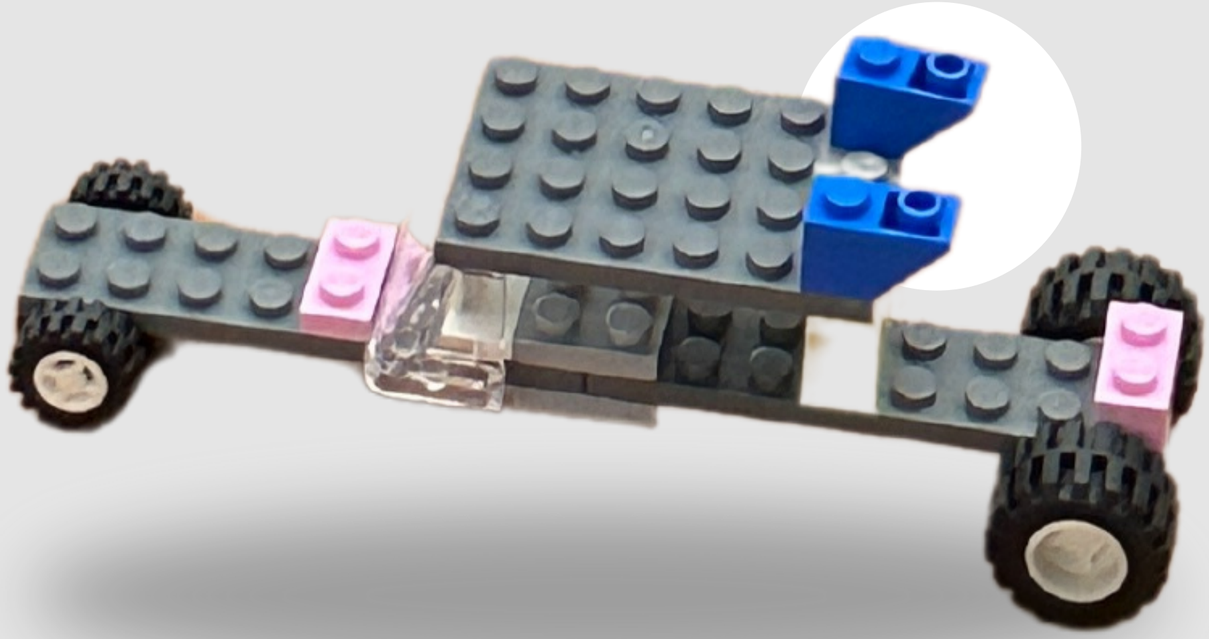
SCM 517

The Lego Project

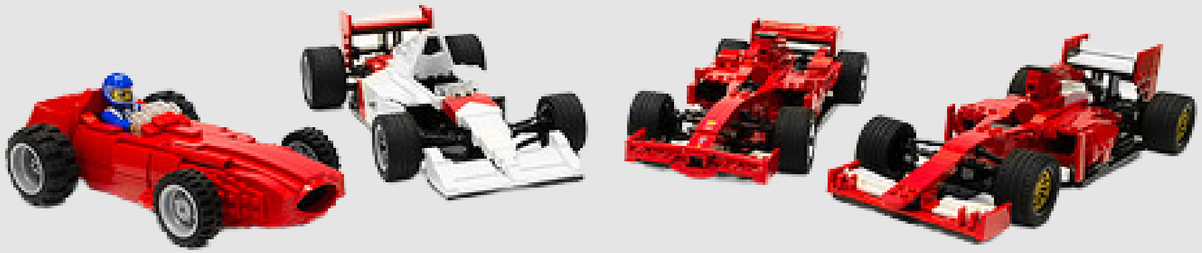
2023

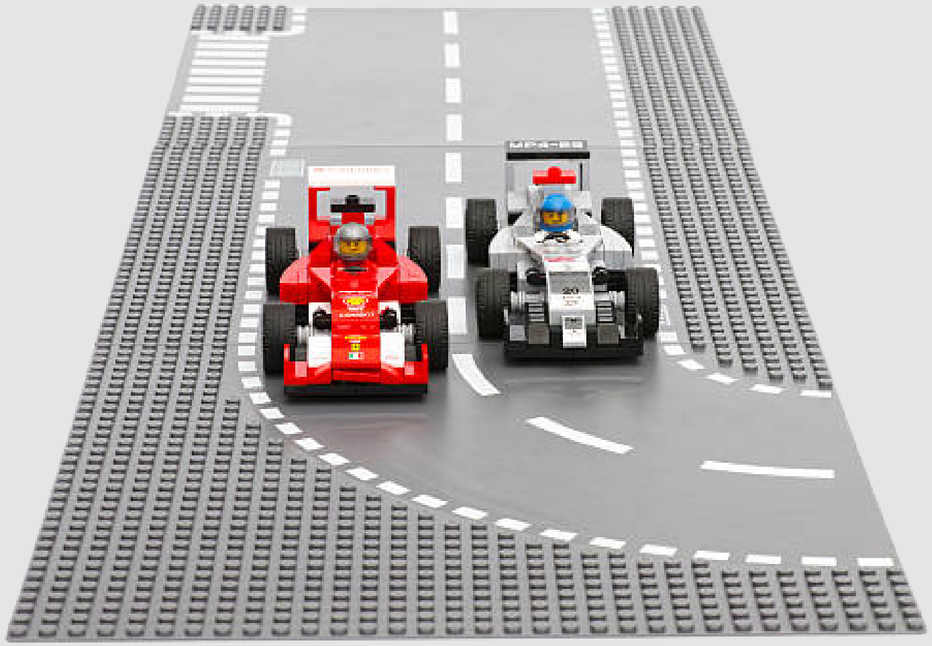


Team 364

Objective

To Design Experiment for constructing a car that can travel the farthest distance.





