Proposal

Impact of Drag in the Distance of Flight in Paper Aeroplanes

Group: The Engineers
City College of New York
05/03/2025 - 05/09/2025
Funding Requested: $15.50

Abstract

The initial history of flying and the creation of origami are closely related to the history of paper airplanes. Although the exact place of origin is up for question, early paper gliders most likely first appeared in China and Japan around 500 BC. In his interest for flight, Leonardo da Vinci also experimented with paper models, which are now used to test theories by pioneers of modern aviation. Popularized in the 1930s and 1940s, the modern paper airplane is a fun version of these early flight experiments (Clark, 2017). Real-world concepts like aerodynamics and flight stability, as well as problem-solving and innovation, may all be understood through paper airplanes. They are an effective and entertaining way to teach and learn STEM, engineering, and physics. The purpose of this experiment is to build and test paper planes with different drags to identify its effects on the flight of the plane. This experiment will provide us with knowledge about the aerodynamics of a plane. In this project, we will change the basic design of a paper plane and see how this affects its flight. To be more specific, we will increase the drag of the plane through the design and to see if this changes how far the paper plane flies.

In this experiment we expect to see that drag will slow it down and shorten its flight path. The outcome of this experiment will result in the paper airplane with the most drag to be the slowest and travel the shortest distance.

Introduction

Paper airplanes, despite being made from something as simple as a sheet of paper, can teach us a lot about how flight works. According to *Scholastic*, paper planes interact with the same basic forces that affect real airplanes such as lift, thrust, drag and gravity. People have been experimenting with flight for centuries. Even today, paper planes are a fun and easy way to explore how design affects flight. They are easy to make, affordable, and adaptable to minor adjustments like changing the wings, folding the nose in a different way, or adding weight.

Although there are many different paper plane designs, without testing it would be hard to know how changes in design actually affect flight distance. Researchers at New York University used paper planes to examine how flight really works. They found out that small design changes can lead to noticeable differences in overall flight performance. Their result concluded that even simple adjustments in wing shape, weight distribution, or nose angle can significantly influence how a paper plane performs in flight. According to the *European Journal of Applied Physics*, the forces of drag and lift are two sensitive forces to plane geometry. This means that improving these characteristics can extend flight distance while improving stability. Additionally, *Paper Airplanes HQ* illustrates a wide range of paper plane designs, where each of them are made for different flight behaviors, meaning some are built for distance while others are built for speed. This highlights how the design of an airplane changes the plane's flight performance and stability.

The purpose of this experiment is to test and compare different paper airplane designs to see how drag affects the distance they travel. By analyzing each plane's performance under consistent conditions, we hope to find out which design is the most aerodynamic and flies the best. This experiment not only supports STEM education in a fun, hands-on experiment, but it also gives us a simple, low-cost option to explore ideas that relate to real world aircraft design.

Literature Review

In order to understand the forces such as drag that influences a paper airplane, it is important to understand aerodynamic principles that occur during the experiment. The fundamental concepts that would influence flight of a paper airplane include; lift, drag, gravity, and thrust. All these forces contribute to how effectively an object can stay airborne and how much distance it can cover. A study by Andy Ruina and Kirk D. Long, titled "The Physics of Falling Paper" (American Journal of Physics, 2013), provides an analysis on flat paper shapes when descending and gliding. They emphasize the role of shape stability, orientation, and air resistance in understanding flight paths. Their work also introduces the importance of the glide angle, the angle between the direction of flight and the horizontal plane. In order to achieve a greater gliding efficiency, the glide angle should be smaller. Factors that influence the glide angle are the paper airplane's mass, how it's distributed, and the wings. The better overall stability of the airplane increases overall flight distance.

Additionally, the generation of lift of a paper airplane has a relationship with its angle and wing design. As Ruin and Long mentions, any change in these factors can significantly impact the airplane's lift to drag ratio, which will affect overall distance traveled. With these ideas in mind, in an experiment trying to maximize total flight distance, we must consider a paper airplane's design in terms of symmetry, weight distribution and wing surface area.

The work of James R. Barrowman in his article, "Gliding Flight: Aerodynamics Of Paper Airplanes"(The Physics Teacher, 1984) supports this perspective. Barrowman breaks down the fundamental aerodynamic forces, and applies them to paper airplanes. His analysis demonstrated how critical a role center of gravity and wing load are to achieving stable flight. He explains that a plane with its center of gravity too far back can cause the plane to pitch up and stall, which may lead to a steep dive. These observations are crucial when designing paper airplanes, as small changes can have significant effects on flight behavior. His findings support the idea that a balance between aerodynamic lift and stability is essential to maximize gliding distances.

