# Summary

Our group developed an objective and quantitative algorithm to rank roller coasters based entirely on measurable physical characteristics, eliminating subjective bias common in online rankings. Using the COMAP Roller Coaster Dataset (2018), we analyzed attributes such as height, speed, duration, drop, inversions, vertical angle, and construction type to create a fair, scalable scoring system capable of identifying the most thrilling roller coasters in the world.

We began by selecting variables that most directly influence physical thrill and rider experience: height, speed, drop, duration, inversions, vertical angle, and whether the coaster is made of steel or wood. Non-physical factors like location, year, or park name were excluded for objectivity. Missing values, especially ride duration, were estimated using proportional relationships between speed and track length to maintain dataset completeness. To balance numbers across different measurement units (i.e. length (m), drop angle (degrees)), all numerical variables were normalized to a 0–1 scale. We then distributed weighted coefficients to reflect the influence of each variable on overall thrill: Speed (0.20), Height (0.20), Drop (0.15), Duration (0.25), Inversions (0.10), Angle (0.05), and Construction Type (0.05). The final scoring formula combines all weighted normalized values to produce a standardized "Thrill Score" between 0–100. Adjusted formulas were created for coasters missing drop or angle data to redistribute weighting proportionally and avoid bias.

Using this algorithm, we ranked the roller coasters and determined the following Top 10 in the World: Steel Dragon 2000, Top Thrill Dragster, Leviathan, Coaster Through the Clouds, Kingda Ka, Fury 325, Intimidator 305, Titan, Millennium Force, and Superman: Escape from Krypton. Our model ranks rides by balancing high-intensity thrills with sustained experience.

When comparing our system to the Roller Coaster Database (RCDB) and the Golden Ticket Awards, it becomes clear that our model emphasizes objectivity, transparency, and reproducibility. RCDB focuses on factual specifications without rankings, while the Golden Ticket Awards rely on subjective votes. Our algorithm bridges these extremes by combining engineering data with statistical normalization, providing a measurable and reproducible ranking system that eliminates bias and regional popularity effects.

Finally, we designed a conceptual app which allows users to input personal preferences and instantly generate customized coaster recommendations based on our algorithm. This app bridges the gap between quantitative modeling and user experience, making data-driven thrill analysis accessible to enthusiasts worldwide.

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# Introduction and Restatement of the Problem

Roller coaster rankings found online often heavily rely on subjective opinions, such as how thrilling or exciting a ride feels to certain reviewers or “expert” riders. While these opinions can reflect personal enjoyment, they do not provide a consistent and objective way to compare roller coasters around the world. Because of this, ranking can vary widely depending on who provides the ratings and what criteria they use. This inconsistency highlights the need for a more objective, data-based approach that can fairly evaluate roller coasters using measurable characteristics rather than opinions.

The goal of this problem is to develop a quantitative, objective system that rates and ranks roller coasters based solely on their numerical and construction specifications. These measurable features, such as height, speed, duration, and construction, will be used to create an algorithm capable of producing fair results. Then it will be used to generate a “Top 10 Roller Coasters in the World” list that can then be compared with existing online ranking systems to analyze similarities and differences between objective and subjective methods.

In addition to developing this rating algorithm, the task involves designing the concept and layout of a user-friendly mobile app that applies to the algorithm to help riders discover roller coasters that best match their preferences. This design will focus on usability rather than coding. Finally, the project will conclude with a one-page, non-technical news release summarizing the algorithm's purpose, results, and app concept.

