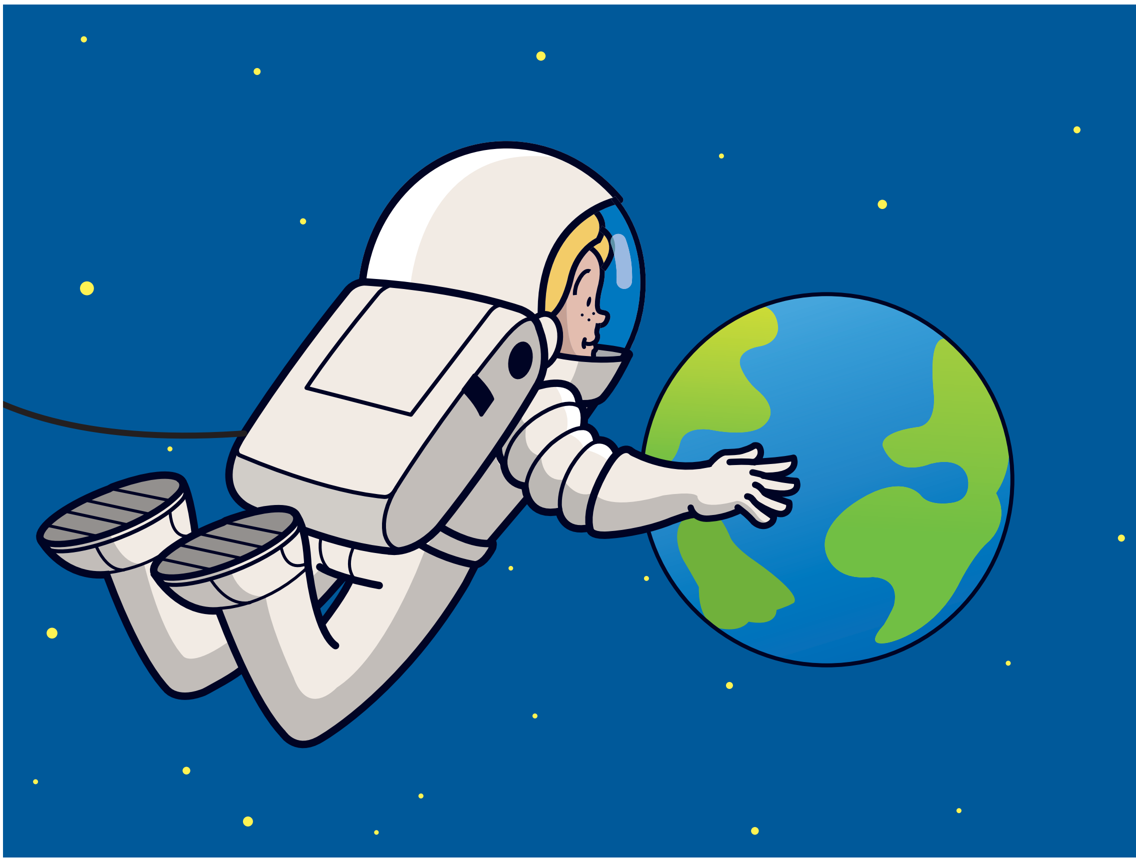
Chapter 1 Being an astronaut

Have you ever dreamed of flying in space? You could look down on the Earth far below, or upwards at more stars than you could ever see from the ground. And you could float around, free as a bird, with no weight to pull you down!



Many people have had this dream. A few have made it come true. These are the **astronauts**, and they have worked hard for their dream.

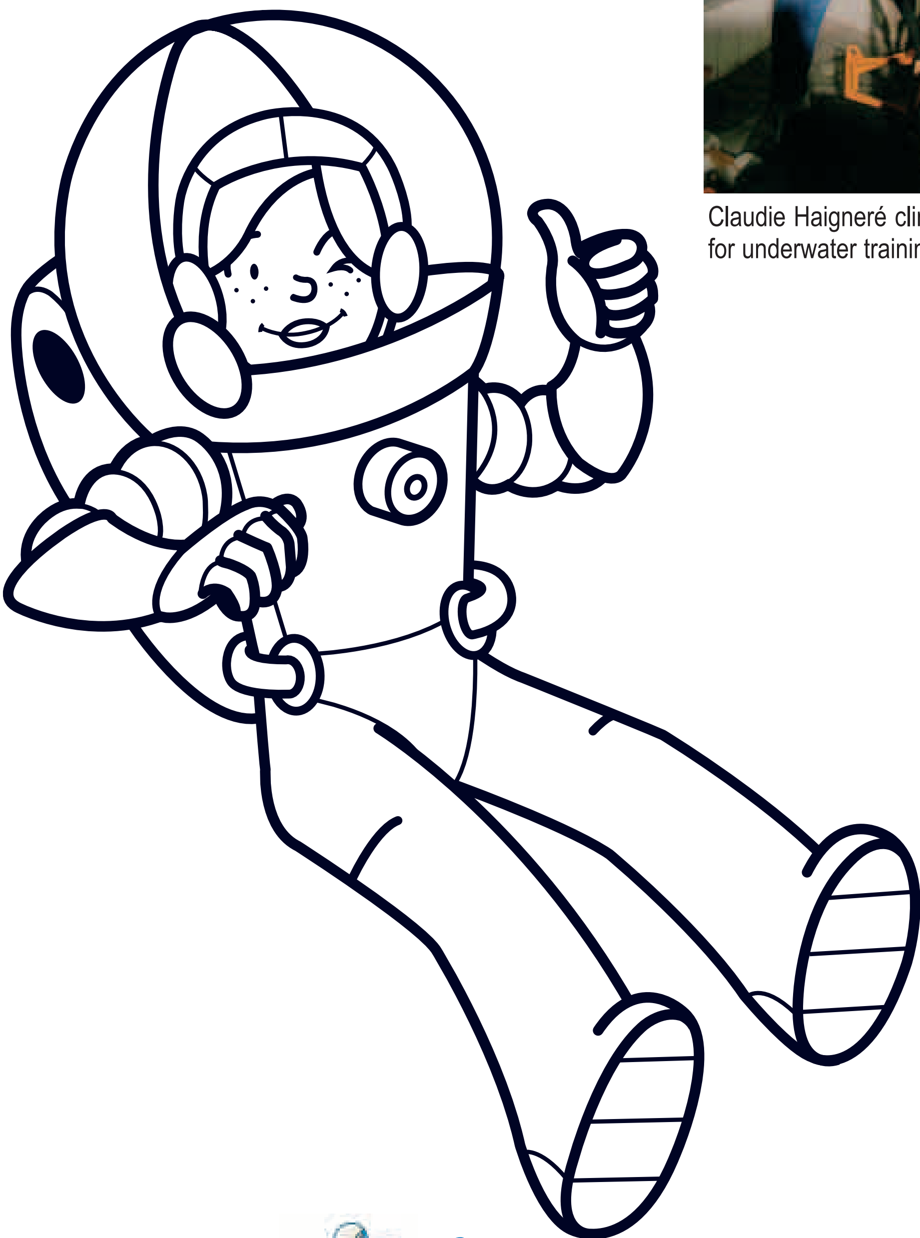
Think about it!

- What do you already know about astronauts?
- What do you already know about space?
- What would you like to know more about?

Astronauts are usually **scientists**, **pilots** or **engineers**, but they all have many different skills.

The training astronauts need is long and hard, their work is difficult and sometimes dangerous, but nevertheless there are always plenty of people who want to try. There are always plenty of people who fulfil their dreams.

Claudie Haigneré climbing into her spacesuit for underwater training.

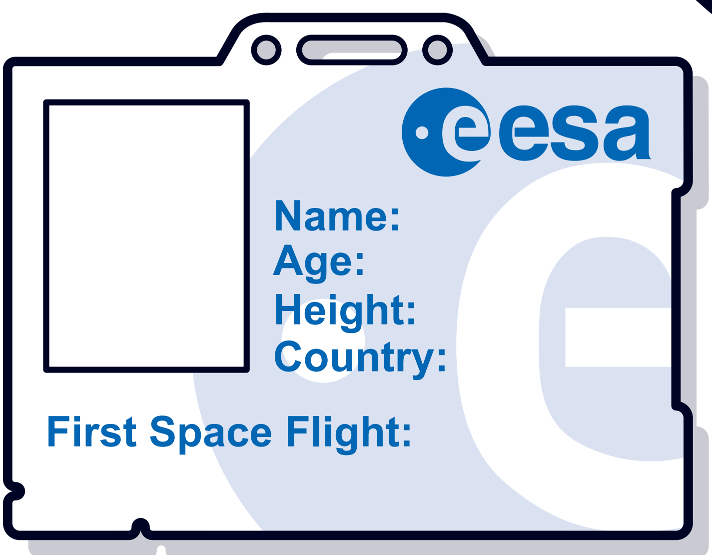


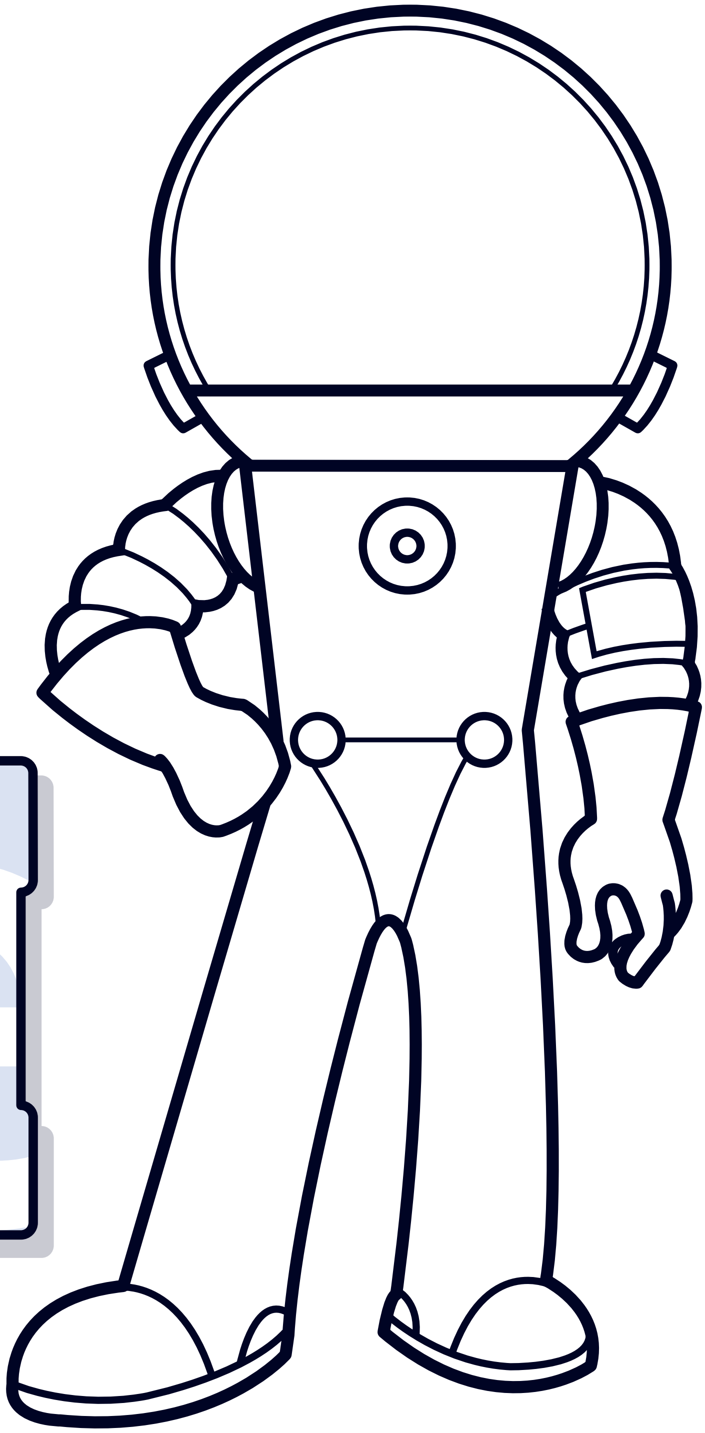
1.1 What is an astronaut?

