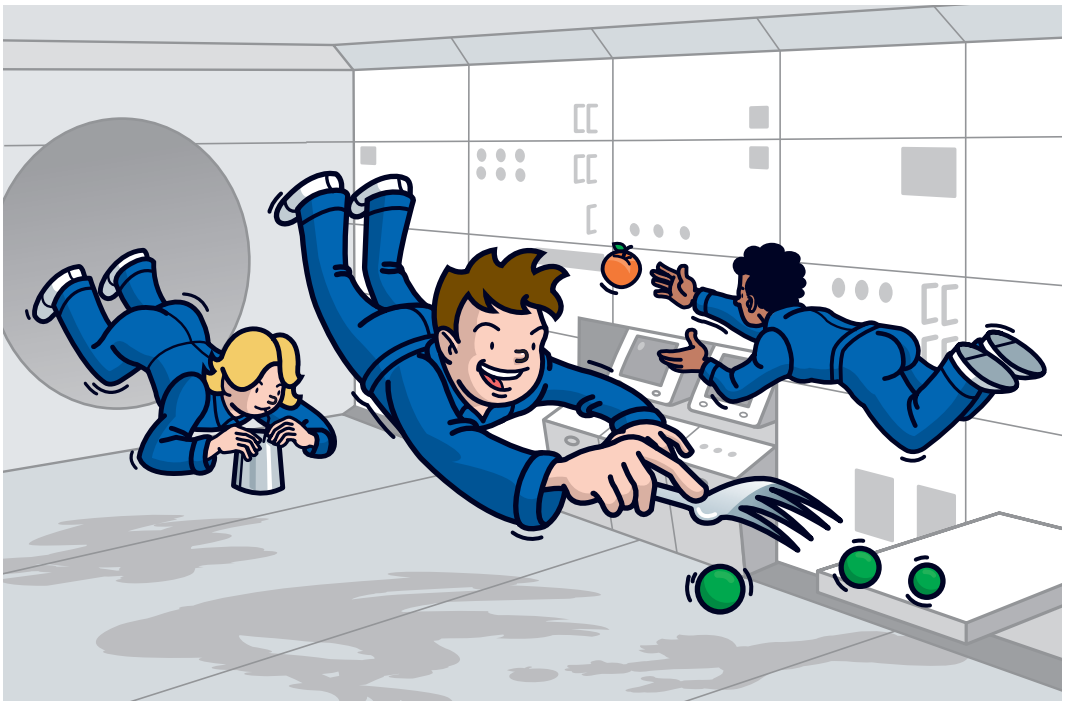
Life on the Space Station is very strange, at least until the astronauts get used to it. The Space Station goes round the entire Earth in just 1.5 hours. So the crew sees the Sun rise and set 16 times every day! The strangest thing, though, is weightlessness. “Up” and “down” mean nothing on the Space Station. Astronauts float wherever they want to go.



Sometimes weightlessness makes them feel sick and dizzy. But when they get used to it, they find it is great fun – although it can also be a nuisance. If you leave something lying around on the Space Station, it will float away. So you have to be tidy!

Eating is tricky. Astronauts eat food from plastic bags with a spoon, and drink from squeeze bottles with a straw. If they are not careful, globs of food and blobs of water will wander away until they stick to a wall or an astronaut catches them.

Worksheet: Dizzy astronauts (1)

●●○

The first couple of days of a space mission, the astronauts get dizzy – and maybe even feel sick. Because there is no 'up' and 'down', their senses can be confused.

Try to be an astronaut

1. Ask a friend to stand still somewhere in the classroom.
2. Sit in a chair with wheels and put on a blindfold.
3. Ask another friend to spin the chair.
4. Tell your friend when to stop spinning.
5. When the chair stops, point at your standing friend,
6. Remove the blindfold.

Did you point at the right spot?

Did you feel sick?

Astronauts performing orientation experiments.

Worksheet A: Dizzy astronauts (2)

●●○

Do the same experiment as on the previous page, but spin yourself, standing up.

André Kuipers

Did you point at the right spot?

Did you feel sick?

Did you manage to keep your balance?

Discuss:

- In what situations do you think it is difficult to keep your balance?
- What movements make you feel sick?
- What do you think it would feel like not knowing which way is “up” and which “down”? Do you think you could get used to it?

Did you know?

Some of the astronauts prepare for space by lying with their heads downwards for 45 minutes each day a couple of weeks before their space mission.

To help the astronauts get a feeling of up and down, in some parts of the Space Station the ‘floor’ is painted brown and the ‘ceiling’ white, and the lights are in the ‘ceiling’. Are there different colours on your floors and ceilings?

Worksheet B: Liquids in space

Water on board the Space Station behaves differently than we are used to on Earth: it floats around in spheres. For this reason, there is no sink on board, and the astronauts can't drink from a cup – liquids are kept in sealed bags.

Frank De Winne trying to catch a drink.

Water in spheres:

1. Fill a jar with oil.
2. Pour coloured water carefully into the oil and watch the coloured water. Describe the shape of the water:

3. Put a lid on the jar and flip it. Describe what happens:

4. Let the jar stand still for a while. Describe what happens:

Explore:
Try with other kinds of liquids and see what happens. You can pour coloured water into the water or pour vinegar or honey into both oil and water.

Think about it!

Imagine you are weightless.

- How would you wash yourself?
- How would you drink your juice?
- How would you go to the toilet?

Worksheet C: An astronaut's day – and your day

●●○

Astronauts are very busy on board the Space Station. To help them remember everything they have to do, they have a timetable that tells them when to eat, work and have time off.

Write down your timetable. Remember to think about:

- At what time you have breakfast.
- When you have to go to school.
- What you do in your spare time – and when.
- At what time you watch your favourite TV programme.
- When you go to bed.

My timetable:

	Morning	**Afternoon**	**Evening**
Monday			
Tuesday			
Wednesday			
Thursday			
Friday			
Saturday			
Sunday			

Worksheet D: Day and night

●●○

Astronauts will see the Sun for 45 minutes and then be in the darkness for 45 minutes – the whole day through. This is very different from what we are used to on Earth. If the Sun rises at midnight, the Sun will set at 00:45. Calculate when the next sunsets and sunrises will appear:

00:00	Sunrise	00:45	Sunset

Think about it!

- Would you be able to sleep for 45 minutes, be awake for 45 minutes and then sleep for 45 minutes again, the whole day through? (The astronauts don't, they try to get eight hours of sleep in one go!)
- On board the Space Station there is no up and down, which means you can't lie down to sleep. Would you manage to sleep in any position? (Astronauts sometimes strap themselves to a wall!)

Worksheet E: The year through (1)

●○○

What are the names of the seasons:

_____ _____

_____ _____

What are the names of the months:

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

How many weeks are there in a month?

_____

How many weeks are there in a year?

_____

Think about it!

It takes the Earth a day to spin around its own axis and a year to orbit the Sun once.

- Can you think of more ways to divide a year?
- How do other cultures now and in earlier days divide the year?