Top Features

To identify the best combination of factors.

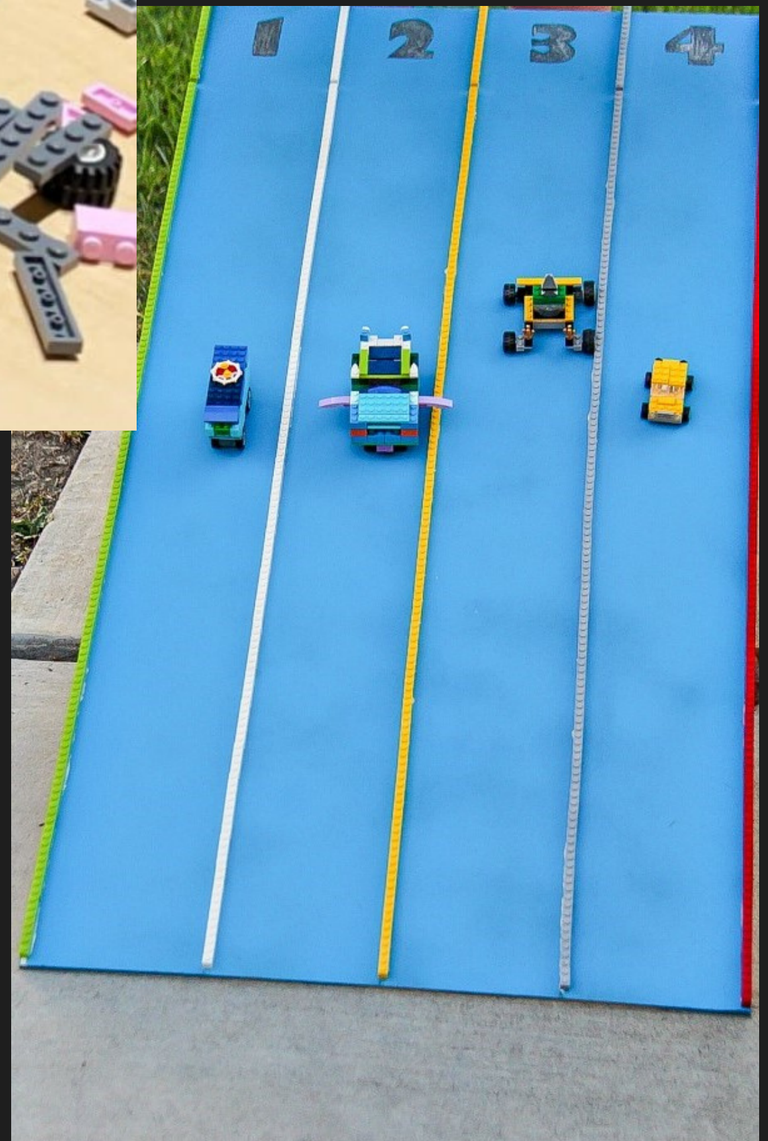
Cost Effective

To create most cost effective design experiment

Controlled Process

To maintain controlled environment to minimize blocking effect

Description of Design Experiment



Experiment Setup

- 3 Replications
- 4 factors

Identify Factors

Total number of observations will be 3*24=48 to identify the important factors

Track (Ramp)

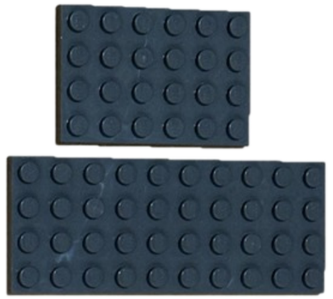
22 degrees inclination of the ram (we used white board as our ramp)

Control Process

Set up a clear path (carpet flooring)
Closed Room to minimize blocking.

