Paper Airplanes and Beyond

Amruth Pabba
Ms. O'Neil
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Purpose

Which paper airplane design flies the farthest?

Hypothesis

If the dart, the classic and the classic glider are tested for distance of flight, then the dart will fly the farthest. The reason for this result is because the dart has inner folds and this makes it more aerodynamic (Hui, 1988).

Review of Literature

Newton's Laws of Motion contribute a lot of basics to aerodynamics. Without aerodynamics, today's modern planes or paper airplanes would not exist (Schmidt, 1996).

Isaac Newton was an English scientist who lived in the 17th century. Newton created The Laws of Motion, a set of rules which are very important in physics. The first law, law of inertia, states that an object will keep going straight unless a force acts on the object. This means that any force, such as gravity, will change the object's trajectory in some way or other. The second law is force equals mass times acceleration. Newton's third law is that every force has the same or opposite reactions ("Forces", 2006).

The Laws of Motion are very important when studying aerodynamics. Aerodynamics is the study of how moving air acts around objects that are solid (Schmidt, 1996). Aerodynamics involves 4 forces: thrust, gravity, drag and lift (Schmidt, 1994). Thrust is a force that moves objects forward. Gravity is a force that gives objects weight and does not let them get off of earth. Drag is a force that consists of resisting air molecules. Lift is a force that lets an object get off the ground (Schmidt, 1996).

Using aerodynamics, a new type of vehicle was invented. In 1903, Wilbur and Orville Wright made the first flying vehicle, or airplane. This started a new field called aviation (Weinstein, 2009). An airplane has only 2 parts: wings and the body. The wings usually hold a source to make thrust, such as an engine. The wings also are aerodynamically shaped to let the airplane fly. Airplanes go up because the wing's curve lets the air below be cool and the air above getting hot and speedy, making a layer of buoyancy below the wing. This lifts the wing, which causes the whole plane to go up (Schmidt, 1994). Aviation has classified that a plane has

3 axes: yaw, roll and pitch. Yaw is the directional axis, roll is the lateral axis and pitch is the longitudinal axis (Robinson, 2000). Elevators are parts on a wing to climb in altitude or dive in altitude (Macaulay, 1988). A rudder on the tail at end of plane body allows the plane to turn on the directional axis. Ailerons on the wings allow the plane to turn on the lateral axis (Schmidt, 1994).

The airplane inspired many to convert this invention into a paper form. The ideas that came out of many minds involved aerodynamics. All paper airplanes got some parts from the real airplane. Some common similarities are wings, a body and elevators (Morgan & Morgan, 1993). Most paper airplanes are meant to be made with an 8.5in by 11in piece of paper (Schmidt, 1994). There are many paper airplane designs. One design is the dart. The dart is a straight flying plane (Hui, 1988). Another design is the classic. This design is very old and can do very cool tricks if the ailerons are modified (Schmidt, 1994). The one which is smaller and has a locking system is the classic glider. This design can fly far if launched at proper speeds but does have a tendency to dive randomly. But when building all of these designs, the key is to use the same amount of energy on all the creases. The more pressure used on the fold, the lighter the fold is. If creased properly, the flight length could change dramatically. Aerodynamics really plays a major roll when making a mini replica of a flying machine which flies in real life (Robinson, 2000).

Airplanes rely on many principles developed by Sir Isaac Newton. Without Newton, planes would not have been discovered (Schmidt, 1996). Aerodynamics has its four forces that play a major role in aviation. Without aerodynamics, the modern wing on jets would not have been developed. Without the modern wing, we wouldn't have as much flying speed as today.

Even without aerodynamics, the fun little paper airplanes would not have been thought of or even have been invented (Schmidt, 1994).

Material's List

4M Electric Plane Launcher Kit

2 AA batteries for launcher

Phillips Screwdriver

30 pieces of Staples® 216 mm by 279 mm multipurpose paper

Ruler or straightedge for creases

25.7175 cm high table or chair

Measuring Tape (min. 7 meters)

