

Alexandria Paley

Lab Practicum Assignment

Chosen Lab: Inquiry Lesson/Lab: Scaling and Paper Airplanes from AAPT pages 13-19

- I. Lab Experience
  - a. Overview of the chosen lab: The lab that I chose deals with students understanding of how the weight of a glider and the surface area of the wing affects the flight of the glider. In this activity students create various gliders and choose their best design for gliding. Then they determine the weights and surface areas of each of their new glider designs and document the relationship they identify. This activity uses a variety of mathematics that students should be fluent with as well as analysis of graphs to interpret data and answer questions. After they complete the first activity they then have to compare the surface areas and weights of various objects and then various glider shapes, making comparisons between all 3 throughout the course of the experiment. At the conclusion, each group has to analyze their results and then develop a hypothesis about what makes a good glider based on the data that they collected.
  - b. Documentation of completed lab: Please refer to the attached documents showing the completion of the lab activity
  - c. Demonstrates samples of student work: I did not do this activity with my classes so I documented my work as well as took images of me completing the lab activity. Please see the documents attached, as stated in b above.
- II. Teacher Reflection
  - a. Describe how the activity connects to physics learning outcomes: This activity is great for students being able to make connections between something that they use frequently and are familiar with to concepts of fluids, weights, and surface areas in physics. It was very interesting to me to see that the data I collected was very good to supporting the idea that surface area and weight are directly proportional and essential to determining the flight of a glider. I was hesitant in the beginning that the concepts would be too challenging for me to do and then analyze/collect but it was actually very direct, straight forward, and I think it would greatly help and benefit students in their analysis and understanding of flight. I do wish that when it came to the questions and conclusion of the activity that there were more questions leading the students to understanding why gliders fly and that it isn't only the weight and surface area but that friction and contact with the air molecules affects flight as well. I think that concept was not highlighted in the introduction as well as throughout the analysis questions. I also think that including that information would help students who maybe didn't obtain the desired results or had a lot of error when developing a glider style that would fly well. I

believe that if students worked through this activity they would develop not only an understanding of the key principles behind flight and motion but also connections to why some materials fly better than others. I think after completing this, students would be able to make the connections between concepts in physics dealing with both kinematics and motion as well as fluid dynamics.

- b. Reflect on pros/cons and age/development appropriateness of the activity to myself/students: I think that this was very age appropriate for high school aged students who had previously taken a geometry course. The mathematics that is required of them is on grade level and should not be a problem for them to complete. Also, they should be able to follow along with the various designs and surface area calculations fairly easily. I will say that I struggled in the beginning with determining the mass of the paper and then developing the proper ratios. I was confused at how paper was weighed when purchased by the ream and the paper I used didn't say the mass per sheet size so I had to first determine that myself. Once I did that, the rest of the math was on grade level, as previously mentioned. Also, I think this would be a great opportunity to teach students to use excel to graph their data and develop a line of best fit. It is important in physics to use best-fit lines so that outlier data points are not taken into consideration when looking at the relationship as well as the slope of the line generated. This activity has a lot of teachable moments for students with skills and strategies that they will use throughout the rest of their careers.

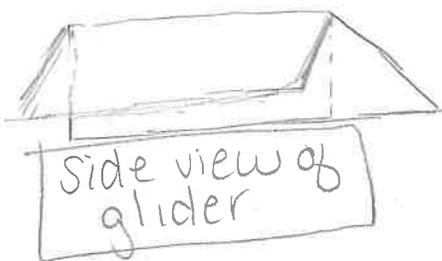
Glider Design Data Table

	Glider 1	Glider 2	Glider 3	Glider 4	Glider 5
Length (in)	11"	9"	7"	5"	3"
Width (in)	8"	7"	6"	5"	4"
Wing top surface Area (in <sup>2</sup> )	33.0 in <sup>2</sup>	22.3 in <sup>2</sup>	14.7 in <sup>2</sup>	10.4 in <sup>2</sup>	4.3 in <sup>2</sup>
Starting surface Area (in <sup>2</sup> )	88 in <sup>2</sup>	63 in <sup>2</sup>	42 in <sup>2</sup>	25 in <sup>2</sup>	12 in <sup>2</sup>
Glider weight (lb)	0.0094 lb	0.0067 lb	0.0045 lb	0.0027 lb	0.0013 lb