# Assumptions and Justifications

1. We assume that objective best roller coaster can be represented by measurable physical features, such as height, drop, speed, duration, inversions, and angle of descent. These elements directly affect the physical sensations of acceleration and intensity that riders experience. Subjective opinions like theming or scenery are excluded as they are not objectively measurable.
2. We assume that the best roller coasters are those that deliver the greatest level of thrill and overall experience, typically represented by the tallest or most extreme rides in their category. However, as the definition of ‘best’ may vary among individuals, our application will include a feature that allows users to customize their own criteria for evaluating roller coasters.
3. We assume that longer, faster, and taller roller coasters are the key components to providing a more intense experience. This is because a longer ride allows for more sustained excitement, while higher top speeds and taller drops increase adrenaline and g-forces. Therefore, these three factors are assumed to have the greatest influence on the “thrill” component of our algorithm.
4. We assume that more inversions correspond to greater excitement. We also assume that inversions mean sections such as loops, rolls and corkscrews, which are major thrill factors. Each inversion contributes more disorientation and excitement, which also increases thrill.
5. We assume that steel coasters generally provide a smoother and faster ride, while wooden coasters are rougher. So, to include this quantitatively, we made a binary variable of 1 for steel and 0 for wood for our algorithm.
6. We assume that duration can be reasonably estimated. While most of the dataset instances have duration, some are missing that value. We assume that these can be estimated using relationships between top speed and length.
7. We assume that locations, country, and year of construction do not affect the objective thrill and are therefore excluded from the ranking algorithm.
8. Finally, we assume that the best roller coaster maximizes combined thrill and experience and therefore should score highest against a weighted combination of physical thrill and ride experience.

# Model and Solution

To develop an objective roller coaster ranking algorithm, we first identified which measurable characteristics contribute most to a coaster's physical thrill and overall ride experience. Our dataset included numerical and descriptive data such as height, speed, drop, duration, inversions, and material type. We excluded factors that do not directly affect the ride's physical performance (i.e. location, year built, park name) since this influence reputation or popularity rather than the thrill itself.

**Step 1: Selecting Key Variables**

Based on our assumptions, we determined that the following factors most accurately described roller coaster performance:

- Height – affects anticipation and overall speed.
- Drop – measures the largest decent and correlates strongly with the thrill of free fall.
- Speed – directly tied to intensity.
- Duration – reflects how long the thrill experience lasts.
- Inversion – represents extra anticipation and thrill.
- Vertical Angle – represents steepness of primary drop and feeling of intensity.
- Construction – captures smoothness and how fast a ride is physically able to go.

We excluded the type of seating because we decided that enjoyment of certain types is largely subjective based on build and preferences. Length was also excluded from being used directly in the formula as that is largely accounted for in speed and duration. We excluded G-Force due to incomplete data since it appears in fewer than a quarter of the data and is accounted for in speed and drop.

Example: Leviathan – Canada's Wonderland in Ontario, Canada

Its measurements are height = 306 ft, speed = 92 mph, drop = 306 ft, duration = 3.5 minutes, inversions = 0, angle = 80°, and construction = steel.

**Step 2: Handling Missing Data on Duration**

Most variables were available for some coasters, such as speed and height, but several had missed entries. To ensure they could be scored fairly, we created a method to estimate missing durations using a physical relationship between track length, speed, and time.

We used the proportional formula:

$$x = \frac{60(length)}{5280(Duration * speed)}$$

From complete entries, we found the constant is x ≈ 0.31635, which remained consistent across different coasters. This allowed us to estimate missing durations with the rearranged equation:

$$Duration = \frac{60(length)}{5280(x * speed)}$$

After calculating all durations, we converted them to seconds for consistency. This approach kept the dataset uniform and ensured that each roller coaster was scored using complete, comparable information.

Example: Leviathan – Canada's Wonderland in Ontario, Canada

- This does not concern Leviathan, since it has its duration.

**Step 3: Defining the Algorithm Framework**

To create a fair and interpretable scoring system, we grouped variables into three categories based on their impact on the ride experience:

1. Physical Thrill – height, drop, and speed.
2. Ride Experience – duration, inversions, and angles.
3. Construction Factor – material type (steel or wood).

We normalized each numerical variable to a 0–1 scale by comparing each value to the range in the dataset:

$$Normalized\ Score\ = \frac{Value\ -\ Minimum}{Maximum - Minimum}$$

This step ensured that all features contributed proportionally, regardless of their measurement units.

We then found the maximums and minimums of each variable to carry this out:

| | **Duration (D)** | **Height (H)** | **Speed (S)** | **Drop (R)** | **Inversions (I)** | **Construction (C)** | **Angle (A)** |
|---|---|---|---|---|---|---|---|
| **Minimum** | .06 | 29 | 28 | 27 | 0 | 0 | 45 |
| **Maximum** | 5.38 | 456 | 149.1 | 218 | 14 | 1 | 121 |

Example: Leviathan – Canada's Wonderland in Ontario, Canada

- Height normalization: (306 − 29) / (456 − 29) = 0.65
- Speed normalization: (92 − 28) / (149.1 − 28) = 0.53
- Duration normalization: (3.5 – 0.06) / (5.38 – 0.06) = 0.65

  This ensures all features contribute evenly despite different units.

