DAVID SANG

First flight

The Wright brothers

Orville Wright makes the first powered flight at Kitty Hawk, USA, 17 December 1903

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It's 100 years since the Wright brothers made the first powered flight. Unlike the try-it-and-see methods which had been used by many of the previous attempts, the Wrights approached the problem of flight in a scientific way and beat the competition.

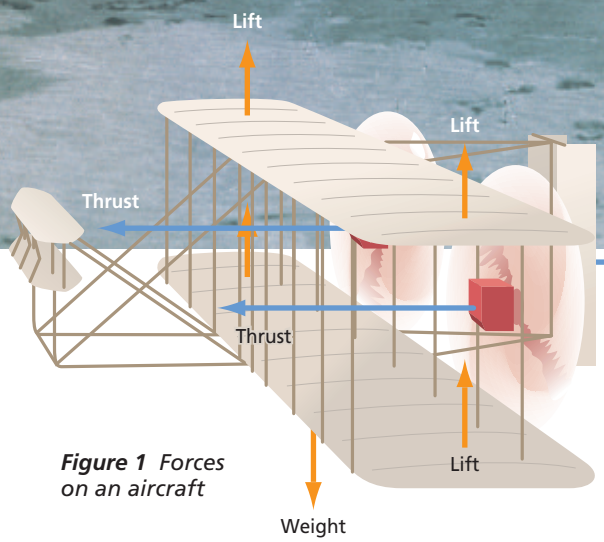


Figure 1 *Forces on an aircraft*

GCSE key words
Forces
Air resistance
Newton's third law of motion

People had flown before 1903, in balloons and gliders, but Wilbur and Orville Wright were the first to travel in a powered, heavier-than-air craft. They did it on 17 December 1903.

The Wrights lived in Dayton, Ohio. They were a relatively uneducated pair, and didn't finish high school, but they were clever technically. The two young men set up a printing shop, having built their own printing press by recycling broken parts. In 1893, when Wilbur was 26 and Orville was 22, they switched to making and repairing bicycles, calling themselves the Wright Cycle Company. Bicycles were a highly-developed technology in the late nineteenth century, making good use of lightweight but strong materials, just the stuff you need to know about to make an aircraft.