Worksheet A: I am an astronaut

The European astronauts wear their national flag on their suits to show what country they come from.

1. Draw your face or glue a picture of yourself inside the helmet.
2. Fill in the identity card.
3. Colour the flag on the astronaut’s sleeve.



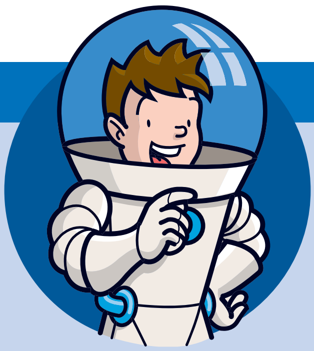


Worksheet B: European Astronauts

Astronauts come from all over the world. In Europe, 17 different countries are working together in an **organisation** called the **European Space Agency**, or **ESA** for short.

ESA has its own **Astronaut Corps**. Right now, the European Astronaut Corps has 13 astronauts.

Draw the flag of your country:



Think about it!

Apart from national flags, what other flags do you know?

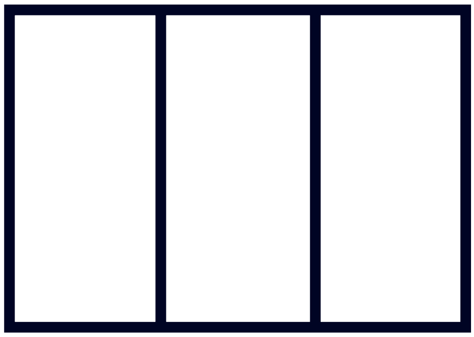
- What are they used for?
- What do they represent?
- What shapes do they have? Are they all rectangular?

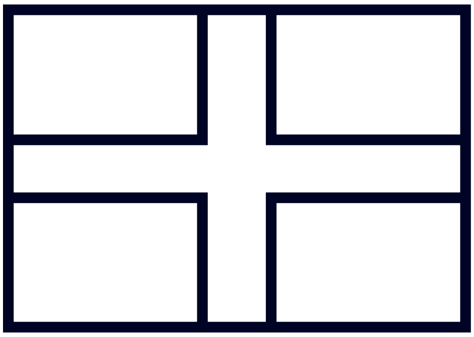
Worksheet C: European Flags

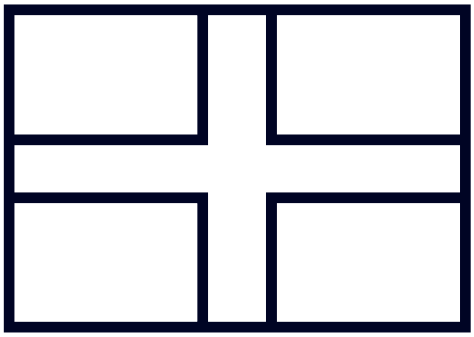
●●○

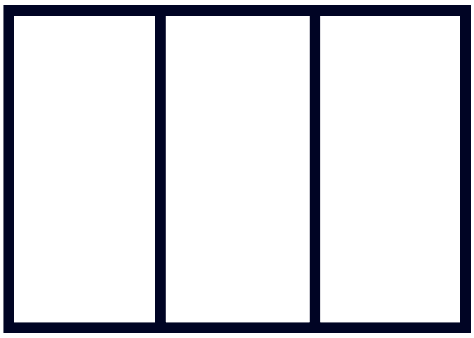
Colour the flags of the 17 countries in ESA in the following two pages:


Austria

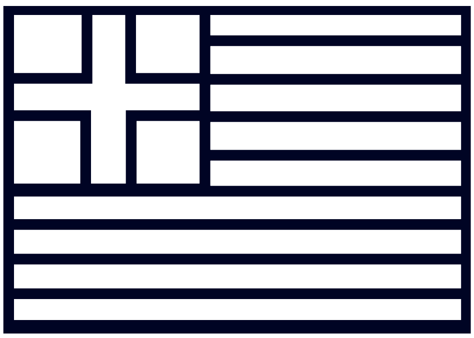

Belgium

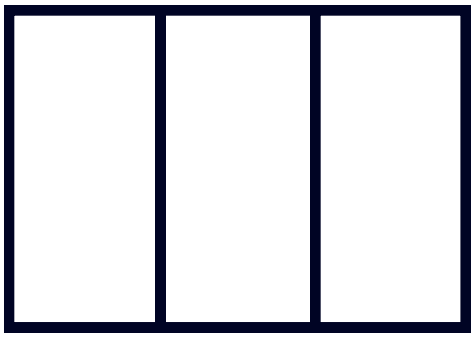

Denmark


Finland

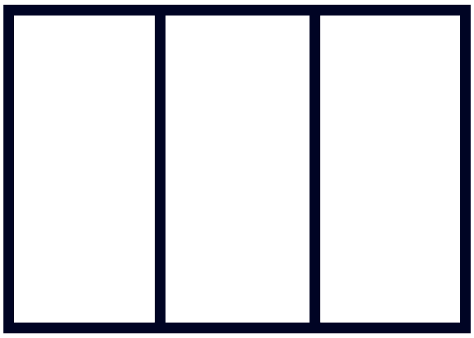

France


Germany


Greece

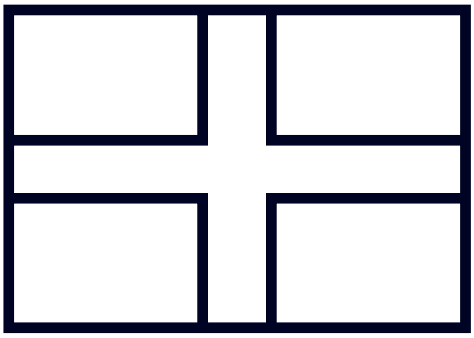

Ireland

1.1 What is an astronaut?


Italy

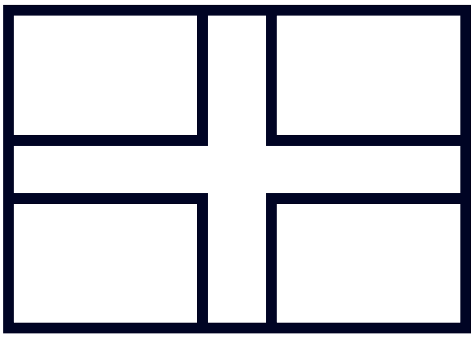

Luxembourg

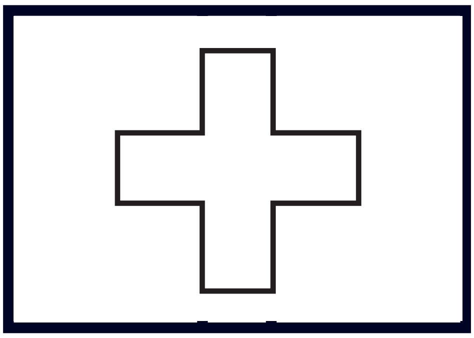

The Netherlands

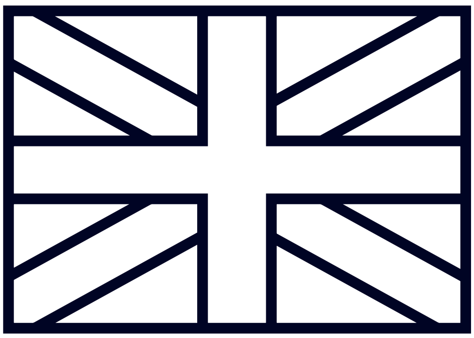

Norway


Portugal


Spain


Sweden


Switzerland


United Kingdom

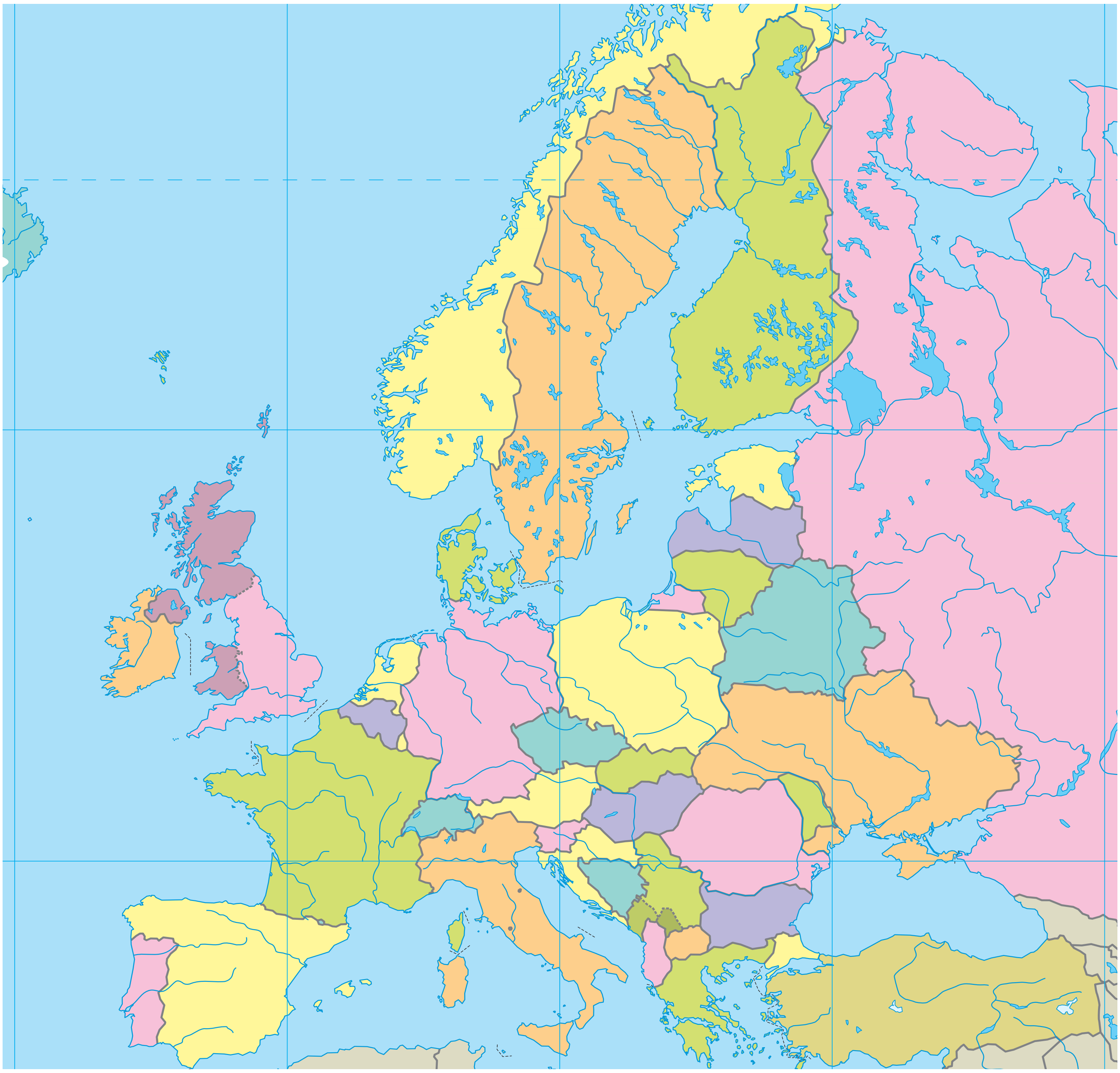
Worksheet D: European Astronauts

Look at this map of Europe and use an atlas to find out:

1. Where are you right now? Mark it on the map.

2. Mark where north, south, east and west are by writing the letters N, S, E, W on top, bottom and each side of the map.

3. What are the other European countries? Mark the names of the 17 ESA countries on the map.



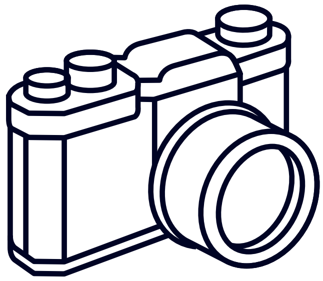
Worksheet E: What will you take into space?

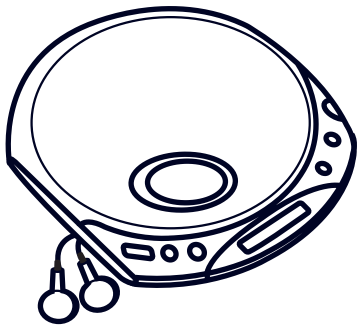
Astronauts are allowed to take some personal belongings on their missions to space. Some take a book or a CD. Others might take a camera or a gift from a close friend.

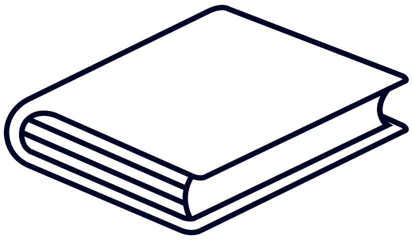
What would you take with you if you were allowed to take only five items?

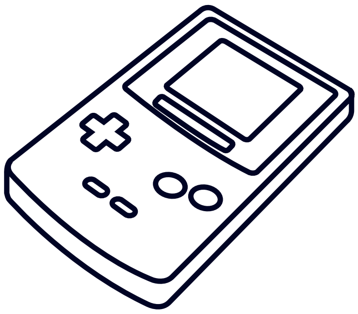
I will take:

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________









Think about it!

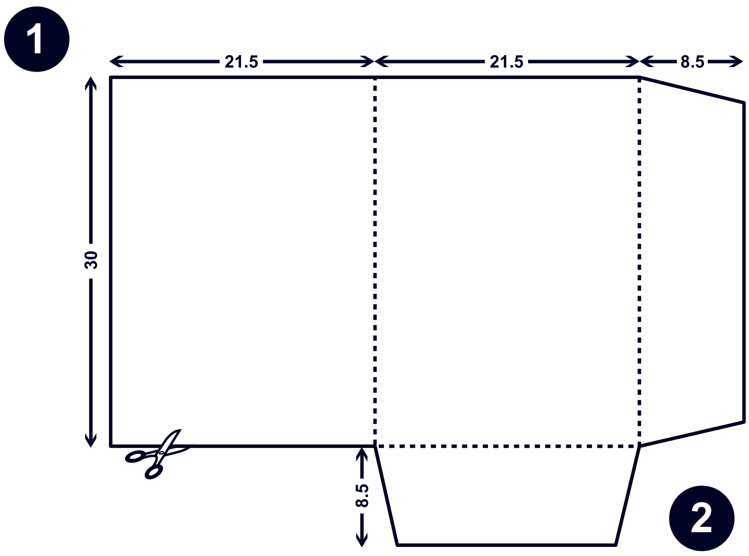
- What are your hobbies?
- In space, would it be possible to do the things you normally do in your spare time?

Worksheet F: Make a "Mission log folder"

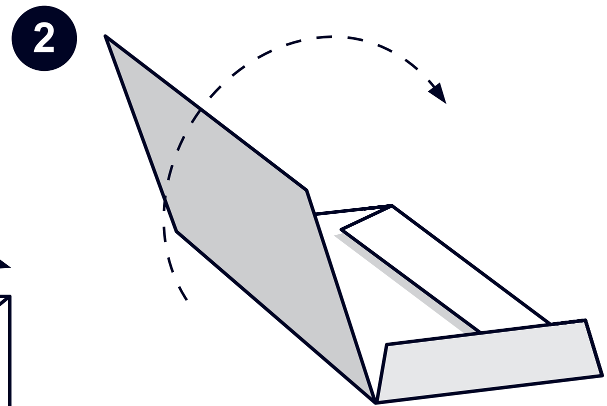
Astronauts have to be really tidy and make sure they keep all the important notes in a **mission log**.

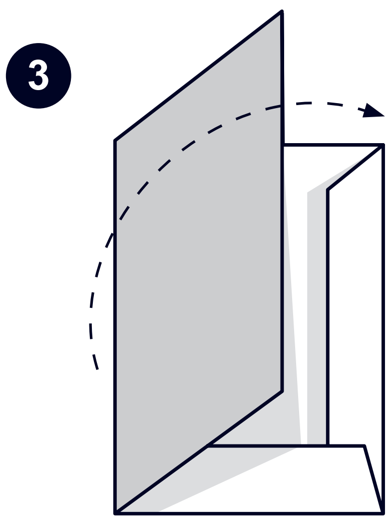
Make a "Mission log folder" to keep all your worksheets and pictures neatly together. Look at the description below and follow the steps:

1. Measure the carton (8.5cm, 21.5cm, 21.5cm, 8.5cm). Use a pencil and a ruler to mark out, where to cut your carton.
2. Cut the carton.
3. Fold the carton as shown below.
4. Decorate it (for instance with flags or a mission logo).



You need:
- a pencil
- a ruler
- a carton





1.2 Gravity

In space, it feels like everything is floating. This is because everything becomes **weightless**. This is probably the biggest difference from being on Earth, where everything – and everybody – is pulled down towards the ground.

On Earth, we can all feel this downward pull, but we are so used to it that we sometimes do not even think about it. This pull or attraction we feel is **gravity**.

Worksheet A: Experience gravity in the gym

Drop it!

- Hold a ball in the air – away from your body. Release it. Observe and describe what happens.

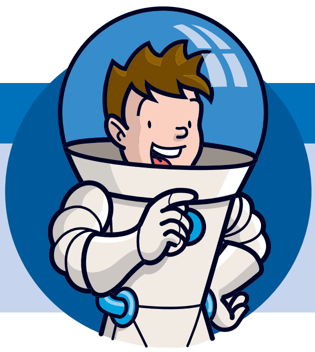
- Play with balls of different sizes and weight. Throw them, drop them, and observe gravity's effect on the balls. Discuss what you observe in groups and with your teacher.

How does your body react to gravity?
Lie on your back with your legs up against a wall for a minute or two. If you can do a handstand, you can also try this.

a. Describe what you feel.

b. Discuss what happens to the blood in your body when you are doing this.

c. Discuss why you think this happens.