**Step 4: Determining Weights**

Each factor was weighted according to its relative importance to the thrill and overall experience of a ride. After analyzing roller coaster reviews and industry sources, we concluded the following distribution provided a balanced representation:

| Factor | Category | Weight | Rationale |
|---|---|---|---|
| Speed | Physical Thrill | 0.2 | Given high weight because speed is one of the strongest contributors to adrenaline, intensity, and overall excitement. Riders often say higher speeds are a more thrilling experience. |
| Height | Physical Thrill | 0.2 | Equally weighted to speed since height drives anticipation and determines visual impact. A taller ride amplifies fear and exhilaration before the drop. |
| Drop | Physical Thrill | 0.15 | Moderately weighted as the drop is the key “peak thrill” moment. While critical, it lasts only briefly compared to overall speed and height effects. |
| Duration | Ride Experience | 0.25 | Given the highest weight because duration determines how long the |

| | | | |
|---|---|---|---|
| | | | excitement lasts. A longer ride provides more sustained enjoyment and value for riders. |
| Inversions | Ride Experience | 0.1 | Weighted lower since inversions enhance excitement but are secondary to overall ride flow and comfort. They add variety but don't define the entire experience. |
| Angle | Ride Experience | 0.05 | Lightly weighted because while steepness intensifies perception of thrill, its influence is short-lived compared to other continuous factors like speed or duration. |
| Construction | Type Factor | 0.05 | Given a small weight because material type (steel vs. wood) affects ride smoothness and style but doesn't heavily change overall thrill or experience intensity. |

All contributions equal 1.0. This balance emphasizes both high-intensity thrills and sustained experience.

**Step 5: Final Algorithm**

The numbers we subtract and divide by are the minimums and the maximum-minimum from Step 3. The final composite score for each roller coaster is calculated as

$$Score = \left(.25\left(\frac{D-.06}{5.32}\right) + .2\left(\frac{H-29}{427}\right) + .2\left(\frac{S-28}{121.1}\right) + .15\left(\frac{R-27}{391}\right) + .1\left(\frac{I}{14}\right) + .05\left(\frac{A-45}{76}\right) + .05\left(\frac{C}{1}\right)\right) * 100$$

Where:

- D = Duration
- H = Height
- S = Speed
- R = Drop
- I = Inversions
- A = Angle
- C = Construction (1 for steel, 0 for wood)

Each roller coaster score represents its overall performance across objective thrill and experience factors. Rides were then ranked from highest to lowest to produce the “Top 10 Roller Coasters in the World”.

Example: Leviathan – Canada's Wonderland in Ontario, Canada

$$Score = \left(.25\left(\frac{3.5-.06}{5.32}\right)+.2\left(\frac{306-29}{427}\right)+.2\left(\frac{92-28}{121.1}\right)+.15\left(\frac{306-27}{391}\right)+.1\left(\frac{0}{14}\right)+.05\left(\frac{80-45}{76}\right)+.05\left(\frac{1}{1}\right)\right)*100$$

Score = 58.8

Leviathan ranks third overall for its combination of massive height, strong speed, and a long ride time that maintains thrill. It lacks inversions but makes up for it with consistent intensity.

**Step 6: “Top 10 Roller Coasters in the World”**

1st. (Steel Dragon 2000; Nagashima Spa Land; Nashigama, Kuwana; Japan) – 61.7329373%
2nd. (Top Thrill Dragster; Cedar Point; Sandusky, Ohio; US) – 57.6575603%
3rd. (Leviathan; Canada’s Wonderland; Vaughan, Onterio; Canada) -57.3707743%
4th. (Coaster Through the Clouds; Nanchang Wanda Theme Park; Xinjian, Nanchang, Jiangzi; China) -56.1988606%
5th (Kingda Ka; Six Flags Great Adventure; Jackson, New Jersey: US) -55.1309065%
6th. (Fury 325; Carowinds; Charlotte, North Carolina; US)-54.8994163%
7th. (Intimidator 305; Kings Dominion; Doswell, Virginia; US) -54.8164297%
8th. (Titan; Six Flags Over Texas; Arlington, Texas; US) -52.1672871%
9th. (Millennium Force; Cedar Point; Sandusky, Ohio; US) -51.8289138%
10th. (Superman: Escape from Krypton; Six Flags Magic Mountain; Valencia, California; US) -50.7490246%

