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A mathematics walk through the Liseberg amusement park.

For SEFIMWG2016, 27 June 2016, Ann-Marie.Pendrill@fysik.lu.se

As you come down the hill from Chalmers towards Liseberg, you may first notice the giant Ferris wheel, next to Korsvägen, and behind it, the free fall drop tower AtmosFear, which offers you nearly 3s of Free Fall, before you enter the magnetic brakes.

I How far do you fall during 3s?

1) 30m
x) 45 m
2) 90 m

This is close to the main entrance, but today we will use the southern entrance, to avoid crowds aiming for a sing-along concert with Lotta.

Your first stop in the park will be the WaveSwinger / Chainflyer "Slänggungan". Watch it while it is being loaded.

II: If there is an empty swing when the ride starts, how will it hang during motion compared to the swing with a heavy person in, just in front or behind?

1) The empty swing will hang in the same angle as the other swings.
x) The empty swing will hang in a smaller angle than swings with a person in.
2) The empty swing will hang in a larger angle

Just to the right (east) of SLÄNGGUNGAN, take the bridge over to the other side of the river and look closer at the loop of the roller coaster KANONEN (the Cannon). You may notice that the loop is not a circle, but has a larger radius of curvature at the bottom.

III: How would you describe this loop shape mathematically

1) Ellipse
x) Circular arcs with larger radii at the bottom, matched on the sides to a circular arc with smaller radius at the top
2) Cornu spirals matched to a circular arc at the top

Roller coasters are classical examples of energy conversions, with an interplay of kinetic and potential energy as the train moves around the curves, loops, hills and valleys of the track. In KANONEN, the traditional lifthill is replaced by a hydraulic launch, giving the train sufficient kinetic energy to move over the first hill. Can you use energy conservation (together with the photo) to estimate differences in experience between different seats as you move over the top of the loop?

IV: If a rider in the middle of the train moves weightlessly over the top, then ...

1) riders in all seats will be weightless as they move over the top.
x) riders in the back will experience approximately 0.4g (i.e. a downward directed force from the seat of 0.4mg) as they move over the top
2) riders in the front will experience - 0.4g (i.e. hanging down onto the shoulder harnesses)

At the end of the ride, magnets on the train induce eddy currents in the braking fins, giving a smooth increase of the braking force as the train enters the braking area and the remaining kinetic energy is absorbed by the brakes and converted to heat. Similar braking fins are mounted at the beginning of the track (see photo) and are taken down, with a hissing sound, just before launch , and then raised again - can you figure out why?

BALDER – A modern wooden roller coaster

Next to Kanonen is a more traditional-looking roller coaster, which has been voted the best wooden coaster in the world during its opening year 2003 and also in 2005. The track has a built-in "parabolic flight", letting the rider experience near weightlessness.

Liseberg's position close to the center of Göteborg means that Balder has neighbours, who don't always appreciate happy roller-coaster-rider screams throughout the long summer evenings.

In early 2004 a number of tunnels were added for damping the sound.

V: The photo to the right was taken as one of these tunnels was constructed. It also shows the "Balder coordinate system" with a vertical distance of about 2.5m between horizontal beams. As you move over this hill, you may experience weightlessness (free fall) for how long?

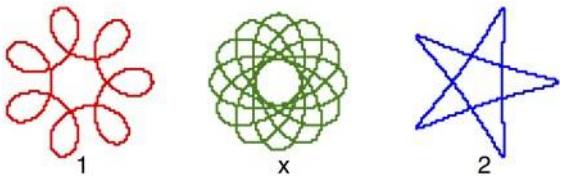
1) 1.2 s
x) 2.0s
2) 2.4 s

VI: In the northern end of Balder, the train returns three times, each time a bit lower. What can you say about the speed for these three passages? (You may want to use the stopwatch on your phone to check)

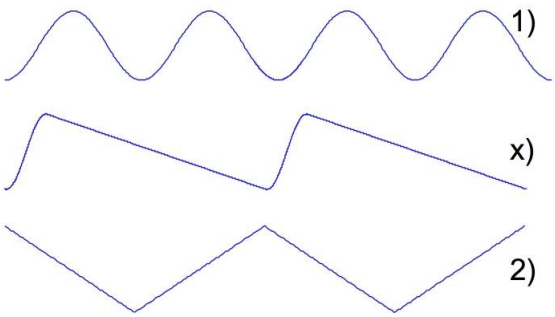
1) The train moves with essentially the same speed every time
x) The train moves faster on the lowest part of the track
2) The train moves faster on the highest part of the track

Continue north towards the Rabbit Land "KANINLANDET" where you find a classical teacup ride KAFFEKOPPEN, themed as a giant coffee grinder. Observe the ride for a while.

VII: Which of the shapes below describes best how a cup moves during a ride?

