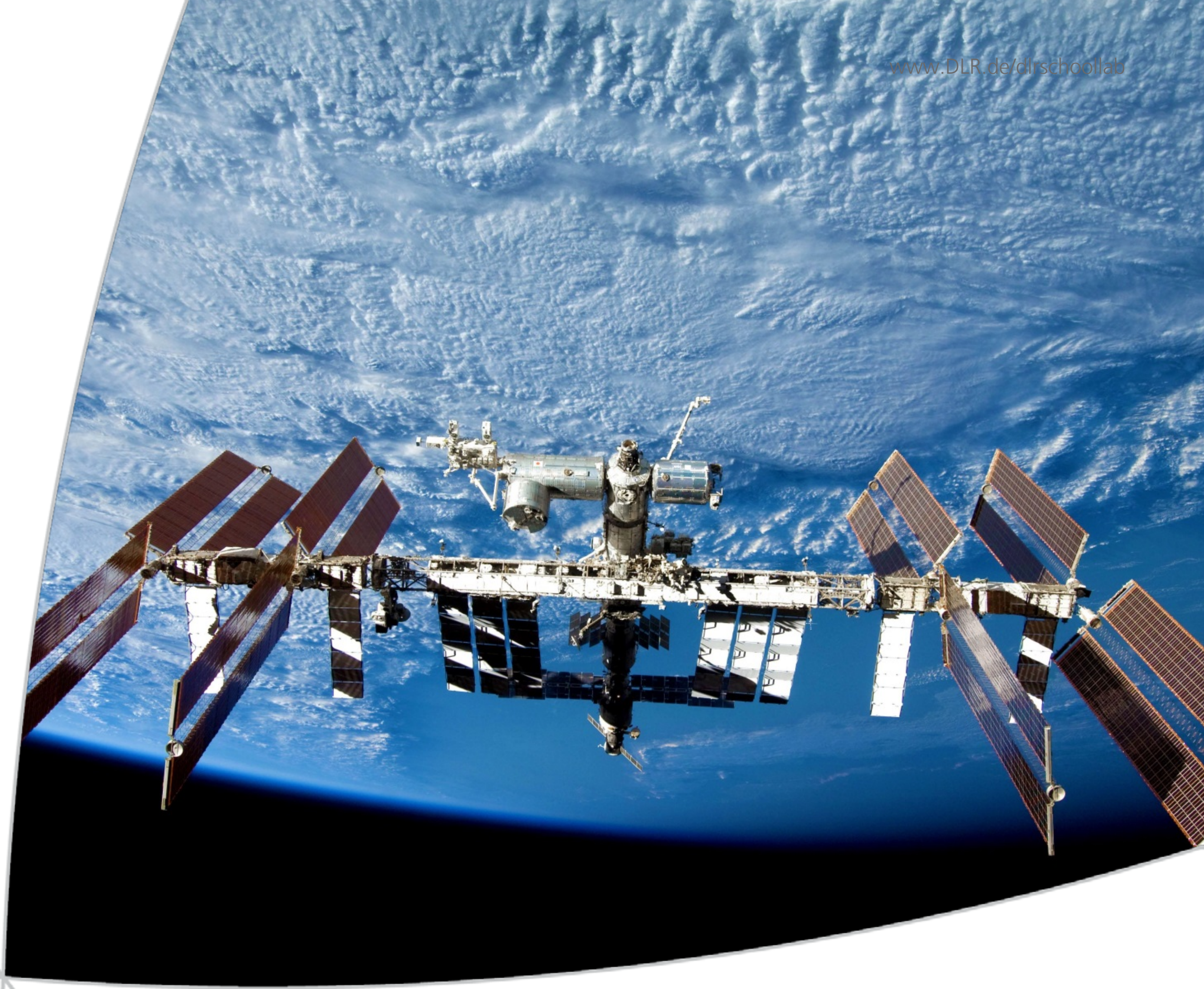


DLR_School_Lab Köln

Microgravity

The miniature drop tower

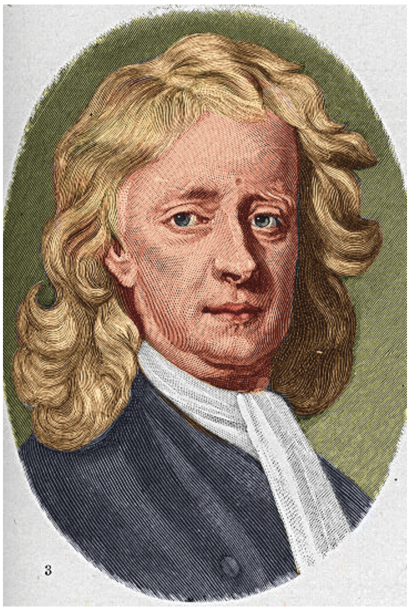
An astronaut floats through the space station and picks a pen floating in front of him out of the air. We have seen pictures like this on television. But why are the objects on a space station weightless? In this experiment, we intend to answer that question.

What is gravity?

Of course, people have always known that objects fall to the ground if you let them go. But it was not until the 17th century that Sir Isaac Newton devised the law of gravity: All objects attract each other. The gravitational force corresponds to the mass of the objects and their distance from each other. Earth attracts an apple and at the same time, the apple attracts the earth. However, because the earth's mass is so much larger than that of the apple, it is the apple that moves towards the earth.

The force of gravity is the weakest of the four basic forces in physics. However, because gravity is effective over long distances and it is not possible to shield yourself from it, gravity defines the orbit of planets and the structure of the universe. So how do we get rid of this force? How do we become weightless? We need an opposing force...

Astronaut Susan J. Helms in the Russian Zarya module of the International Space Station (Photo: NASA)



Sir Isaak Newton (1643-1727)

Inert masses

