

# Paper Helicopter Project

In this project, the following aspects of the paper helicopter were altered to see the influence they have on flight times: material used in construction of the helicopter, wing length, body length, and paperclips attached to the bottom of the helicopter. The following table shows the factors used in this project, as well as their respective levels and values:

## Factor Information

Factor	Type	Levels	Values
Material	Fixed	2	Card Stock, Paper
Wing Length(mm)	Fixed	2	70, 120
Body Length(mm)	Fixed	2	70, 120
Paper Clips	Fixed	3	1, 2, 3

There was a total of 24 model helicopters, each dropped 3 times from the 2<sup>nd</sup> floor of East Carolina University's Sci-Tech lobby. One student was in charge of dropping the helicopter, the other student was in charge of timing the helicopter until it touched the ground. Thus, totaling 72 data entries.

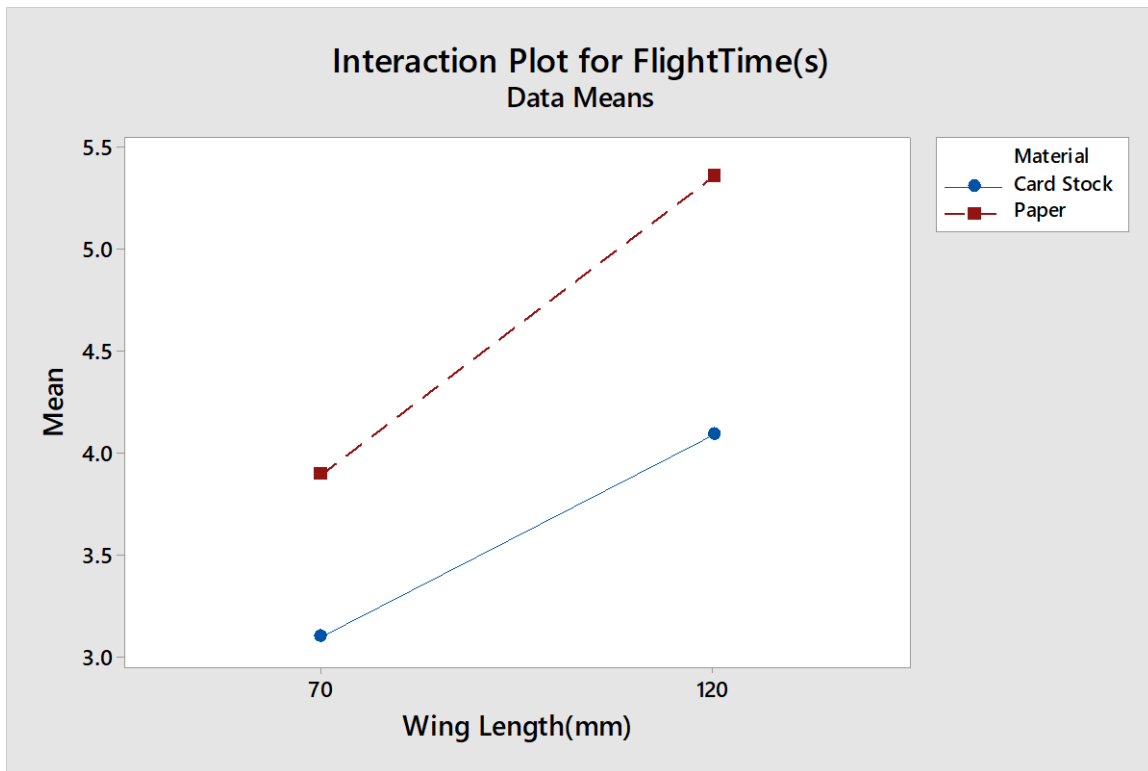
Based upon the results, the following group of factors significantly interact with each other: Material, Body Length, Wing Length, and Paperclips.

## Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Material	1	19.0550	19.0550	373.40	0.000
Wing Length(mm)	1	27.2076	27.2076	533.16	0.000
Body Length(mm)	1	0.1284	0.1284	2.52	0.119
Paper Clips	2	6.9839	3.4920	68.43	0.000
Material*Wing Length(mm)	1	0.9988	0.9988	19.57	0.000
Material*Body Length(mm)	1	0.0133	0.0133	0.26	0.612
Material*Paper Clips	2	8.1278	4.0639	79.64	0.000
Wing Length(mm)*Body Length(mm)	1	0.0470	0.0470	0.92	0.342
Wing Length(mm)*Paper Clips	2	0.0601	0.0300	0.59	0.559
Body Length(mm)*Paper Clips	2	0.1528	0.0764	1.50	0.234
Material*Wing Length(mm)*Body Length(mm)	1	0.2521	0.2521	4.94	0.031
Material*Wing Length(mm)*Paper Clips	2	0.3997	0.1999	3.92	0.027
Material*Body Length(mm)*Paper Clips	2	0.0446	0.0223	0.44	0.649
Wing Length*Body Length(mm)*Paper Clips	2	0.0650	0.0325	0.64	0.534
Material*Wing Length(mm)*Body Length(mm)*Paper Clips	2	0.4752	0.2376	4.66	0.014
Error	48	2.4495	0.0510		
Total	71	66.4606			

From the ANOVA table, Material and Wing Length interact; Material and Paperclips interact; and Material, Wing Length, and Body Length interact. Hence; Material, Body Length, Wing Length, and

Paperclips is a group of factors that significantly interact with each other. To exemplify the significant interaction between factors, the following graph shows the interaction plot between Wing Length and Material.



From the interaction plot, it's evident that a paper helicopter has significantly higher flight time than a card stock helicopter. Furthermore, changing wing length from 70mm to 120mm has an approximate increase of 33% in flight times in both card stock and paper. Thus, the levels of Wing Length influence the effect of changing levels in Material.

As shown below, using Tukey's Method to compare every combination of factors and grouping flight times within a 95% confidence interval by using different letters when flight times are significantly different, will show which combinations are most aerodynamic at the top:

## Grouping Information Using the Tukey Method and 95% Confidence

Material*Wing Length (mm)*Body Length (mm)*Paper Clips	N	Mean	Grouping
Paper 120 120 1	3	6.38000	A
Paper 120 70 1	3	6.10000	A
Paper 120 70 2	3	5.31000	B
Paper 120 120 2	3	5.21333	B C
Paper 70 70 1	3	4.76667	B C D
Paper 120 70 3	3	4.64667	B C D E
Paper 70 120 1	3	4.50667	C D E F
Paper 120 120 3	3	4.49333	D E F
Card Stock 120 70 2	3	4.48333	D E F
Card Stock 120 120 2	3	4.33667	D E F G
Card Stock 120 70 3	3	4.22333	D E F G
Card Stock 120 70 1	3	3.99333	E F G H
Card Stock 120 120 3	3	3.84000	F G H I
Paper 70 70 2	3	3.75667	G H I
Paper 70 120 2	3	3.72667	G H I
Card Stock 120 120 1	3	3.68000	G H I
Card Stock 70 70 2	3	3.47333	H I J
Paper 70 70 3	3	3.34000	H I J
Card Stock 70 120 1	3	3.33000	H I J
Paper 70 120 3	3	3.25667	I J
Card Stock 70 120 2	3	3.15000	I J
Card Stock 70 120 3	3	2.90333	J
Card Stock 70 70 3	3	2.88333	J
Card Stock 70 70 1	3	2.85333	J

From the data gathered in this experiment, a helicopter made from paper, with wing length 120mm, body length of 120mm or 70mm, and with 1 paper clip attached to the bottom produces the most aerodynamic from the available factors and their respective levels. However, to produce a helicopter with higher flight times it would be suggested to increase the range between wing lengths and body lengths to determine diminishing gains in flight time. Furthermore, to gather more accurate flight times one could set up a metal detecting plate that stops a timer when the paperclip hits the plate.