# Estimation of Surface Area of Wings

The simple geometric shapes I am using to estimate the area of my gliders are right triangles and rectangles. Each glider is comprised of 2 identical right triangles and 2 identical rectangles. I will determine the base and height of one triangle then multiply it by 2. I will determine the length and width of the rectangle and also multiply it by 2. I will add these two quantities together to determine the surface area of my glider. The equation I will use for the triangle area is  $\frac{1}{2}b \cdot h$  (see calculations pages) and the equation I will use for the rectangle area is  $b \cdot h$  (see calculations page.)

Below is a simple sketch of the gliders I designed and built, highlighting the data I will collect on each glider. Please note, drawing is not to scale.



\* note \*  
in each glider the triangle area was always smaller than the rectangle area.

top view of glider



# Wing Top Surface Area Calculations

Each Glider has 2 right triangles and 2 rectangles

$$A_{\Delta} = \frac{1}{2} b \cdot h \quad \text{and} \quad A_{\square} = L \times W$$

## Glider 1

$\Delta$	$\square$
$b = 2.00 \text{ in}$	$L = 6.75 \text{ in}$
$h = 2.00 \text{ in}$	$H = 2.15 \text{ in}$

$$A_{\Delta} = \frac{1}{2} b \cdot h \quad A_{\square} = L \times H$$
$$A_{\Delta} = \left[ \frac{1}{2} (2.00 \text{ in}) (2.00 \text{ in}) \right] 2 \quad A_{\square} = [6.75 \text{ in} (2.15 \text{ in})] 2$$
$$A_{\Delta} = 4.00 \text{ in}^2 \quad A_{\square} = 29.0 \text{ in}^2$$

$$\boxed{\text{Top S.A.} = 33.0 \text{ in}^2}$$

## Glider 2

$\Delta$	$\square$
$b = 1.75 \text{ in}$	$L = 5.50 \text{ in}$
$h = 1.75 \text{ in}$	$H = 1.75 \text{ in}$

$$A_{\Delta} = \left[ \frac{1}{2} (1.75 \text{ in}) (1.75 \text{ in}) \right] 2 \quad A_{\square} = [5.50 \text{ in} (1.75 \text{ in})] 2$$
$$A_{\Delta} = 3.06 \text{ in}^2 \quad A_{\square} = 19.3 \text{ in}^2$$

$$\boxed{\text{Top S.A.} = 22.3 \text{ in}^2}$$

## Glider 3

$\Delta$	$\square$
$b = 1.50 \text{ in}$	$L = 4.15 \text{ in}$
$h = 1.50 \text{ in}$	$H = 1.50 \text{ in}$

$$A_{\Delta} = \left[ \frac{1}{2} (1.50 \text{ in}) (1.50 \text{ in}) \right] 2 \quad A_{\square} = [(4.15 \text{ in}) (1.50 \text{ in})] 2$$
$$A_{\Delta} = 2.25 \text{ in}^2 \quad A_{\square} = 12.5 \text{ in}^2$$

$$\boxed{\text{Top S.A.} = 14.7 \text{ in}^2}$$

## Glider 4

$\Delta$	$\square$
$b = 1.15 \text{ in}$	$L = 3.50 \text{ in}$
$h = 1.15 \text{ in}$	$H = 1.30 \text{ in}$

$$A_{\Delta} = \left[ \frac{1}{2} (1.15 \text{ in}) (1.15 \text{ in}) \right] 2 \quad A_{\square} = [(3.50 \text{ in}) (1.30 \text{ in})] 2$$
$$A_{\Delta} = 1.32 \text{ in}^2 \quad A_{\square} = 9.10 \text{ in}^2$$

$$\boxed{\text{Top S.A.} = 10.4 \text{ in}^2}$$

## Glider 5

$\Delta$	$\square$
$b = 0.75 \text{ in}$	$L = 2.50 \text{ in}$
$h = 0.75 \text{ in}$	$H = .75 \text{ in}$