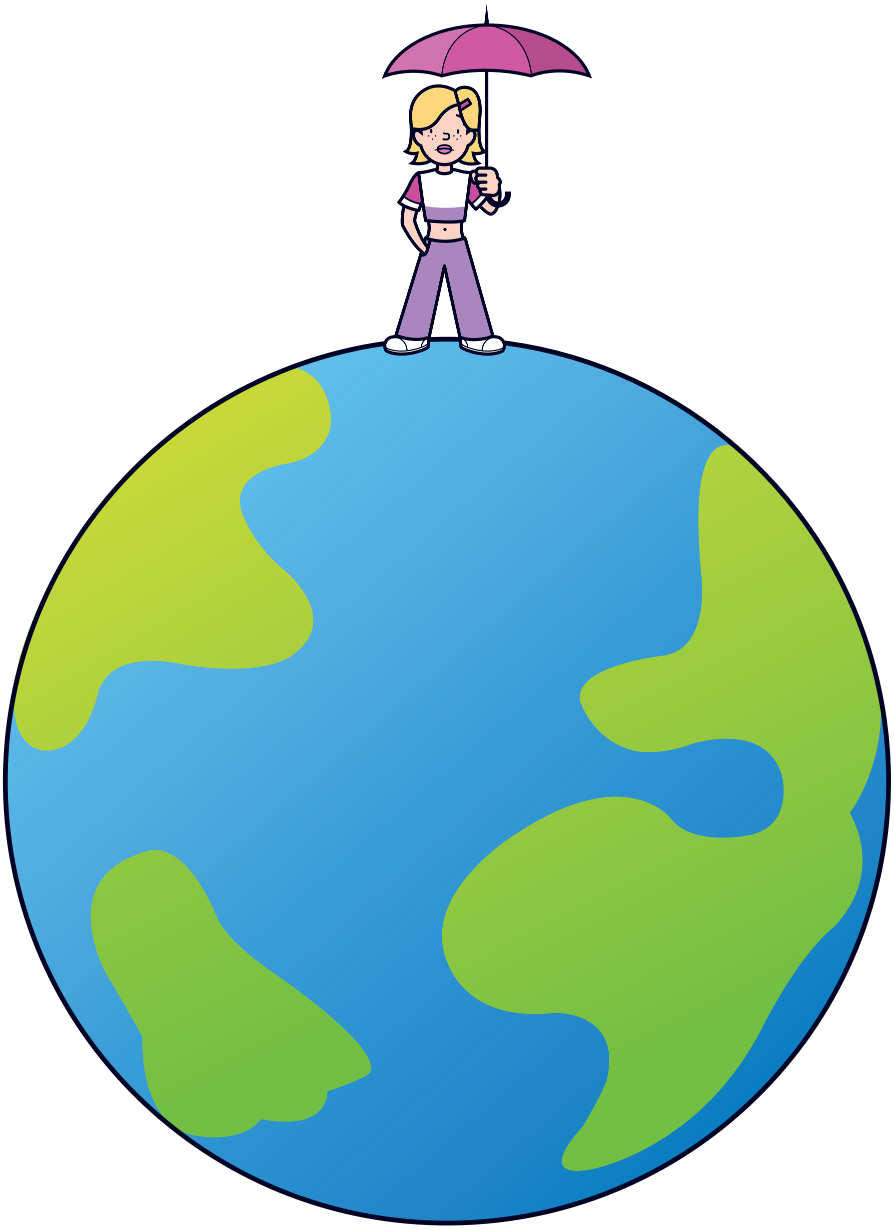
Think about it!

What would the human body look like if it was made for living on a planet with no **gravity**?

Worksheet B: Raindrops keep falling on my head (1)

●●○

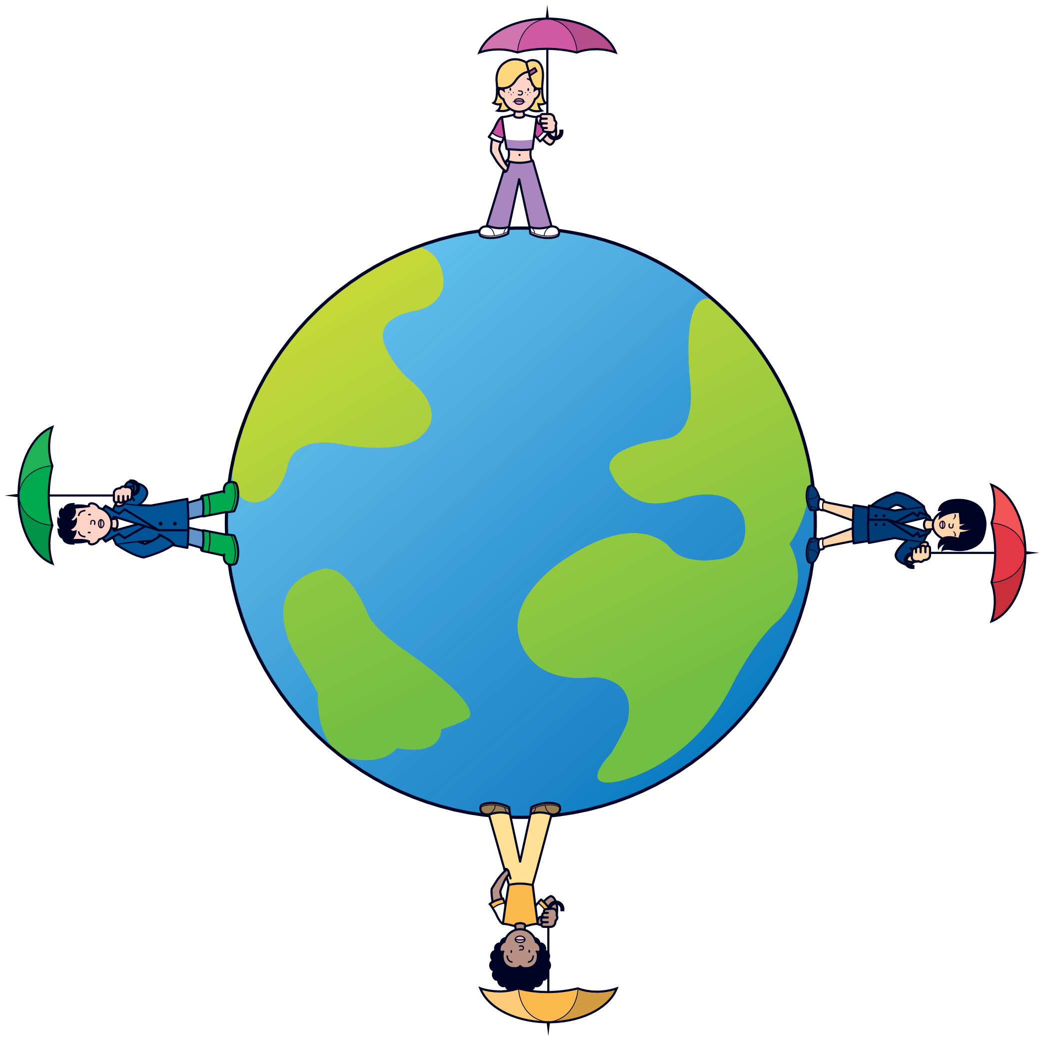
1. Draw some clouds into the picture.
2. Draw raindrops falling from the clouds.



Worksheet B: Raindrops keep falling on my head (2)

●●○

1. Draw some clouds into this picture.
2. Draw raindrops falling from the clouds.



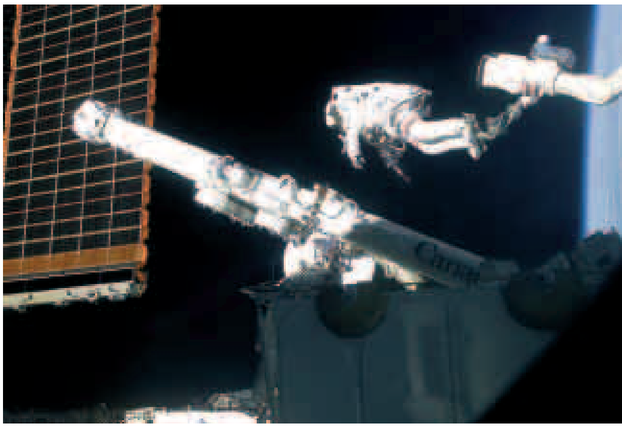
Think about it!

- How did you draw clouds and rain? Explain your thinking.
- Discuss in what direction the raindrops fall and what actually makes them fall.

Worksheet C: Gravity – it's everywhere

Gravity is everywhere in the **Universe**. Every bit of **matter** pulls on every other bit of matter. You are made of matter, so this includes you! You are actually pulling a tiny bit on the person sitting next to you. But you can't really feel this, because the pull is so small. The more mass something has, the stronger its pull. You feel it all the time: the Earth is much, much, much bigger than you so you can feel its pull. And this pull is the force that holds you on the ground.

The more matter an object has, the greater the pull it has on another object.


Astronaut during a spacewalk.

Which has more matter – and therefore greater pull?

1. You or your classmate?

Answer: ______________________________________

2. You or the Earth?

Answer: ______________________________________

3. The Sun or the Earth?

Answer: ______________________________________

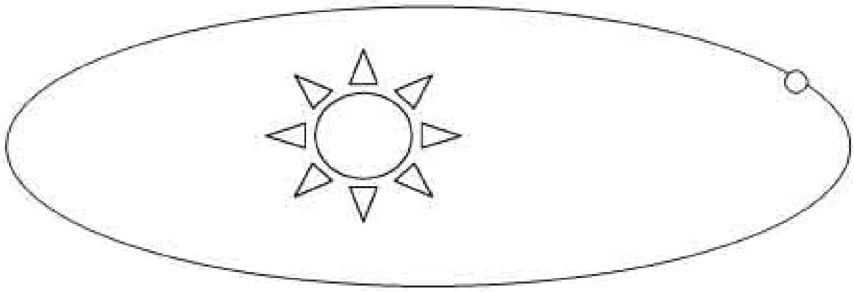
4. The Earth or the Moon?

Answer: ______________________________________

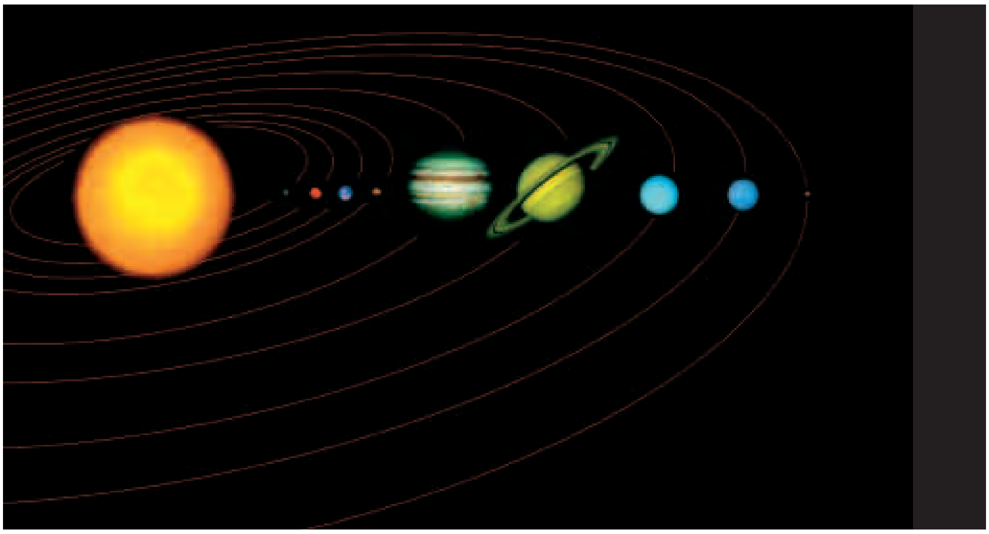
Worksheet D: The Solar System

Since the Sun is much bigger than the Earth, it has a greater pull on the Earth than the Earth has on the Sun. This makes the Earth **orbit** the Sun.

