PROBLEM STATEMENT

In this project, we are addressing the challenge of determining the set of factors that genuinely influence the distance travelled by the Lego car. We aim to explore the underlying principles governing the car's motion and identify key elements that contribute to its performance.

OBEJCTIVE & GOAL

OBJECTIVE:

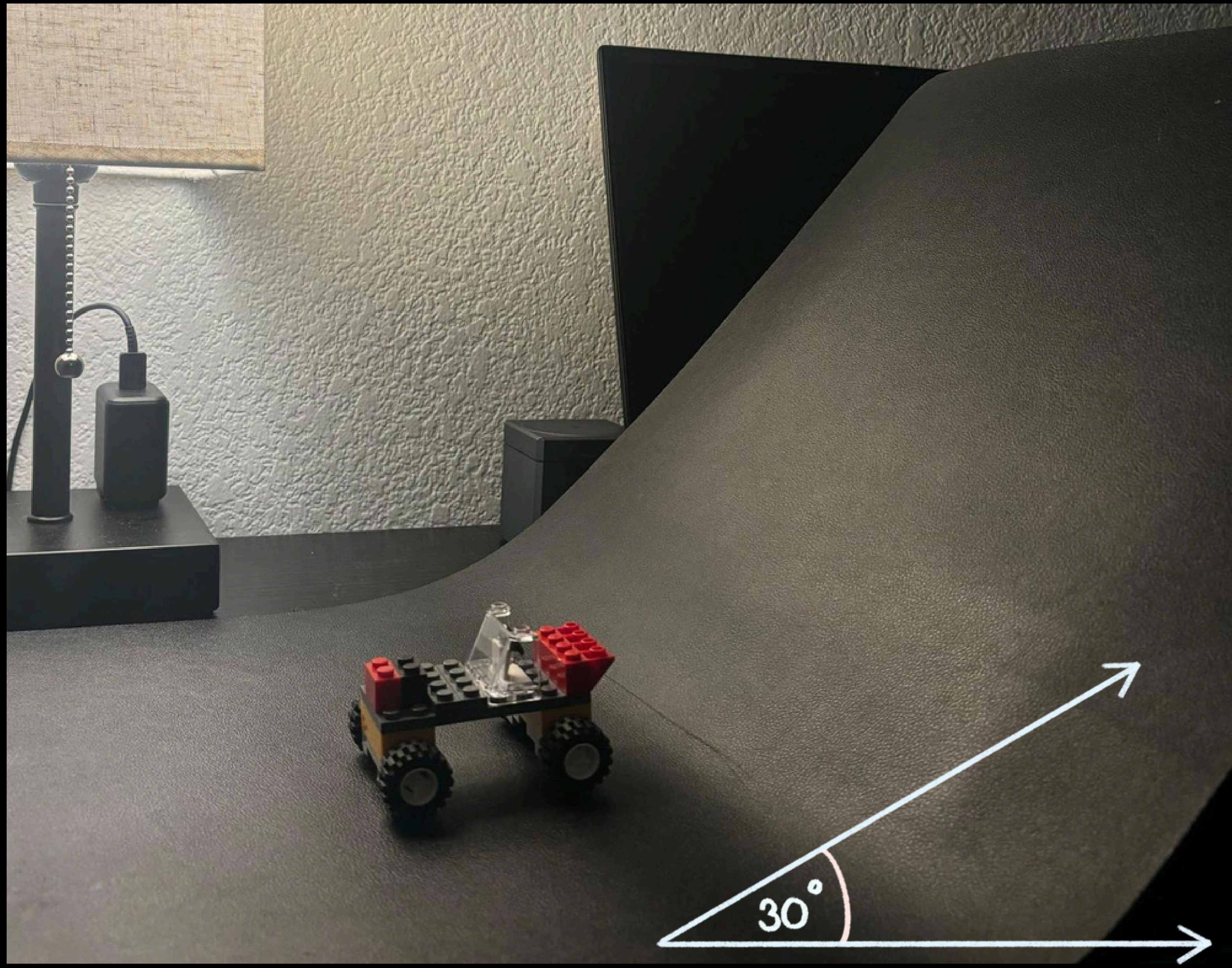
To create a cost-effective Lego vehicle designed to travel the maximum possible distance.