$$A_{\Delta} = \left[ \frac{1}{2} (.75 \text{ in}) (.75 \text{ in}) \right] 2 \quad A_{\square} = [(2.50 \text{ in}) (.75 \text{ in})] 2$$
$$A_{\Delta} = 0.56 \text{ in}^2 \quad A_{\square} = 3.8 \text{ in}^2$$

$$\boxed{\text{Top S.A.} = 4.3 \text{ in}^2}$$

# Glider Weight Ratio Calculations

Original paper S.A =  $8.5 \times 11 \text{ in} = 93.5 \text{ in}^2$   
original paper mass =  $5 \text{ lb} / 500 \text{ sheets} = 0.01 \text{ lb/sheet}$

Glider 1 ratio

$$\frac{93.5 \text{ in}^2}{.01 \text{ lb/sheet}} = \frac{88 \text{ in}^2}{x} \quad x = 0.0094 \text{ lb}$$

Glider 2 ratio

$$\frac{93.5 \text{ in}^2}{.01 \text{ lb/sheet}} = \frac{63 \text{ in}^2}{x} \quad x = 0.0067 \text{ lb}$$

Glider 3 ratio

$$\frac{93.5 \text{ in}^2}{.01 \text{ lb/sheet}} = \frac{42 \text{ in}^2}{x} \quad x = 0.0045 \text{ lb}$$

Glider 4 ratio

$$\frac{93.5 \text{ in}^2}{.01 \text{ lb/sheet}} = \frac{25 \text{ in}^2}{x} \quad x = 0.0027 \text{ lb}$$

Glider 5 ratio

$$\frac{93.5 \text{ in}^2}{.01 \text{ lb/sheet}} = \frac{12 \text{ in}^2}{x} \quad x = 0.0013 \text{ lb}$$

## Glider graph questions

1) The general equation for this graph is a linear straight line using the  $y=mx+b$  formula. Please refer to the "Glider Weight vs. Surface Area" Graph.

The slope of this graph represents the weight/surface area of each glider in  $\text{lb./in}^2$  and shows that the weight of the glider is directly proportional to the surface area of the glider. This data is found on the "Glider weight vs. Surface Area" graph.

2) The slope of this graph represents the weight/surface area, or how much force the glider has in a given wing top surface area. Because this relationship is directly proportional, every increase in weight or force must also result in an increase in surface area and vice versa. The line of best fit also extends to zero because if the glider has no mass/weight then it also can't have a surface area.

3) weight/surface area ratio for various materials

material	Density	Surface Area	Weight
Aluminum bar	$2.70 \text{ g/cm}^3$	$A = b \cdot h = 3 \text{ in.} \times 3 \text{ in.} = 9 \text{ in}^2$	$.0646 \text{ lb.}$
Steel sphere	$8.05 \text{ g/cm}^3$	$A = 4(\pi \times .450)^2$ $A = 2.54 \text{ in}^2$	$.0360 \text{ lb.}$
Glass sphere	$2.47 \text{ g/cm}^3$	$A = 4(\pi \times .375)^2$ $A = 1.77 \text{ in}^2$	$.01757 \text{ lb.}$

Surface Area Sphere =  
 $A = 4\pi r^2$

If we want to compare the surface area to weight of various objects then we should still obtain the same directly proportional relationship where the denser materials have a greater surface area. Also, anything that has mass and takes up space is matter so if an object other than the gliders has no mass/weight then it also can't have a surface area so the line of best fit should still go through zero. Please refer to the graph "Weight vs. Surface Area - Various Density Objects!"