You might know that strange feeling you have in your stomach when a lift suddenly starts or stops. If we stand on scales in a lift, we make the following observation: when the lift accelerates upwards, the scales show an increase in weight. When the lift accelerates downwards, they show less weight. Of course we have not lost weight in this time; it is inertia that is responsible for the changes on the scales. If you try and move an object, you will experience resistance. Put simply, the object "resists" being accelerated. It is therefore inertial when stationary. This inertia is larger the greater the mass of the object is.

Therefore, when the lift accelerates downwards, our body momentarily remains in its original position. The floor and the scales move down, the force with which the body presses down onto the scales decreases and the scales show less weight.

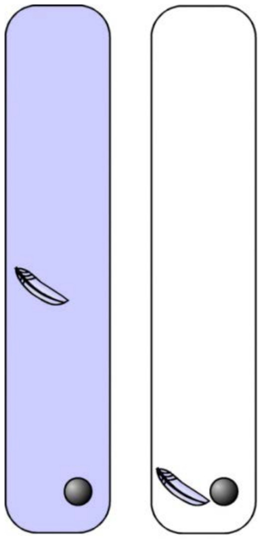
Weightlessness

Imagine now that the elevators cable breaks and the lift freefalls downwards. In this case, the scales would no longer indicate any weight at all. We would be weightless.

A system is defined as being weightless when no acceleration can be measured within it.

Technological possibilities

Weightlessness in a falling lift does not last for long – not only because the lift will inevitably hit the ground, but because the air within the elevator shaft creates friction and brakes the lifts fall somewhat. Only in a vacuum do all objects fall at the same speed: a feather will fall just as fast as a metal ball.

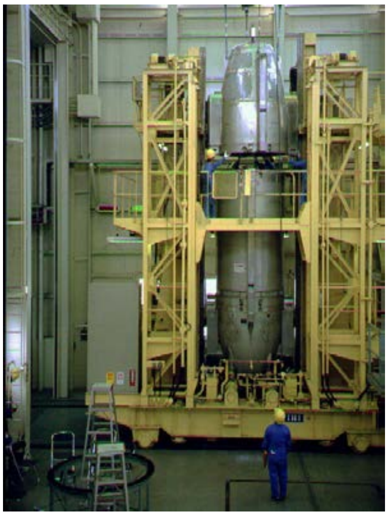


Fall of a feather and a metal ball through air (left) and in a vacuum (right)

It is for this reason that the air is pumped out of the drop tower in Bremen before any experiments begin. However, vacuum is only an "aid" in creating weightlessness – in principle, they are not connected.