Worksheet E: The year through (2)

●○○

1. How many days are there in a year?

_____

2. Are there always the same number of days in a year?

_____

3. How often does it vary?

_____

4. How many days are there in a month?

_____

5. Are there always the same number of days in a month?

_____

6. How often does it vary?

_____

7. How many days are there in a week?

_____

8. How many hours are there in a day?

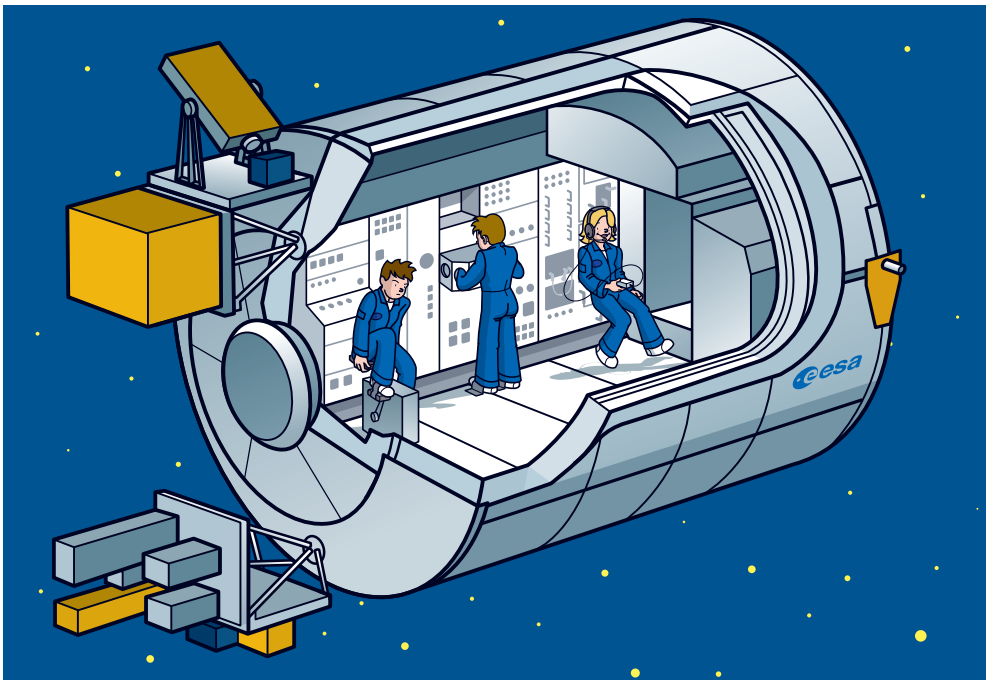
_____

9. How many minutes are there in an hour?

_____

Think about it!

- How many hours are there in a week?
- How many minutes are there in a whole day?



Astronauts work, relax and sleep just like people on Earth. They try to keep to regular hours, but sometimes there is just too much to do.

Spanish astronaut Pedro Duque talking to schoolchildren on Earth.

An important job is to look after the Space Station itself. They have to make sure that all the complicated equipment is working properly, and if it is broken they have to fix it.

Then they can do their scientific work. They must keep an eye on dozens of science experiments. Some are controlled by scientists on the ground, using radio or TV. But the astronauts have to check that all is going well. Sometimes they do experiments on themselves, to see how their bodies are managing in weightlessness.

For a few hours each week, they also spend time talking to people on Earth and showing them what their life is like. They especially like talking to students and schoolchildren.

Worksheet A: Keeping it clean and tidy

●●○

Since the astronauts can't easily go to a shop and buy what they need, they try to repair as much as possible with what they already have onboard the Space Station. They try to re-use and also recycle as much as possible.

Keeping the Space Station clean is also an important task for the astronauts, as well as being well organised – there is a lot of equipment, but not much space!

Project: Healthy environment – the astronaut way
Work in groups and discuss in full class.

Make a plan for:
- How you can improve the conditions in your classroom.
- How you can re-use and recycle more of your rubbish.

Include in your plan:
1. **What** you would like to improve.
2. **How** you propose to do it.
3. **Who** is responsible for it.
4. **How** and **when** you should check whether your plan is working.

Keeping it neat and tidy.

Think about it!

- What makes a place healthy to be in?
- What would you like your classroom to look like – what is important for you to feel comfortable?
- What can you change to improve the conditions in your classroom, to make it a better place for all of you?
- What do you do with your rubbish – what do you recycle or re-use? How can you re-use and recycle more of your rubbish?

Worksheet B: Experiments in Space – Plant growth (1)

●●○

The astronauts perform a lot of scientific experiments on board the Space Station. Some of the experiments are on plant growth. Plants grown in space get confused in what direction to grow because there is no 'up' and 'down'. Find out how your plants will grow.

1. Plant seeds and place them at different places (in the classroom, outside – at warmer places and at colder places). Place some of the plants in the shade and some in light.

2. Measure the temperatures regularly (daily or weekly) while growing the plants and write down the temperatures in a table. Note also how the plants are growing and write down what you see.

Seeds:
You can use different types of seed for your plant experiment, such as cress or radish, mustard, maize or rocket salad!

Discuss and find out!

- Discuss and find out at which temperatures the plants grow better and how much light they need.
- Describe other factors that might have influenced the growth of your plants.
- Discuss how you could protect your plants from extreme temperatures.

Frank de Winne with plant experiment.

Think about it!

How do you think plants would grow in space where there is no real "up and down"?

Challenge: Make a list of what plants would need to survive in space.

Worksheet B: Experiments in Space – Plant growth (2)

Time:	Temperature:	Growth:

Worksheet C: Watching the Earth – Time zones (1)

●●●

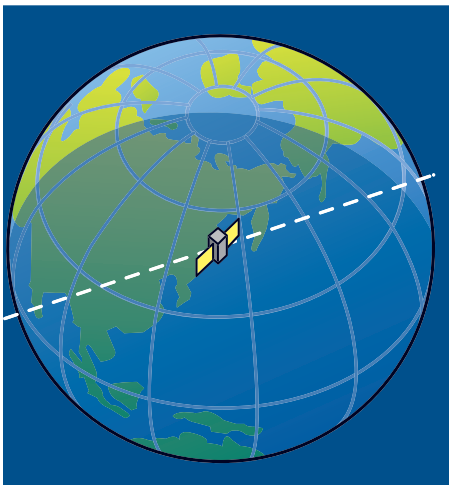
Introduction

One of the things the astronauts on board the Space Station enjoy most is watching the Earth pass by. They can see big cities, roads, lakes and mountains. They can also see cloud formations and the Moon, as in the picture below.

When looking at the Earth from far away, you can see the Earth spinning. It spins around its own axis once every 24 hours.

There is always one part of the Earth facing the Sun, while the other part is in shadow.

- When facing the Sun, it is daytime.
- When in shadow, it is night time.



When the Sun is at its highest position, the time of day is about 12:00 where you are. But when it is midday at your place, it will be midnight on the other side of the Earth.

Worksheet C: Watching the Earth – Time zones (2)

●●●

Demonstration
Let the torch represent the Sun. Point the torch at the globe. Turn the globe around its own axis and see how half of the Earth is in the shadow while the other half is in sunlight.

You need:
- A torch
- A globe

1. Find out where you are right now on the globe. In what direction will this place be heading at:

   a. 12:00 in the day?

   b. 24:00 in the night?

   c. 06:00 in the morning?

   d. 18:00 in the evening?

2. Find a place on the opposite side of the globe.

   a. What would the time be in this place when the time is 12:00 where you are?

   _____

   b. What would the time be in this place when the time is 24:00 where you are?

   _____

   c. What would the time be in this place when the time is 06:00 where you are?

