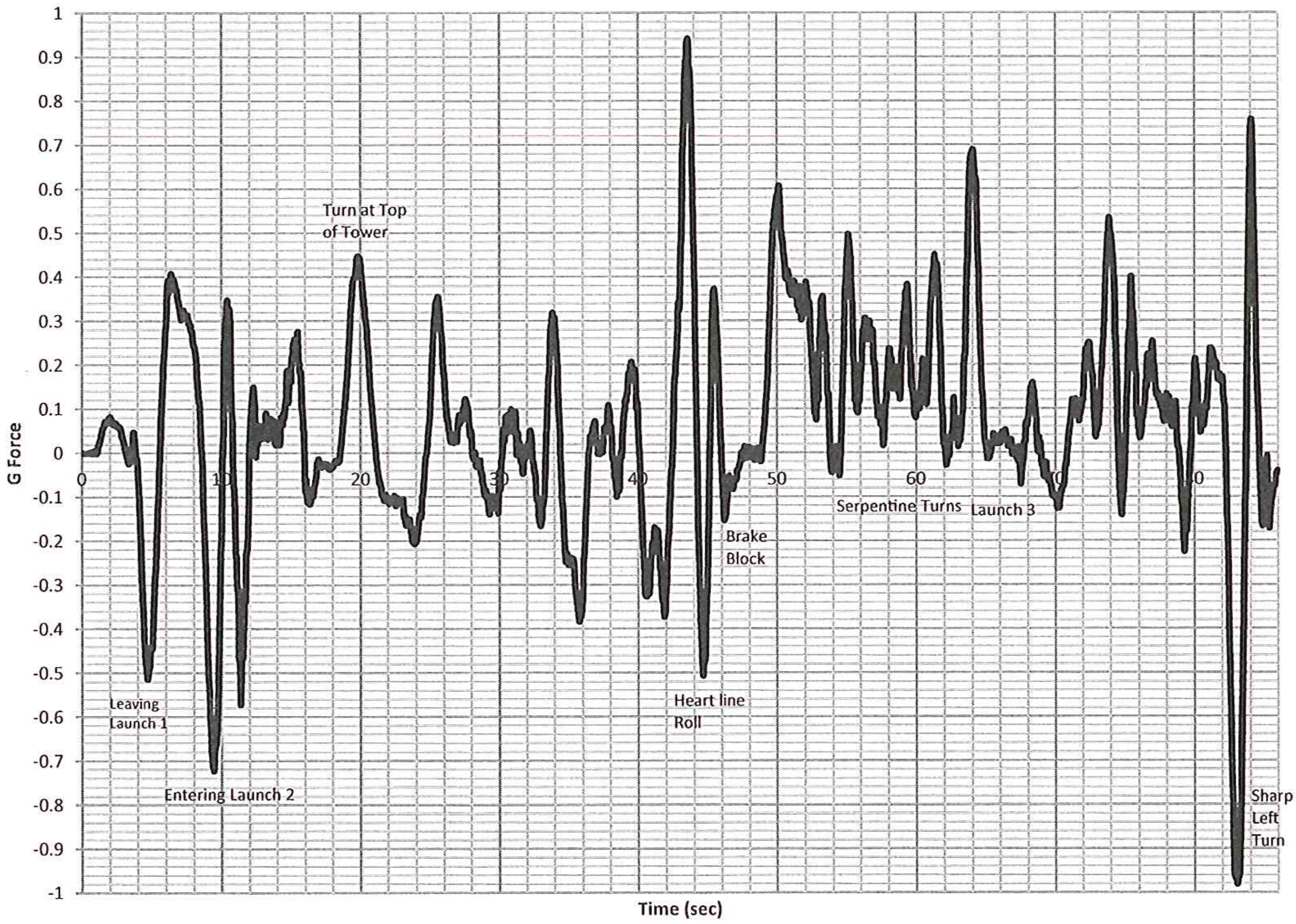
# Cheetah Hunt Lateral G Force (RR4)



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