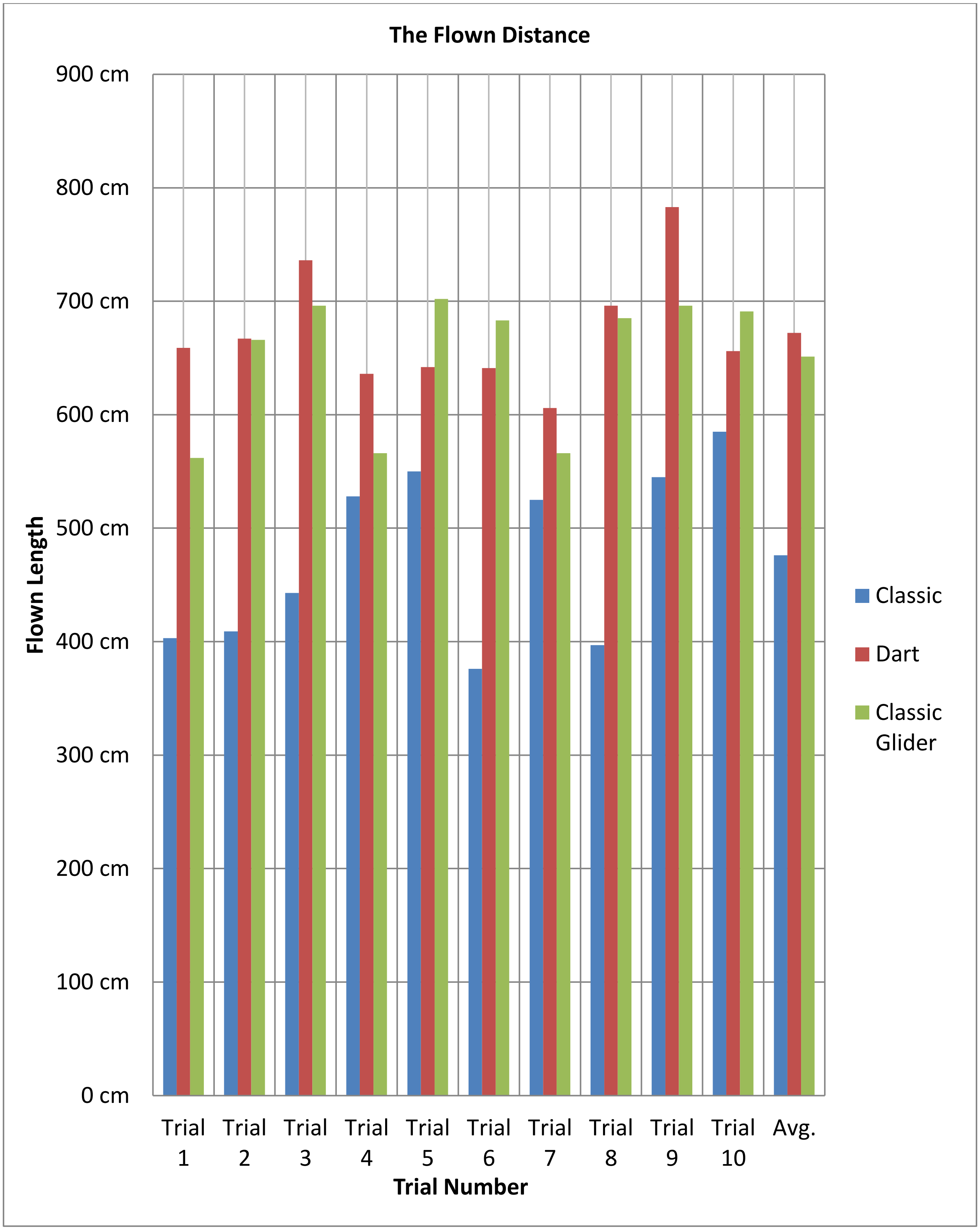
Paper and writing utensil for data recording

Procedure

1. Gather materials.
2. Build 4M Electric Plane Launcher (Appendix A).
3. Put the launcher on the 25.7175 cm high surface.
4. Take a piece of 216 mm by 279 mm paper.
5. Fold the piece of paper into a dart (Appendix B1).
6. Switch on the launcher and wait 5 seconds for the launcher to warm up.
7. Drop the plane from the top facing forward, in to the grooves of the airplane launcher and give the plane a push if needed.
8. Measure the distance the plane flew using the measuring tape.
9. Record the data.
10. Do steps 4-9 another 9 times.
11. Repeat steps 4-10, but instead of a dart, fold the paper into a classic (Appendix B2).
12. Repeat steps 4-10, but instead of a dart, fold the paper into a classic glider (Appendix B3).
13. Clean up testing area. Analyze data.

The Results from Testing

Model	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9	Trial 10	Avg.
Classic	403 cm	409 cm	443 cm	528 cm	550 cm	376 cm	525 cm	397 cm	545 cm	585 cm	476 cm
Dart	659 cm	667 cm	736 cm	636 cm	642 cm	641 cm	606 cm	696 cm	783 cm	656 cm	672 cm
Classic Glider	562 cm	666 cm	696 cm	566 cm	702 cm	683 cm	566 cm	685 cm	696 cm	691 cm	651 cm


The Flown Distance
900 cm
800 cm
700 cm
600 cm
500 cm
400 cm
300 cm
200 cm
100 cm
0 cm
Flown Length
Trial 1
Trial 2
Trial 3
Trial 4
Trial 5
Trial 6
Trial 7
Trial 8
Trial 9
Trial 10
Avg.
Trial Number
Classic
Dart
Classic Glider

Conclusion

The purpose of this experiment was which paper airplane design flies the farthest. The hypothesis for the experiment was if the dart, the classic and the classic glider are tested for distance of flight, then the dart will fly the farthest. The reason for this result is because the dart is very small and does not have a tendency to dive or bank (Hui, 1988). The hypothesis was supported by the data.

The results of the experiment showed that the classic had an average of 476 cm traveled distance, with a standard error of +/-52.25 cm. The dart had an average of 672 cm traveled distance, with a standard error of +/-44.25 cm. The classic glider has an average of 651 cm traveled distance, with a standard error of +/-35 cm.