   _____

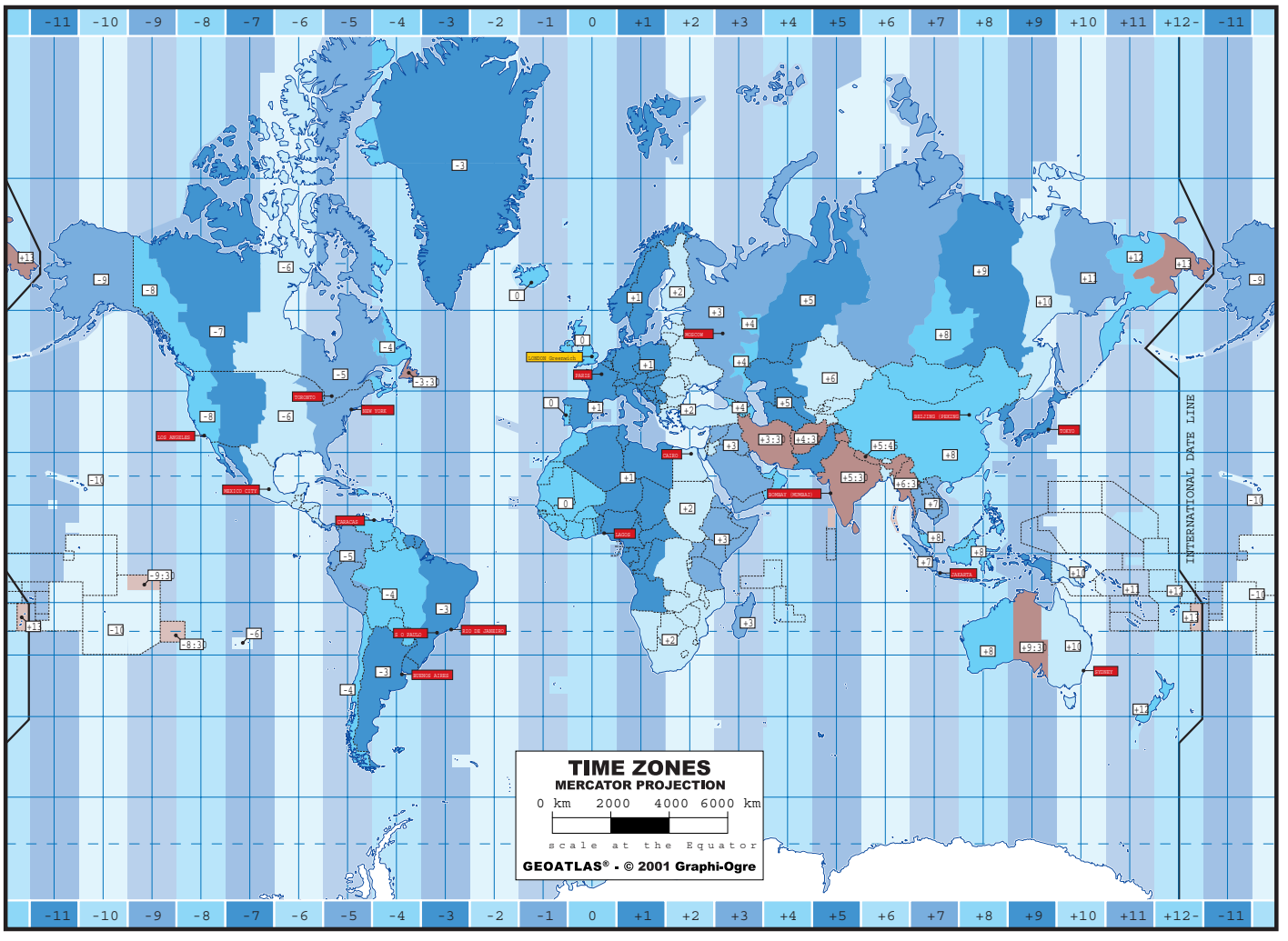
   d. What would the time be in this place when the time is 18:00 where you are?

   _____

Worksheet C: Watching the Earth – Time zones (3)

The Earth has been divided into 24 parts – one for every hour. When the time is 12:00 in the UK and Portugal, the time is 13:00 in most of western Europe, while it is 14:00 in Finland, Greece and most of the countries in eastern Europe.

Look at the map below and find out how the Earth is divided into time zones.



Worksheet C: Watching the Earth – Time zones (4)

Singapore harbour.

1. What's the time in Vienna when it is 14:00 in Moscow?

2. What's the time in Lisbon when it is 21:00 in Helsinki?

3. What's the time in Sydney when it is 08:00 in Nairobi?

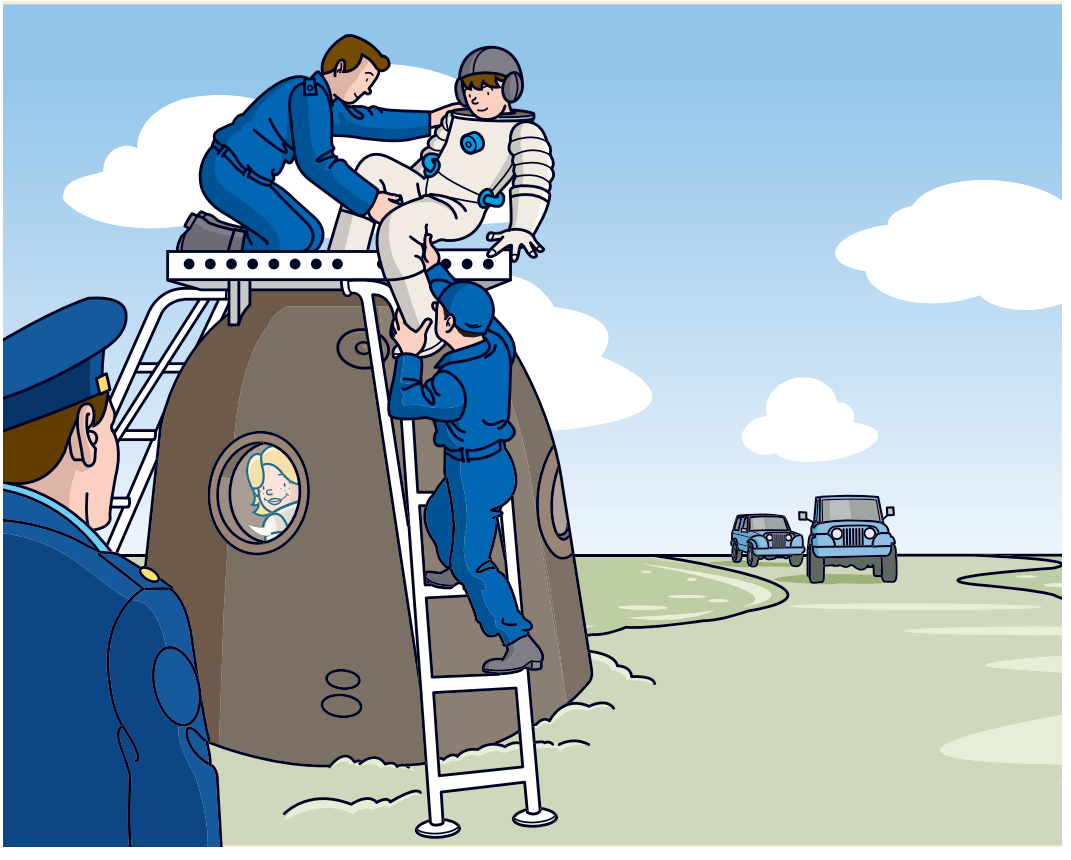
4. What's the time in Vancouver when it is 16:00 in Singapore?

5. What's the time in Lima when it is 24:00 in Tokyo?

When it is time for the astronauts to go home, they are usually sad to leave, but they are looking forward to seeing their families again.

Soyuz landing with a parachute.

They pack up their things, and climb into the spacecraft that will bring them back to Earth. Then they "undock" from the Station. This means that the spacecraft is no longer attached to the Space Station. At first, the spacecraft is going as fast as the Space Station, but then it slows down and starts its journey through the Earth's atmosphere – slowly, bit by bit. The return takes about three and a half hours before the parachutes pop out to slow down the spacecraft enough to land safely.



After the capsule has landed (above) it is opened (left) and the astronauts are examined by a doctor (below).

