Introduction and Restatement of the Problem:

Most online roller coaster rankings rely on subjective opinions rather than objective ride data, such as height, speed, or drop. However, in this project we were provided with a dataset containing various traits of operational rollercoasters and tasked with creating a Top 10 ranking based solely on measurable features.

Using the algorithms developed to generate this ranking, we were then told to design the concept for a user-friendly app that can match riders with the roller coasters best suited to their preferences, using factors that we thought would represent the overall rollercoaster experience.

Assumptions with Justifications:

In developing our roller coaster ranking model, several key assumptions were made to simplify the problem while keeping the results realistic and meaningful. These assumptions guided the selection of variables, the weighting of categories, and the final scoring system.

Category Weightings:

The three main categories in our model, Thrill, Vomit Factor, and Safety, were weighted based on assumptions about what riders generally value in a roller coaster. The weights reflect the group's consensus on the relative importance of each factor.

1. Thrill Factor: We assumed thrill had the most weight since it is a common factor that most people look for in roller coasters.
2. Vomit Factor: Unlike thrill, vomit factor includes ride duration as longer exposure to rapid movement increases the likelihood of discomfort or nausea.
3. Safety: Safety was assumed to depend primarily on construction material and ride age. Older rides or those built with less durable materials such as wood were considered less safe due to higher maintenance requirements and increased structural risk.

Data Selection Assumptions:

The choice of which coaster features to include in each category reflects our assumptions about what drives each score:

Thrill: Height, speed, drop height, G-force, and vertical angle were selected because these features are directly linked to excitement.

Vomit Factor: Duration, number of inversions, G-force, and vertical angle were included to capture the physical strain and disorientation that cause nausea.

Safety: Material type, operational status, and age, were used to approximate structural reliability and user safety.

Normalization Assumption:

We assumed that all numeric features could be normalized to a common scale so that variables were a percentage of the average score in that category. This made sure that variables with different units could be fairly combined, simplifying computation and ensuring that no single variable dominates the overall score solely due to its scale.

Model Limitations and Reasonable Simplifications:

Excluding subjective measures: Rider reviews or ratings were not included because they are subjective and vary widely.

Operational Status: Only currently operating rides were included, under the assumption that defunct or seasonal rides would not contribute meaningfully to the ranking

Equal Impact Across Riders: The model assumes all riders respond similarly to physical factors like G-force or inversions, recognizing that individual tolerance varies but cannot be objectively measured with the given data.

Justification Summary:

These assumptions were necessary to create a data-driven, objective, and reproducible model. By focusing on measurable ride characteristics and logically weighting them according to their expected impact on thrill, discomfort, and safety, we ensured our model captures what most riders value while remaining mathematically sound.

Our Model for Ranking Rollercoasters:

Our model for ranking rollercoasters relies on three major factors: **thrill**, **vomit factor**, and **safety**. **Thrill** accounts for **62.5%** of our ranking, **vomit factor** accounts for **18.75%**, and **safety** accounts for **18.75%**. To calculate the values for each factor, we determined the weight of certain data points in determining the thrill, nausea, and safety levels of each rollercoaster. Let's go over an example with our highest-ranked rollercoaster, Kingda Ka at Six Flags.

This coaster has the following stats:

Height (feet)	Speed (mph)	Length (feet)	Inversions (YES or NO)	Number of Inversions	Drop (feet)	Duration (sec)	G Force	Vertical Angle (degrees)
456	128	3118	NO	0	418	0:28		90

Per our system, thrill is calculated with the following weight.