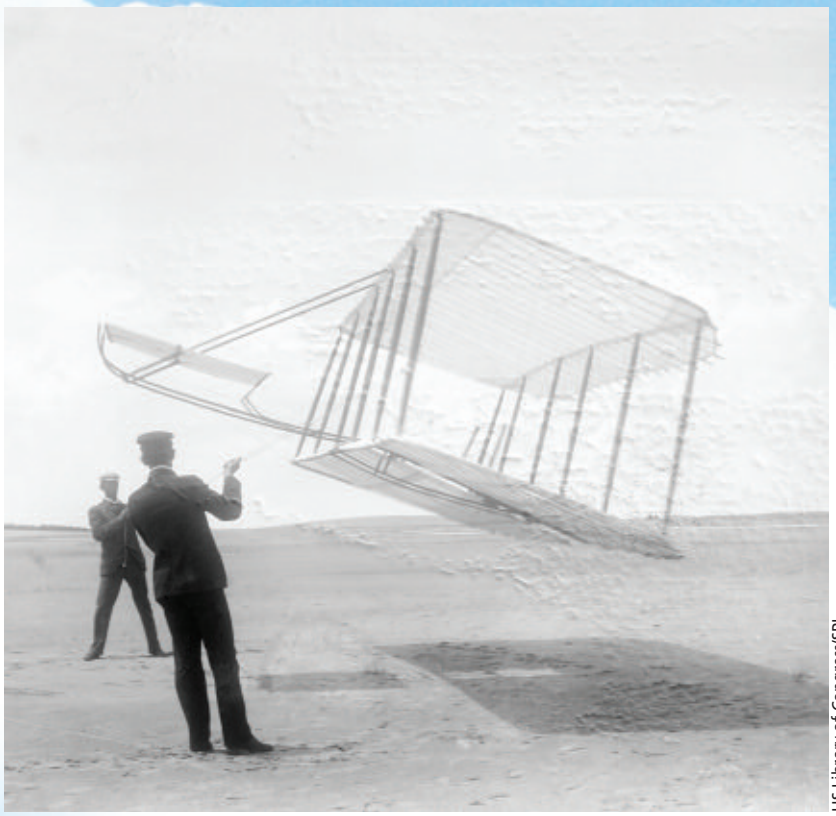
BOX 1 FORCES ON AN AIRCRAFT

Figure 1 shows the forces acting on an aircraft.

- The forward **thrust** is provided by the engine, turning the propeller, which pushes air backwards.
- The backward force of **drag** is another name for air resistance, or friction with the air.
- The downward force, the aircraft's **weight**, is caused by gravity.
- The upward force of **lift**, which acts on the aircraft's wings, balances its weight.

As an aircraft accelerates down the runway, the lift gradually increases, until it is enough to overcome the weight. At top speed, the aircraft cannot go any faster because the drag force is so great that it equals the forward thrust of the engine.

To change direction, the pilot can tilt the aircraft. The lift force on the wings then has a sideways component, and this pushes the plane round.



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***Above:** Orville (foreground) and Wilbur Wright testing a glider as a kite in 1901*

STUDYING FLIGHT

Like many people at the time, the brothers were fascinated by the possibility of flying. In 1899, they built their first model aircraft, with a wingspan of 5 feet (1.5 m). This helped them to understand the forces which act on a flying machine (see Box 1). The vital thing is to be able to produce an upwards force, **lift**, to counter the aircraft's weight.

Imperial units have been given for measurements because that is what the Wright brothers used.

The Wrights wanted to make a kite capable of lifting a man off the ground, but they realised that their home town was no good as a trial ground. Strong winds were rare and the ground was hard, so in the summer of 1900 they moved to Kitty Hawk, on the Atlantic coast of North Carolina. Here they had reliable winds and sandy beaches for soft landings.

Wind tunnels are still used today, for testing whole aircraft. Cars are also tested, to minimise drag on them.

They built a double-winged glider with a wingspan of 17 feet (5.2 m). For lightness, the wings consisted of a skeleton of bent ash wood covered with fine fabric. Its total weight, including the pilot, was just 85 kg. Using existing data, they calculated the lift which would be provided by the glider's wings, and they achieved some glides up to 120 m, but the lift was much less than they had calculated. It was clear to them that a complete re-think was needed if they were to lift a heavy engine into the air. They went home to Dayton.

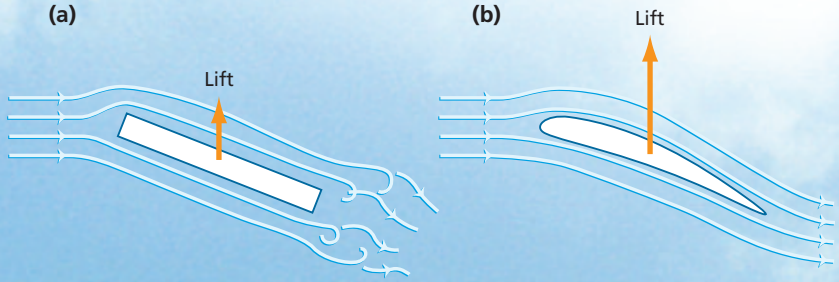


***Figure 2** How air flows over an aircraft wing. (a) Rectangular. (b) Aerofoil*

WILBUR BECOMES A SCIENTIST

The Wrights had been using data and formulae published in scientific journals, but they no longer trusted them. They set about finding out the best way to produce lift for themselves. First, they built a wind tunnel. This was a chamber with a fan at one end to blow air through it. Inside the tunnel, they positioned model aircraft wings in the flow of air, attached to balances to measure the forces acting on them. They changed a lot of variables — the air speed, the angle and area of the wings, and their shape. From this, they drew graphs to show the relationship between lift and air speed, and deduced the best shape and angle for their wings (see Box 2).