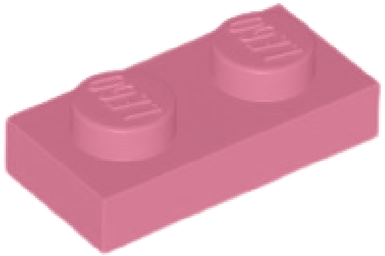
Design Factors

4 factors



Length

Longer car →
better performance, less stability

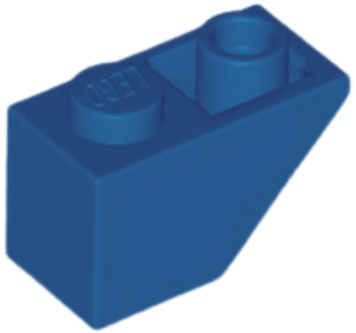


Air Dams

Putting Air Dams →
no significant change in distance

Wheels

Two more wheels →
decreased distance covered



Spoilers

Added spoilers →
no significant effect on distance

DOE: Experiment Readings

48 Readings

Index	Order	Length	Air Dams	Number of Wheels	Spoilers	Distance	Price
1	20	1	1	-1	-1	156 cm	21400
2	32	1	1	1	1	137 cm	23200
3	39	-1	1	1	-1	159 cm	23600
4	8	1	1	1	-1	163 cm	21200
5	41	-1	-1	-1	1	163 cm	24200
6	12	1	1	-1	1	153 cm	21400
7	7	-1	1	1	-1	195 cm	21200
8	30	1	-1	1	1	140 cm	22400
9	46	1	-1	1	1	120 cm	24600
10	10	1	-1	-1	1	185 cm	21400
11	13	-1	-1	1	1	180 cm	21400
12	37	-1	-1	1	-1	120 cm	23600
13	15	-1	1	1	1	206 cm	21400
14	44	1	1	-1	1	128 cm	24400
15	11	-1	1	-1	1	175 cm	21400
16	1	-1	-1	-1	-1	151 cm	19700
17	17	-1	-1	-1	-1	155 cm	21400
18	4	1	1	-1	-1	160 cm	19900
19	29	-1	-1	1	1	140 cm	22400
20	23	-1	1	1	-1	200 cm	21600
21	16	1	1	1	1	166 cm	21400
22	3	-1	1	-1	-1	153 cm	19700
23	38	1	-1	1	-1	140 cm	23600
24	24	1	1	1	-1	171 cm	21600

Index	Order	Length	Air Dams	Number of Wheels	Spoilers	Distance	Price
25	33	-1	-1	-1	-1	150 cm	23200
26	34	1	-1	-1	-1	136 cm	23400
27	26	1	-1	-1	1	176 cm	21600
28	40	1	1	1	-1	170 cm	24200
29	2	1	-1	-1	-1	142 cm	19700
30	19	-1	1	-1	-1	166 cm	21400
31	27	-1	1	-1	1	164 cm	21600
32	47	-1	1	1	1	165 cm	24600
33	35	-1	1	-1	-1	135 cm	23400
34	48	1	1	1	1	154 cm	24600
35	6	1	-1	1	-1	149 cm	19900
36	31	-1	1	1	1	99 cm	23200
37	14	1	-1	1	1	147 cm	21400
38	9	-1	-1	-1	1	160 cm	21200
39	25	-1	-1	-1	1	188 cm	21600
40	42	1	-1	-1	1	179 cm	24200
41	28	1	1	-1	1	147 cm	22400
42	5	-1	-1	1	-1	165 cm	19900
43	21	-1	-1	1	-1	182 cm	21400
44	36	1	1	-1	-1	140 cm	23400
45	22	1	-1	1	-1	144 cm	21600
46	18	1	-1	-1	-1	150 cm	21400
47	45	-1	-1	1	1	142 cm	24400
48	43	-1	1	-1	1	153 cm	24400