Another relevant study by M. I. M. Wahab and A. M. M Faudzi, published in the *Eurasian Journal of Physics and Functional Material*, explores the optimization of the designing of paper airplanes through tests. In their article, "Design and Optimization of Paper Airplanes," demonstrated how changes in physical properties such as wing length, fold precision, and center of gravity can change a flight's outcome. In their research for longer flight times and distance, they discovered that pl;anes with longer wingspans and narrower bodies tend to have better results. The author highlights that in their experiment, consistent launch techniques and environmental control are very important, ensuring more precise results.

All three articles reveal an understanding of physical design, like wing shape, mass distribution, launch stability, play a critical role in determining how far a paper airplane flies. Ruina and Long use physics in determining glide efficiency. While Barrowman provides a foundational idea of aerodynamics modeling. Additionally Wahab and Faudzi support these ideas with experimental findings.

With our experiment we hope to achieve similar results to Wahab and Faudzi, which would provide additional support to the findings of Barrowman and Ruina.

Project Narrative

Step 1: Choosing a Basic Airplane Design

- Something we need to keep in mind and to keep constant is to keep the multiple sheets of the same kind of paper and paper airplane design, this means we need to use the same kind of paper along with a simple and consistent folding pattern for every plane that we make.

Step 2: Creating Airplanes with Different Wingspans

- Following the simple and consistent design of each plane we make, we then modify only the wingspan of each version, this can include folding the wings at different widths, and/or folding winglets on the wings of the plane. We will differentiate the wing span of each plane by measuring and recording each wingspan of each plane with a ruler.

Step 3: Labeling Each Airplane

- After differentiating each wingspan, we differentiate each plane based on its wingspan by numbering them in order from Plane 1 - Plane 5. The plane number will have a direct relationship with its wingspan (Plane 1 = smallest wingspan, Plane 2 = bigger wingspan…. Etc)

Step 4: Choosing and setting up a Testing Area

- For the purpose of this experiment, our main focus is wingspan; therefore, we will conduct this experiment in an indoor environment with little to no wind. Next we will use a hallway or a rectangular shaped room, this is needed so we can have a straight line of flight. Lastly, we will set a consistent starting line using masking tape.

Step 5: ThrowIng the Airplanes

- After setting our starting point, we will stand behind the masking tape line, roughly where our feet will almost be teaching that line. To optimize our results, a few things we will keep in mind as we are throwing the paper airplanes is that we will do our best to keep the throwing angle, throwing strength, and our throwing motion consistent throughout every trial.

<u>Step 6: Measuring the Distance Flown</u>

- We will measure the distance the paper airplane flies from the starting line to the point where the airplane first comes in contact with the ground using a measuring tape. We will record this distance in a notebook.

<u>Step 7: Repeat for Accuracy</u>

- We will throw each airplane 5 times to make our results more accurate. Each trial will be recorded. Once the 5 trials are over, we will calculate the average distance of that specific airplane's wingspan.

<u>Step 8: AnalyzIng the Data</u>

- Once every paper airplane has been thrown (5 trials each plane), we will look at our data and see if there are any patterns between different wingspans, this will help us go into our final step which is drawing a conclusion for this experiment

<u>Step 9: Drawing a Conclusion</u>

- After analyzing our data we can draw a conclusion that wingspan proved to be a positive, negative, or an ineffective means on distance the paper airplane travels