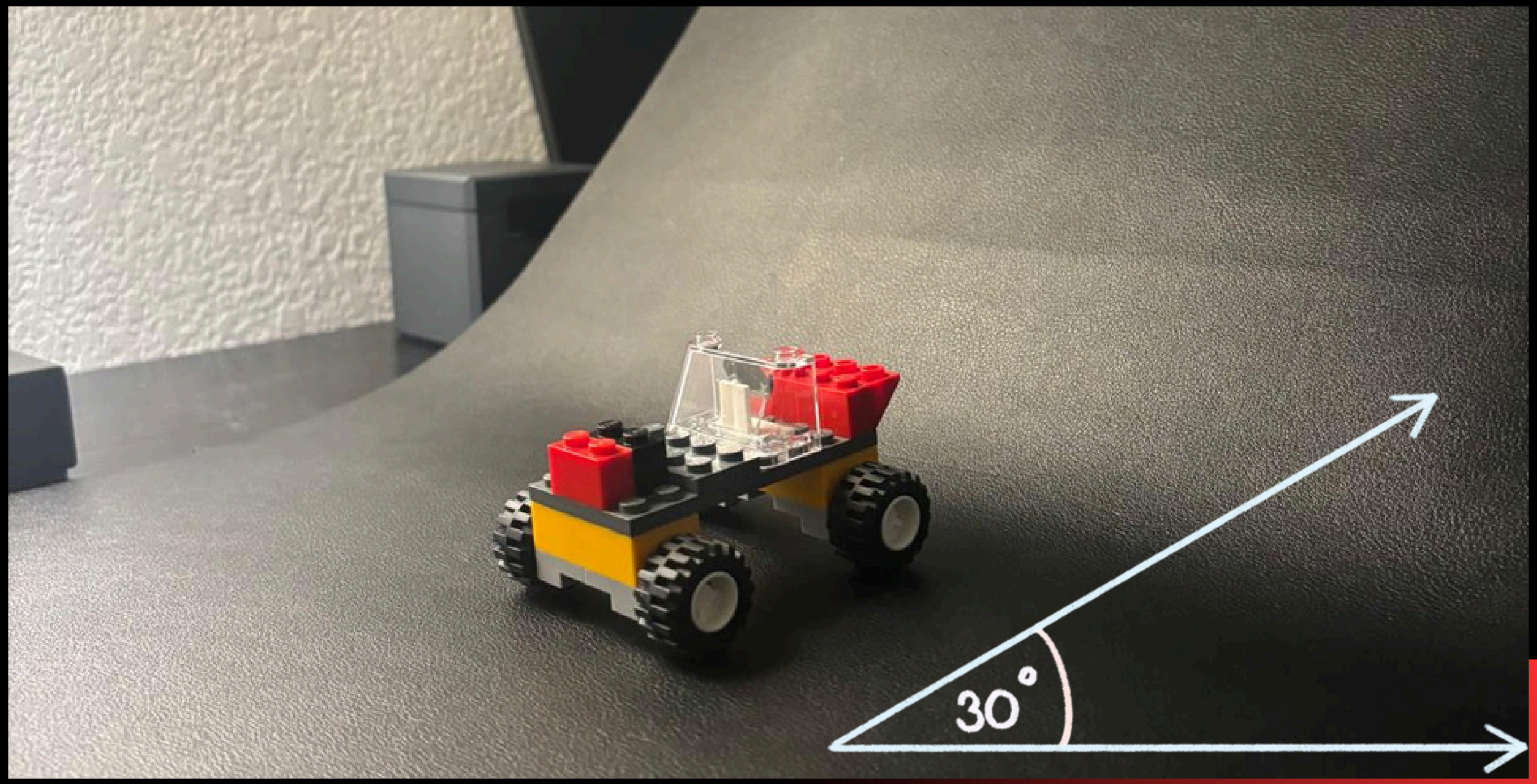
GOAL:

The goal is to conduct a two-level, four-factor DOE to identify the significant characteristics and interactions that contribute to achieving our objective.

OVERVIEW OF THE SETUP

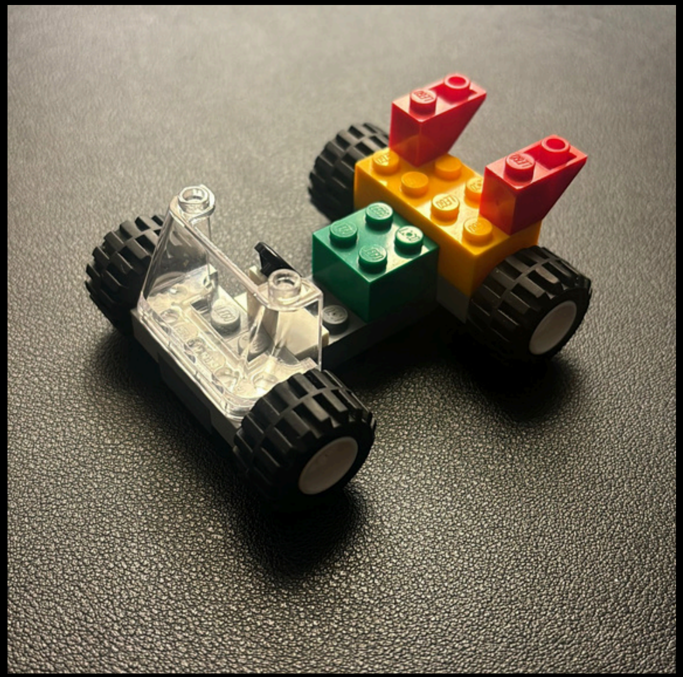
The project focuses on using a fixed number of Lego pieces to assemble a car, with the primary objective being to maximize the distance it travels from a 30-degree inclined ramp. The study is based on the principles of design of experiments, where we perform a screening experiment to identify and analyze the factors that significantly influence the response variable, which is the distance traveled.