Factor	Weight
Height	8
Speed	10
Length	5
Number of Inversions	7
Drop Height	10
G-Force	8
Vertical Angle	9

For each component, we first verify that the value is a number. We then determine what percentage of the mean the coaster's value in each category is and multiply it by its weight. For height, we would use the following formula:

$$8*(h_{coaster}/h_{avg})$$

After we then take the weighted average of all of these factors with the following calculation:

$$(8*(456/h_{avg}) + 10*(128/s_{avg}) +5*(3118/l_{avg}) + 7*(0/i_{avg}) + 10*(418/d_{avg}) + 0 + 9*(90/a_{avg})) / (8 + 10 + 5 + 7 + 10 + 0 + 9$$

Note that any factors that have no listed values in our dataset are set to zero, and their weights are not used in the average calculation. By performing this calculation, we get a thrill value of 1.87. This value essentially means that the thrill of this rollercoaster is 87% greater than the average. Similar calculations are performed for vomit factor and safety with the following weights.

Vomit Factor:

Factor	Weight
Height	5
Speed	7
Length	8
# Inversions	10
Drop Height	7
G-Force	10
Vertical Angle	9

Factor	Weight
Construction (Wood or Steel)	7
Status (Operating or Not)	10
Year/Date Opened (Age) (Current year - year, older is "worse")	5

Safety:

By performing the same calculations for nausea and safety, and applying our overall weights for our three main factors, with the **safety score and thrill score contributing positively, while vomit factor is subtracted using the following equation:**

$$Score = thrill*1.0 + safety*0.3 - nausea*0.3$$

For Kingda Ka, we get a score of 1.74, meaning that it is **74%** better than the average coaster.

Analysis:

Table 1: Our Top 10 Rankings

Rank	Name	Park	Location	Thrill	Vomit	Safety	Score
1	Kingda Ka	Six Flags Great Adventure	New Jersey, United States	1.87	1.52	1.09	1.74
2	Top Thrill Dragster	Cedar Point	Ohio, United States	1.76	1.43	1.09	1.66
3	Steel Dragon 2000	Nagashima Spa Land	Kuwana, Mie, Japan	1.69	1.56	1.09	1.55
4	Superman: Escape from Krypton	Six Flags Magic Mountain	California, United States	1.52	1.18	1.09	1.49
5	Soaring Dragon & Dancing Phoenix	Nanchang Wanda Theme Park	Nanchang, Jiangxi, China	1.71	1.83	1.09	1.49
6	Fury 325	Carowinds	North Carolina, United States	1.56	1.40	1.09	1.46
7	Formula Rossa	Ferrari World Abu Dhabi	Abu Dhabi, United Arab	1.52	1.35	1.09	1.44

			Emirates				
8	Millenium Force	Cedar Point	Ohio, United States	1.50	1.36	1.09	1.42
9	Red Force	Ferrari Land	Spain, Europe	1.43	1.15	1.09	1.41
10	Altair	Cinecittà World	Rome, Italy	1.71	2.08	1.09	1.41

Table 2: Comparison between our rankings and rankings on the internet

Ranking	Our Algorithm	Golden Ticket Awards: 2018 Top 50 Steel Coasters	Coster Force: CoasterForce'/s favourite coasters 2018
1	Kingda Ka - Six Flags Great Adventure	**Fury 325 - Carowinds**	Steel Vengeance - Cedar Point
2	Top Thrill Dragster - Cedar Point	Millennium Force - Cedar Point	Lightning Rod - Dollywood
3	Steel Dragon 2000 - Nagashima Spa Land	Steel Vengeance - Cedar Point	Taron - Phantasialand
4	Superman: Escape from Krypton - Six Flags Magic Mountain	Expedition GeForce - Holiday Park	Maverick - Cedar Point
5	Soaring Dragon & Dancing Phoenix -	Superman: The Ride - Six Flags New	Twisted Colossus - Six Flags Magic

	Nanchang Wanda Theme Park	England	Mountain
6	**Fury 325 - Carowinds**	Apollo's Chariot - Busch Gardens Williamsburg	Skyrush - Hersheypark
7	Formula Rossa - Ferrari World Abu Dhabi	Iron Rattler - Six Flags Fiesta Texas	Helix - Liseberg
8	Millenium Force - Cedar Point	Leviathan - Canada's Wonderland	Voyage - Holiday World
9	Red Force - Ferrari Land	Maverick - Cedar Point	X2 - Six Flags Magic Mountain
10	Altair - Cinecittà World	Diamondback - Kings Island	El Toro - Six Flags Great Adventure

Using the data available from our 2018 dataset, we categorized each roller coaster based on three key criteria: Safety, Thrill, and Vomit Meter. We then assigned weights to each of these factors and calculated an overall score for every coaster by multiplying the values by their respective weights.