The other planets in our **Solar System** are also attracted by the Sun's gravitation. They all orbit the Sun.



Look at the picture of the Solar System below and write down the names of the planets.



Think about it!

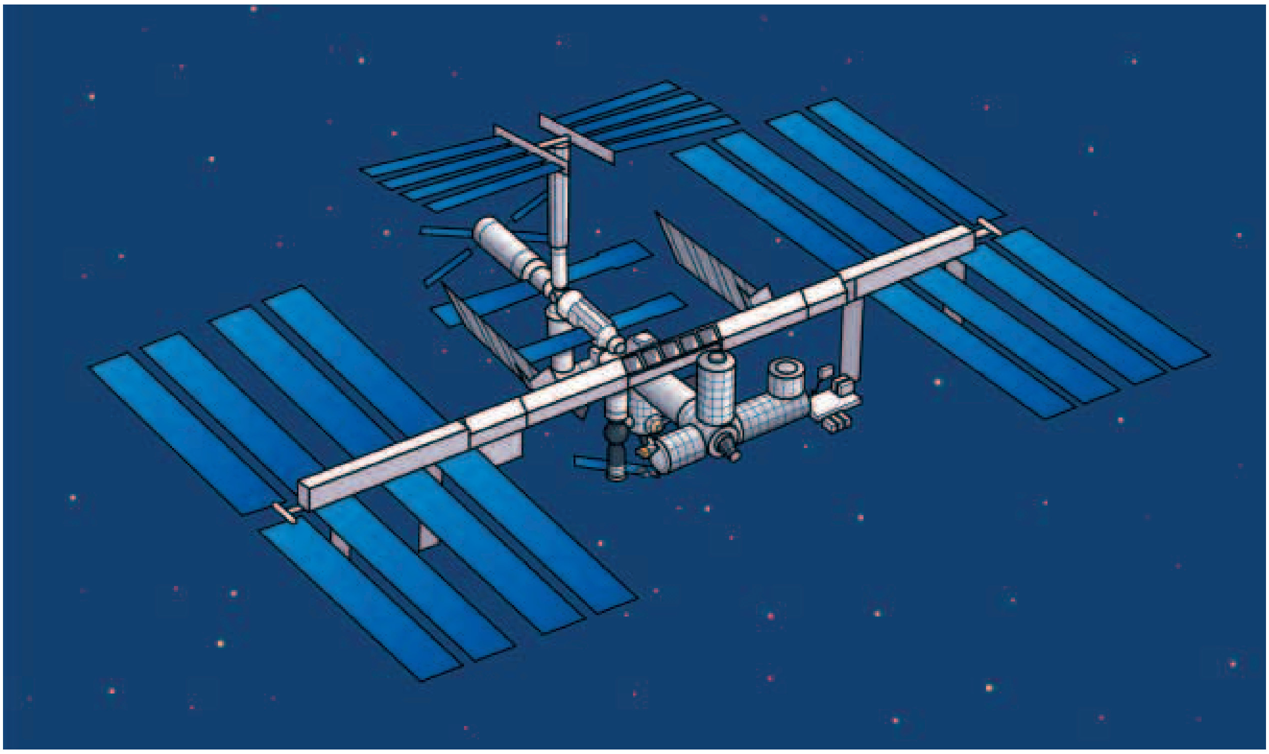
The Earth's gravity pulls on the Moon, which makes the Moon go round the Earth. This is because the Earth is bigger than the Moon. But the Moon has some pull on the Earth as well. You can actually see this pull: the Moon tugs on the water in the oceans and causes the **tides**.

Challenge: Find out how often there is high tide and low tide.

1.3 Weightlessness

One place where there is no **weight** pulling things downwards is on board the International Space Station. The Space Station is like a **laboratory** in the sky, where astronauts can live and work.

The Space Station travels in an orbit round the Earth, 400 kilometres above our heads. The Space Station is circling so fast that it does not fall down to Earth.



Think about it!

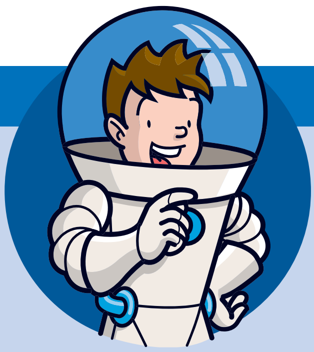
Scientists perform experiments on board the Space Station to find out how things behave in weightlessness and therefore the effect of gravity on things. They experiment on plants, on the astronauts' bodies, on materials of all sorts and many other things.

- Imagine you were on board the Station. What kind of experiments would you carry out?

Because the Space Station has the correct speed and direction, it does not fall *down* to Earth, but keeps on falling *around* the Earth.

Because it is falling, the Space Station and everything inside it is weightless. The astronauts float around inside it, and often fly down the corridors.

If you could run very, very fast, you would go into orbit, too. But you would have to reach a speed of 8 kilometres a second – a hundred times faster than a racing car!



Think about it!

The exact speed needed for the International Space Station to orbit the Earth is 28 000 km per hour or 7.8 km per second. This means it takes the Space Station only 1.5 hours to travel around the Earth once!

- How much time does it take you to walk 7.8 km?
- How many km can you walk in 1.5 hours?

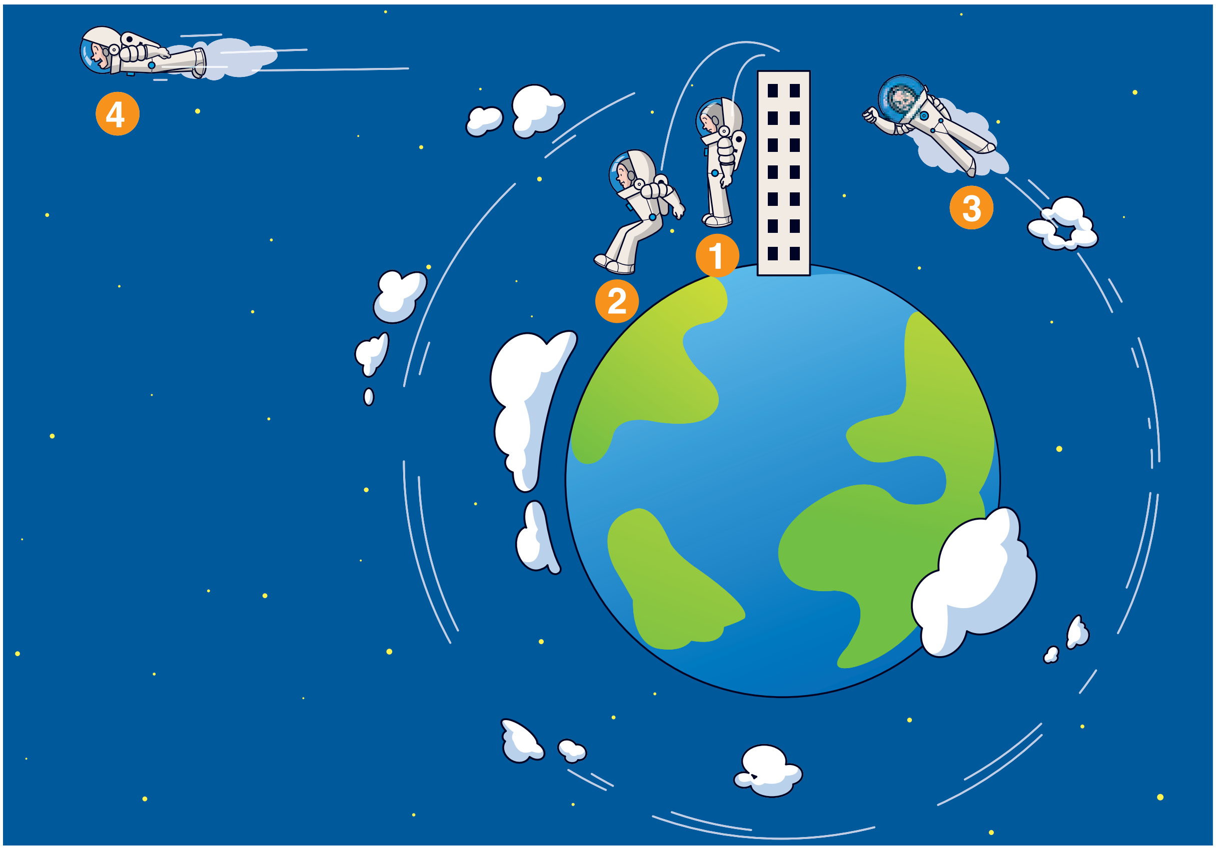
Worksheet A: What is needed to orbit the Earth?

Look at the picture and read the statements in the boxes below. The astronaut can make four different jumps, and each statements below describes one of these. Find out which statement belongs to which jump and find out what is needed to orbit the Earth.

Cut out the four boxes and glue them in the correct order next to the four jumps 1, 2, 3 and 4.

A: The astronaut has so much forward speed that he ends up in outer space.

B: The astronaut runs and has some forward speed as he jumps off the tower. After a while, he falls to the ground.



C: The astronaut has the exact direction and speed needed to fall and fall around the Earth without hitting the ground. He is in orbit.

D: The astronaut jumps straight off the tower. He has no forward speed. He falls to the ground immediately.

1.3 Weightlessness

Worksheet B: Can you escape the force of gravity? (1)

●●○

Try jumping up in the air. You soon come back to Earth. You can't escape from gravity – but just for a moment, you are free from its effect. Like an astronaut, you feel weightless.

Imagine and discuss with your classmates:

What does it feel like...

…the moment a roller coaster starts to go upwards. And what it feels like just as it starts to go downwards again.

What does it feel like...

… the moment a lift starts to go upwards. And what it feels like just as it starts to go downwards again.

What does it feel like...

… when a car drives over a bump in the road. And what it feels like on a swing at the highest point, just as the swing changes its direction.

Write a few sentences about one or two of examples you have talked about.

____

____

____

A funfair.

1.3 Weightlessness

Worksheet B: Can you escape the force of gravity? (2)

●●●

1. Place an object on top of a weighing scale and let the scale rest on your palms.

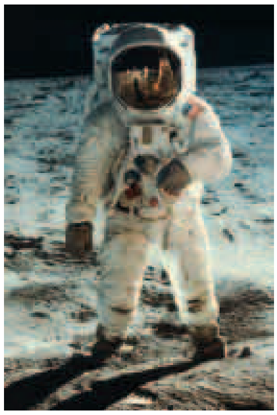
2. Record the object's mass while you are standing still.