When the astronauts are back on the ground again, they feel terribly heavy. They can hardly stand up, and even breathing is hard. Some have been weightless for months, and now their ordinary weight is too much for them. They have to rest in bed and take medicines to make them strong again. But in a few weeks they will be much better. They will tell people on the ground about their adventures and discoveries. And they will hope to go into space again.

Worksheet A: A spacecraft returning to Earth (1)

●●○

When two surfaces rub against each other, friction is caused. Friction will arise when you rub your hand over your thighs.

Rub your hands over your thighs. Vary the speed. What do you experience?

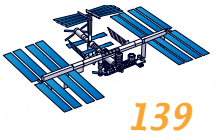
Friction also slows down things, and uneven surfaces create more friction.

You need:
- A ball
- A skateboard and/or something else with wheels

Experiment

1. Decide where to try out your experiment. You should try it out on different surfaces – for example, a smooth corridor, on asphalt, on grass…
2. Roll the ball and/or push the skateboard over the different surfaces. Describe what happens.

What happens?



Worksheet A: A spacecraft returning to Earth (2)

●●○

One type of friction is friction against the air. This is called air resistance.

Experiment

1. Crumple up one of the sheets into a ball.
2. Drop both from the same height.
3. Do they fall at the same speed?
   Describe what happens:

You need:
2 A4 sheets

Artist's impression of the ATV returning to Earth.

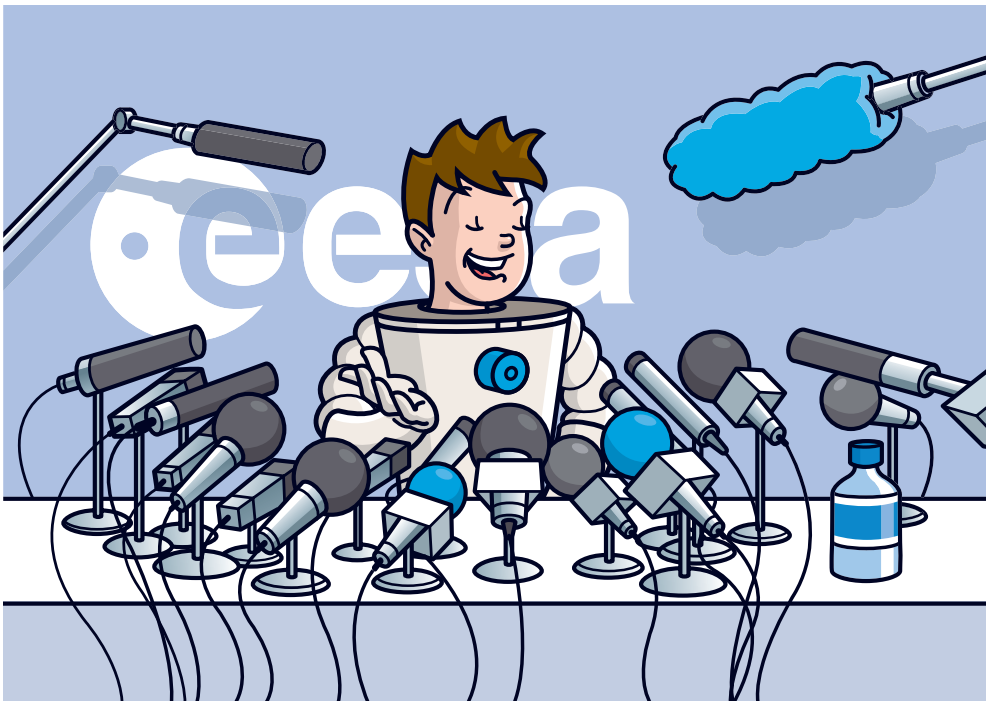
Air resistance is what spacecraft experience on their return to Earth. The temperatures rise, and the faster the spacecraft travels, the higher the temperatures get. Therefore, the spacecraft goes slowly on its way back to Earth and it needs special heatshields to keep the astronauts safe. The temperatures can still rise to 1600 degrees Celsius!

Worksheet B: Prepare an interview with an astronaut

●●○

When the astronauts have returned to Earth, a lot of journalists are curious to know what it was like on board the Space Station.

Work in groups. Pretend that one of you is a journalist and the others are the astronauts who have just returned to Earth.



1. Prepare to interview the astronauts.
   a. Prepare the questions the journalist will ask the astronauts.
   b. Prepare the answers the astronauts will give to the journalist.
2. Rehearse the interview and perform it for the class.
3. Write up the interview nicely. Take a picture or make a drawing and put it all together. Gather all the interviews made in your class and make a poster or a newspaper.

Worksheet C: Make your own memory game (1)

●○○

On the following pages, you will find 12 pairs of pictures.

Preparations

1. Talk about what you see in the pictures and what you have learned about astronauts and space.
2. Use the pictures to make cards for a Memory Game.

You need:
- The pictures on the next pages,
- A4 size card,
- Glue and
- Scissors.

a. Glue the pictures on to one side of the card.
b. Glue the back cover picture (all the same picture) on the other side of the card.
c. Cut the pictures – make sure they all have the same size).

Memory game rules

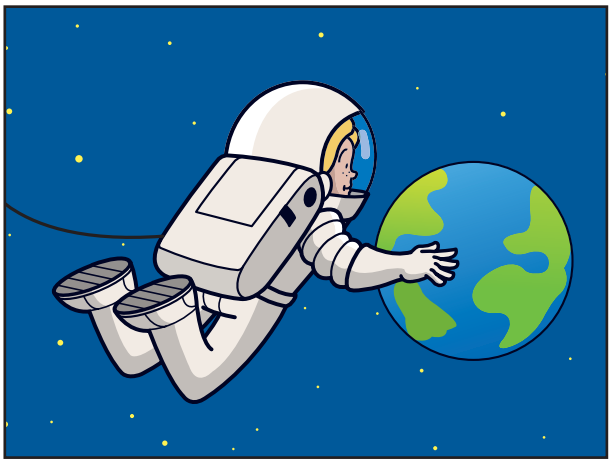
2-4 players

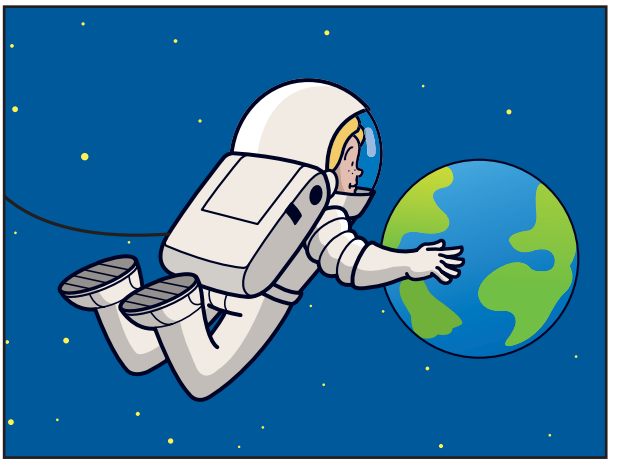
- Put all the cards face down.
- Mix all the cards, so that nobody knows which pictures are where.
- Decide who starts the game by throwing a dice – the one with the highest number starts.

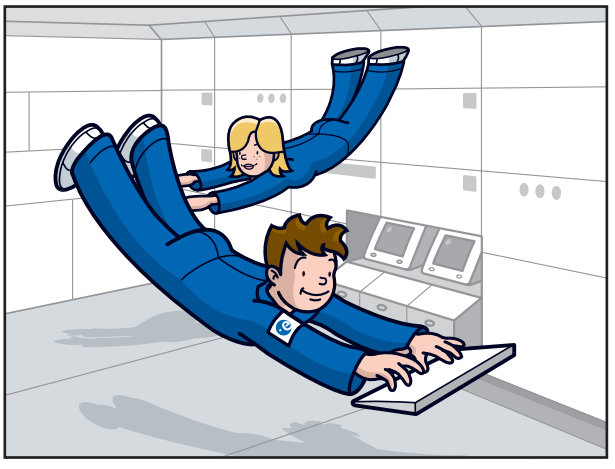
Player 1 picks up two pictures and shows them to everybody. If there are two identical pictures, the player keeps the two cards and picks another two cards. If the cards are not a pair, Player 1 has to turn the cards over and put them back where they were.