In contrast, both the Golden Ticket Awards and CoasterForce relied on subjective data gathered from polls rather than quantitative measurements. The Golden Ticket Awards surveyed an international group of experienced roller coaster enthusiasts, while CoasterForce collected votes through an online forum, asking users to rank their favorite coasters in lists of <10, 10, 20, or 40. They averaged each coaster's ranking across submission and normalized it by the number of times it was ridden. However, CoasterForce's sample size of only 59 participants makes its results significantly less representative than Golden Ticket Awards.

Since these two ranking systems depend heavily on public opinion and rider preference, their results differ greatly from ours. Our algorithm focuses on objective data, independent of popularity or reputation.

If the weighting of our factors were averaged across a larger population, our results would likely align more closely with public rankings. Additionally, our dataset did not account for external influences such as height restrictions, accessibility, or medical limitations which may also impact real-world rankings.

Overall, each ranking system–ours, Golden Ticket, and CoasterForce–approaches the "Top Ten Rollercoasters" problem with a distinct methodology. While ours emphasizes data driven objectivity, the others prioritize subjective experience. Together, they highlight how both analytical and experiential perspectives can shape perceptions of what makes a rollercoaster interesting and memorable.

Conclusion:

In this project, our team developed a data-driven model to objectively evaluate roller coasters across three key categories: Thrill, Vomit Factor, and Safety. By collecting and analyzing quantitative ride data, we created a scoring system that normalizes and weights features such as height, speed, drop, G-force, inversion, duration, and structural factors. This approach allowed us to produce a consistent overall ranking, identifying coasters that excel in excitement while maintaining safety and comfort.

Our results demonstrate that measurable characteristics can reliably capture the qualities riders value most. Record-breaking coasters such as Kingda Ka, Steel Dragon 2000, and Millennium Force ranked highly, reflecting both their intense thrill and balanced design.
While the model provides a strong, objective framework, it has limitations. It does not account for subjective experiences such as ride theming, wait times, or individual tolerance to motion. Additionally, the model relies on the availability and accuracy of online ride data, which may not reflect real-time maintenance or operational changes.

For future improvements, our model could be enhanced by integrating user feedback and experience based rating to capture subjective enjoyment, incorporating dynamic ride conditions and maintenance data for real time safety scoring, and expanding the app interface to allow personalized recommendations based on individual comfort preferences. These enhancements

would have the ranking system more comprehensive and adaptable while keeping it transparent and data-driven.

Ultimately, our project illustrates how mathematics, physics, and design thinking can be combined to quantify an inherently subjective experience providing both riders and researchers with a practical, insightful, and adaptable tool for evaluating roller coasters worldwide.

Non-Technical Document

Math Meets Thrill: A Data-Driven Way to Find the World's Best Rollercoasters

Team G004 - Massachusetts Academy of Math and Science

From Opinions to Equations

Every year, thousands of thrill seekers debate which roller coaster is the "best". Most rankings rely on personal opinions, that is, until now. Stepping up to the challenge, we developed a mathematical system that measures excitement, safety, and intensity, using real engineering data. Our goal: remove bias and show what truly makes a coaster great.

How We Turned Rides into Numbers

We collected ride statistics from online rollercoaster data to create an algorithm that evaluates each ride in three categories:

- **Thrill:** Physical excitement and adrenaline, super important to the average rider
- **Vomit Factor:** Motion intensity and disorientation, how likely are you to throw up
- **Safety:** Reliability and ride stability, those wooden coasters probably shouldn't be 200 years old, right?!