3. Kneel down and watch carefully what happens to the indicator just as you are going down.

4. Stand up and watch carefully what happens to the indicator as you move up.

5. Write down and discuss what is happening.

You need:
- A scale,
- Yourself
- An object



An astronaut on the Moon.

Think about it!

On the Moon, your **weight** would be about 1/6 of what it is on Earth – even though your body has the same **mass**. What would it feel like walking on the Moon where your weight would be much less than on Earth?

On board the Space Station, your weight would be close to zero. What would that feel like?

Worksheet C: How does an astronaut's body behave in space?

●●○

Sometimes weightlessness makes astronauts feel sick and they get confused about which way is up and which way is down. Because there is no weight for muscles to push against, astronauts must exercise – or their muscles disappear. Astronauts become "taller" when in space – this is because there is no weight squashing their bodies.

André Kuipers, weightless on the Space Station.

Measure your height immediately after getting out of bed in the morning. Do the same just before you go to bed. Let someone at home help you and do the measurements 3 to 5 days in a row. Record the findings in the table. Find out: Is there a difference in the height of your body? If it is, why do you think that is? (You can also try to do this by measuring a grown-up).

	Day 1	Day 2	Day 3	Day 4	Day 5
Height morning					
Height night					
Difference in height					

1 Teacher's background

1.1 What is an astronaut?

Lesson – core elements:

Pupil's text:	Astronauts: • Fly in space, float around – free as a bird; • Often trained as scientists, pilots or engineers; • Need various skills and have to train a lot; • Many people dream of being an astronaut.
Worksheets:	The European astronauts come from all over Europe. In chapter 1.1, we focus on: • Countries • Flags • Nationality • Identity (fill in identity card) • Personal belongings and hobbies • Europe (map, countries, North-South-East-West, lakes, oceans etc.)

Subjects represented:
Geography
Social Science
Language
Arts

Background information:
Astronauts are the human dimension of space exploration, and have always attracted interest – sometimes hero-worship – from people on the ground.

The first human in space was Yuri Gagarin, a Russian cosmonaut. He was launched from Baikonur on board a converted missile in April 1961 and traveled just once around the world in a primitive Vostok capsule. More than 40 years later, almost 500 men and women have followed him into space. Some have spent longer than a year in orbit, and International Space Station crews can now expect a tour of duty of around six months.


Yuri Gagarin.

Gagarin was an "expendable" Soviet Air Force lieutenant; today's astronauts are usually highly qualified scientists, engineers, medical doctors or test pilots. But all of them need to be able to do useful work outside their own professional expertise – it is seldom possible to send up scientific specialists, so one astronaut must be able to do many people's jobs.

He or she will receive a great deal of help from thousands of others on Earth, both in training and during a mission. Astronauts aboard the Space Station may have to supervise dozens of experiments while they are aloft, and rely on help from Earth-bound researchers as well as their mission controllers, who monitor a spacecraft's systems closely and provide a steady stream of help and advice.

There have never been many astronauts (or cosmonauts, as the Russians call them) at any one time. The European Astronaut Corps, for example, has only 13 members. They are very carefully selected from the hundreds of qualified people who apply for every post, and then often spend years of training on Earth for a single flight into space. What are the attractions? Who would want to be an astronaut?

Former European astronaut Umberto Guidoni puts it this way:

> *"Most astronauts are puzzled by the question. Who would be anything else? The experience of weightlessness, the pleasure of doing a difficult job that few people will ever have the chance to do, makes it worthwhile. And of course, the view – gazing out of portholes is a favourite recreational activity in whatever spare time a busy astronaut may have. – But not usually the view into space. It's the Earth you watch, at least nine tenths of the time: Always changing, always interesting, always beautiful."*

André Kuipers looking out of a window on the Space Station.

In other words: the view, and the weightlessness – both unique to their jobs. The astronauts can only admire the view when they look out of a porthole; weightlessness is a constant – always present and always something they have to cope with. It can be exhilarating, but it brings problems. The human body evolved on Earth, in a gravity field: absence of weight leads to bone and muscle loss as well as other lesser problems. After a long space mission, astronauts need rest and medical care to return to normal.

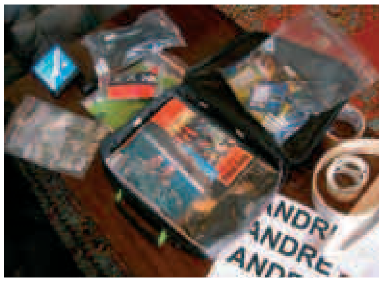
And weightlessness usually makes for harder work. To perform even the simplest task – typing on a computer keyboard, for example – astronauts must anchor themselves firmly, or they would simply drift away. Tougher jobs, such as the spacewalks required to assemble the Space Station, put strains on muscles that never evolved for the task, and can be exhausting.

European Space Agency (ESA)

The European Space Agency (ESA) was created in 1975 and today it represents the space communities of 17 European countries (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom). However, only 10 of those European countries are taking part in the International Space Station Programme: Germany, France, Italy, the Netherlands, Belgium, Denmark, Norway, Sweden, Spain and Switzerland.

For more information visit: www.esa.int/spaceflight

Ideas and hints for the Worksheet activities:
This chapter can be used as an introduction to a lesson or a series of lessons about astronauts and space. Whether you choose to work thematically, more project-based or would like to create a role-play storyline, the worksheets in this chapter provide you with different activities which you can use to introduce the pupils to what it is like to be an astronaut and what it is like being in space.



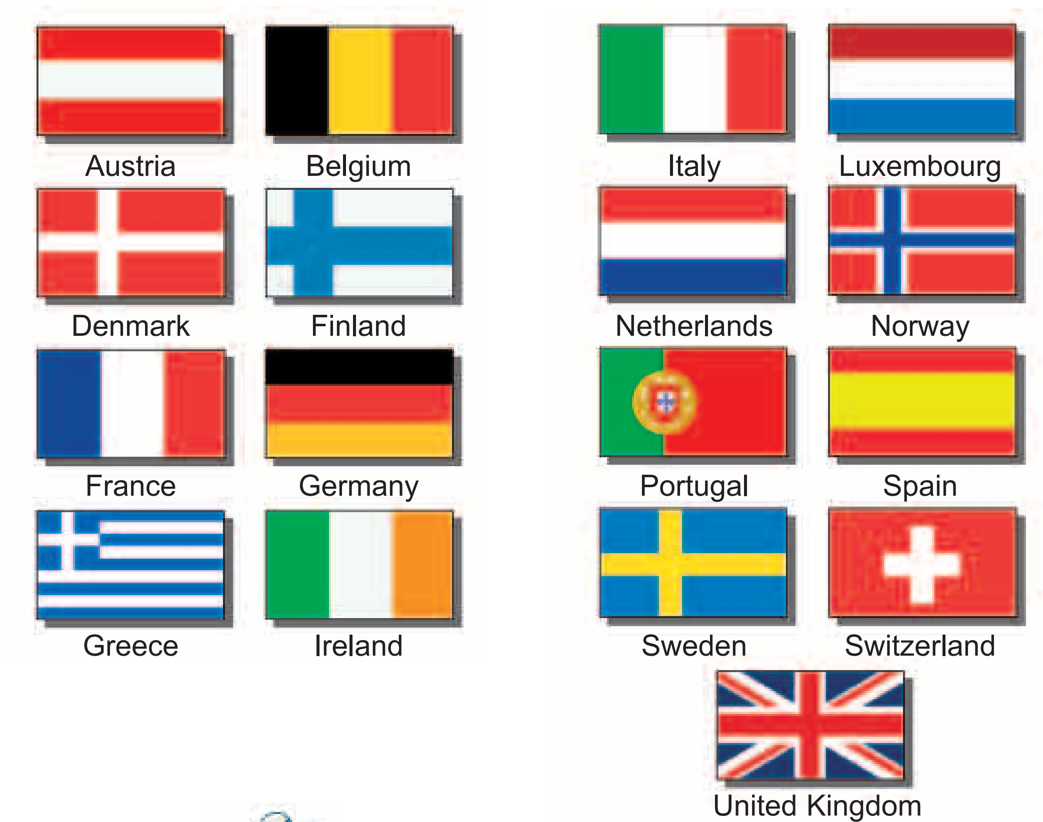
Private things to bring along...

You may want to start with finding out what the pupils already know about astronauts and space – use the "Think about it!" questions to map their knowledge:

"Think about it!
- What do you already know about astronauts?
- What do you already know about space?
- What would you like to know more about?"

You can also ask the pupils what they would like to know about space and astronauts, write it up and make a list. A self-assessment form can be found at the end of the kit – this can be used any time during the period and at the end of the period.

Worksheet C: European Astronauts – page 5, 6
The flags of the 17 Member States of ESA:



Worksheet D, European Astronauts, page 7

Further ideas and explorations:
This unit can lead to:

- More extensive work on what creates our personality and identity.
- Finding out more about the European astronauts, by visiting: www.esa.int/esaHS/astronauts.html
- More extensive work on how to use maps and for instance mark major rivers, lakes, oceans and mountains on the map provided in the worksheet.

Additional activity: Make a clay astronaut
In connection to this chapter you can make a clay astronaut. An easy way of making a human figure is by using rolls and balls of clay as the basis:

1. Make one big roll for the body.
2. Use four small rolls for arms and legs
3. Make one ball for the head.
4. Dip a toothbrush in water and use the wet toothbrush to roughen the clay where you want to attach an arm.
5. Do the same with the part of the arm that you want to attach to the body.
6. Fix the two parts together and press lightly so there is no air between the two pieces of clay.
7. Assemble all the body parts.
8. After the basic shape the pupils can decorate the astronaut with a face, a suit etc.

If the school has the facilities the clay can be decorated with coloured silt or glazes and then baked in the oven.

Additional activity: Design a mission logo
Every astronaut crew who fly to the ISS have their own logo. This logo is sewn onto their astronaut suits. It represents their specific mission.

The mission of Pedro Duque, Spanish ESA astronaut, was called Cervantes. The designer explains the logo like this:

"The astronaut looks to the sky and extends his hand towards the stars that he hopes to reach some day. He, like Cervantes' hero, Don Quixote, is anxious to explore the Universe to discover the mysteries of life. In the constellation, the biggest star is the one placed there by man: the International Space Station, which already shines above our heads and will be the oasis for the conquerors of space".

1 Teacher's background

Let your pupils design a mission logo – you can use it to decorate the folders or to put on the pupils' costumes if you are planning a performance. – See chapter "What is the International Space Station".

Frank De Winne presenting the logo of his mission.