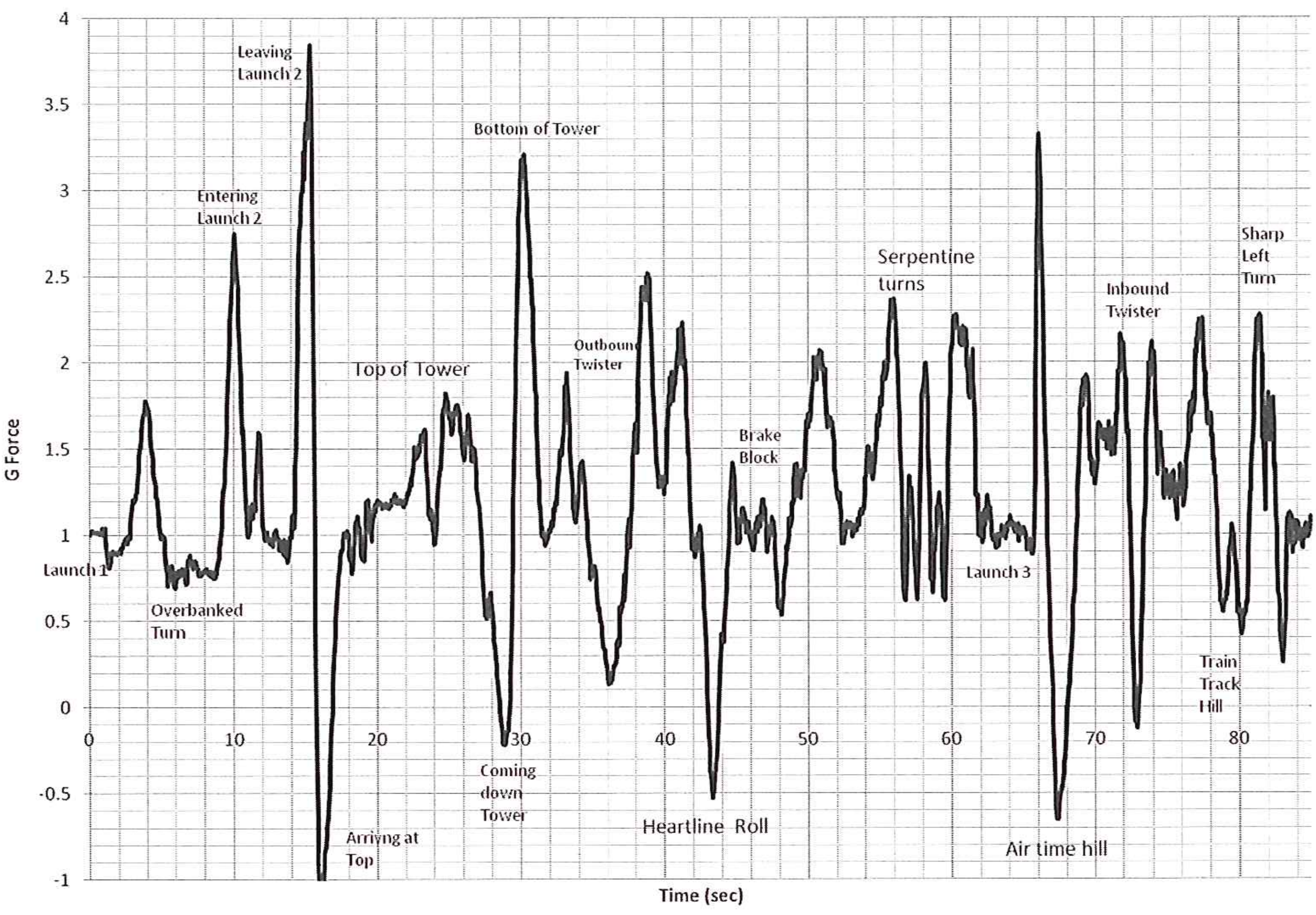
## Cheetah Hunt Vertical G Force (RF1)



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