Flying weightless

David Sang

Astronauts in orbit around the Earth experience weightlessness, and this is something they must be trained for. One way they do this is to travel in a large aircraft flown by experienced pilots who can put the aircraft through a special manoeuvre in which the occupants are weightless for up to 30 seconds.

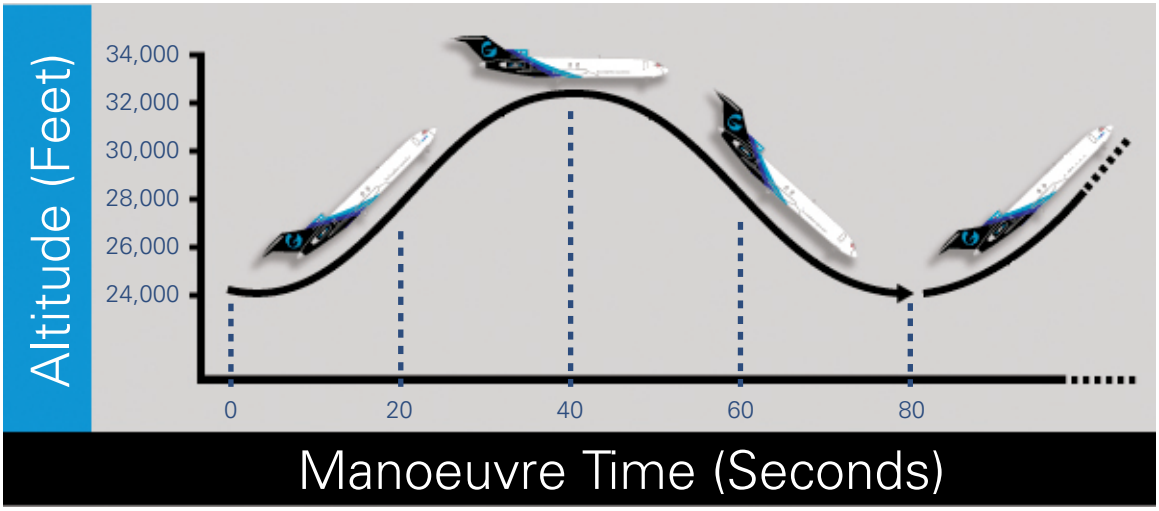
To achieve this, the aircraft flies steeply upwards and then tips over into a downward, parabolic path. It is during this phase that the passengers experience weightlessness. Although the experience lasts only a short time, passengers can perform simple experiments and learn to control their body position.

The pilots can adjust the path of the aircraft to achieve the reduced gravity which astronauts will experience if they ever visit another planet such as Mars (where gravity is roughly one-third of the value on Earth).

Underwater work

An alternative technique used in training is to work underwater where the upthrust of the water cancels out the astronaut's weight. The experience of moving arms and legs is different from that experienced in true weightlessness because of the drag of the water.

Astronauts Soichi Noguchi and Stephen K Robinson in the immersion tank at NASA's Neutral Buoyancy Laboratory in Houston, Texas. They are accompanied by divers to ensure their safety.



The Zero-g aircraft completes several manoeuvres in succession.

A parabola is the curved path followed by a ball or other object when thrown through the air.

What to look for

The photograph on pages 10-11 was taken on 29 April 2007.

- All the interior surfaces of the aircraft are padded to prevent injury to weightless passengers.
- The crew member on the left is setting Hawking spinning freely in mid-air.
- Hawking was diagnosed with amyotrophic lateral sclerosis, a form of motor neurone disease, over 40 years ago. He is almost completely paralysed so extra care was needed to prevent him from coming to any harm.
- Also in the picture is Nicola O'Brien, a nurse practitioner who is Hawking's aide.

Hawking has applied to fly into space in a tourist spacecraft to be launched in 2009.

Flights in the ZeroG aircraft are offered as a tourist attraction at various US airports.

Physicist Stephen Hawking of Cambridge University experiencing weightlessness inside an aircraft as it follows a parabolic path.This manoeuvre is used in astronaut training.

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NASA

Free-fall, weightlessness and acceleration

Why do astronauts experience weightlessness? Are they really free from gravity?

There are two different situations to think about. Firstly, consider an astronaut in the International Space Station orbiting the Earth. The ISS travels 350 km above the Earth's surface. The illustration shows this orbit to scale; the Earth's radius is 6400 km, and the ISS is well within the Earth's gravitational field.

In fact, it is the pull of the Earth's gravity which keeps the ISS in its circular orbit. If the Earth's gravity was switched off, the ISS would fly off in a straight line, at a tangent to its orbit.