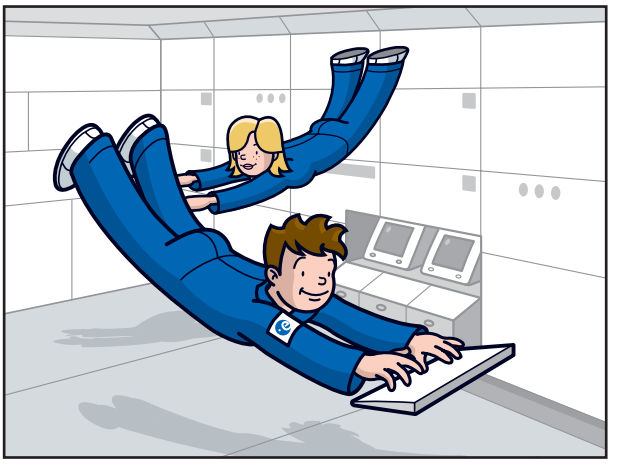
Then it is the next player's turn to pick up two cards.
The game continues until there are no more cards on the table.
The winner is the one with the most cards.

Worksheet C: Make your own memory game (2)

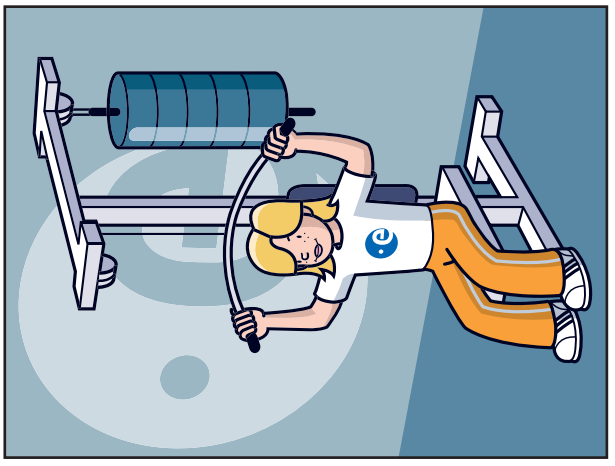


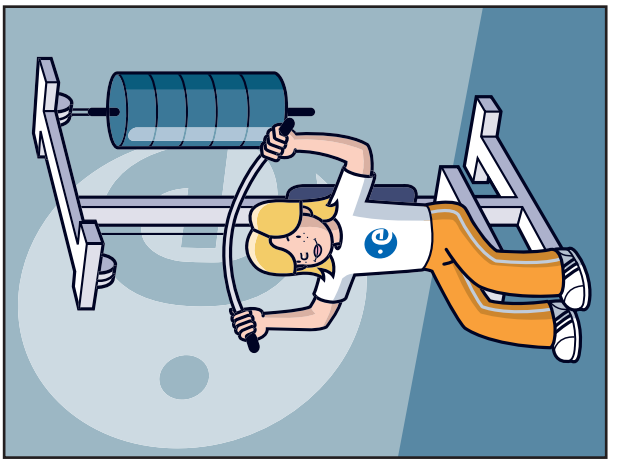


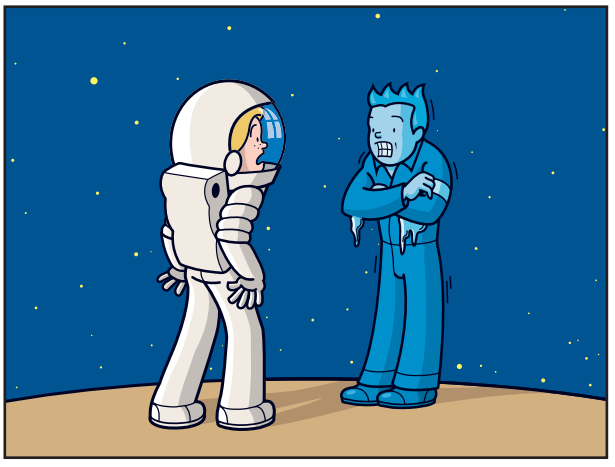


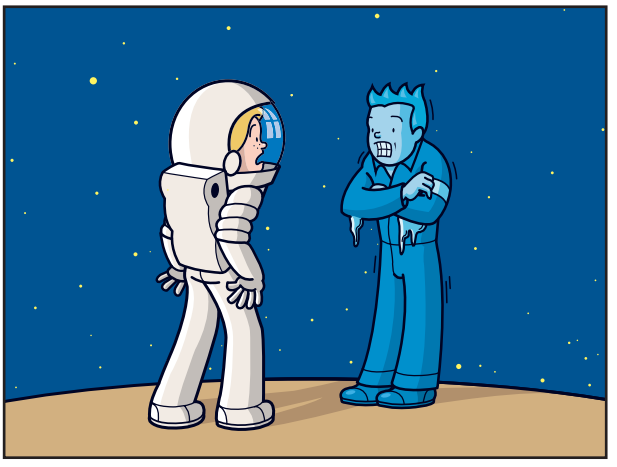


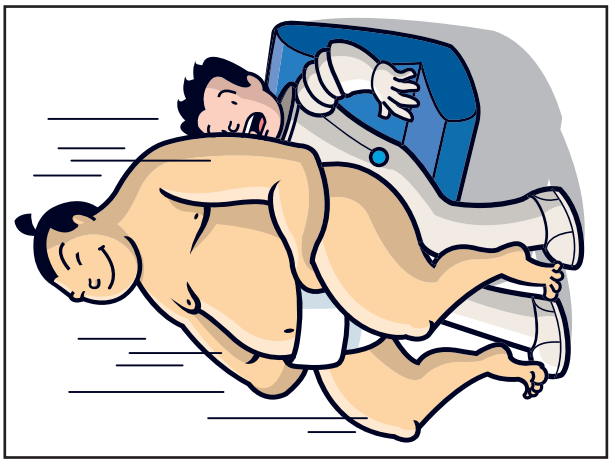
Worksheet C: Make your own memory game (3)

