Project 2

Engineering Statistics

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Airplane improvement data.

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Factors

- Nose type:
  - Flat: This nose type has a straight face on its nose that looks like a "T" rather than coming to a point, making the plane taller and shorter.
  - Pointed: This nose type comes to a fine point in the front making the plane shorter and longer.

  This factor was chosen to see which type is better overall since both have advantages and disadvantages. It was a simple factor that could easily be tested.

- Pieces of duct tape:
  - 1: One square piece of duct tape was added to the middle of the underside of the plane.
  - 2: Two square pieces of duct tape were added to the middle of the underside of the plane in the same place.
  - 3: Three square pieces of duct tape were added to the middle of the underside of the plane in the same place.

  This factor was chosen to see how a slight weight adjustment would affect the flight distance. The weight (tape) was placed in the middle on the underside and the factor tests how the magnitude of that weight placed there affects distance. This was also a simple factor that could easily be tested.

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Airplane Images

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Excel Data

		Nose type	
		Flat (1)	Pointed (2)
Pieces of tape	1	325.5	207
		317	192
		322.5	207
		496	202
	2	244.5	189
		345.5	208.5
		281	193
		206	219.5
	3	215	217.5
		312	217
		199	257.5
		181	194

ANOVA table and model

Anova Table:

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample	15889	2	7944.5	3.075208	0.070979	3.554557
Columns	36895.04	1	36895.04	14.28157	0.001374	4.413873
Interaction	25372.33	2	12686.17	4.910642	0.019864	3.554557
Within	46501.25	18	2583.403			
Total	124657.6	23				

Model:

$$X_{ijk} = \mu + \beta_j + Y_{ij} + E_{ijk}$$

Our model does not include the row effect because the p-value for it is greater than alpha (0.05). The column effect and interaction have p-values less than alpha so they are included in the model.

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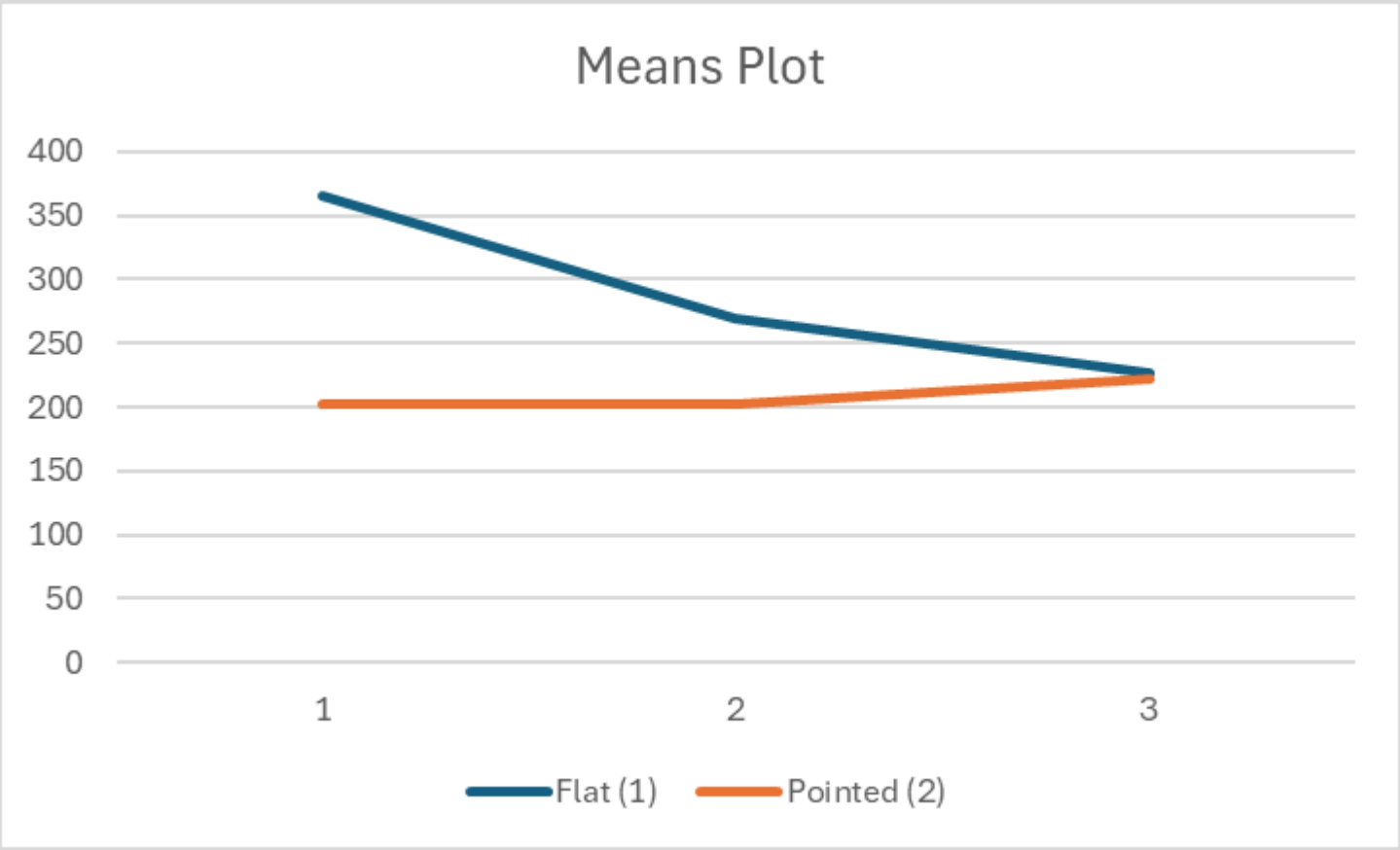
Interaction/Means plot