#### 4) Surface area to weight ratios for various glider styles

	Glider 1	Glider 2	Glider 3	Glider 4	Glider 5
Wing surface area (in <sup>2</sup> )	$(\frac{1}{2}b \cdot h)2 + 2(b \cdot h)$ $(\frac{1}{2}(2)(2)2 + 2(6.75)(2.15))$ $A = 33.0 \text{ in}^2$	$2(b \cdot h)$ $2(9)(1.50)$ $A = 27.0 \text{ in}^2$	$A = 2(\frac{h \cdot b \cdot b}{2}) = 2.25 \text{ in}^2$ $A = \frac{1}{2}(b \cdot h)2 = 1.125 \text{ in}^2$ $A = (1.5)(1.5)2 = 4.5 \text{ in}^2$ $A = 7.875 \text{ in}^2$	$A = (\frac{1}{2}b \cdot h)2 = 1.5025 \text{ in}^2$ $A = b \cdot h2 = 5.25 \text{ in}^2$ $A = 5.8125 \text{ in}^2$	$A = (\frac{a+b}{2})h)2 = .375 \text{ in}^2$ $A = (\frac{1}{2}b \cdot h)2 = .0625$ $A = 2(b \cdot h) = 2 \text{ in}^2$ $A = 2.4375 \text{ in}^2$
glider weight (lb.)	0.0094 lb	0.0067 lb	0.0045 lb	0.0027 lb	0.0013 lb

\* I used the same size paper as I did for my original gliders that were all the same glider of various sizes. The weights are the same, so see work for original glider design if necessary \*

\* Also, please refer to pictures to see the 5 different glider shapes \*

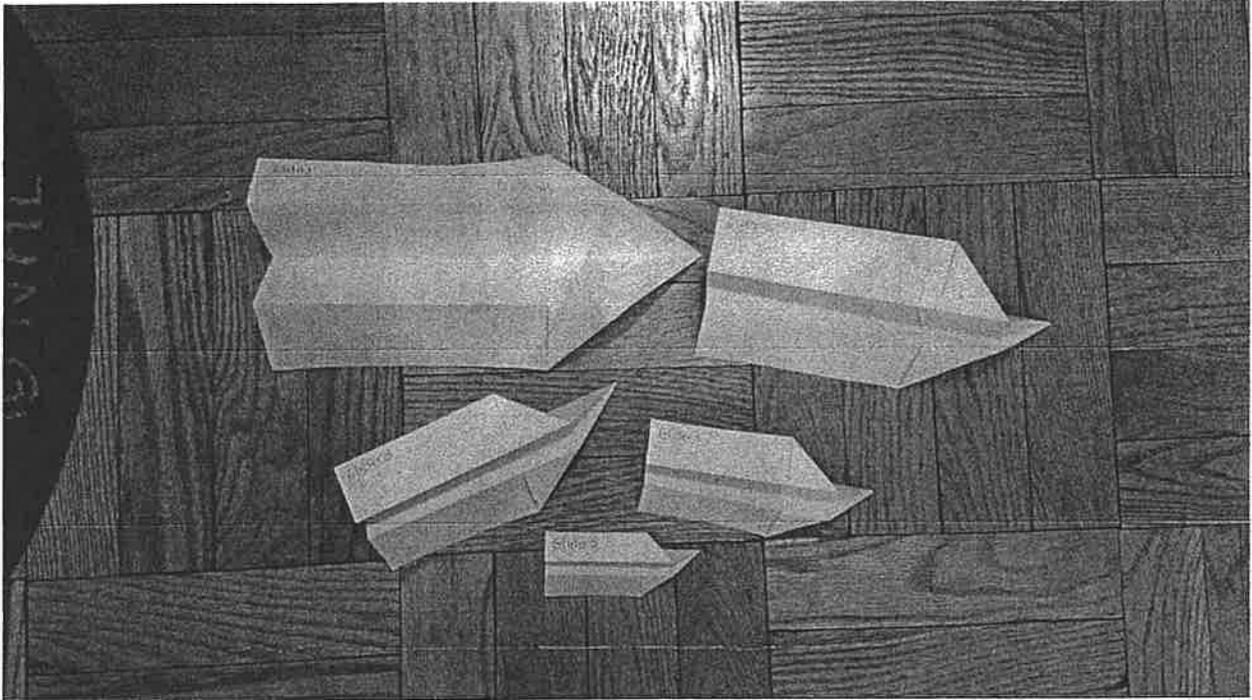
After I made new gliders with various geometric shapes on their wings I noticed that the wing surface area is still directly proportional to the glider weight as I found in my original data and experiment. If you analyze the line of best fit, smaller mass gliders had a steeper curve (the first 3 data points) than the larger gliders (last 2 data points). This data is plotted on the "5 various glider designs" graph.

5) I found that my gliders of smaller weight and smaller wing surface area glided better in both cases than my larger gliders in both weight and surface area.