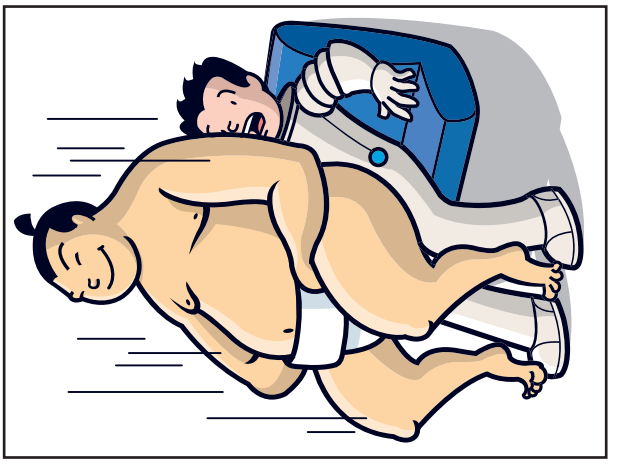




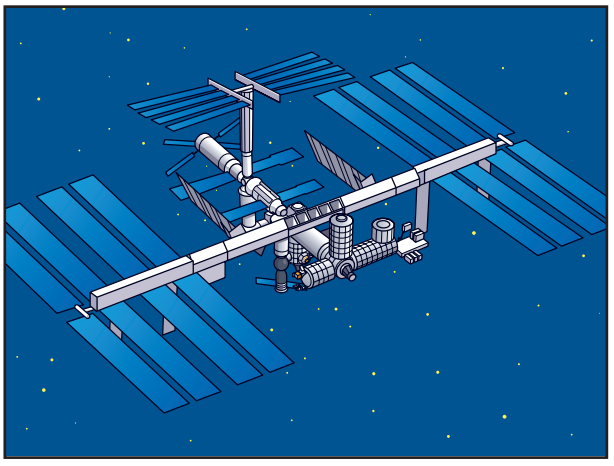


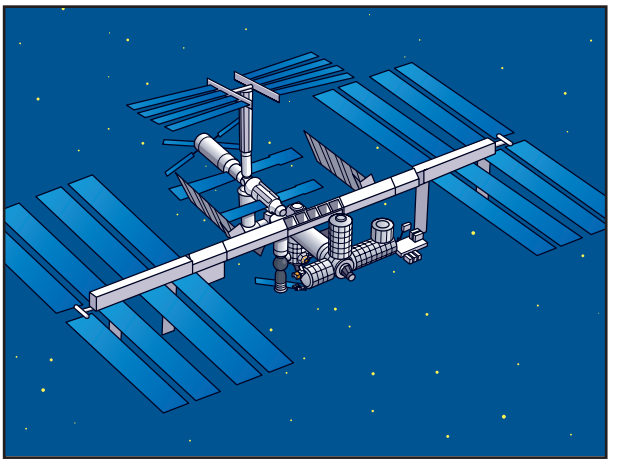


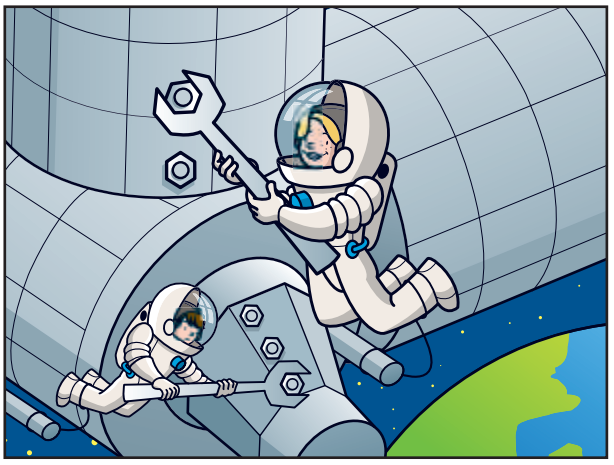


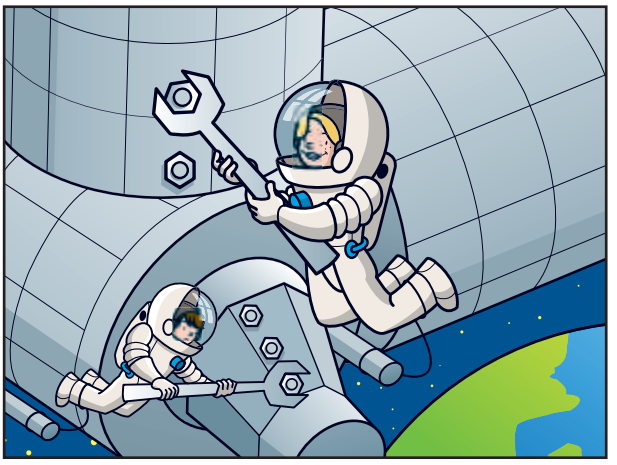


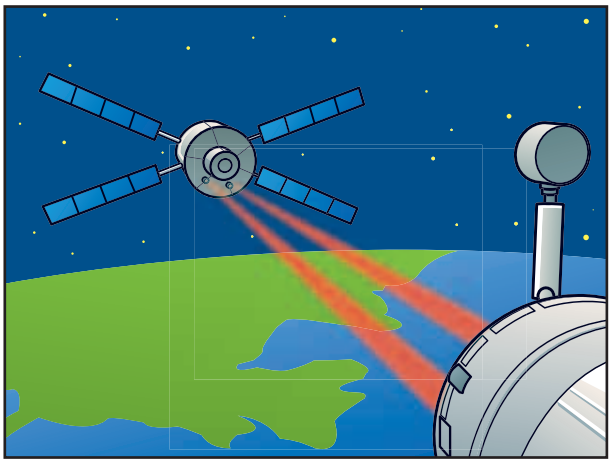
Worksheet C: Make your own memory game (4)