Each factor was normalized (scaled 1-10) so that coasters with different data points could be compared fairly. The weighted scores were then combined into an overall ranking.

"We wanted to show that math can quantify fun." – Team G004

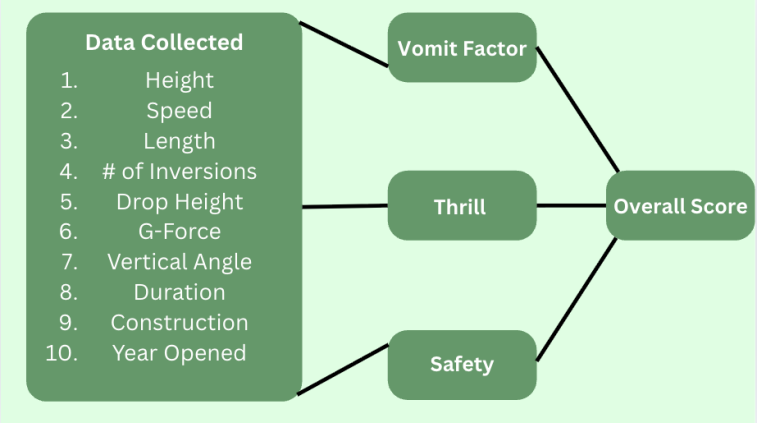

Figure 1: Flow chart depicting the data that went into our scoring system and overall score

Results: The Numbers Behind the Thrills

Our model confirmed that record-breaking rides earn their reputations for a reason.

- **Top Thrill Dragster:** With one of the higher thrill scores, this coaster is not only safe but will take you on the ride of a lifetime.
- **Soaring Dragon & Dancing Phoenix:** This coaster has one of the highest Vomit Factor scores, providing motion sickness with every ride.
- **Kingda Ka:** Our #1 rated coaster, with a good balance between thrill, vomit factor, and safety, ensuring a memorable ride with safe landings.

Unlike fan-voted lists, our ranking explains why these rides dominate; the data reveals the precise blend of speed, drop, and structure that defines world-class performance.

'CoasterMania: Our Concept App

To make our result accessible, we designed a concept app called CoasterMania. The app allows users to search by location, filter by thrill, vomit factor, and safety, as well as receive personalized coaster recommendations based on their comfort level.

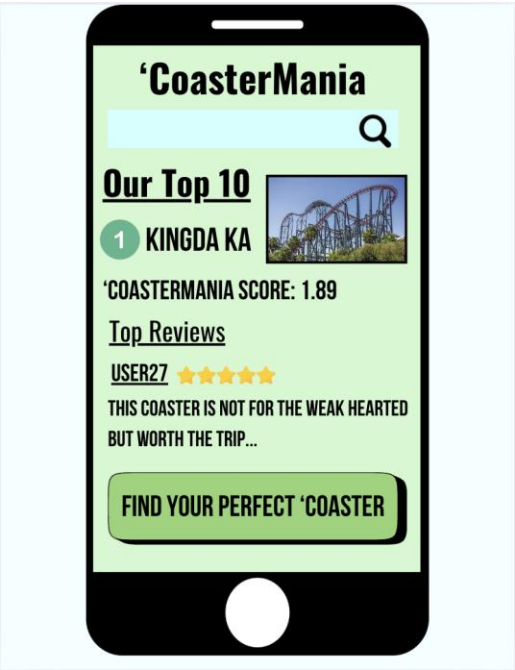

Figure 2: Home page of the app that includes the top 10 list and search bar to browse rides across the world.