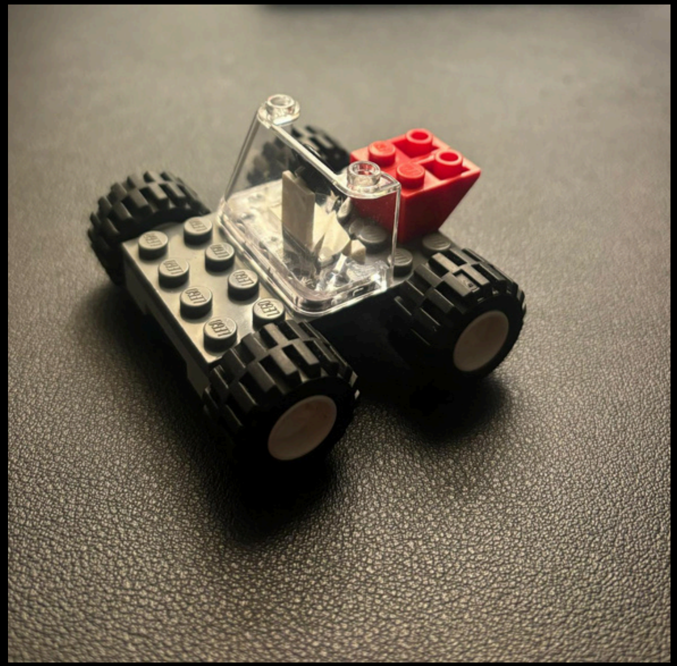


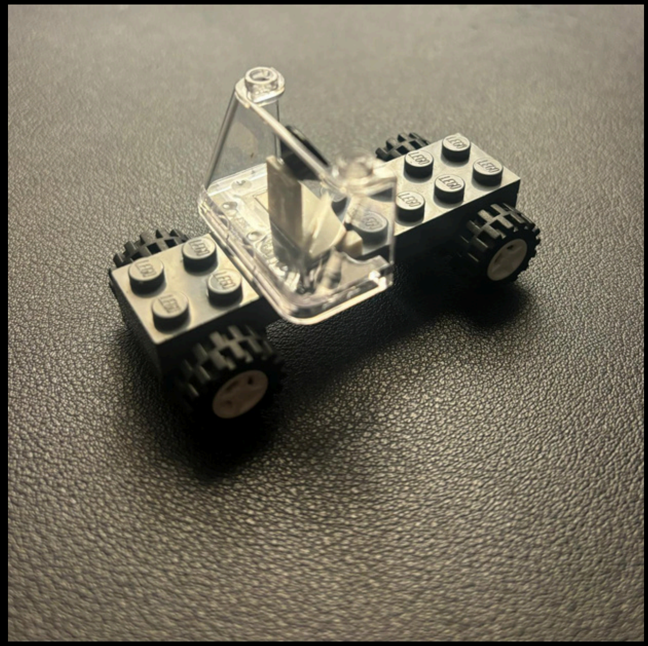


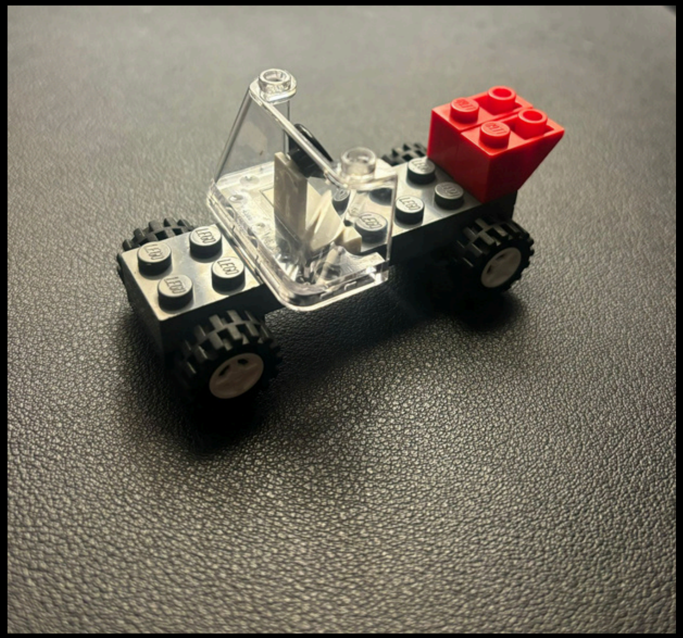
DESIGNS TESTED

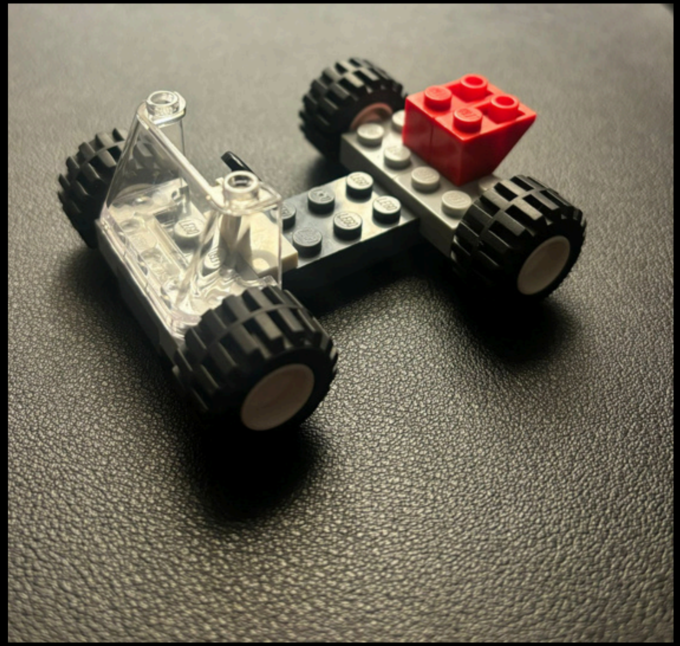
DOE serves as a powerful framework for systematically improving car design by leveraging data driven insights into key factors and thier interactions.