In effect, the ISS is endlessly falling towards the surface of the Earth, but the curvature of its orbit is just right for it to follow the curve of the Earth's surface. We say that the spacecraft is in free-fall, and so are the astronauts inside it.

Imagine that you were inside a lift when its cable broke. As the lift accelerated freely downwards, you would be in free-fall. You would be able to take your feet off the floor and twist and turn in midair just like a weightless astronaut – until you reached the bottom of the shaft.

Free from gravity

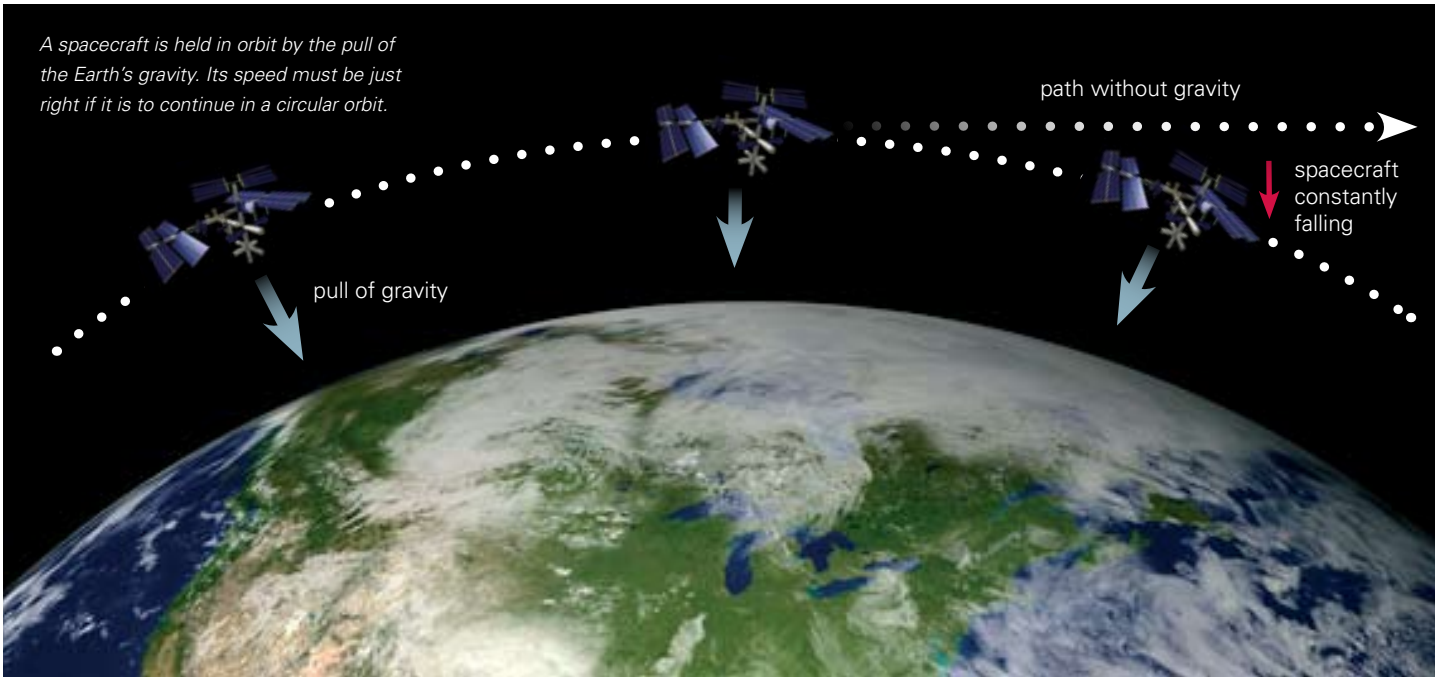
How can an astronaut truly escape from gravity? This can happen on a long space flight such as to the Moon or to another planet. The further the spacecraft is from Earth, the weaker is the pull of the home planet's gravity. Eventually, deep in space, with the rocket motors switched off, the astronauts on board will experience weightlessness because of the absence of gravity.

Now switch on the rocket motors. As they make the spacecraft accelerate forwards, the astronauts feel a force pushing them back in the other direction (just as you are pushed back in your seat as a car accelerates forwards).

Thinking about this, Albert Einstein realised that (unless you could look out of the windows of your spacecraft) you wouldn't know whether you were being pulled by gravity or accelerating because of the force of your rocket motors. That simple idea led him towards his General Theory of Relativity.

David Sang is Physics editor of Catalyst.

Russian cosmonauts Oleg Kononenko (top) and Sergei Volkov experience weightlessness during Expedition 17 of the International Space Station.



A spacecraft is held in orbit by the pull of the Earth's gravity. Its speed must be just right if it is to continue in a circular orbit.