The Design and Analysis of Roller Coasters

Erik M. Olague

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- Many languages still use the term "*Russian Mountain*"

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- Through the 1920's, roller coasters reamined popular.

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- In 1959, Disney opened *Matterhorn Bobsleds*, the world's first steel roller coaster.
- Allowed for the extreme manipulation of the track.

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- New designers such as **Bolliger and Mabillard** and **Intamin AG** came to prominence during the coaster wars.
- People have always wondered if roller coasters are safe, the coaster wars didn't change that.

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- Designers employ a complex set of rules on the design of the track.

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- Guide wheels hold the train in the horizontal.

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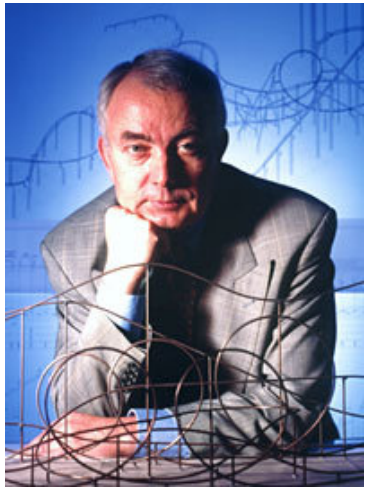
- "Anti-rollbacks" will catch the train if the chain breaks.
- Responsible for the iconic sound on the lift hill.

Art in Roller Coasters

- Roller Coasters really are peices of art.



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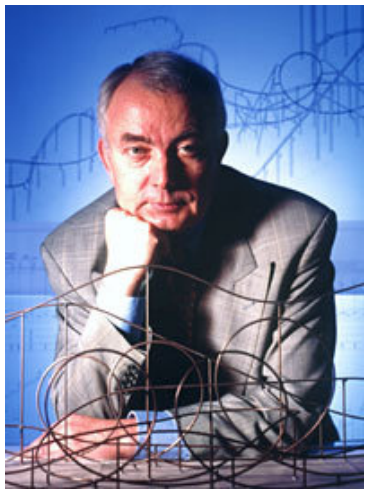

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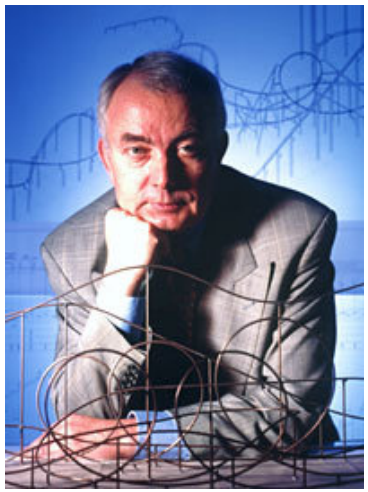

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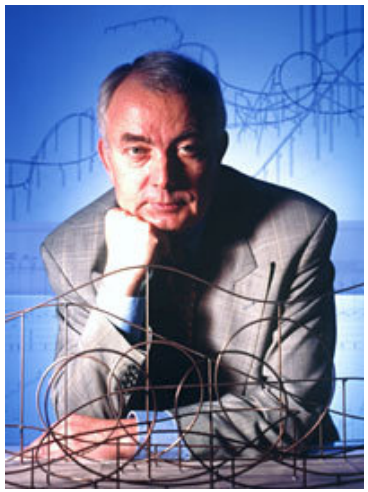
- Designers take into account human physiology and psycology when producing a design.
- Observing the track can lead riders into the mind of the designers.



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- What about your favorite roller coaster do you like?
- What is the pacing on the greatest roller coasters?
- How does your favorite roller coaster feel?
- If you were to make your dream coaster, what would it be like?

Good Roller Coaster Qualities

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- Wooden roller coasters often have vibrations, but their track is still smooth.
- "Rough" roller coaster paths can be uncomfortable even on steel coasters.
- What mathematical properties does a smooth track have?

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- Most modern-day roller coasters are continuous in their second derivative.
- More twisted roller coasters are continuous in their third and higher derivatives.

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- Forces are created when the train is changing direction in some form or another.
- Turns and pullups on drops create positive *vertical* g-forces.
- Cresting a hill creates negative or zero g-forces.
- Some turns and twisting motions create *lateral* g-forces.

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- $$a = \frac{v^2}{r}$$
- Smooth forces implies smoothly changing radius, implying a smooth second derivative.
- When does the third derivative have to be smooth?

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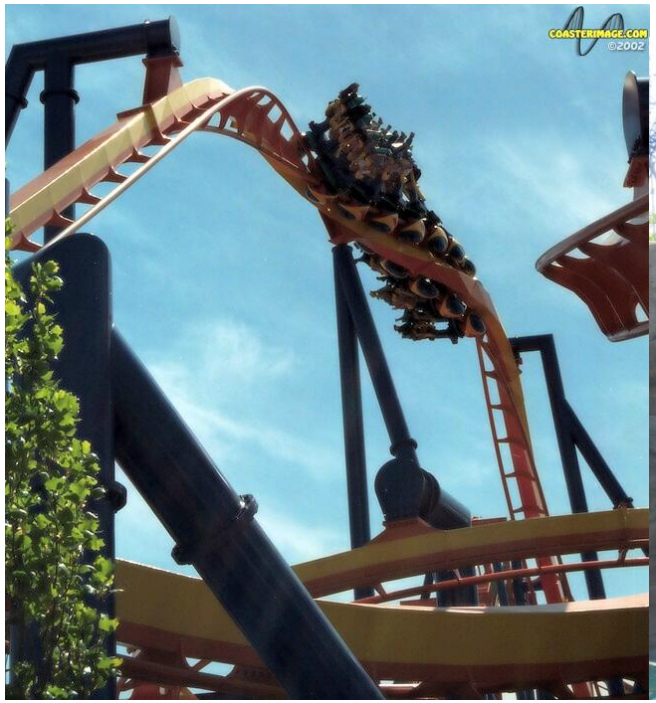
- 

Figure: Courtesy of rcdb.com

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- That means the rate at which the track is changing its direction is not constant.
- Therefore, the designers had to make sure that the track was continuous on the third derivative.

What's Up with this Track?

Figure: Courtesy of rcdb.com

Strange Track Shapings

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- To prepare for the drop, the track seems to first raise.
- It's almost as if it were twising *around* something.

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- Werner Stengel pioneered many design techniques, one of which is called heartlining.
- Stengel also was able to push through today's modern loop, known as the clothoid loop.
- The reason why roller coasters are as comfortable as they are is largely because of Stengel.

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- Heartlining can be extended to all pivots, such as headlining and kneelining.
- More useful to see in an editor.

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- You can actually be more in control of a ride if you make the track look more out of control.
- High speed turns, large changes in banking and large changes in force are better modeled through heartlining.
- Allows designers to "hide" things.

Enough Lecture!

- Let's build an actual roller coaster.

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- Let's build an actual roller coaster.
- We'll see one of mine first.

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- Let's build an actual roller coaster.
- We'll see one of mine first.
- Get your creative jucies flowing!