The scientific explanation for the results is due to the aerodynamic shape and inner folds, the dart performed better than other airplanes (Hui, 1988).

Attempts to limit error in this experiment included launching the planes from the same height, making sure the launcher was running at the same speed all the time, and having 100% accuracy when folding the paper airplane.

Some possible sources of error were jamming the paper airplane in the launcher, not giving the plane a push and switching on the launcher after you place the airplane in the grooves.

A limitation to this experiment was controlling the planes from crashing into the ceiling.

From this experiment, the following items were discovered: paper airplanes involves a lot of backhand physics, a science fair experiment is harder than it seems, Hobby Lobby is not as boring as it seems, and that science fair projects require lot of hard work.

In the future, this experiment could be improved by doing more trials, using a lighter type of paper and overclocking the launcher to launch at higher speeds.

In the real world, this information can be useful to airplane companies, toy designers, toy manufacturers and paper airplane competitors.

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Appendix A

1. “Push the plastic rings into the base plate holes.
2. Push the electric motors into the plastic rings. They will be very tight, but a tiny amount of washing up liquid plastic will help. You may need some help with this.
3. Push a pulley onto each spindle. Do not push the pulley all the way down the spindle – it could rub and slow the motor down.
4. Push a plastic disc onto each pulley. They will be very tight, but a tiny amount of washing up liquid plastic will help. You may need some help with this.
5. Adjust the motor positions so that the plastic discs are level. There should be a gap of abut 1mm between the discs. You may need to tilt the motor a bit to adjust to the right gap distance. An optimum gap distance will facilitate the discs gripping the plane body for launching.
6. Cut the wire into four equal lengths. Strip the insulation off the ends using scissors or wire strippers and twist the bare wire strands together.
7. Connect the wires to the battery box using the terminal block. Put the red wire from the battery compartment into one slot. Put the black wire from the battery compartment in one slot. On the opposite slot of the red wire slot, put two red wires and tighten the screws above the terminal block using the screw driver. Do the same for the opposite slot of the black wire. Use 2 white wires instead of red wires. Tighten the screws above. You may stick the terminal block onto the underside of the base plat with a sticky pad.
8. Put a sleeve on each wire coming out of the terminal block.

9. Turn over the base plate.
10. Put the red wire from the terminal block on to the "+" slot in the red motor and slide the sleeve on.
11. Put the white wire on the other slot on left motor and slide the sleeve.
12. Do steps 10 and 11 with the right motor instead.
13. Using a small piece of the sticky pad, paste the terminal block on to the bottom of the base plate.
14. Using a Phillips screwdriver, open the battery box and put 2 AA batteries in it and close. Screw the cover back on.
15. Using sticky pads, paste the battery box on to the bottom of the base plate.
16. Turn over the base plate.
17. Put the guide pieces on.
18. Turn on the launcher to see if it works.
19. Put the Suction cup holders on using the bolts, washers and suction cup pieces.
20. If it works, the launcher is ready to launch a plane" (Middlesex University, 2005).

Appendix B1

1. Take a piece of 216 cm by 279 cm paper.
2. Fold the two vertical sides together, crease correctly and unfold to make the vertical center crease.
3. Valley fold (fold inward) the two corners to lie along the center fold made in step 2.
4. Valley fold the two sides to the center. It should look like a bullet or a dart.
5. Mountain fold (fold outward) the airplane at the center crease and make sure the wings meet up.
6. Fold the left wing to the lower edge. Don’t crease until the wing is perfectly lined up with the bottom.
7. Do step 8 with the right wing.
8. Open out both wings to 90 degrees.
9. The classic is now ready (Schmidt, 1994).

Appendix B2

1. Take a piece of 216 cm by 279 cm paper.
2. Fold the two vertical sides together and crease correctly (do not unfold).
3. Mountain fold one of the corners to the bottom.
4. Do step 3 to the other corner on the opposite side.
5. Mountain fold one folded corner to the bottom, again.
6. Do step 5 with the other folded corner.
7. Mountain fold one of the corners to the bottom, for the last time.
8. Do the same thing with the other folded corner, for the last time.
9. Bring the wings (formed in steps 7 and 8) up to 90 degrees.
10. The dart is now ready (Hui, 1988).

Appendix B3

1. Take a piece of 216 cm by 279 cm paper
2. “Fold the two long sides together, crease firmly and open to form the vertical center crease.
3. Fold two corners in to lie along the center crease. Try to make the edges lie exactly along the crease. (Robinson, 2000, p.24) ”
4. Bring the top corner downward to touch a point 85 mm away from the lower edge.
5. Bring the upper corners to the center crease, but leave a triangular flap sticking out.
6. “Fold the small triangle upward to hold the two corners together.
7. Use the center crease to mountain fold the paper in half behind. (Robinson, 2000, p.25)”
8. Fold the left wing to the lower edge. Don’t crease until the wing is perfectly lined up.
9. Do step 8 with the right wing.
10. “Open out both wings to 90 degrees. (Robinson, 2000, p.25)”
11. The classic glider is now ready.