

Forces in Fluids • Enrich

A Wing for All Circumstances

A wing is an example of an *airfoil*. An airfoil is a shaped surface designed to provide lift. As Figure 1 shows, there are many different shapes of airfoil. When engineers decide what shape to use in an airplane, they must think about two factors:

Lift: The upward force caused by the pressure on the top side of the wing being lower than the pressure on the bottom side of the wing.

Drag: The air friction on the wing as it moves through the air.

In general, an airfoil with a more sharply curved upper surface creates more lift. Unfortunately, it also creates more drag, which slows the airplane down. A less curved upper surface produces less lift, but has less drag. When taking off and landing, during which it is moving relatively slowly, an airplane needs all the lift it can get, but is not as hampered by drag. At faster speeds, reducing drag is more important.

If you have flown in an airplane, you may have noticed that various flaps extend from the front and back edges of the wing. The pilots use these flaps to change the shape of the wing for various flying conditions. At takeoff and landing, with the flaps extended, the airfoil is more curved (like Figure 1a). At fast cruising speed, with the flaps pulled in, it is flat and smooth (like Figure 1c).

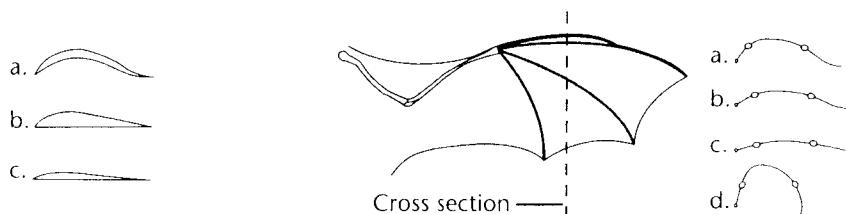


Figure 1

Figure 2

Flying animals also change the shapes of their airfoils to meet different circumstances. A bat's wing is made of skin stretched across its long arm and finger bones. By curling its fingers, a bat controls the shape of its airfoil. The questions below refer to the cross sections of the bat's wing in Figure 2. Answer them on a separate sheet.

1. Would a bat use airfoil *a*, *b*, or *c* when coming in to land? Why?
2. Which of the three airfoils might a bat use while chasing a fast insect in straight flight? Why?
3. Which airfoil might a bat use in flight of average speed? Why?
4. What do you think would happen if the bat were to hold one wing in shape *a* and the other in shape *c* at the same time? Explain.
5. Why do you think the bat would probably not hold its wing in shape *d* while flying?