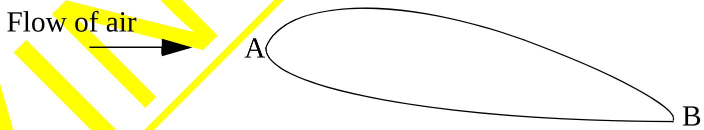
# Flying with Bernoulli

Flying in an airplane and looking out the window, have you ever wondered how can an 800,000-pound metal bird take-off and stay in flight? Although Jacob Bernoulli never saw powered flight—he died in 1705—it was the "principle" that carries his name the physical phenomenon that allow us, and birds, to fly. Bernoulli's Principle says that a rise—or fall—in pressure in a flowing fluid (air is a fluid) must always be accompanied by a decrease—or increase—in the speed of the fluid. Conversely, an increase—or decrease—in the speed of the fluid results in a decrease—or increase—in pressure. This is at the heart of a number of everyday phenomena. As a very trivial example, Bernoulli's principle is responsible when a shower curtain gets "sucked inwards" when the water is first turned on. What happens is that the increased water/air velocity inside the curtain (relative to the still air on the other side) causes a pressure drop. The pressure difference between the outside and inside causes a net force on the shower curtain which sucks it inward. A more useful example is provided by the functioning of a perfume bottle: Squeezing the bulb over the fluid creates a low pressure area due to the higher speed of the air, which subsequently draws the fluid up.

Bernoulli's principle also tells us why windows tend to explode—rather than implode—in hurricanes: The very high speed of the air just outside the window causes the pressure just outside to be much less than the pressure inside, where the air is still. The difference in force pushes the windows outward, and hence explode. If you know that a hurricane is coming it is therefore better to open as many windows as possible to equalize the pressure inside and out—of course, covering the outside of the window with shutters is even better.

Another example of Bernoulli's principle at work is in the motion of a curve ball in baseball and the previously mentioned lift of aircraft wings. In both cases the design is such as to create a speed differential of the flowing air past the object on the top and the bottom. For aircraft wings this comes from the design and movement of the wings and flaps. Such a speed differential leads to a pressure difference between the top and bottom of the object, resulting in a net force being exerted, either upwards or downwards.




Airplanes and birds have a wing design where air molecules starting together at "A" must meet at point "B" at the same time. In order for this to happen, the wind speed under the wing must be less than the wind speed over it. Because the top side has greater speed it also has lower pressure and the wing will be "sucked up" and lift. Next time you fly in an airplane, look at the flaps extend out at takeoff; this adds lift at take-off, which is where it is really needed. Once desired altitude is reached, they recede.