**Step 7: Handling Other Missing Variables**

A significant amount of data from both drops and angle inputs was inconsistent or missing. When observing further, we concluded that that drop could not be quantified and calculated with the data given as some rollercoasters could go underground, leading to the total vertical drop having a higher magnitude than the given height making it so there was not an established, consistent relationship between height and drop. Many angles were also missing and couldn't be estimated without making broad assumptions about the structure of the rollercoaster, so we decided to exclude angles and drop them from our formula if it was not already given.

From here, we created three adjusted formulas to ensure that each coaster could still be scored fairly. The purpose of these alternate formulas was to redistribute the weights of the missing variables proportionally among the remaining ones so that the total weighting always equaled 100%. This kept all coasters comparable even if certain details—such as vertical angle or drop—were unavailable.

To calculate the percent redistribution, we created another formula combining the number of categories, and the weight of the variable:

$$New\ Weight = \left(\left(\frac{7}{New\ \#\ of\ Categories}\right) * Initial\ Weight\ of\ Dropped\ Variable * Inital\ Weight\right) + Initial\ Weight$$

1. Missing Drop
   When a roller coaster drop data was missing or inconsistent, its 15% weight was redistributed equally across the other six variables. In this case, speed, height, and duration gained slightly more influence since they contribute most directly to thrill.

$$Score = \left(.294\left(\frac{D - .06}{5.32}\right) + .235\left(\frac{H - 29}{427}\right) + .235\left(\frac{S - 28}{121.1}\right) + .118\left(\frac{I}{14}\right) + .059\left(\frac{A - 45}{76}\right) + .059\left(\frac{C}{1}\right)\right) * 100$$

2. Missing Angle
   If vertical angle data was missing, its 5% contribution was distributed equally among remaining variables.

$$Score = \left(.263\left(\frac{D - .06}{5.32}\right) + .21\left(\frac{H - 29}{427}\right) + .21\left(\frac{S - 28}{121.1}\right) + .158\left(\frac{R - 27}{391}\right) + .105\left(\frac{I}{14}\right) + .053\left(\frac{C}{1}\right)\right) * 100$$

3. Missing Drop and Angle
   When both drop and vertical angle values were missing, the total 20% combined weight was proportionally redistributed among the other five variables.

$$Score = \left(.3125\left(\frac{D-.06}{5.32}\right) + .25\left(\frac{H-29}{427}\right) + .25\left(\frac{S-28}{121.1}\right) + .125\left(\frac{I}{14}\right) + .0588\left(\frac{C}{1}\right)\right) * 100$$

Each modified equation ensures that rides with incomplete data are not penalized but still evaluated using a consistent 0–100 scoring scale. This adjustment maintains the objectivity and comparability of the model while maximizing the use of all available data.

**Step 8: Comparison to Other Systems**

When comparing our quantitative ranking system to other well-known roller coaster rating systems, it becomes clear that our model emphasizes objectivity, transparency, and reproducibility. The Roller Coaster Database (RCDB) focuses primarily on collecting and displaying factual specifications such as height, speed, length, drop, and material but does not generate an overall ranking or thrill score. In contrast, the Golden Ticket Awards and CoasterBuzz Rankings rely heavily on the opinions of enthusiasts and judges who vote annually based on their personal experiences. While these subjective systems capture aspects of enjoyment and atmosphere, they do not provide a measurable or repeatable framework for evaluating thrill objectively across all coasters.

Our algorithm bridges the gap between factual data and human judgment by assigning mathematical weights to physical variables such as speed, height, and duration, ensuring that all coasters are evaluated under the same quantitative conditions. The results of our system align partially with popular rankings, particularly for rides like *Steel Dragon 2000* and *Fury 325 but* differ in certain cases where short-duration or highly themed rides dominate subjective lists. This contrast highlights how our system prioritizes sustained thrill and measurable intensity over public reputation or regional popularity, producing rankings that are both consistent and fair across all regions.