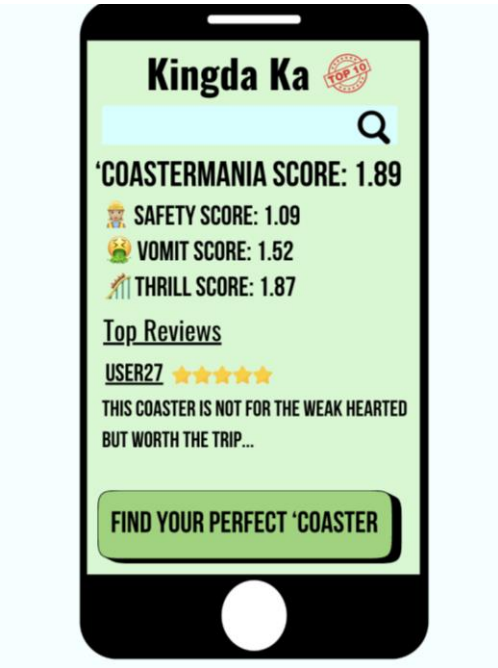

Figure 3: Layout of roller coaster page

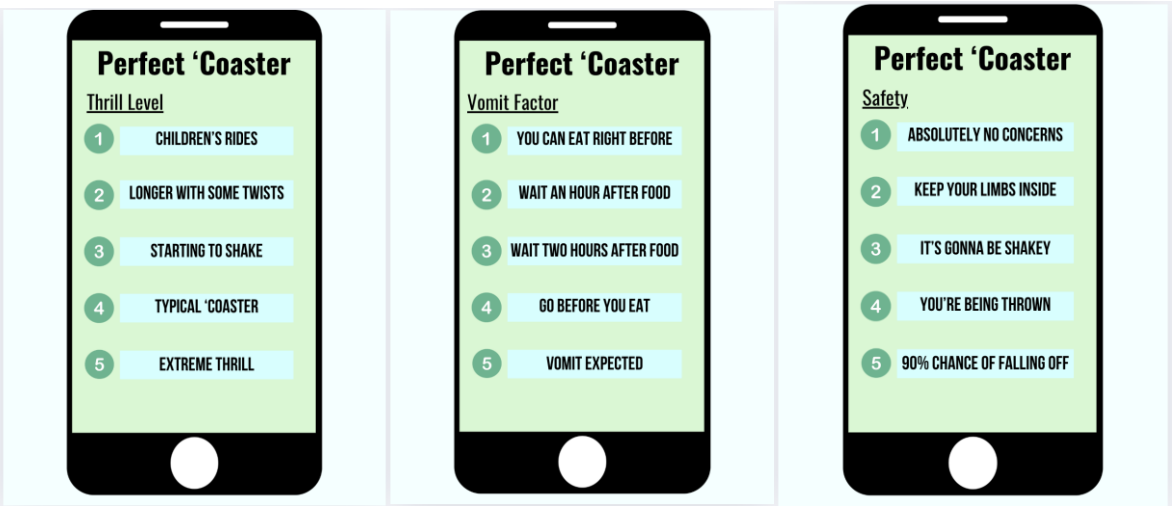

Figure 4: Our personalized filter for the user to choose their preferred rollercoaster

Users can instantly find coasters nearby, explore detailed ride states, or even discover which parks have the highest-rated thrills according to our model. With its engaging interface, CasterMania transforms our data into a tool for both thrill-seekers and casual riders.

Why This Matters

Our project shows how data and design can make subjective experiences measurable. By combining math, physics, and creativity, we created a transparent and adaptable way to evaluate amusement rides, one that could evolve with new data, locations, or even personalized rider profiles.

AI Use Report:

We did not use AI on this assignment.

Reference List:

2018 Top 50 Steel Coasters • Golden Ticket Awards (2018). https://goldenticketawards.com/2018-top-50-steel-coasters/

Pokemaniac. (2019, January 1). *CoasterForce's favourite coasters 2018*. CosterForce. https://coasterforce.com/forums/threads/coasterforces-favourite-coasters-2018.43168/