Analysis: DOE

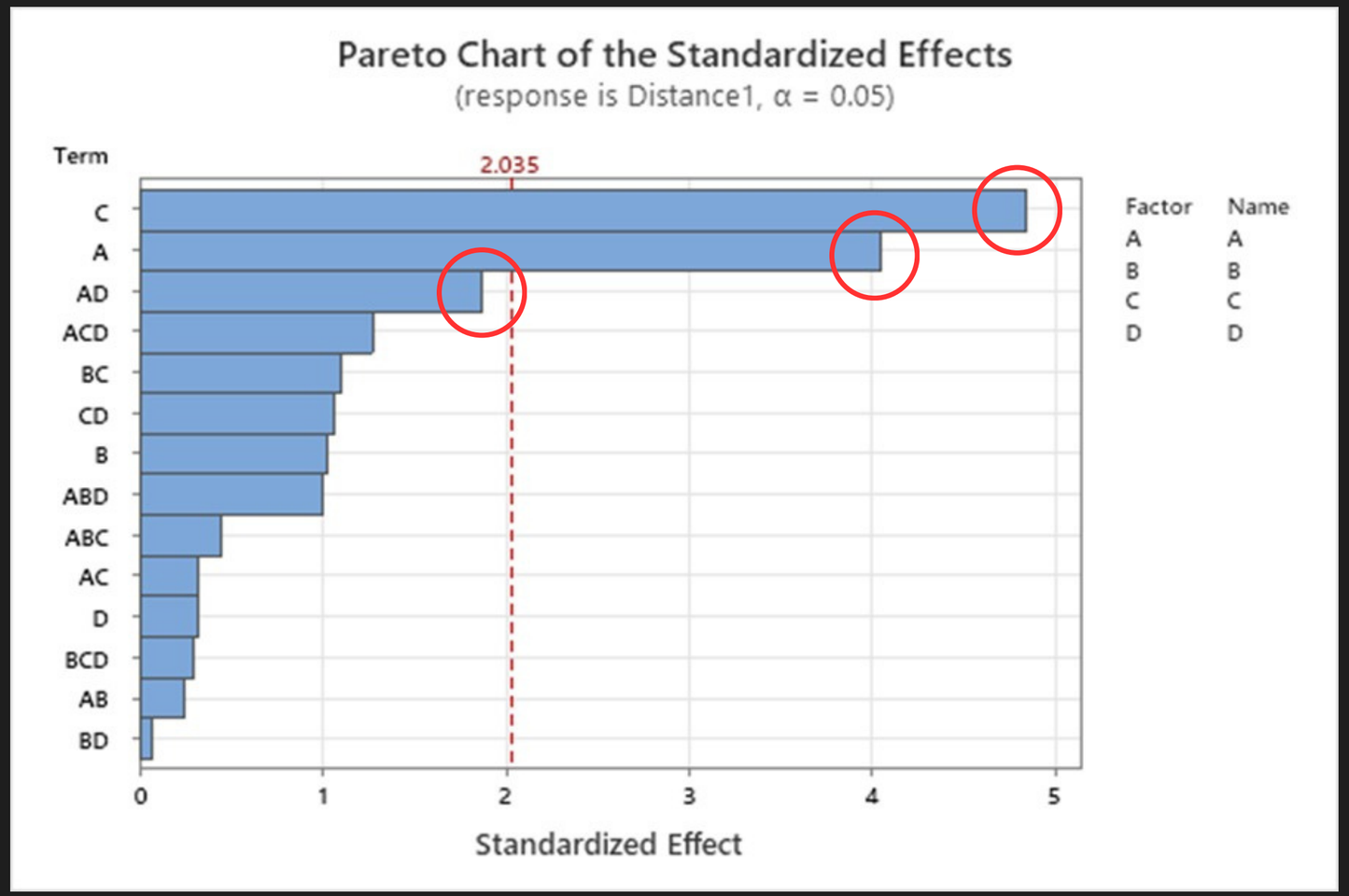
Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	14	12685.5	906.10	3.57	0.001
Linear	4	10417.3	2604.31	10.27	0.000
A	1	4162.7	4162.69	16.41	0.000
B	1	266.0	266.02	1.05	0.313
C	1	5963.0	5963.02	23.51	0.000
D	1	25.5	25.52	0.10	0.753
2-Way Interactions	6	1524.6	254.10	1.00	0.441
A*B	1	15.2	15.19	0.06	0.808
A*C	1	25.5	25.52	0.10	0.753
A*D	1	892.7	892.69	3.52	0.070
B*C	1	305.0	305.02	1.20	0.281
B*D	1	1.0	1.02	0.00	0.950
C*D	1	285.2	285.19	1.12	0.297
3-Way Interactions	4	743.6	185.90	0.73	0.576
A*B*C	1	50.0	50.02	0.20	0.660
A*B*D	1	256.7	256.69	1.01	0.322
A*C*D	1	414.2	414.19	1.63	0.210
B*C*D	1	22.7	22.69	0.09	0.767
Error	33	8371.5	253.68		
Lack-of-Fit	1	77.5	77.52	0.30	0.588
Pure Error	32	8294.0	259.19		
Total	47	21057.0			

ANOVA, or Analysis of Variance, is a statistical method used to analyze the differences among group means in a sample

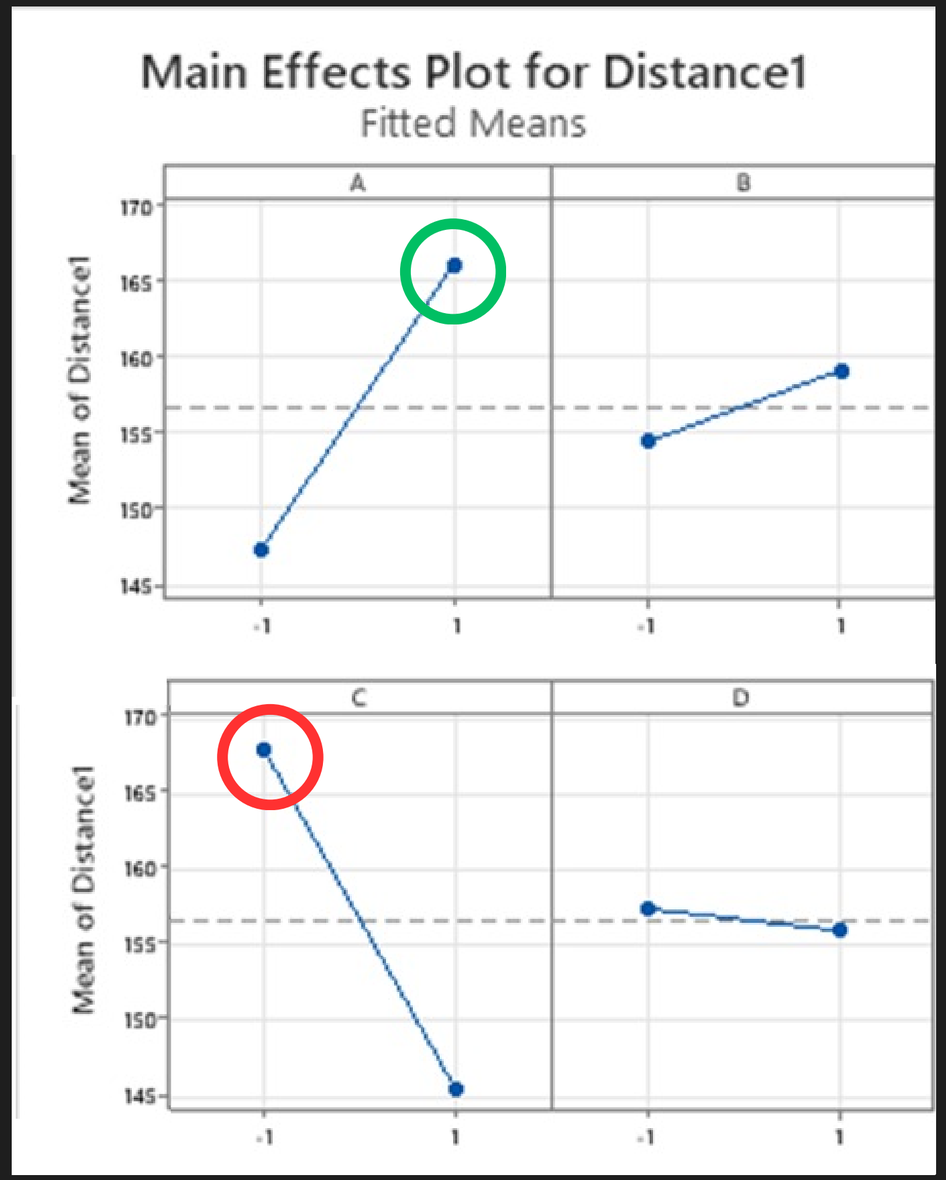
Based on ANOVA, F-Value and Normal Plot, **Factor A (Length)** and **Factor C (Number of Wheels)** are significant factors