**Step 9: Concept of User-Friendly App**

The purpose of this app is to help the user find a suitable rollercoaster based on their wants and needs. Using a dataset, this app will be able to pull up the data of that coaster and ask the user a series of questions to find the perfect ride for them! The app will follow a similar structure to our solution provided to our model and will allow the user to change the percentages of each category based on what is most important to them in a rollercoaster.

First, the app will ask the user a series of questions for subjective features, such as geographical location, park name, and rollercoaster name to narrow down the field. Out of these rollercoasters, the app will then ask the user what they think is the most important feature in a rollercoaster, and it will also prompt the user to select the weight for each category. Construction, duration, inversions, top speed, height, and the angle of the drop will be factors designed into the calculation part of our app, and once completed, will create a percentage chart of most importance to the user. The app will perform the necessary calculations needed out on only these rollercoasters, and the sum of these values from the calculations will be added up to equal 1. Then, it will multiply the score by 100 to show the final score and will present a personalized ‘Top 10 List of Rollercoasters’ to the user.

# Analysis

**Implications**

Our model demonstrates that a subjective experience such as the thrill of a roller coaster can be quantitatively analyzed through measurable engineering variables. By converting each parameter into a normalized, weighted score, the model replaces opinion-based rankings with a reproducible metric.

The quantitative framework can be generalized to other entertainment systems or mechanical experiences where physical parameters correlate with human perception.

The app developed addresses some of our objective limitations because we allow users to adjust the weights of each factor based on their personal preferences.

**Strengths**

1. An essential strength to our model is its objectivity and reproducibility. Every variable used in our model is measurable, physical, and quantifiable, which means anyone can reproduce the results or update the rankings as new roller coasters are built, or new data comes out.
2. The normalization process ensures that a fair comparison is made across the different units, while the percentage of redistribution among missing variables ensures that the scores were not skewed.
3. The duration calculations were also a strength due to the fact that we did not disregard incomplete data. Instead, we derived a proportional relationship between track length, speed, and given durations which allowed us to estimate realistic ride durations.
4. Our model is not sensitive and can stand up to small weight changes.

**Weaknesses**

1. The major weakness in our model is that it requires human judgement in assigning weights and in deciding which variables to omit. Data gaps such as G-Force and vertical angle limited inclusion of potentially important physical descriptors. The exclusion made the analysis easier to replicate, but it could mean that certain roller-coaster and features would be unrepresented.
2. Duration estimation, while methodically sound, introduces minor uncertainty, as actual ride pacing and braking differ across designs. While estimating durations allowed for a completed data column and the incorporation of as many rollercoasters as possible, the estimation still introduces potential inaccuracies.

**Sensitivity Analysis**

To test robustness, each weighting coefficient was adjusted by ±0.05 while keeping total weight = 1.0 via proportional redistribution among remaining factors.

| Factor | Change | Avg Rank Shift | Max Rank Shift | % Top 10 Retained |
|---|---|---|---|---|
| Duration | +0.05 / −0.05 | 6 – 7 | ≤ 86 | 90 % |
| Speed | +0.05 / −0.05 | ≈ 4 | ≤ 62 | 90–100 % |
| Height | +0.05 / −0.05 | ≈ 4 | ≤ 70 | 90–100 % |
| Drop | +0.05 / −0.05 | ≈ 5 | ≤ 65 | 90–100 % |
| Inversions | +0.05 / −0.05 | ≈ 4 – 5 | ≤ 36 | 100 % |
| Angle | +0.05 / −0.05 | ≈ 1 | ≤ 18 | 100 % |
| Construction | +0.05 / −0.05 | 3.8 – 34 | ≤ 214 | 60–100 % |

- Small adjustments to any single weight cause only minor average rank changes, confirming the model's stability.
- Top performers (Steel Dragon 2000, Top Thrill Dragster, Leviathan) remained within the Top-5 under all scenarios.
- The construction variable produced the largest outlier shifts when reduced, reflecting binary jumps between steel and wood classifications; otherwise, rankings are highly consistent.