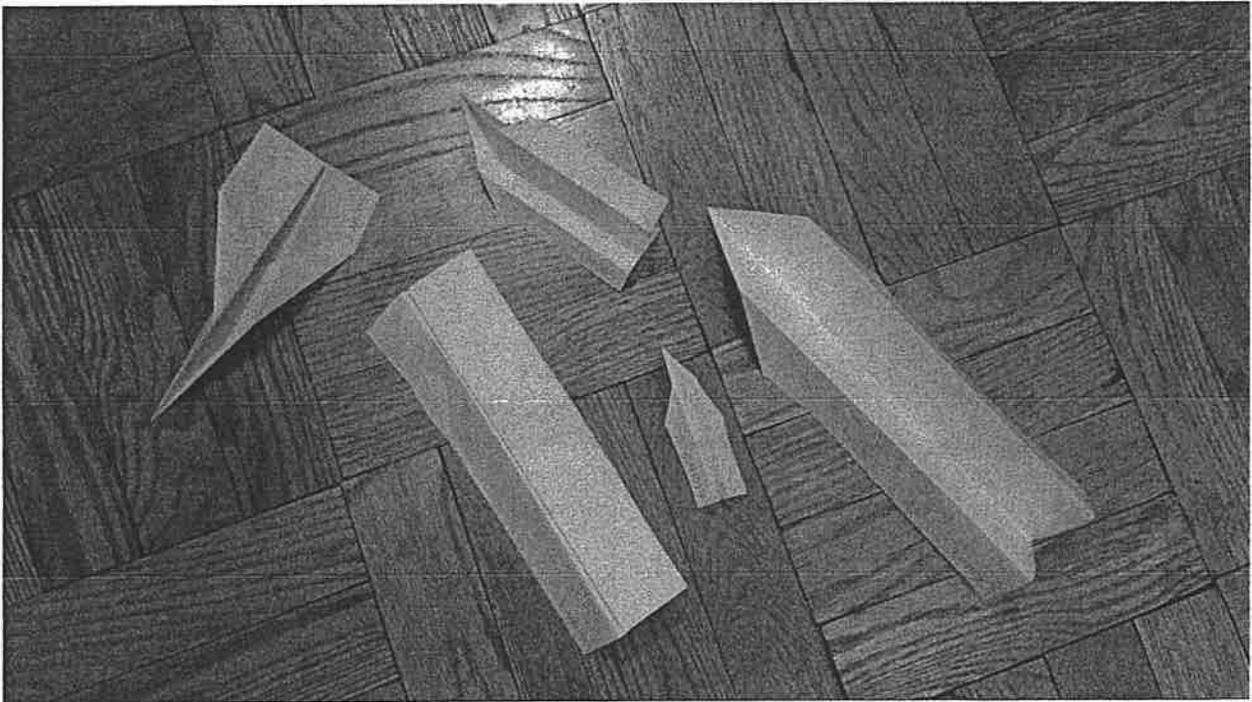
6) I believe that my data is reliable. The measurements were taken carefully and accurately including sig figs throughout the process. Also, the data collected showed the general direct relationship that I had hoped to obtain before beginning the experiment.

7) I believe that surface area affects gliding ability because there is less friction and air resistance in gliders with smaller wing surface areas. This means that the gliders can maintain a longer gliding speed and are therefore more effective gliders than ones with larger surface areas.

