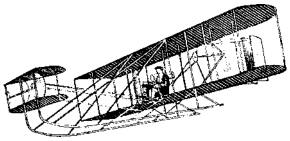


The Aspect Ratio of Wings

Review: As air flows over and under a wing, we know from our study of lift that the air flowing over the top flows faster than the air that flows under the wing. We also know from Bernoulli's Principle that the air that flows faster applies less pressure to the surface it is flowing over. Therefore, since the air flowing over the top of a wing has less pressure (because it is flowing faster), the air pressure on top is less than on the bottom of the wing. The higher air pressure on the bottom "lifts" the wing.

Background: When engineers design a new airplane, the size and shape of the wings are a very important issue. Wings provide the majority of the lift for the airplane, but they also cause drag. Remember that drag is a force that opposes the thrust force. Engineers are always trying to find ways to increase lift and reduce drag caused by the wings.

In addition to flowing faster, the air that flows over the top of the wing also tends to flow inward, toward the fuselage. The air that flows over the bottom is flowing more slowly and tends to flow outward. As these two airflows meet along the trailing edge of the wing, they form a rotating column of air that extends from the wing tip. This is called a wing-tip vortex.

If they are lucky, passengers riding behind the wing of an airplane can sometimes see a wing-tip vortex - particularly if they are flying in the morning or on a slightly humid day. It looks like a long, slim whirlwind that extends from the tip of the wing.

Unfortunately, while they are fun to watch, the same characteristics of the airflow that create wing-tip vortices (the plural of vortex is vortices) also create drag.

Teacher - Led Exercise

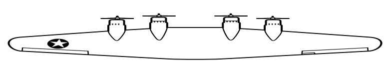
Directions: In their efforts to increase lift and reduce drag, engineers use a mathematical formula called the “aspect ratio”. The “aspect ratio” is simply a comparison between the length and width of the wing:

$$\frac{\textit{length of the wing}}{\textit{width of the wing}} = \textit{aspect ratio}$$

Experiments have shown that a wing built with a higher aspect ratio tends to create less drag than a wing built with a smaller aspect ratio - even when their area remains the same!

Examine the three wings drawn below, calculate the area and aspect ratio of each wing, and fill in the following table. Then, rank the wings according to the drag that each will create, given their aspect ratios. Rank the wing with the least drag, number 1 and the greatest amount of drag, number 3.

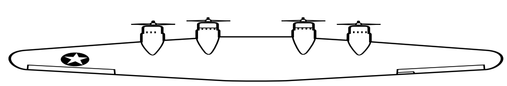
Wing “A”



5 units

20 units

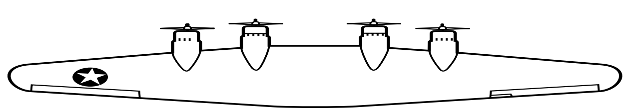
Wing “B”



4 units

25 units

Wing “C”



2 units

50 units

Wing	length	width	area	aspect ratio	drag ranking
A					
B					
C					

Exercise 2

Step 1: Create and draw your own wings below. Shape them like airfoils and give each the same area of 200 square units.

Wing A **Wing B**

Step 2: Label the length and width of each wing.

Step 3: Calculate the aspect ratio for each wing and fill in the table below. Don't forget to include the units!

Wing	length	width	area	aspect ratio	drag ranking
A					
B					

Step 4: Rank the wings according to the drag that each will create, given their aspect ratios. Rank the wing with the least drag, number 1 and the one with the greatest amount of drag, number 2.

The Aspect Ratio of Wings

Teacher - Led Exercise Key

Wing "A": *length: 20 units* *width: 5 units*

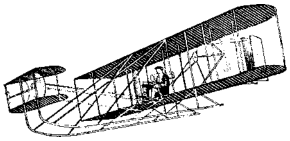
Wing "B": *length: 25 units* *width: 4 units*

Wing "C": *length: 50 units* *width: 2 units*

Wing	length	width	area	aspect ratio	drag ranking
A	*20 units*	*5 units*	*100 square units*	*4*	*3*
B	*25 units*	*4 units*	*100 square units*	*6 R1*	*2*
C	*50 units*	*2 units*	*100 square units*	*25*	*1*

Even though each wing has the same area, 100 square units, Wing "C" has the greatest aspect ratio, and Wing "A" has the smallest aspect ratio. This implies that Wing "A" creates more drag than Wing "C".

Maybe you've wondered why sailplanes and gliders have long, slim wings. Since they don't have engines to provide thrust, their wing shape helps to provide the greatest amount of lift with the least amount of drag.



Exercise 1 Key

Step 1: *Possible wing dimensions and aspect ratios:*

length = 9 width = 8 aspect ratio = 1 R1
length = 12 width = 6 aspect ratio = 2
length = 36 width = 2 aspect ratio = 18
length = 24 width = 3 aspect ratio = 8
length = 18 width = 4 aspect ratio = 4 R2

Wing	length	width	area	aspect ratio	drag ranking
A	*9 units*	*8 units*	*72 square units*	*1R1*	*2*
B	*12 units*	*6 units*	*72 square units*	*2*	*1*

Exercise 2 Key

Step 1: *Possible wing dimensions and aspect ratios:*

length = 100 width = 2 aspect ratio = 50
length = 50 width = 4 aspect ratio = 12 R2
length = 20 width = 10 aspect ratio = 2
length = 25 width = 8 aspect ratio = 3 R1

Wing	length	width	area	aspect ratio	drag ranking
A	*100 units*	*2 units*	*200 square units*	*50*	*1*
B	*20 units*	*10 units*	*200 square units*	*2*	*2*