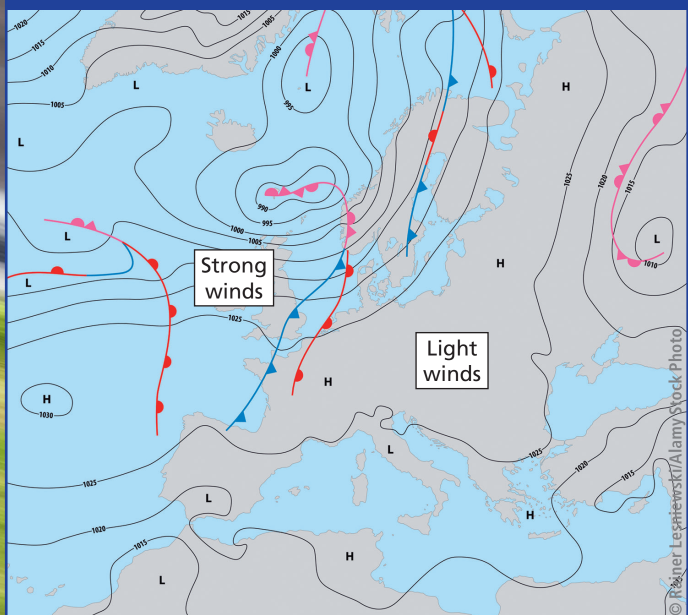
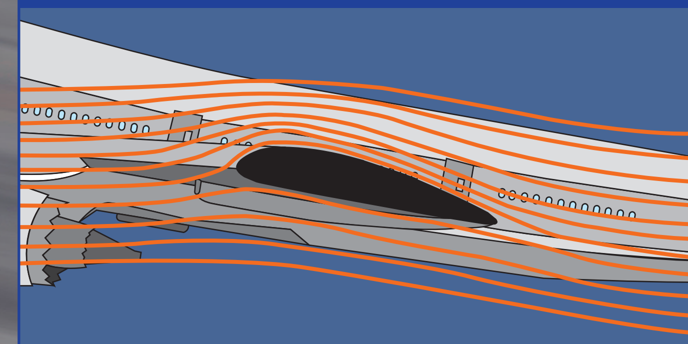
Bernoulli's principle in the modern world

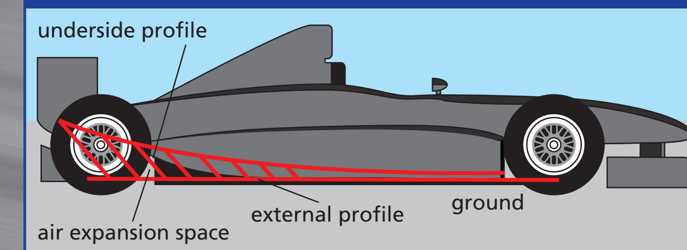
1 The closer the isobars on a weather map, the stronger the winds (H = high pressure, L = low pressure)



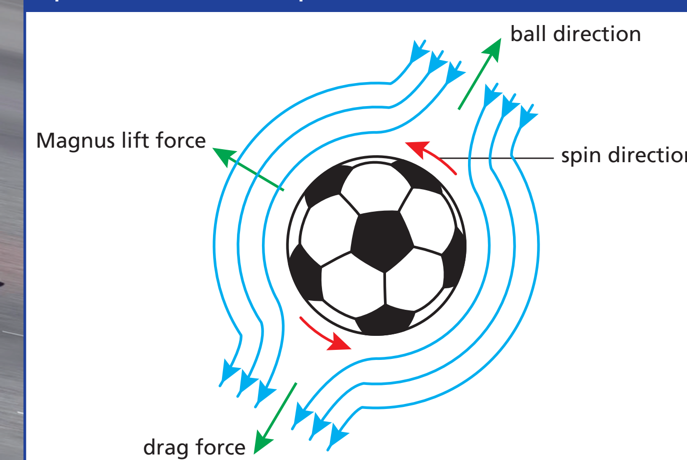
2 Air flow around the wing of an aeroplane, with higher air speed and lower pressure above the wing

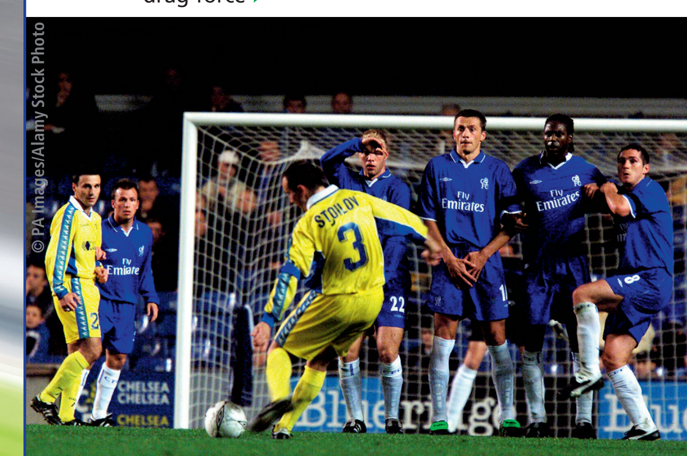


3 Expansion space at the rear of a racing car's skirt reduces pressure and accelerates air underneath the car, helping 'stick' the car to the track



4 A spinning ball curves because of increased air speed and reduced pressure on one side





Daniel Bernoulli (1700–1782) was a Swiss mathematician and physicist who published his influential book *Hydrodynamica* in 1738, just a few years after the death of Isaac Newton. In the book he described what has become known as the Bernoulli principle, which states that, at any point in a fluid, an increase in the speed of the fluid occurs simultaneously with a decrease in pressure.

From Newton's second law of motion ($F = ma$) it is clear that particles in a fluid will accelerate and increase speed as they move into a region of lower pressure, because the pressure difference causes a driving force.

On weather maps isobars are lines joining points of equal air pressure. Multiple isobars close together indicate a large and rapid change of pressure that can rapidly accelerate air to cause strong wind (1).

The reverse effect is relevant to many aspects of modern life. The principle of conservation of energy determines that an increase in fluid velocity causes a decrease in pressure. For fluid that is in equilibrium (steady flow) and is free of viscous forces, the amount of energy at all points in the fluid is identical. If at one point the rate of fluid flow increases in one direction, then to conserve energy the pressure exerted by the fluid — caused by particle movement in other directions — must decrease.

Aeroplane wings are shaped so that, as they cut through the air, air is accelerated over the top of the wing (2), and its speed relative to the wing is faster across the top surface than the bottom. Pressure is reduced over the top of the wing, and the resultant pressure difference creates lift.

Skirts on Formula 1 racing cars (3) separate the air moving underneath the car from the air surrounding the car. As air flows underneath the car it is constricted by the car's shape, making it accelerate and reducing its pressure. Higher-pressure air above the car 'sticks' the car to the surface, allowing it to corner and brake more quickly than without the skirt. The expansion space towards the rear of the car slows the air, increases its pressure and optimises the downward forces on each of the wheels.

In sport, throwing or kicking a ball in a way that makes it spin accelerates air more on one side, reducing the pressure and making the ball curve (4). You can see this for yourself here:

https://tinyurl.com/curve-ball

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