For further introduction you could:

- Have a discussion about what a logo is used for.
- Discuss colours, symbols and shapes in logos.
- Let the pupils collect other logos.
- Let pupils think about a design and make a drawing.

For a mission badge:

1. Make a sketch for your mission logo.
2. Draw your final design onto paper and cut it out.
3. Draw the outlines of the logo on a piece of cloth.
4. Cut out the cloth around the outline.
5. To decorate the mission logo, use imprint, permanent ink-pens or patch-work:
   a. From the paper design, cut out each element (per colour).
   b. Draw the outlines of the different elements on pieces of cloth.
   c. Cut out the different parts.
   d. Sew the parts onto the background (the outline of the logo).
6. Use locking stitch to make a nice finish around your badge.


Pedro Duque training to be fit for space.

Related topics:
The training of an astronaut
What is the International Space Station International Cooperation (in chapter: What is the International Space Station)
An astronaut's day – and your day (in chapter: Living on board the International Space Station)

Websites:
The European Astronaut corps:
http://www.esa.int/esaHS/astronauts.html
Profiles of the European Astronauts:
http://www.esa.int/esaHS/eurastronauts.html

1.2 Gravity

Lesson – core elements:

Pupil's text:	Difference between being on Earth and being in space (gravity, weightlessness) Gravity pulls on us We can all feel this pull, but we are so used to it, we take it for granted
Worksheets:	Experience gravity by using balls and their body weight in the gym Concept: centre of gravity Gravity is all over in the Universe (everything pulls on everything) Solar system (gravity makes the planets orbit the Sun)

Subjects represented:
Science
Language
Gym (Sports) / P.E.
Arts

Background information:
Gravity is something we all take for granted. We are used to solid ground beneath our feet, we know that "what goes up, must come down" and 99% of us never give it another thought.


Experiencing gravity on a swing.

To this day, no one really knows what gravity "is". But we do know how gravity works. Every piece of matter in the Universe attracts every other piece of matter. The more matter, the more attraction; but the attraction decreases when the distance between the pieces increases. For this reason, the planets – which have much less mass than the Sun - are orbiting the Sun. And the Moon is orbiting the Earth. Because we walk on the surface of a huge lump of matter – planet Earth – these basic facts are not at all obvious. In fact, it took many centuries and some of the best brains the human race has ever produced to work out just what was really happening.

What is weight? It's what we feel when gravity presses us against the Earth. Can our weight change? Yes, and without going on a diet. When you step into a fast elevator, you notice a brief feeling of heaviness as it accelerates upward – and a similar feeling of lightness if the elevator is going down. These aren't just feelings – you really are heavier or lighter, at least for a few moments.

What if we're not touching the Earth? That depends. Sitting on a swing, for example, doesn't count: we are pressing against the seat of the swing, our weight is carried by ropes or chains and then through the framework of the swing to the Earth. Much the same is true when we are flying in an airliner, whose wings are supported by the air just as the chain supports the swing.

But if we are falling – freely falling, no wings or chains allowed, then we have no weight at all. Strictly speaking, the air resists our fall to some degree, so it's not exactly a "free" fall. But as all Earth-bound humans learn by the time they are old enough to walk, falling is usually a very brief experience that comes to an abrupt and often painful end.

Pedro Duque experiencing weightlessness on board the Space Station.

Note that weightlessness in free fall doesn't mean we have escaped gravity. We have escaped the effect of gravity, at least for a moment.


Pedro Duque training.

Ideas and hints for the worksheet activities:

Worksheet A, Experience Gravity in the Gym, page 11

Astronauts often get puffy faces and skinny legs when they are in space. Since they are in weightlessness, there is nothing pulling the body fluids downwards – the fluids are more equally distributed throughout the body.

Let the pupils play with balls and use their body weight to experience the effect of gravity. Imitate the "puffiness" by letting the children lie on their backs with their feet up in the air.

Make an experiment with two A4 sheets of paper and a small ball (e.g. squash ball). Crumpled up one of the sheets into a ball (same size as the squash ball). Drop squash ball and the paper ball from the same height. Afterwards repeat the experiment with the paper ball and the paper sheet. Talk about how the balls fall to the Earth at the same speed and how the paper ball and the paper sheet – that obvious are of the same mass – are not falling with the same speed, due to air resistance (friction) that slows down the paper sheet.

Questions for the pupils:
- What do you see?
- Do they hit the ground at the same time?
- Do they fall with the same speed?

Worksheet B: Raindrops keep falling on my head, pages 12,13

Hand out the first page of the two worksheets on "Raindrops keep falling on my head". Ask the pupils to draw clouds above the Earth. Then ask them to draw raindrops falling from the clouds.

Hand out the second page and ask them to do the same on this worksheet – draw the clouds and the falling raindrops.

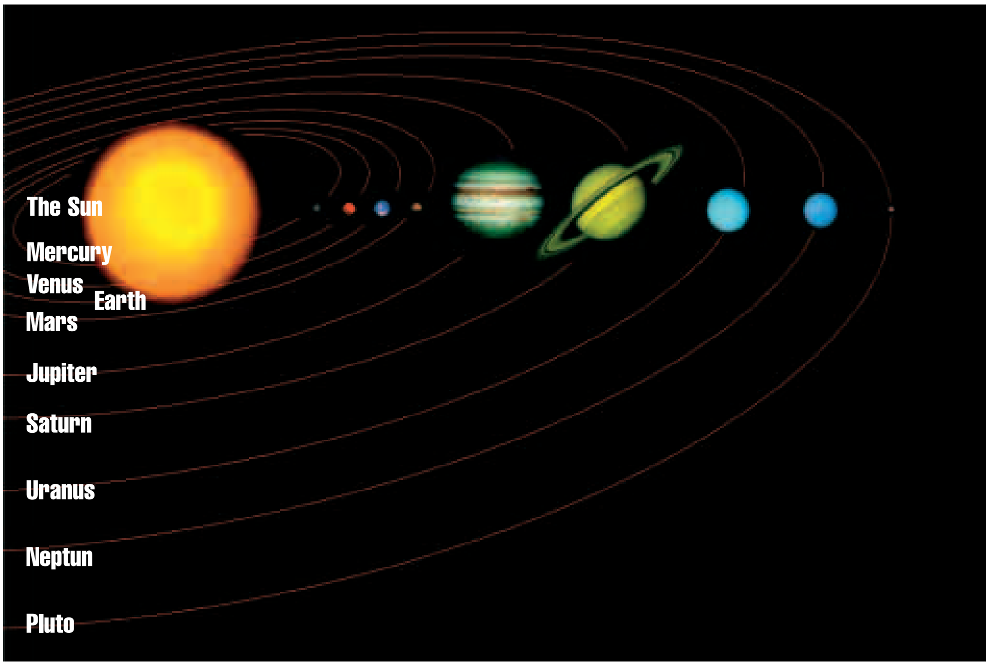
Discuss how the Earth's gravity pulls on everything on Earth and how everything is attracted towards the centre of the Earth. Talk about the clouds and how they surround the globe.

Some students might draw all the clouds above the Earth, not around it. Let them find out about this by themselves (they often do when they start the second worksheet).

Worksheet C, Gravity – it's everywhere, page 14

Answers:
1. Depends on the children's masses.
2. The Earth.
3. The Sun.
4. The Earth.

Worksheet D, The Solar System, page 15



"Think about it", page 15

If you live in an area where you can experience the tides, discuss this with your pupils. Use your daily newspaper or an agenda that gives an overview of the tides to find out when it is high and low tide. (It takes 12 hours and 25 minutes between two high tides).

Background information tides:
There are two high tides on Earth at any given time, which means that the sea level rises and falls in regular intervals due to the gravitational attraction

the Moon has on the Earth – consequently also on its water. The gravitational pulls of Sun and Earth also play a minor role. Tides are highest at full and new Moon, when Earth, Sun and Moon are aligned, and lowest when Moon, Earth and Sun form a right angle. Since it takes 24 hours and 48 minutes for the Moon to be at exactly the same place as the day before (called "lunar day") and the Earth day lasts 24 hours, tidal times change by 48 minutes every day.

This could be a good point to introduce or repeat Earth days (one complete rotation of the Earth), months (one orbit of the Moon around the Earth), and years (one complete turn of the Earth around the Sun).

"Think about it", page 17

Assuming that we walk at a speed of 5 kilometres per hour, 7.8 kilometres would take 1.56 hours or 94 minutes to walk. You can walk 7.5 kilometres in 1.5 hours.

Further ideas and explorations:

Experience Gravity in the Gym

This worksheet can lead to further investigation work on the human body and its different parts. Discuss where the big muscle groups in the body are and why we need bigger muscles in our lower body than in our upper body (look at the connection this has to gravity).

Raindrops keep falling on my head

This activity can lead to further discussion about what is up and down on Earth. – Are people in Africa or Australia walking upside down? Why don't we fall off the Earth?

Gravity – it's everywhere

Let the pupils explore our Solar System. Ask them to find out more about the Sun and the planets in our Solar System using books, the internet and other resources. To summarise what they have found out, they can make posters where they write 5 key words about each of the planets, including nice pictures of the planets, etc.

Related topics:

"Think about it", page 16, relates to chapter 4.2 "Working on board the International Space Station".
"Think about it", page 17, relates to chapter 2.3 E, "Travelling by different means".
Chapter 1.3 "Weightlessness", worksheet C "How does an astronaut's body behave in space?".
Chapter 3.1 "What is a Space Station?", worksheet D "Watch the night sky", and worksheet E "Make a model of our Solar System"
Chapter 4.1 "Living on board the International Space Station", worksheet D "Day and night" and worksheet E "The year through".
Chapter 4.2 "Working on the International Space Station", worksheet C "Watching the Earth - Time zones".