Analysis: Pareto Chart



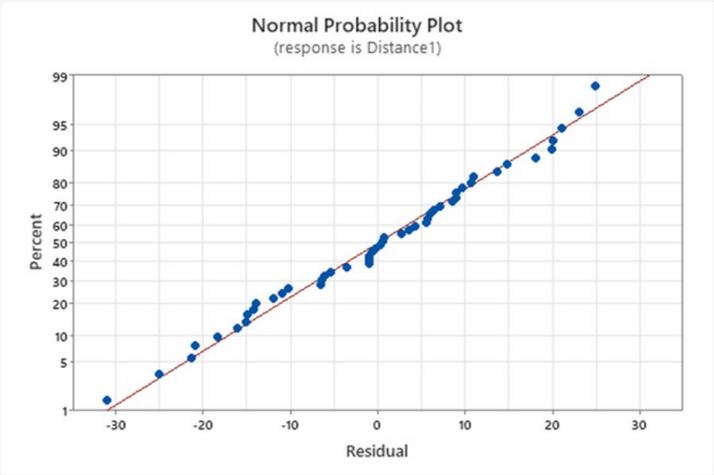
- **Chart Insights:**
  - Highlights all important factors and interaction effects
- **Top Contributing Factors:**
  - Main effect of Factor C
  - Main effect of Factor A
  - Interaction effect of Factors A and D