The Wrights then built a new glider, which proved excellent. In October 1902, Orville wrote, 'We now hold all the records! The largest machine, the longest time in the air, the smallest angle of descent, and the highest wind!' Wilbur had glided a distance of 190 m in 26 s.

DEVELOPING POWER

The next step was to find a suitable petrol engine for a powered aircraft. There wasn't one, so the brothers set about making one. It had to be both powerful and lightweight. They produced an engine which weighed 80 kg (almost as much as their first glider), and which had a power of 9 kilowatts (12 horsepower).

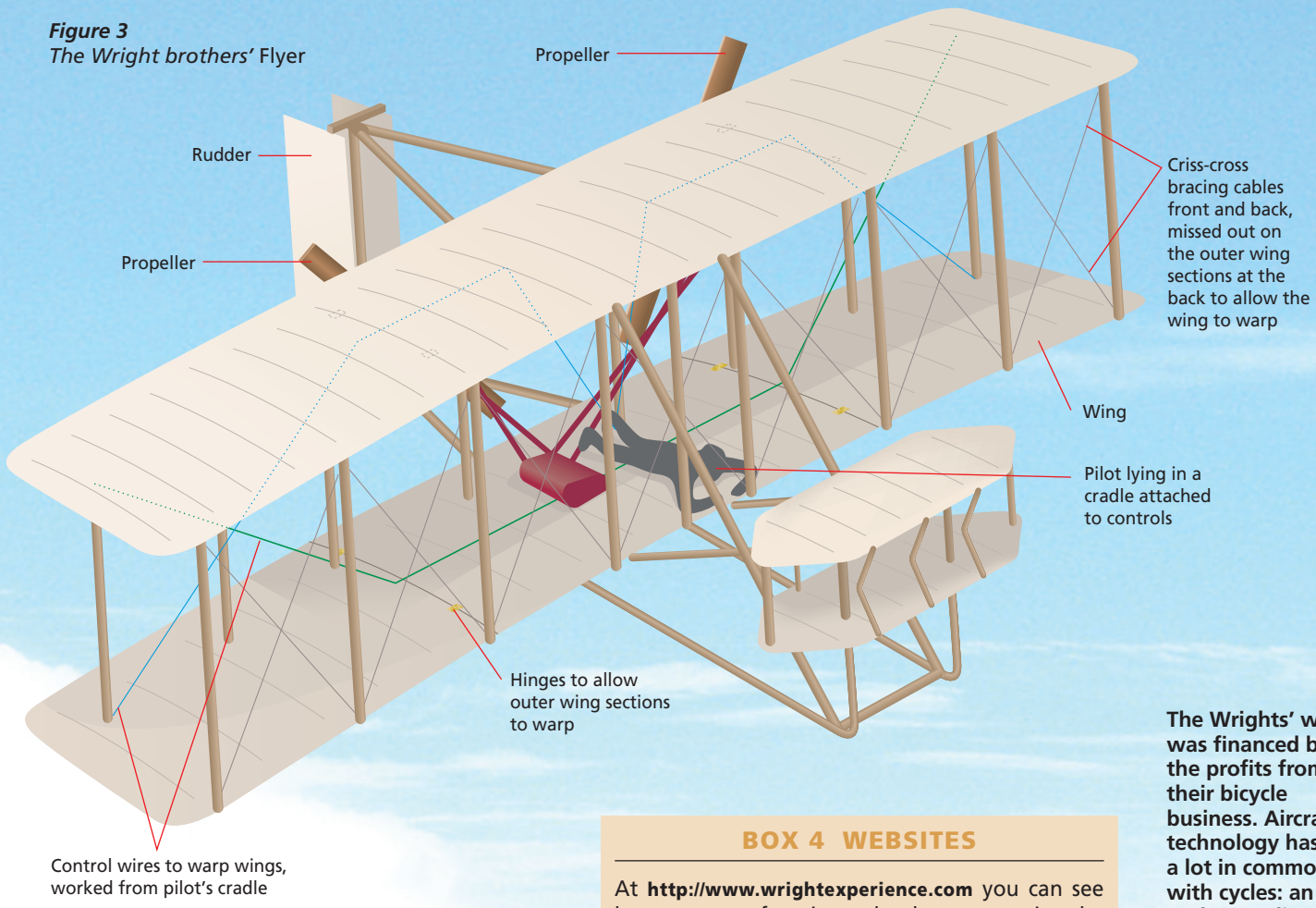
Finally, they had to make a propeller. A well-designed propeller is vital, because this is what pushes the air backwards, providing the thrust to move the aircraft forwards. They carved their propeller out of wood.