It is observed that there is an interaction between the Tape and the nose.
There is a row and column effect.

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Y Hypothesis test

1. Ho: $Y_{1flat} = Y_{2flat} = Y_{3flat} = Y_{1pointed} = Y_{2pointed} = Y_{3pointed} = 0$
   Ha: At least one interaction is not 0
2. Test statistic: 4.911
3. DF: 2
4. P-value: 0.020
5. We would reject the null hypothesis.
6. There is sufficient evidence to prove there is an interaction between the nose type and pieces of tape.

α Hypothesis tests

1. Ho: $\alpha_1=\alpha_2=\alpha_3=0$
   Ha: At least one is not 0.
2. Test statistic: 3.075
3. DF: 2
4. P-value: 0.071
5. We would accept the null hypothesis.
6. There is insufficient evidence to prove there is an effect from the pieces of tape

β Hypothesis test

1. Ho: $\beta_1=\beta_2=0$
   Ha: At least one is not 0.
2. Test statistic 14.282
3. DF: 1
4. P-value 0.001
5. We would reject the null hypothesis.
6. There is sufficient evidence to show that there is an effect from the nose type.

Requirements Check

Requirement	Satisfied?	Why?
Complete Study	Satisfied	Observations have been taken on every possible treatment.
Balanced Study	Satisfied	Each treatment combination has an equal number of units assigned to it.
At Least Two Replicates	Satisfied	We took four samples for each treatment combination.
Errors Normally Distributed	Not Satisfied	See next slide for graph.
Errors Have Equal Variance	Not Satisfied	See next slide for graph.

