A science walk through the Liseberg amusement park.

As you come down the hill towards Liseberg, you may 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

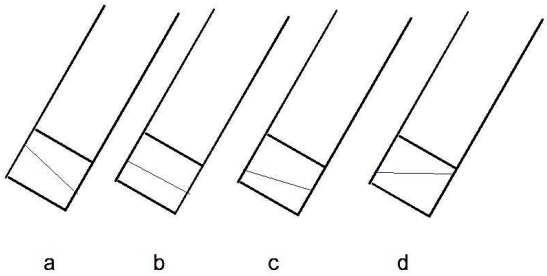
This is close to the main entrance, but today we will use the southern entrance.

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

III. During the physics day, you may bring a little mug with water in the bottom. Hold the mug onto the lap bar as you ride and observe the water. What do you expect will happen to the water level as the ride is in motion.? Which of the images gives the best description?



BALDER – A modern wooden roller coaster

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.
The Balder roller coaster was 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.

IV: 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. This hill includes a built-in parabolic flight, where you may experience weightlessness (free fall). Estimate the height of the "parabolic flight".

1) 3 m
x) 5 m
2) 7,5 m

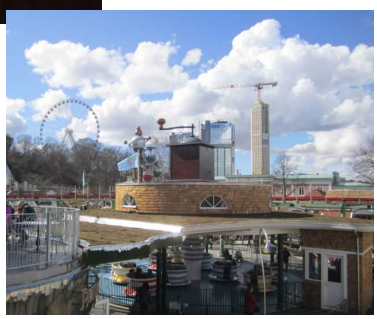
V: For how long can you experience free fall in the hill?

1) 2,0 s
x) 2,4 s
3) 3,0 s

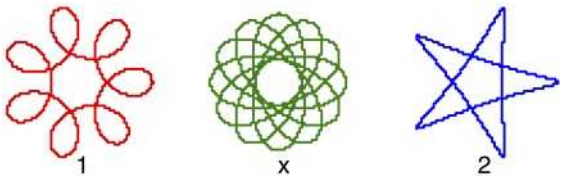
VI: In the northern end of Balder, the train returns three times, each time a bit lower. What can you say about the speed for these three passages? (You may want to use the stopwatch on your phone to check)

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

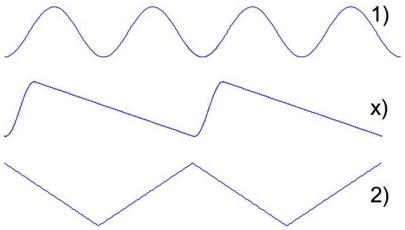
Continue north towards the Rabbit Land "KANINLANDET" where you find a classical teacup ride KAFFEKOPPEN, themed as a giant coffee grinder. Observe the ride for a while.



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?



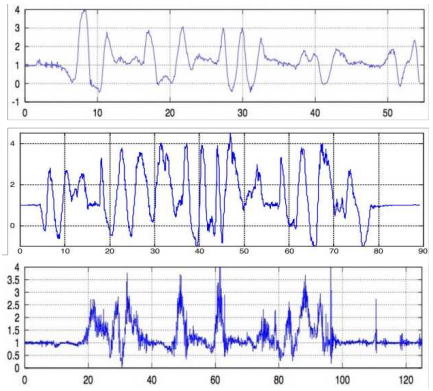
IX Continue to Underlandet. The ride starts with an elevator tour inbto Underlandet. How far down do you travel?

1) 7 m
x) 3 m
2) 0 m

Walk south to the small roller coaster RABALDER and turn west. You will see the amazing Pretzel loop of the roller coaster HELIX.

X The graphs to the right show accelerometer data for three of the main Roller Coasters of Liseberg: LISEBERGBANAN (1987), BALDER(2003) and HELIX (2014).

But which graph belongs to which roller coaster? Write down the names next to the graphs.



XI: Make your way up to Luna park and bring a small soft toy on a string onto the traditional carousel. As the carousel moves, hold onto the string and let the toy swing freely.What can you observe? Describe!

Finally, hand in one response sheet from your group. Don't forget to write your names!

Good luck!

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?

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Responses and comments to the questions

2 1 b, 2 x 1, 2 x 2

X: Balder, Helix, Lisebergbanan

XI: The pendulum motion seems to change direction, but if it started towards Mölndal, it will continue towards Mölndal, and if it started towards Balder, it will continue swinging back and fort toward as and from Balder. See the little video clip https://youtu.be/FL1zRhwLVPk from a playground carousel and https://youtu.be/qcOIAHcypp4 from an earlier carousel at Liseberg?

Comments

I. 3 seconds free fall. Quick calculation: From 0 to 30 m/s, average velocity 15m/s during 3s

II. Slänggungan: That mass does not influence the angle is a consequence of the Equivalence Principle (intertial mass, in *ma,* is equal to the gravitational mass, in *mg*). More discussions and assignments about Chain flyer rides in Physics Education 51 (1) 15014 2016

III. Balder: I counted three beams of parabola, i.e. 7.5m, which takes about 1.2s on the way up and then 1.2s on the way down. More about Balder

IV. The train moves with essentially the same speed all three times. I usually assign this as a task for some of the groups and encourage them to discuss uncertainties in their phone measurements.
It gives an illustration of the energy losses in roller coasters. During about 250m of track, the train has lost potential energy corresponding to 7.5m – an average of 3cm/m, or an effective friction number of 0.03.

V. The star. (The alternative in the middle is essentially the orbit for the JukeBox.)

VI. Trampoline jumps – a combination of harmonic oscillator and free fall. For small jumps (where the feet never leaves the mat) the velocity will be a sine function. During high jumps, the time in contact with the mat is a very small part of a full jump cycle. During the time in the air, the velocity falling linearly, with g. In the short contact time, the velocity must increase rapidly. Nice examples for all kinds of modelling exercises. Could have been standard textbook problem, if trampolines had been common, when standard problems were constructed. Read more: http://iopscience.iop.org/0031-9120/50/1/64

Roller coasters.

Balder (from 2003): ... characterised by many occurrences of "air time" with "zero g". Relatively moderate "Positive g's"

Helix (From 2014): Many cases of both negative and large positive g's. Short note: http://tivoli.fysik.org/fileadmin/tivolifysik/Liseberg/helix/first_drop.pdf

Lisebergbanan is from 1987, Classic, but feels quite shakey after going on Helix. Long ride, Noisy data.

> A comment about timing in roller coasters. There are basically two timings applying to roller coasters. One is the time from leaving the station until coming back again. The more relevant time for riders is the shorter time between leaving the lift hill chain and entering the final brake. The graphs did not include the final stretch to the station

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