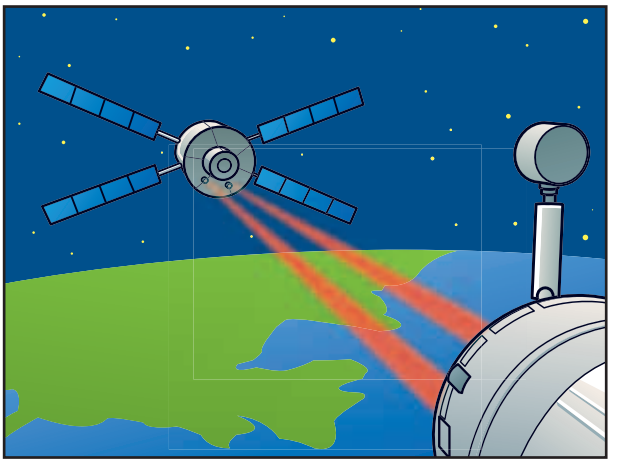




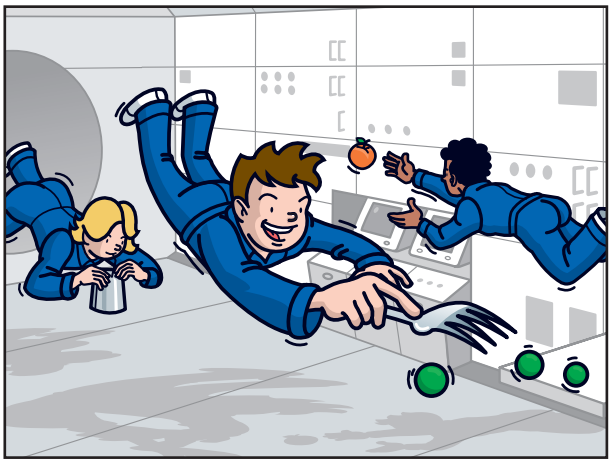


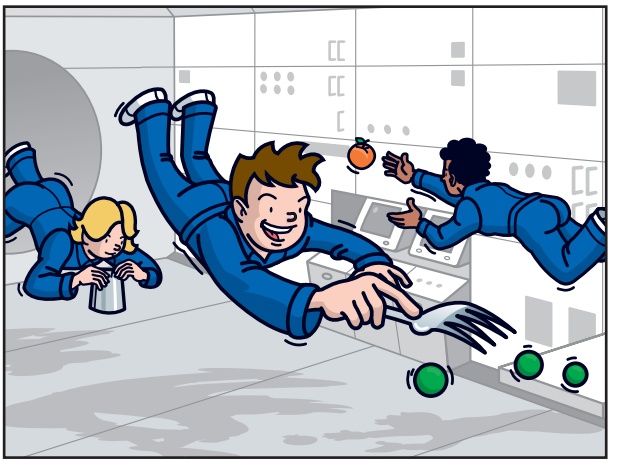


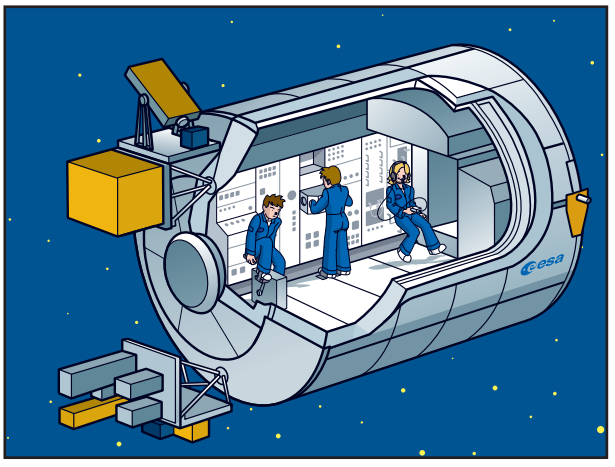


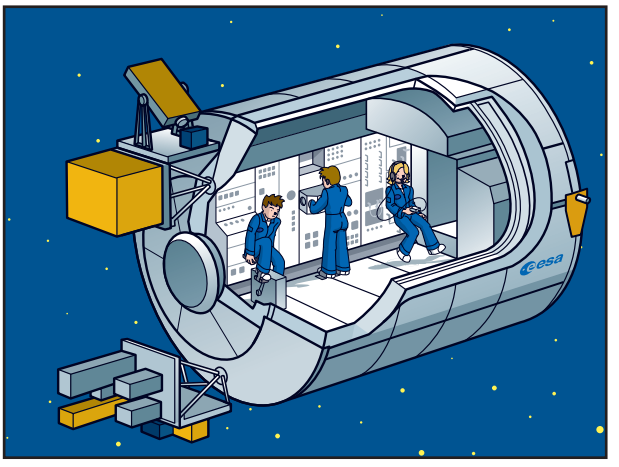


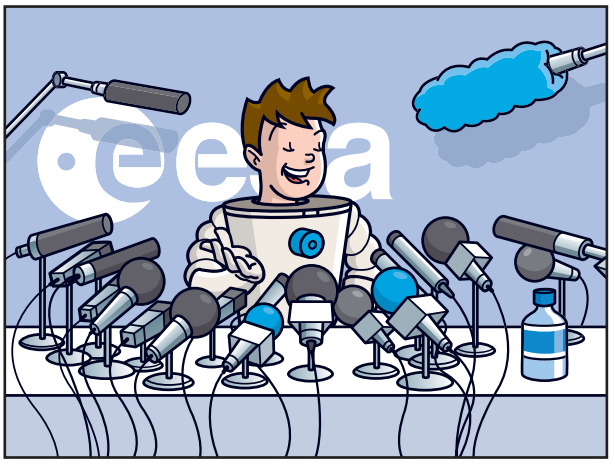
Worksheet C: Make your own memory game (5)

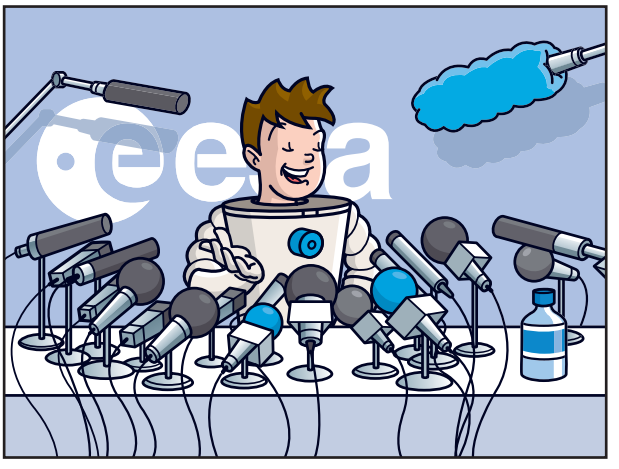












4 Teacher's background

4.1 Living on board the International Space Station

Lesson – core elements:

Pupil's text:	Life on board the ISS is different – weightlessness – no real 'up and down' Some astronauts get dizzy Everything floats (you have to be tidy!) It takes the ISS 90 minutes to orbit the Earth once
Worksheets:	Balance, orientation Liquids in space – forms spheres The daily schedule – yours and an astronaut's (planning) Sunrise and sunset (day and night), seasons Months, weeks, days, hours

Subjects represented:
Maths
Science
Language
Social Science

Background information:
For the permanent ISS crew, the Station is their home for up to six months. At present, there are only two or three long-term residents at any one time. But at regular intervals, a Soyuz "taxi flight" brings three more astronauts for a short stay, and by the time the ISS is complete it will accommodate a crew of seven.

It is an odd – in fact, unique – existence. For half of its 90-minute orbit, the ISS is in bright sunlight; for the other half, it is in darkness: only three-quarters of an hour separate dawn from dusk. For obvious reasons, the crew live and work to the familiar 24-hour cycle of the planet that spins beneath them (they use GMT for reference), but their biological "body clocks" may take a while to settle down.

Weightlessness, though, is the dominant factor and the weightless environment is also the prime scientific purpose of the station. The first effect of weightlessness is often dizziness and space-sickness, and many astronauts have an unpleasant day or two before their bodies adapt. Soon, though, astronauts begin to enjoy the experience of floating freely, flying around the station's interior as if they were birds.

Frank De Winne "flying high".

An astronaut eating at the "table".

But astronauts are not the only thing that floats freely around the station. Anything, from a pencil to a laptop computer to a vital replacement part for the station's electronics, left unattached to a wall, a "floor" or a "ceiling" is likely to drift off in any direction. So tidiness is essential: you cannot just leave things lying around and expect them to stay put. Velcro and sticky tape are always in great demand.

Eating requires great care, too. Most of the time, astronauts eat with a spoon from plastic bags, and drink through straws from squeeze bottles. In either case, they do so very carefully: sudden movements will lead to chunks of food flying off until they encounter something to stick to, or spheres of liquid wobbling away on orbits of their own, usually pursued by an astronaut.

Still, meals are usually social affairs on board the ISS. There is even a table in the Zvezda module – it gives everyone around it a sense of orientation, although instead of chairs there are foot-sized loops fitted to the floor to provide free-fall diners with an anchor.

A visit to the toilet is another interesting experience. Users must strap themselves down, and prepare for a blast of air from a powerful pump, which serves the same purpose as a water-flush on Earth. Uncomfortable, but effective and hygienic – and a far cry from the crude sanitation used by the first space explorers. But you won't be able to take a shower: the ISS does not have one. (A zero-gravity shower would be possible, but the water requirements make it impractical, and most astronauts say that it is not as comfortable, as the water doesn't run over you as it does on Earth.) Instead, astronauts make do with wet towels and non-lathering soap.

Floating food.

Sleeping arrangements are in some ways much simpler than on Earth: no need for beds or bunks or any kind of mattress: there is no need for anything to take your non-existent weight. Simply attach your sleeping bag to some convenient point, and tuck yourself in. Cover the portholes, put out the lights, perhaps fit some earplugs – with ventilators running continuously, the ISS is not the quietest of bedrooms – and, quite literally, float into sleep. Don't be too surprised if you are awakened by strange shapes drifting close to your face: they are only your own arms.

Ideas and hints for the worksheet activities:

Worksheet A: Dizzy astronauts, pages 122-123

In space, orientation is a difficult concept – there is no direction that everything stands on or falls towards, so there is no up or down. This has advantages: every little bit of available wall space (including floors and ceilings) can be used as storage, for experiments, for computers etc.

An orientation experiment.

Experience has shown, however, that a certain imposed order in the Space Station make astronauts feel more at home and give them a better sense of where things are – otherwise they might end up spinning on their own axis for every tool they want to grab or button they have to push because they cannot find it right away. Artificial 'ceilings' and 'floors' have been created that are painted in different colours and are mainly storage compartments, while "walls" house the experiments, computers, racks etc. In the habitation modules, tables and exercise equipment are mounted to the floor.