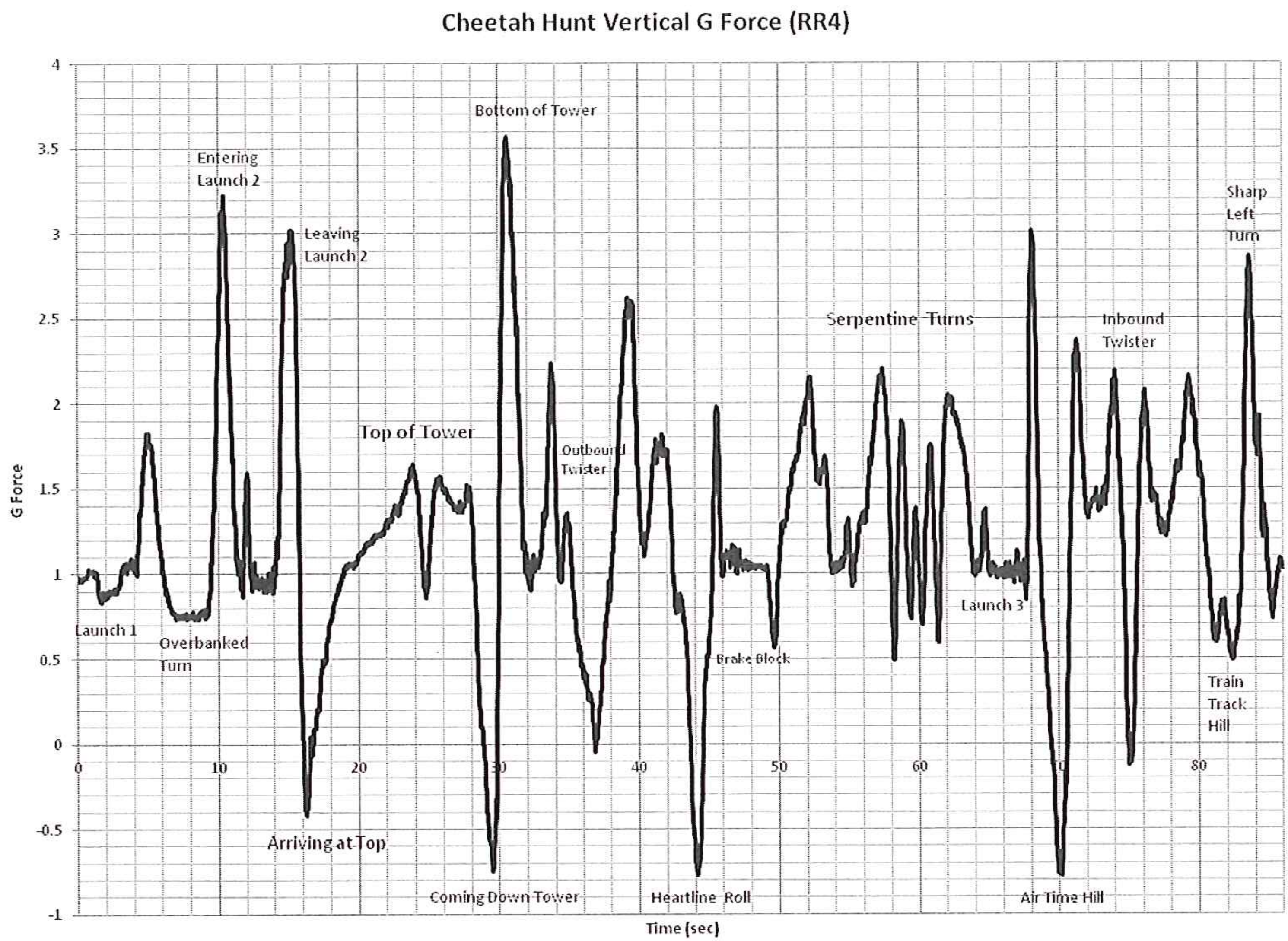




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