ZARM drop tower in Bremen

The drop tower in Bremen is 122m high. Within it, you can achieve 4.74sec of weightlessness. If experiments are catapulted up, you achieve double that time.



Drop capsule in Japanese Microgravity Center Kamisunagawa

In the drop shaft in Japan, you can achieve 10 sec of weightlessness.

What can be done to increase the length of drop time? Build even higher towers or longer shafts? The same thing you can do to make a stone fall for longer- throw it high into the air. This is not an easy task, as the constant friction caused by the air results in the need for some acceleration to even things out. To achieve this, planes and rockets fly in parabolas. A parabola is the trajectory of a stone you throw. With a plane, you can achieve about 25 sec of weightlessness, in a rocket, up to 15 min.

What about the space station?

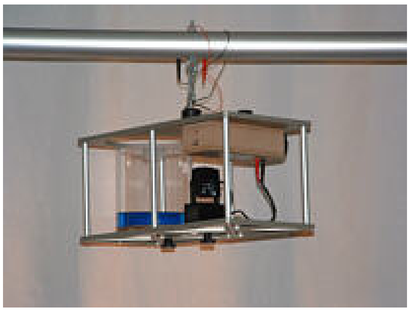
For some experiments, 15 min of weightlessness are not enough. Another possibility for extending the length of time is orbiting a planet. Centrifugal force, which we know from merry-go-rounds, pushes us outwards while we spin around (this force is also connected to inertia). Any object circling earth, for example the International Space Station, is therefore subjected to two opposing forces: gravity, which pulls the space station towards the earths centre and centrifugal force, which pushes it outward. Given the right orbit height and velocity, these two forces will cancel each other out and we will achieve weightlessness.

Our experiments

In the DLR_School_Lab you can carry out experiments about weightlessness with the help of a small drop tower. The drop height is only 2m, so the length of time in weightlessness is 0.6sec. But with the help of a video system we can still see what is happening in our capsule and analyse the results in slow motion.

We will see that forces that are present under the influence of gravity, but not very noticeable, suddenly define the behaviour of objects. What happens when air and water both weigh the same? How do candles burn in weightlessness? How do you transfer liquids from one container to another on the space station? What is a magnetic gravimeter? And why do we need to know all of this?

The miniature drop tower in the DLR_School_Lab Köln



Drop capsule

Our experiments

Airplane "Zero-G" during a parabolic flight (Picture: NOVESPACE)

DLR at a glance

DLR is the national aeronautics and space research centre of the Federal Republic of Germany. Its extensive research and development work in aeronautics, space, energy, transport, digitalisation and security is integrated into national and international cooperative ventures. In addition to its own research, as Germany's space agency, DLR has been given responsibility by the federal government for the planning and implementation of the German space programme. DLR is also the umbrella organisation for the nation's largest project management agency.

DLR has approximately 8000 employees at 20 locations in Germany: Cologne (headquarters), Augsburg, Berlin, Bonn, Braunschweig, Bremen, Bremerhaven, Dresden, Goettingen, Hamburg, Jena, Juelich, Lampoldshausen, Neustrelitz, Oberpfaffenhofen, Oldenburg Stade, Stuttgart, Trauen, and Weilheim. DLR also has offices in Brussels, Paris, Tokyo and Washington D.C.

DLR Cologne

Aviation, space travel, transportation, energy and safety are the research areas pursued in the nine research facilities at DLR Cologne. The basis of the research and development carried out on site are the large testing facilities such as wind tunnels, turbine and materials test benches and a high-flux density solar furnace. The 55 hectare/ 136 acre site is home not only to the research and administrative facilities of the DLR, but also to the European Space Agency's (ESA) European Astronaut Centre (EAC). The DLR has around 1400 employees in Cologne.

_Schwerelosigkeit 140714_GB.docx

About the experiment:

Recommended for grade(s): 4 to 13
Group size: 5 to 6
Duration: 50 minutes
Subject matter:
Physics

DLR
Deutsches Zentrum für Luft- und Raumfahrt

DLR_School_Lab Köln
Linder Höhe
51147 Köln

Head: Dr. Richard Bräucker
Telephone: 02203 601-3093
Telefax: 02203 601-13093
E-Mail: schoollab-koeln@dlr.de
Internet: www.DLR.de/dlrschoollab