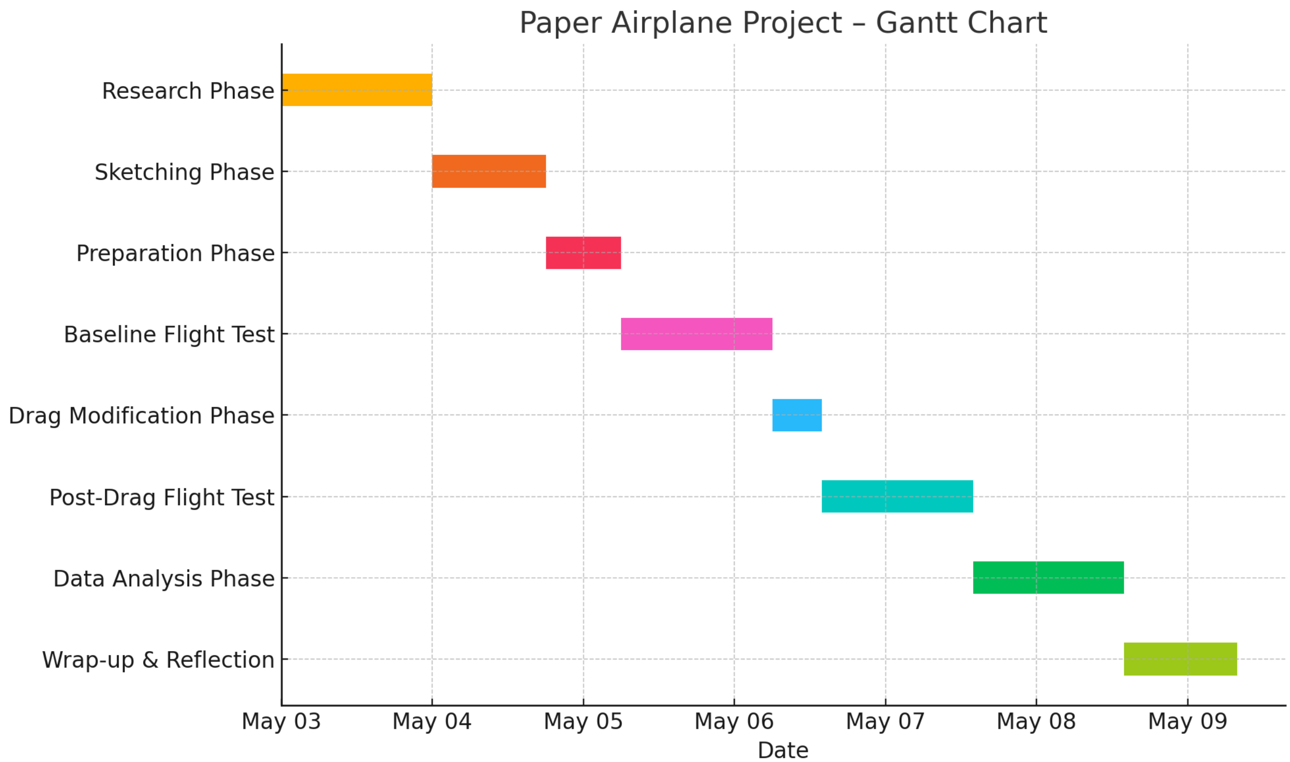
Personnel

This research will be carried out by the five members of the group. All of them attend the City College of New York. Shameer and Jorge are Mechanical Engineering students. Giovanni and Adib are Electrical Engineering students. Selma is a Civil Engineering student. Each group member is in charge of gathering information on paper airplanes before the experiment is carried out. Shameer is in charge of making paper airplanes with different drags for this experiment. He will gain insight from his knowledge of aerodynamics from his mechanical engineering course during this procedure. He will be in charge of identifying and figuring out each paper airplane's drag force. Selma is in charge of launching the planes consistently during each trial. She would be applying her understanding of force and motion to ensure each plane is launched with the same technique. Adib is responsible for measuring how far each plane travels after every flight and keeping track of this data. Giovanni would be preparing the testing space by marking distances and making sure the conditions are consistent throughout the experiment. He will use his attention to detail to set up the testing area. Jorge is responsible for collecting the data. He would be organizing the flight results into a table to help to conclude which design performed best. He would be using the skills he gained from his Data class to organize the results.

The Budget

Material	Quantity	Cost(USD)	Purpose
Printer Paper	1 pack(100 sheets)	$3.00	8.5x11” paper to fold paper airplanes for testing.
Ruler	1	$1.50	Used to draw straight lines to fold and cut accurately.
Masking Tape	1 roll	$2.00	Used to mark the starting line on the ground.
Tape measure	1	$5.00	5-10 meters long to measure how far each plane flies.
Scissors	1	$2.00	Scissors to cut flaps on the planes to increase drag.
Notebook	1	$2.00	Sketch plane designs and record flight distances with observations.
Graphing tool	N/A	Free	Used to create bar graphs of average flight distances.
Total		**$15.50**	

Timeframe



Phase	Tasks
Research	Learn about lift, thrust, drag, and weight. Research paper plane designs. Research wing designs and the influence of drag.
Sketch	Sketch 5 airplane designs. Label important features. Decide on one standard design to use.
Preparation	Gather materials (paper, ruler, scissors, tape). Build the planned paper planes. Create a data table and track flight results (how far the plane had flown).
Baseline Flight	Find a place with stable weather and no wind. Mark a starting line with tape. Fly each plane 5 times and record all results.
Modification	Modify each plane to alter drag.

Testing	Fly each modified plane 5 times in the same location. Measure and record each flight's distance. Record this data.
Data Analysis	Compare the data and graph it.

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