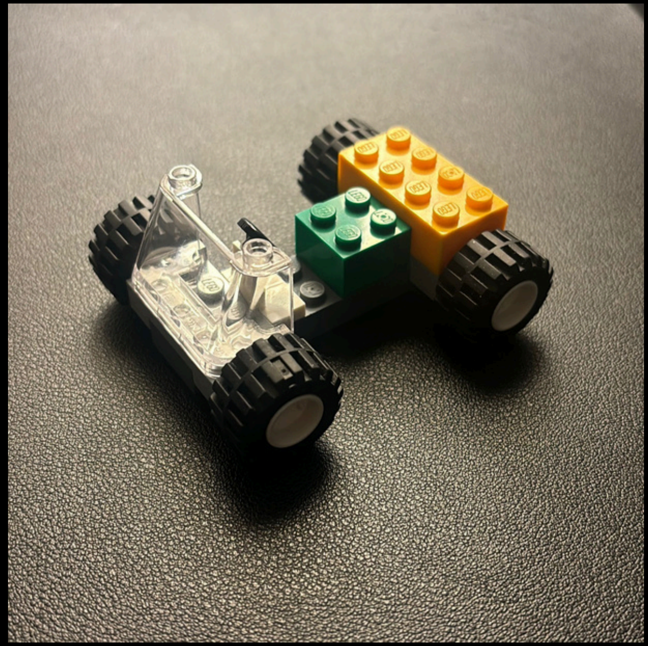




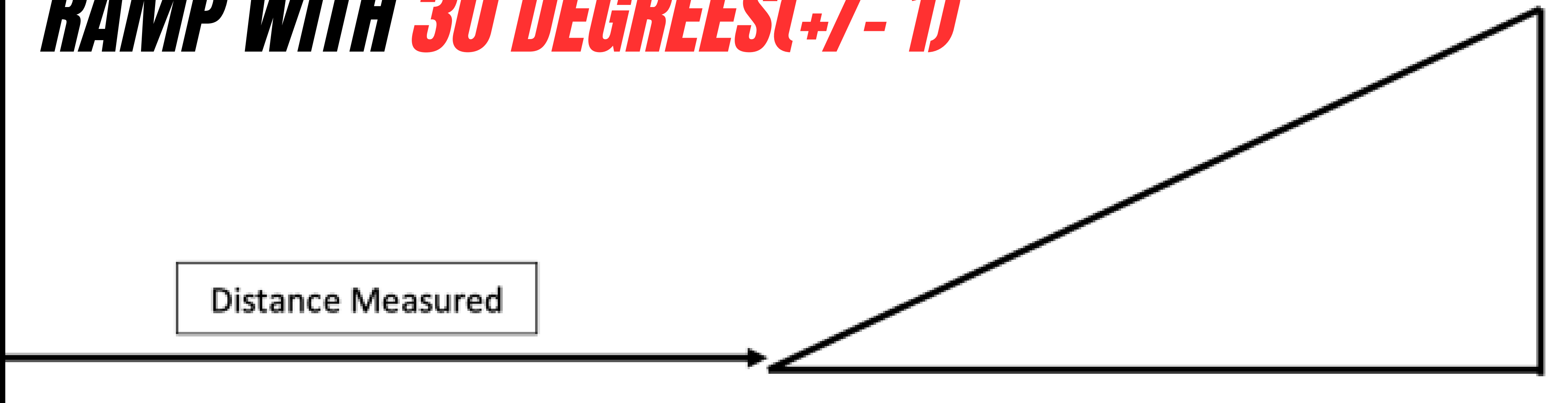








RAMP WITH 30 DEGREES(+/- 1)



FACTORS FOR THE EXPERIMENT

- Wheel Size
  - Small (-1): Reduced wheel size for the experiment
  - Large (+1): Increased wheel size for the experiment
- Tailfin
  - Removed (-1): Tailfin is absent from the setup
  - Present (+1): Tailfin is included in the setup
- Base Width
  - 2 Units (-1): Narrow base width for the experiment
  - 4 Units (+1): Wider base width for the experiment
- Base Length
  - 6 Units (-1): Short base length for the experiment
  - 8 Units (+1): Long base length for the experiment

MEASUREMENTS

VALUE OF N = 2

VALUE OF K = 4

(-) DENOTES THE LOW VALUE
(+) DENOTES THE HIGH VALUE

Once the number of factors was fixed and the preliminary design identified, we used minitab to create a 2-level (high/low) factorial design to run our DOE study and recorded the distance as mentioned in the picture.