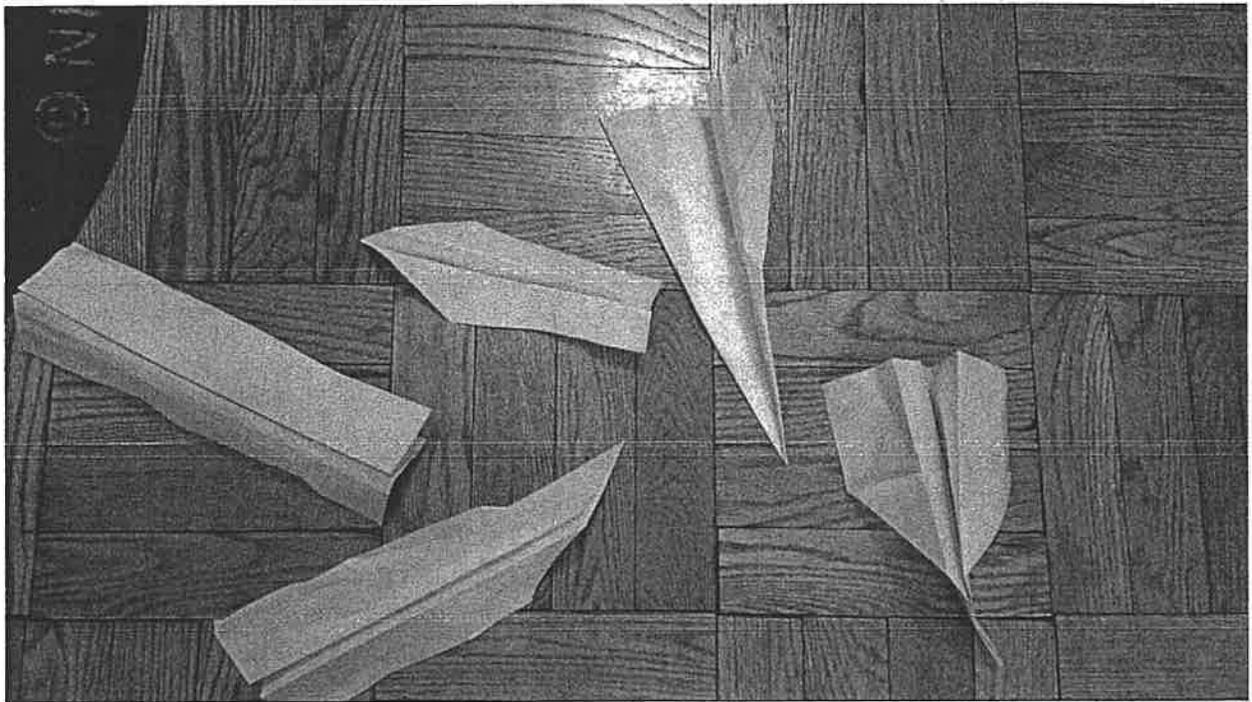
8) I think the reason why some gliders fly better than others is because of the mass of the glider, the wing design, the shape of the wing (surface area) and the friction of the wing to the surrounding air particles + air flow surrounding the wing. Gliders that show the smallest amount of friction will glide better than all other gliders.



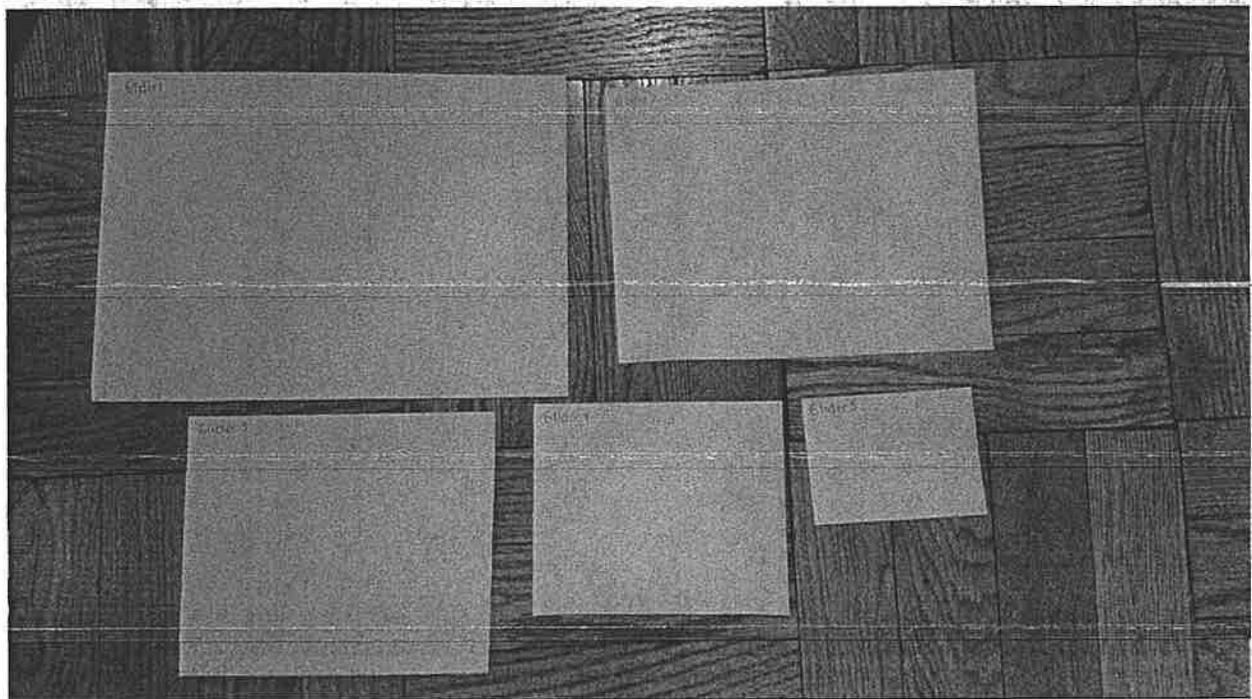
These are the 5 gliders that I made, all having the same wing design. The differences between these is the surface area of the wing and the weight of the paper.