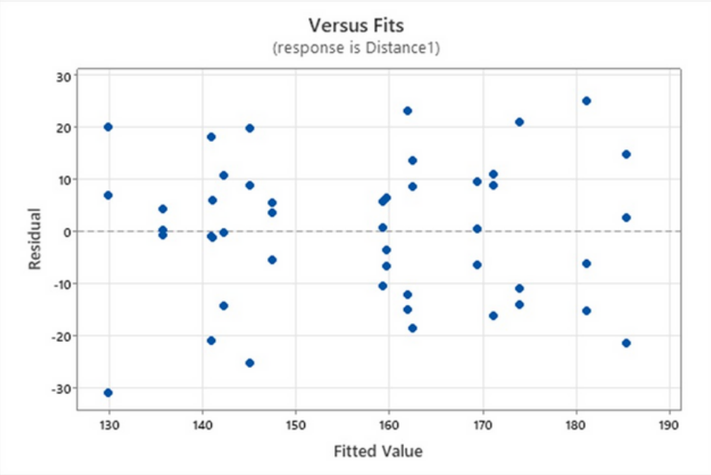
Analysis: Interaction Plots

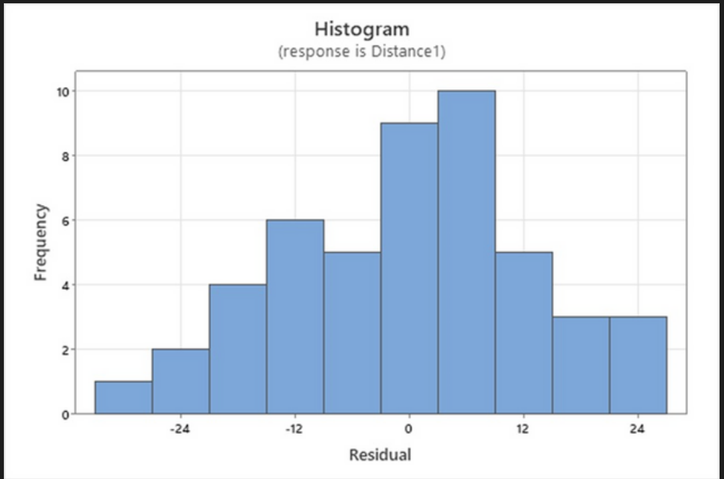


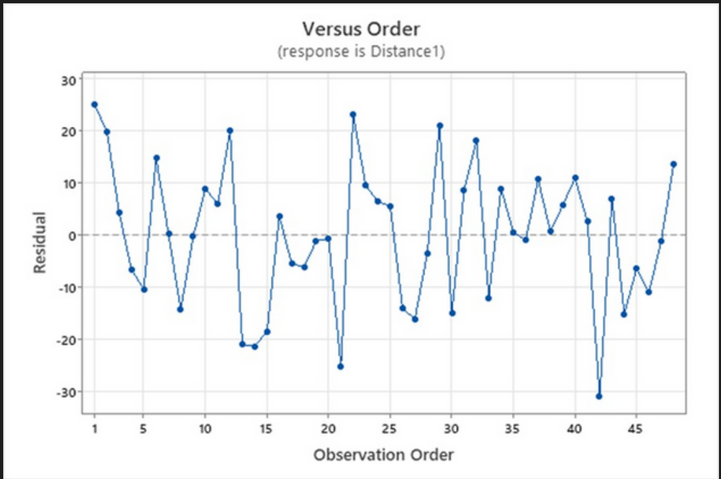
- **Main Effect Plots Analysis:**
  - Maximizing car distance possible by keeping **Factor A value high** and ensuring **Factor C value is low**
- **Influence:**
  - Both **Factors A** and **C** are influential in determining car distance