car #	Wheel Size	Tailfin	Base Width	Base Length	Distance 1	Distance 2
1	-1	-1	-1	-1	65	50
2	1	-1	-1	-1	0	0
3	-1	1	-1	-1	66	63
4	1	1	-1	-1	0	0
5	-1	-1	1	-1	69	72
6	1	-1	1	-1	76	68
7	-1	1	1	-1	77	77
8	1	1	1	-1	62	66
9	-1	-1	-1	1	58	52
10	1	-1	-1	1	76	68
11	-1	1	-1	1	60	64
12	1	1	-1	1	81	90
13	-1	-1	1	1	69	72
14	1	-1	1	1	65	71
15	-1	1	1	1	82	84
16	1	1	1	1	58	65

ANOVA RESULTS

SIGNIFICANT FACTOR

- A,C,D
- AC,AD,CD
- ABC,ACD

ANOVA ANALYSIS GIVES US

- Degree of freedom
- Adj sum of square
- Adj mean square
- F- value
- P-value

Analysis of Variance

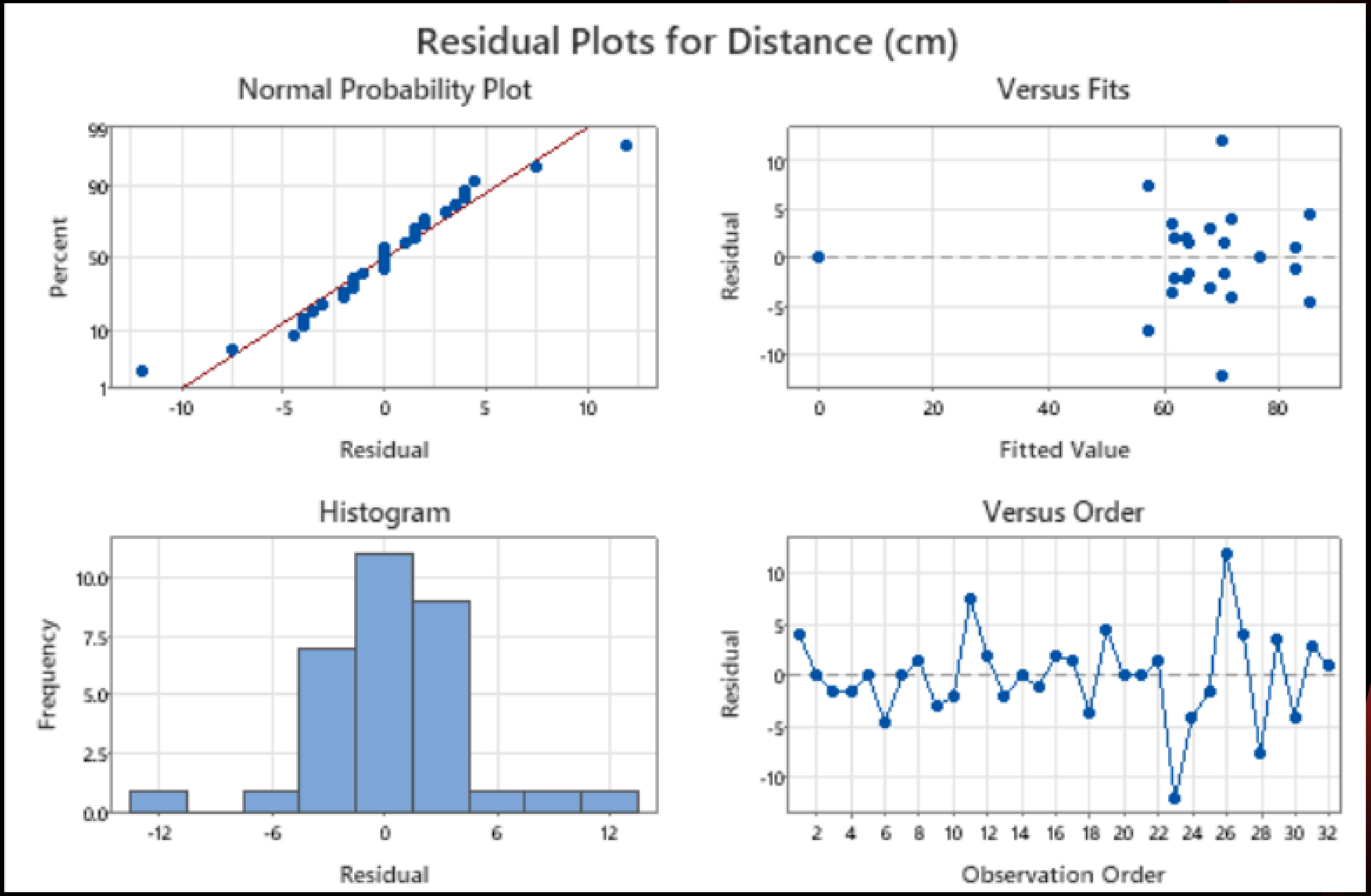
Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	15	18738.5	1249.23	34.52	0.000
Linear	4	8703.4	2175.84	60.13	0.000
A	1	2178.0	2178.00	60.19	0.000
B	1	36.1	36.13	1.00	0.333
C	1	3003.1	3003.13	82.99	0.000
D	1	3486.1	3486.12	96.34	0.000
2-Way Interactions	6	6328.9	1054.81	29.15	0.000
A*B	1	45.1	45.13	1.25	0.281
A*C	1	465.1	465.12	12.85	0.002
A*D	1	2278.1	2278.13	62.95	0.000
B*C	1	8.0	8.00	0.22	0.645
B*D	1	4.5	4.50	0.12	0.729
C*D	1	3528.0	3528.00	97.49	0.000
3-Way Interactions	4	3570.1	892.53	24.66	0.000
A*B*C	1	288.0	288.00	7.96	0.012
A*B*D	1	72.0	72.00	1.99	0.178
A*C*D	1	3200.0	3200.00	88.43	0.000
B*C*D	1	10.1	10.13	0.28	0.604
4-Way Interactions	1	136.1	136.13	3.76	0.070
A*B*C*D	1	136.1	136.13	3.76	0.070
Error	16	579.0	36.19		
Total	31	19317.5			