Lesson – core elements:

Pupil's text:	Weightlessness is experienced on board the Space Station The Space Station is in orbit around the Earth To orbit the Earth, the correct speed and direction is needed When orbiting the Earth, you are in free fall around the Earth When in free fall, you are weightless Moving around in weightlessness feels like floating
Worksheets:	Correct speed and direction needed to orbit the Earth Falling around the Earth Experiences of being weightless on Earth Mass and Weight Measuring height

Subjects represented:
Language
Science
Maths

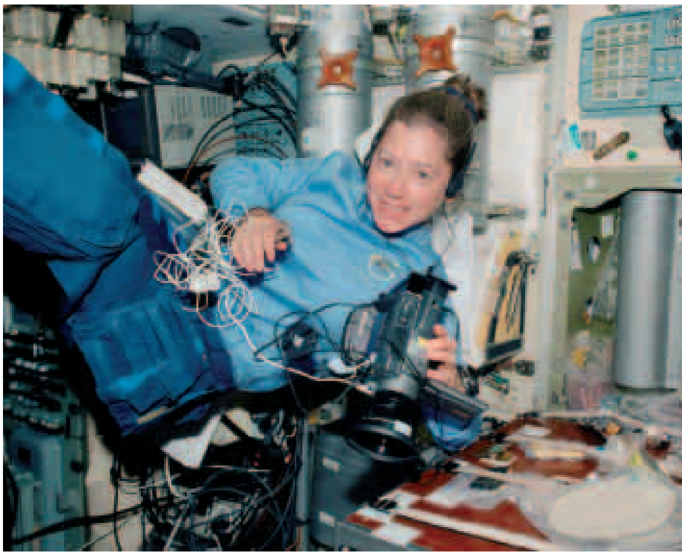
Background information:
The International Space Station is in orbit around the Earth. What does that mean? And why doesn't it fall down?


An astronaut in space.

In fact, the ISS is falling all the time – but it is travelling so fast (about 8 km/s) that it cannot fall "down". It is pulled down by the Earth's gravity, but its forward speed is so great that it swings around the Earth in an orbit, just as the Moon does.

Because the ISS is falling freely, everything on board is weightless. That presents the crew with a number of problems, but it also provides a very special environment for scientific experiments. Some aspects of weightlessness are obvious: astronauts can float freely around the station, for example. Many are more subtle. On Earth, when we go to sleep, convection currents move our exhaled carbon dioxide away from us, and ensure a supply of fresh air. But convection currents only work because warm air is lighter than cold air. In weightlessness, nothing is lighter or heavier than anything else. Without a ventilation fan constantly running, a sleeping astronaut would suffocate in a pool of exhaled breath.

For humans, weightlessness can be exhilarating – although in the long term it may bring serious health problems, and most astronauts suffer from "space sickness" for a day or two as they adapt. But the station's weightless environment allows all manner of scientific experiments that could never work on Earth. It is possible to grow crystals that would never form under the influence of gravity, for instance. Such space-grown crystals could form the basis of new electronic components, or even tailor-made drugs.



Floating on board the Space Station.

At any one time, there could be dozens of weightless experiments underway on the ISS, including experiments in human physiology.

Ideas and hints for the worksheet activities:

Worksheet A: What is needed to orbit the Earth?, page 18

Talk about what it feels like being in free fall (relate to worksheet in chapter 1 about "Gravity": Experience Gravity in the Gym, and to worksheet in chapter about "Weightlessness": Can you escape the force of gravity?).

- Ask the pupils to imagine a huge tower (400 km high). What would happen if you jumped off it? (Answer: You would fall to the ground). Use the illustration of the astronaut jumping from the building to illustrate.
- Ask: What would happen if you were jumping, but were running forwards as well? (Answer: You would still fall to the ground, but land a little bit further away from the tower). (Show illustration of astronaut jumping a bit further forward).
- If you were jumping with a lot of forward speed (impossible for a human being to achieve!) – what would happen? (Answer: You would end up in outer space). (Show illustration of astronaut being "shot" out to outer space).
- Show the picture of the astronaut in orbit around the Earth and let the students try to explain what is happening. (Answer: The astronaut has enough forward speed so as not to fall to the ground, but at the same time, not too much, otherwise he/ she will end up in outer space. – The astronaut has exactly the speed needed to keep on free falling around the Earth (reach orbit).)

Safety warning: Make sure that you explain that this is just an image and that you could never run fast enough or be high enough for this to happen!

Summary:

1. A spacecraft in orbit around the Earth is in free fall around the Earth.
2. When in free fall, the spacecraft and everything inside it are weightless.
3. When in free fall, hence when weightless, it feels like you are floating.

Answers:

- Jump 1: Explanation D
- Jump 2: Explanation B
- Jump 3: Explanation C
- Jump 4: Explanation A

The image you find in the worksheet is based on ideas by Sir Isaac Newton in the 17th century. When the concept is explained referring to Newton's original idea, the illustration is often a cannon on top of a mountain with the cannon ball being fired.

Worksheet B: Can you escape the force of gravity?, pages 19,20

This worksheet can be done quickly: e.g. the pupils can be asked to discuss one of the boxes – or it can be done more extensively: e.g. do all of them, write a story, or ask them to think about more examples of when they can feel weightlessness (for example when jumping off a box onto a mat, jumping up and down on a trampoline). If you have the possibility to try out some of this, you will give the pupils the opportunity to experience this feeling themselves.

Let the pupils use the " Astronaut log" sheet to write up their experiences or ideas from the discussion they've had with their classmates.

Mass: Mass is the amount (quantity) of matter an object contains. The mass of an object is the same wherever it is in the Universe. Mass is measured in kilograms (kg). (We often refer to this as weight in our daily speech).

Weight: The force with which a body is attracted to Earth or another celestial body; it is equal to the object's mass multiplied by the acceleration of gravity. The more mass an object has, the greater its weight. Weight is measured in Newton (N).

(Onboard the Space Station, you would have the same mass, but your weight would be close to zero. On the Moon, your weight would be almost 1/6 of what it is on Earth, as the Moon is much less massive than the Earth, and thus its gravity and your acceleration due to gravity is smaller).

This means: Your mass is the same wherever you go in the Universe, while your weight can change.

Worksheet C: How does an astronaut's body behave in space?, page 21

Astronauts' bodies react in different ways to being in space: some astronauts get nauseous, some get puffy faces and skinny legs. Since there is no gravity to work against, muscle- and bone-loss are consequences for astronauts, unless they perform physical exercise while in space.

The astronauts can actually notice a difference in height when onboard the Space Station. Since they are in weightlessness, there is nothing pulling down on the spines – the spine expands slightly which makes the astronauts a bit taller in space. Your pupils can see the same effect if they measure themselves immediately after getting out of bed in the morning and compare with the height measured at the end of the previous day.

Ask your pupils to measure themselves in the morning and in the evening and fill in the form in the worksheet "How does an astronaut's body behave in space?". Look at the results in class, compare and analyse to find out whether there is any difference (if the measurements are done straight after getting out of bed, it should be possible to see some minor differences as the gravity works on the body and pulls on the spine during the day, which makes us smaller at night). If they don't see any difference, they might see it better if they measure a grown-up – it is important that this is done immediately after getting out of bed!

Further ideas and explorations:

If you would like to cover Newton's three laws of motion in more depth ESA has created a DVD for secondary schools about this topic – to find out more, please visit our website: www.esa.int/spaceflight/education. You can also check the ISS Education Kit for secondary schools, chapter 2 and 4, via our website (online resources): www.esa.int/spaceflight/education.

Additional activity: Speed

In this activity pupils investigate what speed is needed to stay in orbit (related to worksheet *What is needed to orbit the Earth?*):

1. Tie one end of a string around an eraser.
2. Hold the other end of the string in your hand and whirl the eraser around.
3. Make the string shorter and repeat the experiment.
4. Try to make the eraser orbit slowly with a shorter string.

Ask the pupils to imagine what will happen to the speed when the length of the string is changed before actually performing the experiment. Let them make the experiment, observe and describe what happens.

Additional activity: Can you escape the force of gravity?

If you've got an elevator at your school, you might want to try this variation of the experiment in worksheet 2:

You need: scales, somebody to stand on the scales and an elevator

1. Record the weight with the lift standing still.
2. Watch carefully what happens to the scales when the lift moves upwards.
3. Watch carefully what happens to the scales when the lift starts moves downwards.
4. Write down what is happening.
5. Discuss what happened.

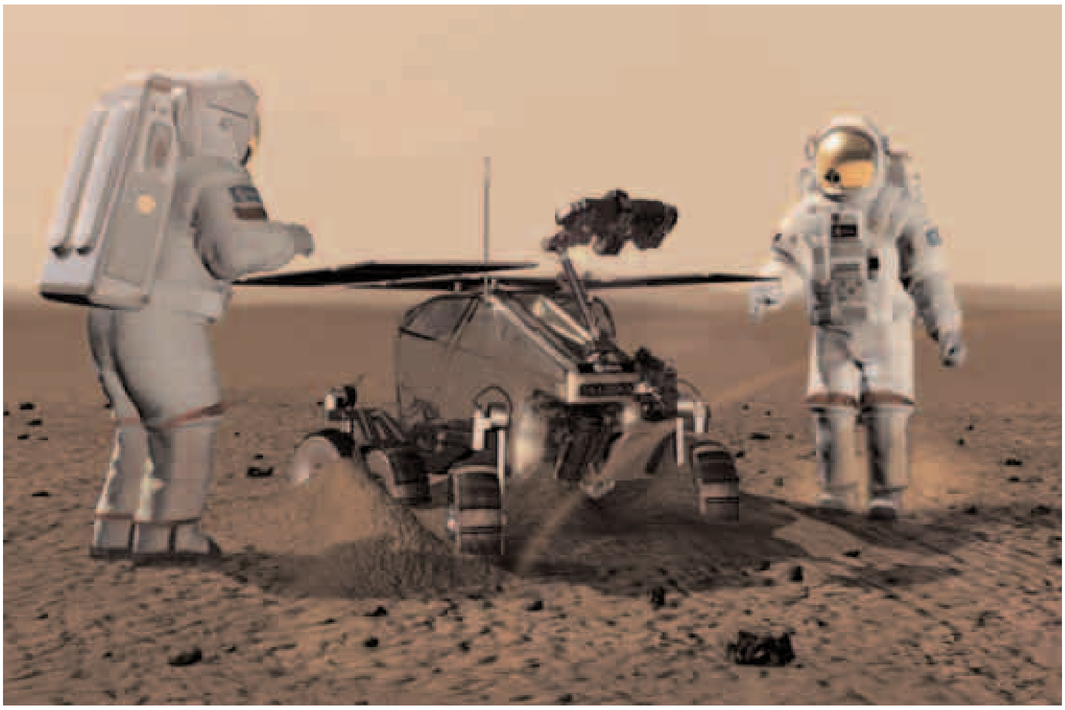
Related topics:

Chapter 4.1 "Living on board the International Space Station", worksheet A "Dizzy astronauts".
Chapter 3.1 "What is a Space Station?".
Chapter 4.2 "Working on the International Space Station", worksheet B "Experiments in space-plant experiments".

Websites:

Newton's three laws of motion:
http://www.physicsclassroom.com/Class/newtlaws/newtltoc.html

Video clips of astronauts onboard the International Space Station: http://www.esa.int/esaHS/SEMSMWZ990E_education_0.html



Artist's impression of astronauts on Mars.