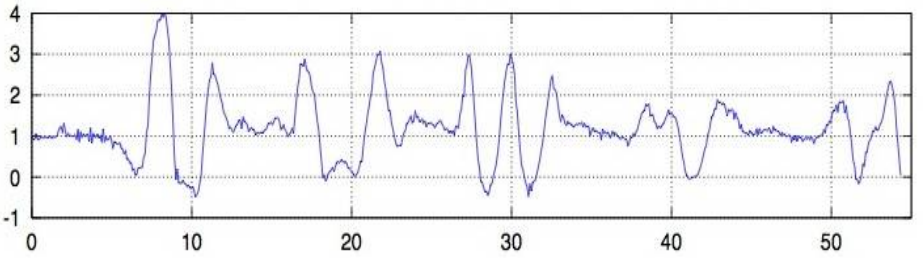


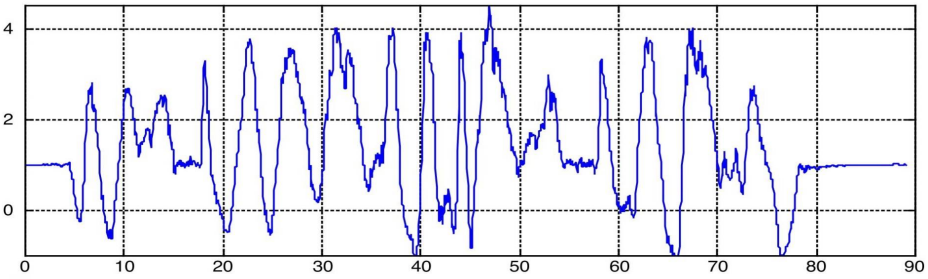
VIII: In Kaninlandet, you also find the BUSHÅLLPLATSEN (Bus stop / "mischief" stop), which includes a small trampoline. Which of the graphs to the right describes best how the *velocity* varies during two high jumps?

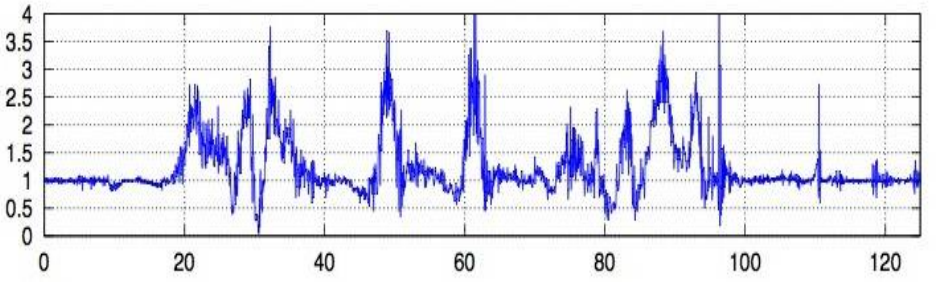


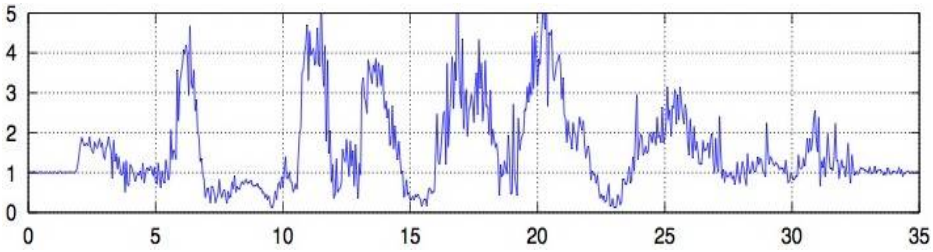
Turn west past the small roller coaster RABALDER and you will see the amazing Pretzel loop of the roller coaster HELIX.

The graphs below show accelerometer data for the four main Roller Coasters of Liseberg: LISEBERGBANAN (1987), BALDER(2003), KANONEN (2005) and HELIX (2014).
But which graph belongs to which roller coaster? Write down the names next to the graphs.









Finally, bring one response sheet from your group to the Trebello restaurant in the centre of the park at 20.00, where those who like also meet for dinner. A symbolic prize will be given to the members of the group with the highest number of correct answers (don't forget to write your names!)

Good luck!
Ann-Marie

As you leave Liseberg, you may choose to exit through the northern main entrance. If you walk the path from Liseberg towards Korsvägen, you may discover the star with Albert Einstein's name. On July 11 1923 he gave his Nobel lecture - at Liseberg. It was the year when Liseberg opened in connection with the World exhibit, hosted in Göteborg. At the time, the round building of Lisebergsteatern was a planetarium – and don't you think that Einstein would have loved the free fall drop tower AtmosFear, with its weightlessness for nearly 3 seconds?

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