RESIDUAL ANALYSIS

Normality (Normal Probability Plot)
The normality assumption appears to be reasonably satisfied.

Equal Variance:
Scattered around zero and not symmetric.

Independence:
The independence assumption is satisfied as residuals scattered without a clear pattern or trend.



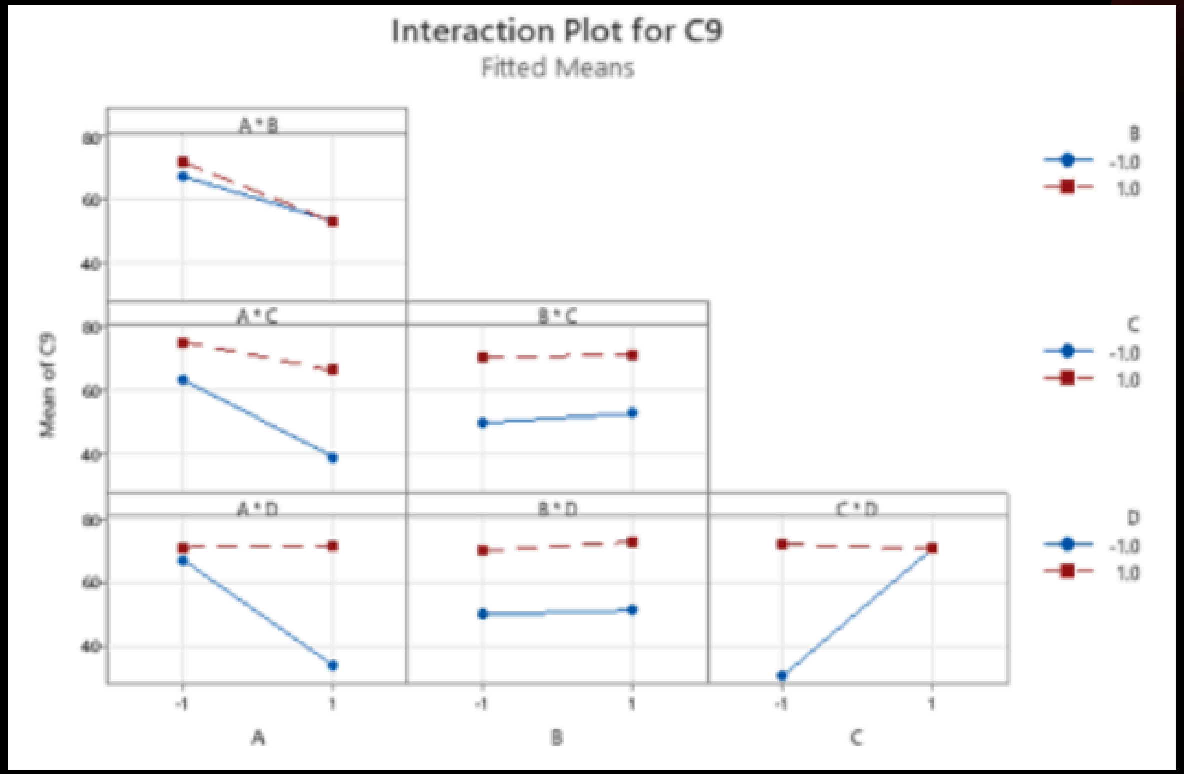
PLOT ANALYSIS

Factors

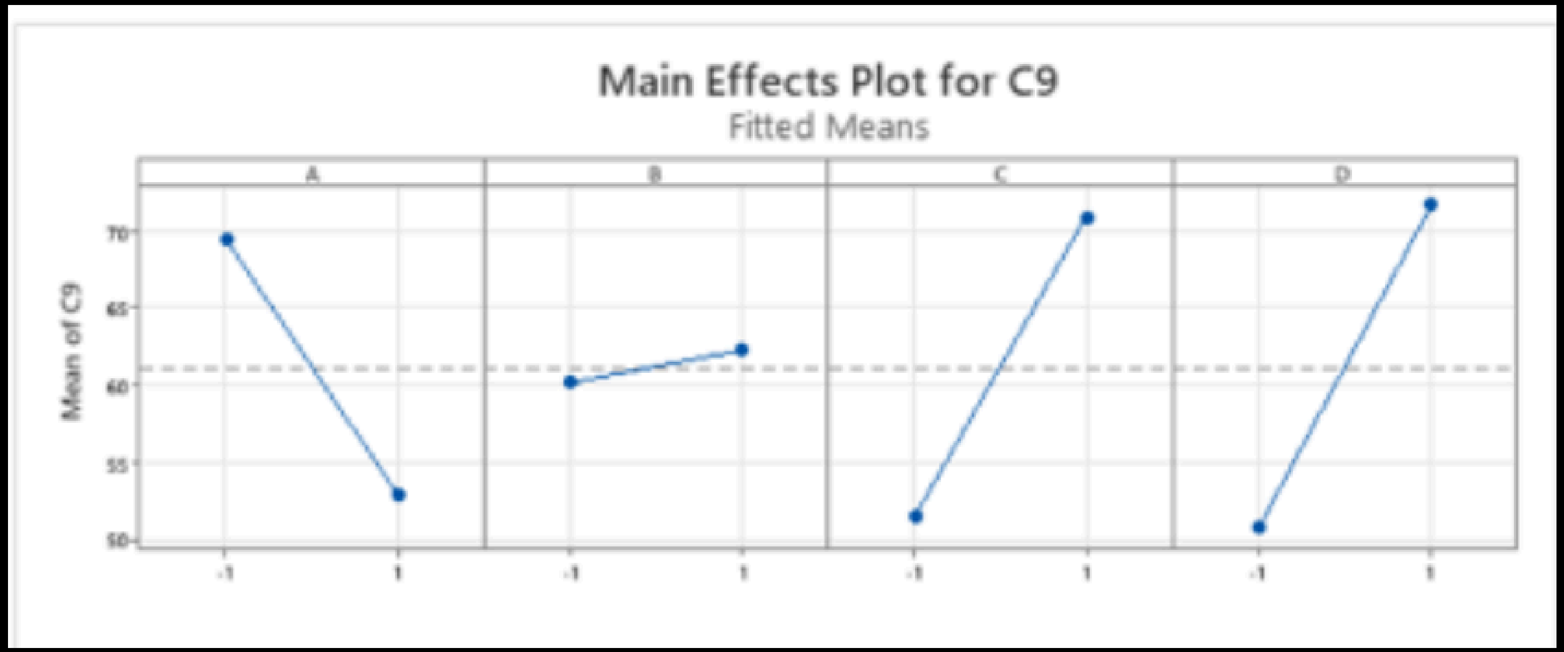
- **A** = Wheels
- **B** = Fin