These are the 5 gliders that I designed for one of the analysis/conclusion questions where I had different designs, weights, and surface areas.

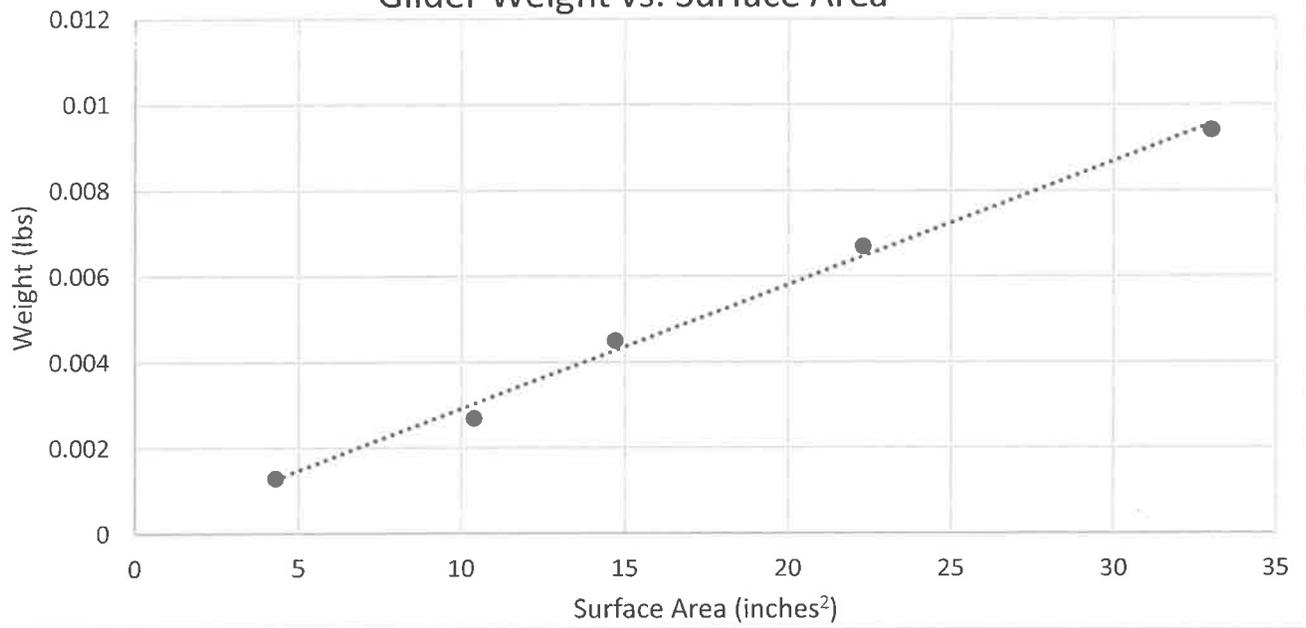


These are the 5 gliders I started with to choose the one that I wanted to make varying shapes of. I selected the one that glided the best.