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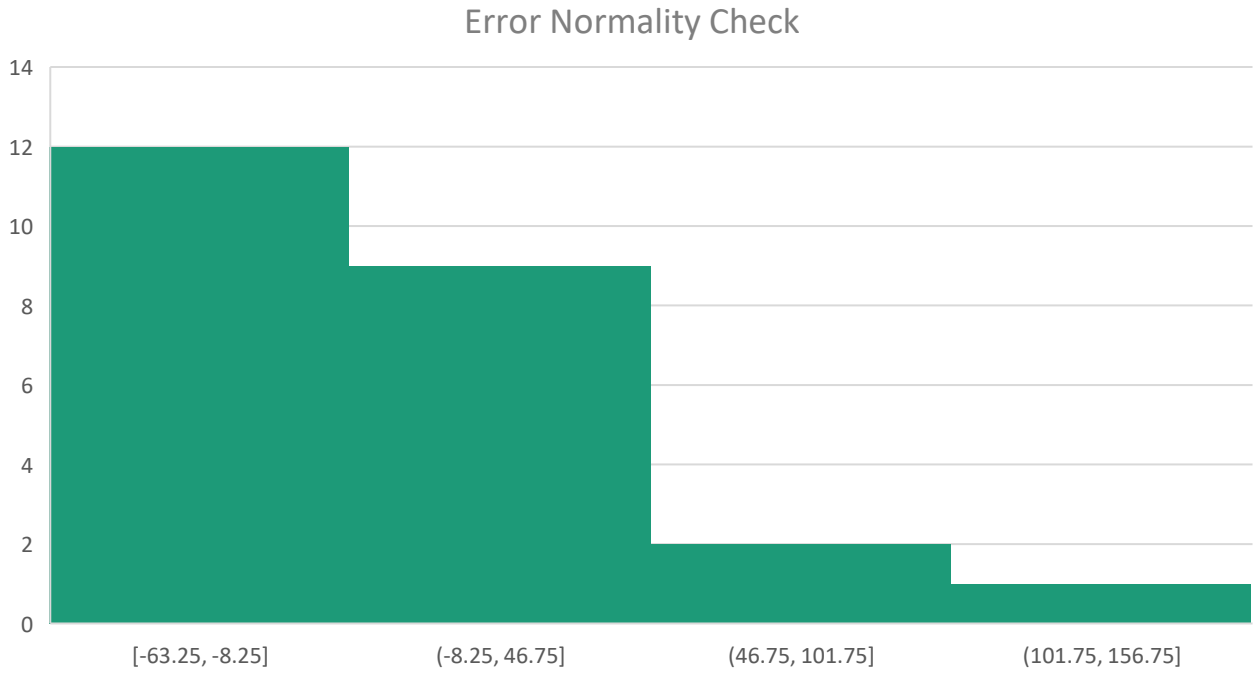
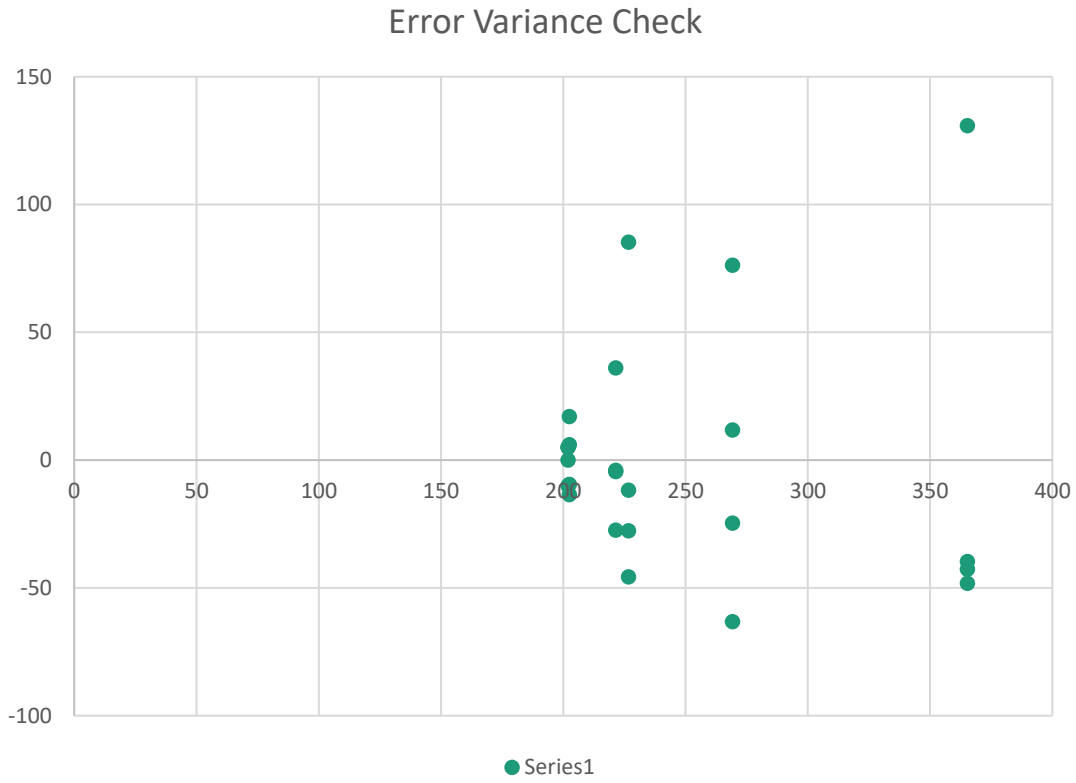
Requirements Check