- **C** = Width
- **D** = Length

Factors aligned ANOVA results

- A,C,D
- AC,AD,CD

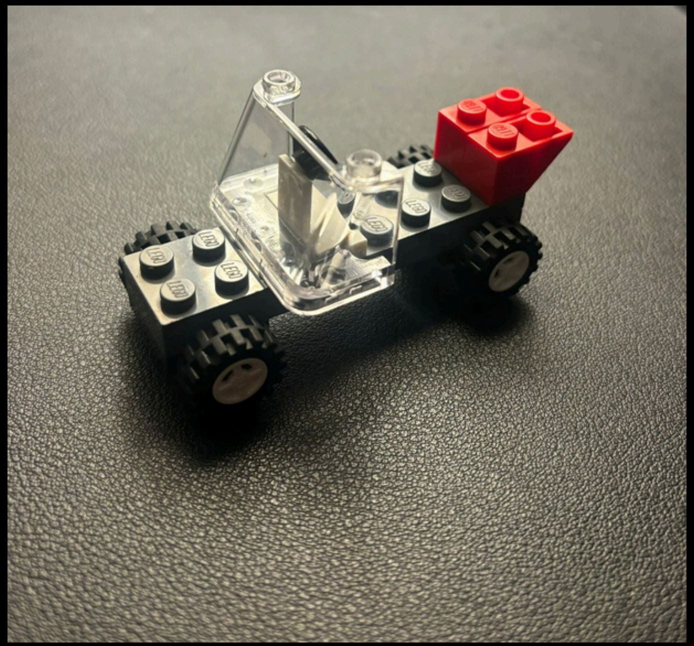


- **Optimization**: Focus on these factors and interactions to improve system performance.
- **Modeling**: Include significant effects in predictive models for better accuracy.
- **Visualization**: Used interaction plots and response surface plots to interpret these relationships effectively.