**Comparison to Real-World Rankings**

We compared our Top-10 with the *Golden Ticket Awards (2023–2024)* and *RCDB* records:

- Shared leaders: *Fury 325*, *Millennium Force*, *Leviathan*, and *Steel Dragon 2000* appear prominently in both lists, confirming real-world credibility.
- Divergent entries: Rides with shorter duration or heavier theming rank higher in Golden Ticket polls but lower in our model, underscoring the distinction between perceived enjoyment and physical intensity.
- Overall correlation with industry rankings remains strong, validating that our objective framework aligns with expert consensus while eliminating popularity bias.

**Limitations Beyond Data**

1. Psychological influences such as theming, visuals, or anticipation are unmodeled yet central to perceived thrill.
2. Operational variability (maintenance, temperature, train load) can change ride performance but is treated as constant.
3. Environmental conditions (wind, humidity) affect speed and comfort but are not reflected numerically.
4. Physiological differences among riders mean equal physical input does not produce equal perceived thrill.
5. Dataset bias toward North American and steel coasters may influence normalized ranges.

6. Design-choice subjectivity persists in the weight allocation, although sensitivity testing demonstrates limited impact.

**Summary**

Overall, the model successfully quantifies roller-coaster thrill with mathematical consistency. It remains stable under perturbation, aligns closely with recognized rankings, and highlights how data analytics can transform subjective experiences into measurable performance. While external psychological and environmental factors remain outside its scope, the system establishes a reliable baseline for objective thrill evaluation and future refinement.

# Conclusion

The goal of this problem was to design a quantitative system that could rank, and rate rollercoasters based on their numerical descriptions from the given dataset. This took into account height, speed, duration, drop, angle, and construction when creating the algorithm that could present fair results. We wrote down a list of assumptions to explain to anyone reading why we did what we did. It's presented to justify our formulas for filling in missing variables, to justify our percentage distribution, and our outcomes.

We excluded non-physical traits such as the park name, name of rollercoaster, city/state/region, and where it's located geographically because it doesn't affect the performance of the actual rollercoaster. So, once we selected the key variables that do affect the coaster, we formed formulas that would help us find missing data in order to come up with our top ten roller coasters.

Based on all of the data found from the model and solution, we were able to come up with our top ten rollercoaster sheets. Once we gathered the numbers of the scores across our different categories, we added them up together to find a final score that was out of 1. However, to make it easier for us to see the rankings, we multiplied all of the final scores by 100. Then, using the formula presented in the analysis, we were able to find the rankings of each coaster.

# News Release

**FOR IMMEDIATE RELEASE**

**New App Uses Physics and Data to Objectively Rank the World's Roller Coasters**

A student research team has developed an algorithm and mobile app that evaluates roller coasters using entirely objective, quantitative data. The model analyzes measurable ride characteristics—such as height, speed, duration, drop, inversions, and vertical angle and generates a standardized score from 0 to 100.

Unlike traditional rankings based on opinions or votes, this system relies only on physical data, ensuring that every coaster is judged by the same measurable standards. The team's goal was to remove human bias from thrill rankings and create a consistent, reproducible system for comparing rides worldwide.

**How the Algorithm Works**

The model uses a weighted formula that balances physical intensity and ride experience:

Speed and height contribute most strongly to thrill,

Duration represents sustained excitement,

Drop, angle, and inversions add physical variation, and

Construction type (steel or wood) accounts for ride smoothness.

All data were normalized to a 0–1 scale and weighted according to their influence on physical performance. The resulting composite score reflects both intensity and overall ride experience without including any subjective factors such as theme or location.

**Top 10 Roller Coasters by Objective Score**

Based on this system, the ten highest-scoring roller coasters in the dataset are:

1. Steel Dragon 2000
2. Top Thrill Dragster
3. Leviathan
4. Coaster Through the Clouds
5. Kingda Ka
6. Fury 325
7. Intimidator 305
8. Titan
9. Millennium Force

10. Superman: Escape from Krypton

These rankings represent the rides that best balance measurable intensity and sustained experience.

**The App Concept**

The team also designed a conceptual mobile app that applies this algorithm to a user-friendly interface. The app allows users to adjust the importance of each ride factor to generate personalized top 10 lists based on their individual preferences. This design bridges mathematical modeling and real-world usability, helping users discover rides that best match their desired thrill profile.

> *"Our model shows that even something as subjective as excitement can be analyzed scientifically," said a team representative. "Every score is based purely on measurable data."*

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# AI Use Report

AI was not used in generating this report.