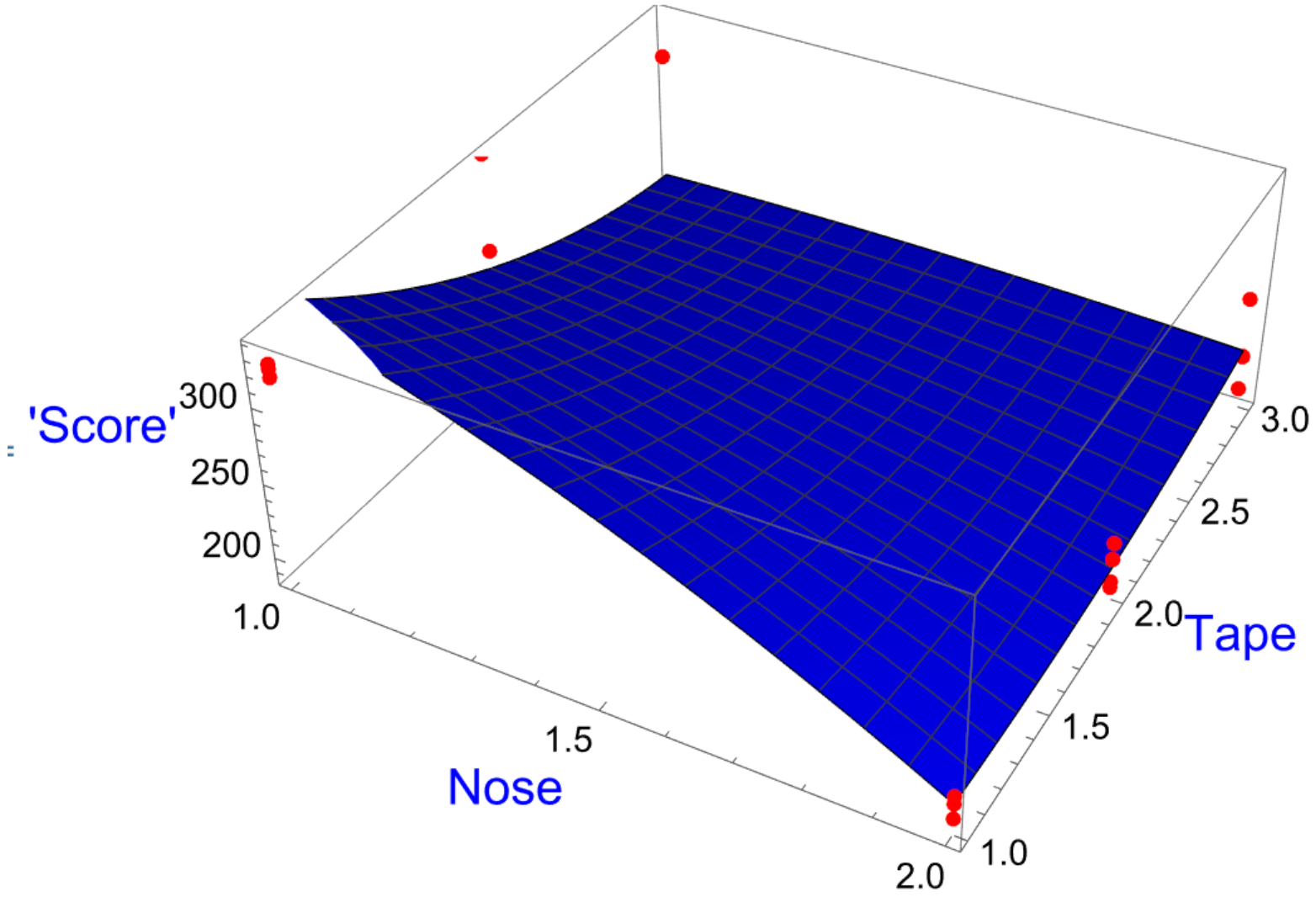




- Error Normality Check does not have a Normal Distribution. Requirement not satisfied
- Error Variance Check has a slight megaphone shape therefore the variances are not equal. Requirement not satisfied.

3-D graph from Mathematica

Include the 3-D graph given by Mathematica



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Results of the optimal design

```
(*The commands below find the maximum point in the 3-
 D plot which is the optimal design*)

r[x_, y_] = response


(*make sure you adjust the range to match your data in the below command*)
FindMaximum[{r[x, y], 1 ≤ x ≤ 2, 1 ≤ y ≤ 3}, {x, y}]
```

Out[•]= $74.7875 + 0.1525\,x - 1.4375\,x^2 + 37.6344\,y - 28.9806\,x\,y + 6.57188\,x^2\,y - 11.0156\,y^2 + 9.35188\,x\,y^2 - 2.04063\,x^2\,y^2$

Out[•]= {89.1475, {x → 1., y → 2.05509}}

```
(*Note that here it tells me that the best combination comes from
 Tape 1 and Nose 2*)
```

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Conclusion and lessons learned

We found that the best design was the plane with the flat nose and one piece of tape. If we were to perform this experiment again and improve on it we would be more precise about the size of the pieces of tape we used as weights. We would also have tried to be more uniform in our mode of throwing the airplanes since throwing them by hand introduces human error.

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How did each person participate?

- Colby: Performed Excel ANOVA.
- Brodric: Created spreadsheets with collected data, described factors, and created model.
- Lorenzo: Performed Mathematica ANOVA. Created 3D Graph
- Jordan: Performed the experiments and provided materials. Tested Requirements for Two-Factor ANOVA.