BOX 2 WING SHAPES

An aircraft moves forward because the propeller pushes air backwards. This is an example of Newton's third law. The force on the aircraft is equal and opposite to the force it exerts on the air.

We can understand lift in a similar way. An aircraft's wing is tilted slightly, so that as it moves forwards it pushes air downwards. The result is an equal and opposite upward force on the wing. A wing with a rectangular cross section will work, but not very well, because it produces a lot of turbulence (Figure 2). An aerofoil shape is better, as it moves smoothly through the air.

Figure 3
The Wright brothers' Flyer



The Wrights' work was financed by the profits from their bicycle business. Aircraft technology has a lot in common with cycles: an understanding of forces is vital, as well as materials which are lightweight, stiff and strong.

BOX 3 DIMENSIONS OF THE WRIGHT *FLYER*

Wingspan = 40 feet 4 inches (12.3 m)
Chord (front to back of wing) = 6 feet 6 inches (2 m)
Wing camber = 1:20
Total wing area = 510 square feet (47 m^2)
Two propellers, each 8.5 feet (2.6 m) in diameter
Propeller made of three layers of 3 cm spruce, glued together, shaped with hatchet and drawshave
Horizontal forward rudder = 48 square feet (4.5 m^2)
Distance from nose to tail = 21 feet 1 inch (6.4 m)
Unmanned weight = 605 pounds (274 kg) including engine, propellers and chain drive
Wing skeleton covered with white French sateen fabric
Propeller shafts made of steel

BOX 4 WEBSITES

At **http://www.wrightexperience.com** you can see how a group of engineers has been recreating the Wright brothers' experiments to make accurate replicas of their aircraft. Watch out for reports of these planes flying on the centenary of the first flight. The site includes detailed plans and lets you see how the wings were warped to provide control of the plane's balance.

The Science Museum in London has a replica of the Wright *Flyer*. Take a look at their online exhibition on flight at

http://www.sciencemuseum.org.uk

Now they were ready to complete their first *Flyer*, and they set off back to Kitty Hawk. On 17 December, at 10.35, Orville made the first flight. It lasted just 20 s and covered 61 m. Then Wilbur went a little further, and by the fourth flight of the day, they began to understand how to control their plane. The pilot lay on his stomach on the lower wing. With his hands he controlled the front elevator, which made the plane move up or down. By twisting his body, he pulled on cords which warped (twisted) the wings, causing the plane to turn right or left. (Nowadays, most aircraft have flaps on the wings to do this.)

Later, Orville emphasised the part that scientific investigation had played in their achievement:

> I look with amazement upon our audacity in attempting flights with a new and untried machine…Yet faith in our calculations and the design of the first machine, based upon our tables of air pressures, secured by months of careful laboratory work, and confidence in our system of control developed by three years of actual experiences in balancing gliders in the air had convinced us that the machine was capable of lifting and maintaining itself in the air, and that, with a little practice, it could be safely flown.

***David Sang** writes textbooks and is an editor of* CATALYST.

● Why did Sir George Cayley's coachman hand in his notice in 1853? Find out about the first manned glider flight. The Wrights were influenced by Cayley's design, including vertical and horizontal control surfaces.

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