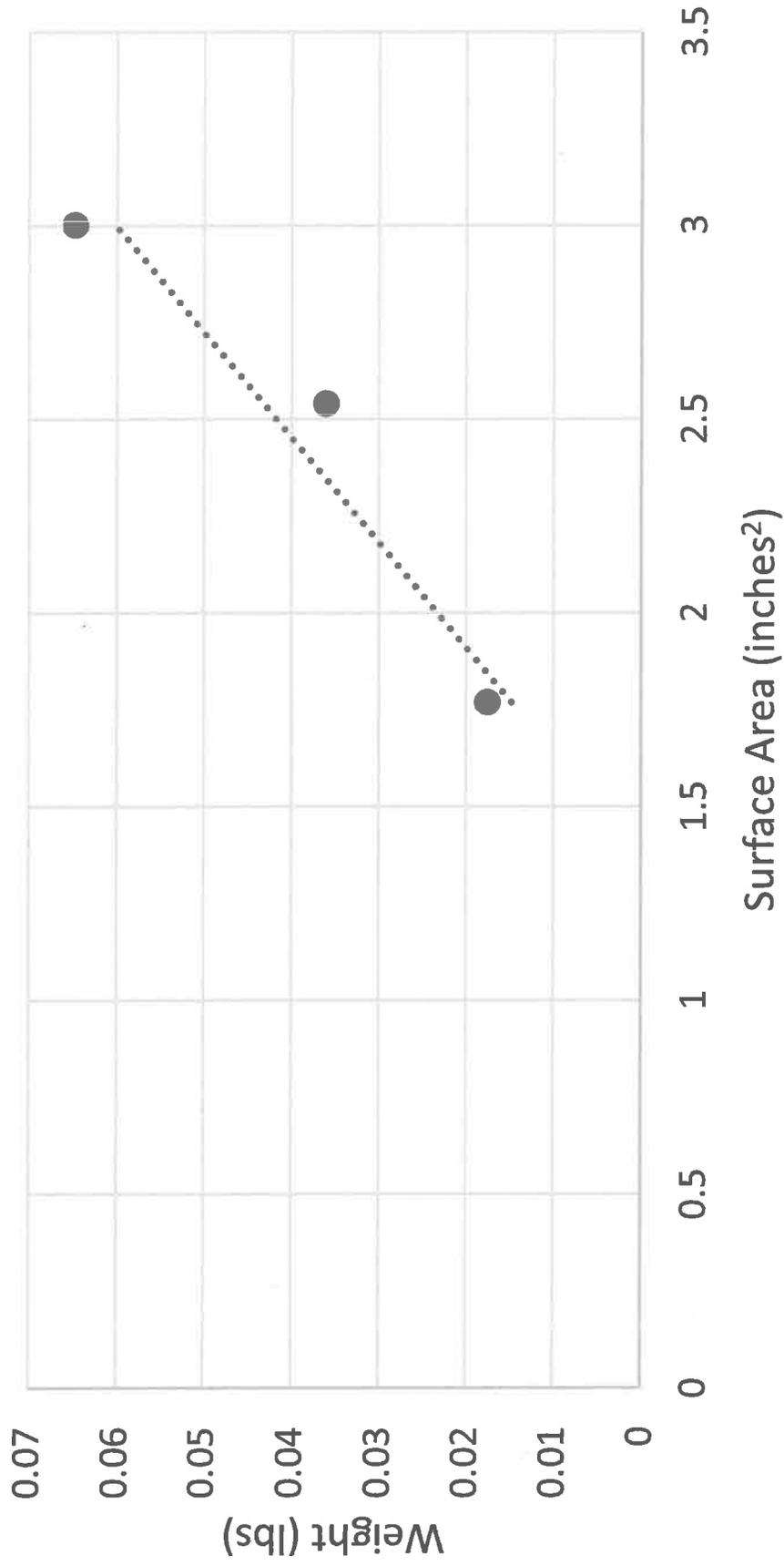


This picture shows the 5 sized pieces of paper that I used to make each of the gliders for the first experiment after I decided on a glider that was my selected design.

Glider Weight vs. Surface Area



# Weight vs. Surface Area- Various Density Objects



5 various glider designs