Analysis: Residual Charts



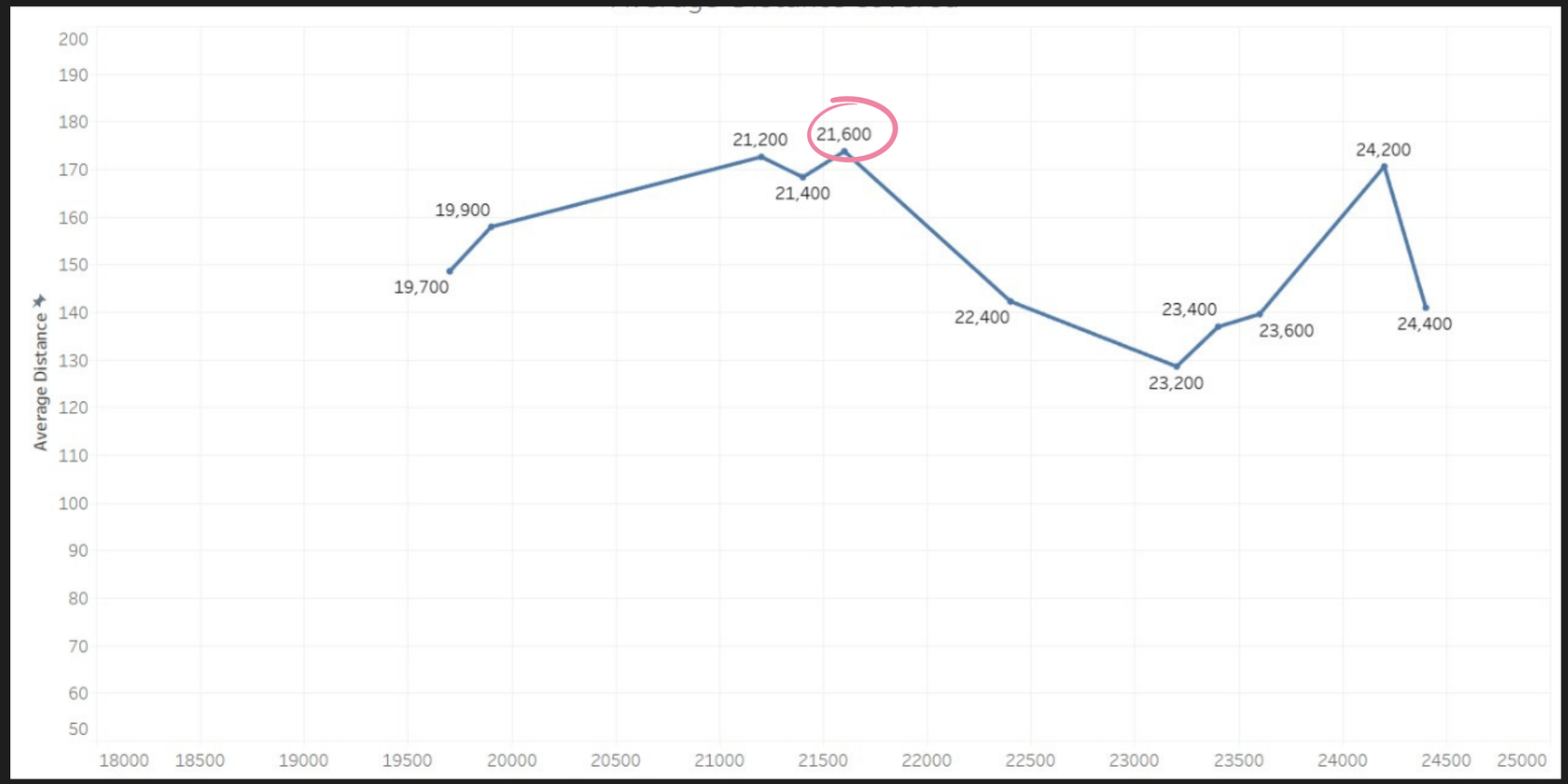






- **Basis of Analysis of Variance**:
  - Residuals assumed to follow a Normal and Independent Distribution (NID)
- **Graphical Evidence**:
  - **Normal Probability Plot**: Majority of points lie on the plot, indicating residuals follow NID
  - **Versus Fits**: Points are randomly distributed, suggesting normality
  - **Versus Order**: Residuals are independent

Financial Analysis



There is **No direct relation** between model with higher cost and distance covered

The cost of the best model in the DoE is **$21,600**

Analysis: Conclusion & Regression Equation

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
15.9274	60.24%	43.38%	15.89%

Fits and Diagnostics for Unusual Observations

Obs	Distance1	Fit	Resid	Std Resid	
42	99.00	129.94	-30.94	-2.34	R

R Large residual

Regression Equation in Uncoded Units

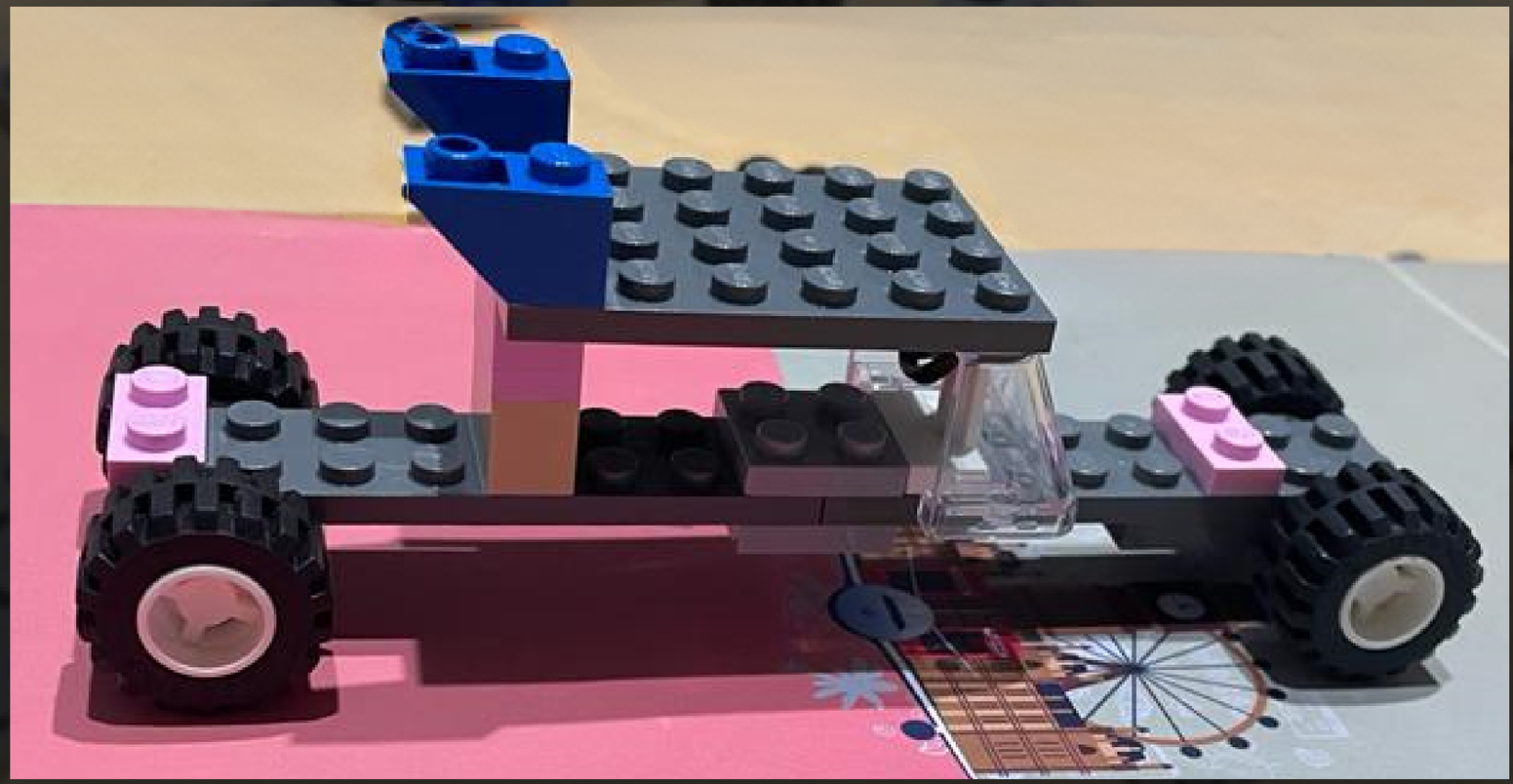
Distance1 = 156.65 + 9.31 A - 11.15 C

- **Maximum Value**: Attained when Factor A is **high** and Factor C is **low**
- **Regression Outcome**: Car traveled **177 cm** as per the equation