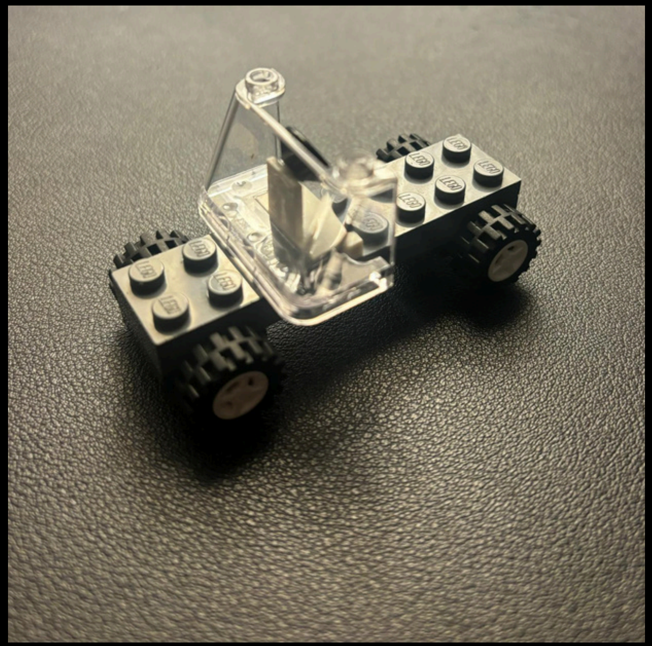
COST ANALYSIS

When evaluating cars for their overall cost-effectiveness, some cars are more expensive upfront but can cover longer distance while others are cheaper in cost but cover shorter distance.



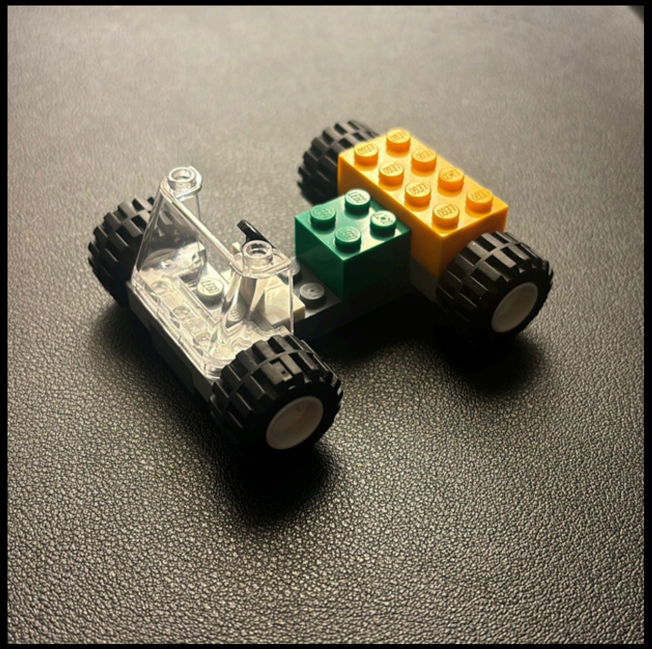
More Cost/ less Distance

Total Cost - $10000
Distance- 63



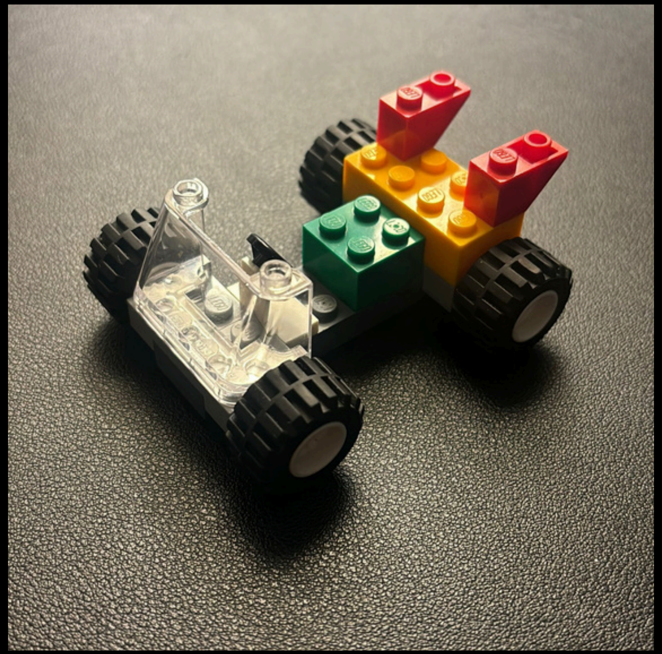
Less Cost/ Less Distance

Total Cost - $9800
Distance - 68



More expensive/ Less distance

Total Cost - $20100
Distance - 84



More expensive/ More distance

Total Cost - $20300
Distance - 90

CONCLUSION

This project demonstrated that the DOE study was highly effective in assessing how various factors influenced the response variable—distance in this case. By applying the DOE methodology, our team was able to design a system that achieved a substantial travel distance while simultaneously reducing costs. These savings might not have been possible without this structured and systematic approach to experimentation.

RECOMMENDATIONS

Recommendations

- **Key Factors Identified**: Weight, spoilers, rear wheel size and small windshield were determined to be the most critical.

- **Final Design**: Featured heavy weight, large rear wheels, spoilers, and a small windshield.

- **Interaction Insights**: Significant interactions, especially involving wheel size, were optimized for cost-effective performance.

- **Additional Savings**: Removing the tailfin reduced costs further without impacting efficiency.