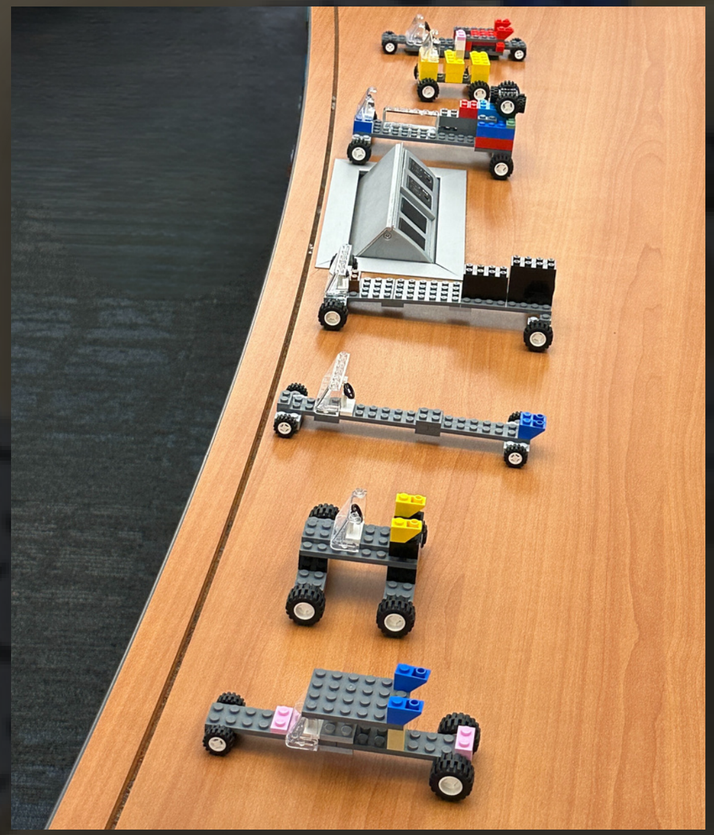
DoE: Recommendations

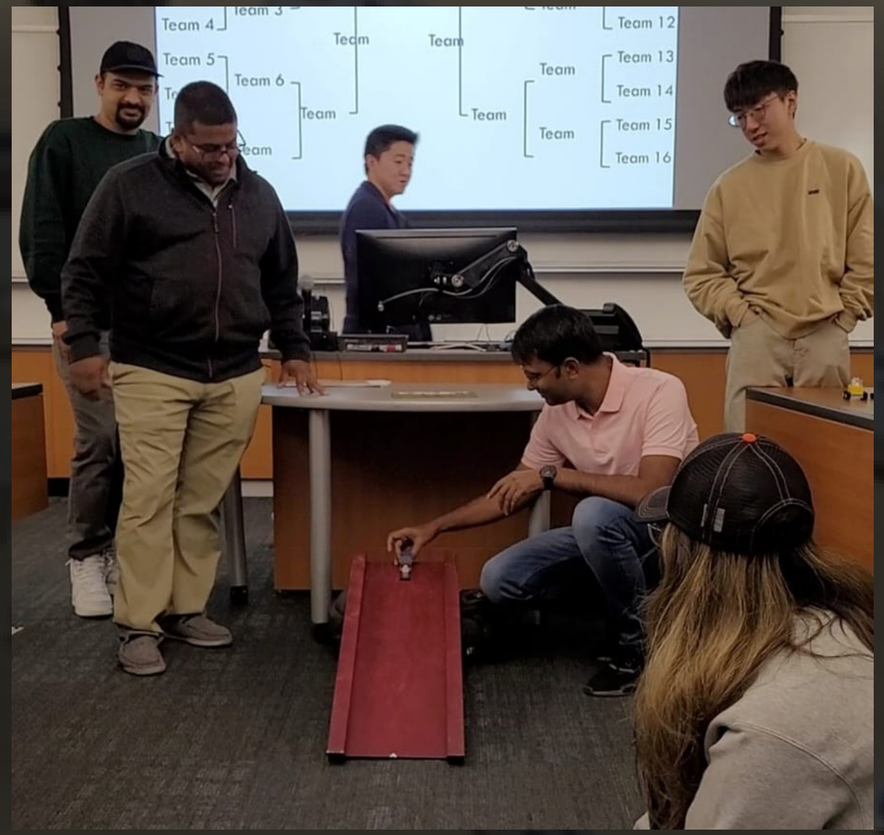
- **Length** and **numbers of wheels** are the two important considerations for designing Lego car which cover the maximum distance.
- **Four wheels car** covered the largest distance. The size of the wheel is highly sensitive to the angle of the wedge. Large wheels are suitable for angle greater than 30 degrees.
- **Stability** and **balance** of the car are critical for successful run of the car.
- DoE is not sensitive to the cost of the car for our design. But we can not make a clear recommendation with respect to price as the experiment was conducted in a narrow price range.

The Final Car!



The Race Day!




Team 4
Team 5
Team 6
Team
Team
Team
Team
Team
Team 12
Team 13
Team 14
Team 15
Team 16

Thank you!