Worksheet B: Liquids in space, page 124

On board the Space Station, water behaves differently than on Earth. It floats around in spheres and has a tendency to stick to surfaces. The reason why water forms spheres is because of surface tension that works between the molecules in the water – it has an inward pull on the molecules at the surface because its tendency to contract to the smallest possible surface area. This makes the water behave as if it had a skin, and it explains why insects can walk on water and why water forms spheres in weightless conditions.

Water spheres on a plant.

Try this experiment with the children: You can see how liquid forms spheres by dropping a few drops of tinted water into a jar with oil. For instance, use olive oil and mix food colouring with water. This way it is easier too see the water when dropped into the oil.

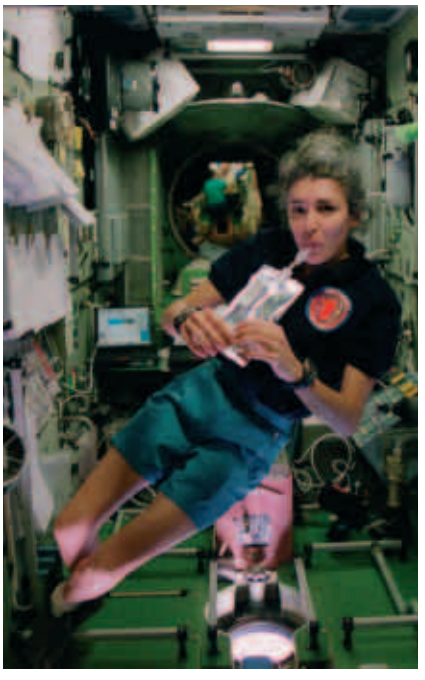
Washing yourself on board the Space Station

As water is not pulled downwards but floats around in spheres and sticks to surfaces, most astronauts find it not as relaxing to have a shower onboard the ISS as on Earth. As they cannot fill a sink when they would like to wash themselves, they take sponge baths and use wet tissues (with soap) instead.

Personal hygiene.

When they shave, they also have to make sure all the hair is collected. When using an electric shaver they need to have a vacuum cleaner next to it the shaver, while when shaving using razor blades, they have to wipe the hair and foam off onto tissues.

When brushing their teeth, they have to do the same as when shaving – they spit into a tissue. Another option is to use toothpaste that can be swallowed.



Having a coffee in space.

Drinking onboard the Space Station

All liquids have to be stored in sealed containers – otherwise they would float around. If you'd like a cup of coffee or tea, there are bags containing a tea bag or instant coffee which you have to fill with hot water.

(For more information about water and water storage, see chapter "Supplying the International Space Station", "Plan a mission").

Going to the toilet on board the Space Station

When astronauts go to the toilet, the first thing they have to do is to strap themselves to it – otherwise they would float around. Instead of using water, the toilet has a suction tube that carries the waste away with an air stream down into a suction hole. The solid waste then gets compressed and stored for later disposal, while urine is collected in a separate container to be recycled.The purified urine is processed and breathing air for the crew is one of the products generated.

Worksheet C: An astronaut's day – and your day, page 125

Astronauts on board the International Space Station have a very strict routine. They have a schedule with the times when to eat, when they need to do an experiment, when they have to contact the control centre on Earth and so on. On Earth we also have schedules. Discuss what the words routine and schedule means.

Let the pupils write down what they do during the day on their worksheet. Alternative: Ask them to interview somebody about their day and write down their schedule.

In a group/pair activity, let the pupils tell the others what they do and compare what is different in their schedules. Let them compare their own activities with what the astronauts do.

When looking at the astronaut schedule, you can ask the pupils questions like for instance:

- What meals do astronauts have? When do they eat?
- When do they sleep?
- When do they carry out scientific experiment or perform maintenance on board the Space Station?
- When do they have time off?
- What is the main difference between the astronauts' and the pupils' schedules?
- Why do you need a schedule?

Worksheet D: Day and night, page 126

Answers:

00:00	Sunrise	00:45	Sunset
01:30		02:15	
03:00		03:45	
04:30		05:15	
06:00		06:45	
07:30		08:15	
09:00		09:45	
10:30		11:15	
12:00		12:45	
13:30		14:15	
15:00		15:45	
16:30		17:15	
18:00		18:45	
19:30		20:15	
21:00		21:45	
22:30		23:15	
00:00		00:45	

Worksheet E: The year through, pages 127-128

Answers:

What are the names of the seasons?

The four seasons referred to in our part of the world are spring, summer, autumn, winter. In other parts of the world other seasons are referred to. Let you students share their experience from other places in the world where they have been.

What are the names of the months?

In the Gregorian calendar the 12 months used are: January, February, March, April, May, June, July, August, September, October, November and December. Other cultures use other calendars. Let the pupils find out more (See below for details).

NB! In all answers below we refer to the Gregorian calendar:

How many weeks are there in a month?

Normally there are four weeks and a few days in a month.

How many weeks are there in a year?

In a year there are 52 weeks.

How many days are there in a year?

A year is normally 365 days.

Is it always the same amount of days in a year?

Every fourth year, the year has 366 days.

How often does it vary?

It varies every fourth year.

How many days are there in a month?

There are 30 and 31 days a month. February has 28 days, except in a leap year (29 days).

Is it always the same amount of days in a month?

No, it varies from month to month.

How often does it vary?

Days per month:

January	31	July	31
February	28 (29 every fourth year)	August	31
March	31	September	30
April	30	October	31
May	31	November	30
June	30	December	31

How many days are there in a week?

There are seven days a week.

How many hours are there in a day?
There are 24 hours a day.

How many minutes are there in an hour?
There are 60 minutes per hour.

"Think about it", page 128.

How many hours are there in a week?
There are 24 hours per day, times seven days a week:
24 x 7 = 168
There are 168 hours a week.

How many minutes are there in a whole day?
There are 60 minutes per hour, 24 hours a day:
60 x 24 = 1440
There are 1440 minutes in a day.

Further ideas and explorations:

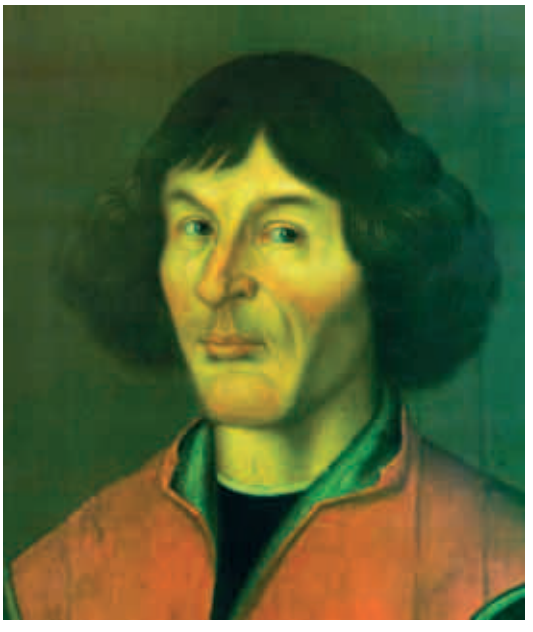
Day and night

You can also let the pupils observe when the Sun rises in the morning and when it sets in the evening. The pupils can then note their findings in a table (e.g. do it once per week over a period of a few months) and then compare their findings as they see the time changes. If the sunset or sunrise is while the pupils are asleep, the teacher or someone at home can note the time. If the local newspapers gives the times for sunset and sunrise, this or an agenda giving these data can be used.

"Think about it", page 127.

The year through

Use this activity to learn about other calendars used in the past or by other cultures. One could also divide the year into seasons (spring, summer etc., or rainy season – dry season), holidays, festivals.



Copernicus

Background information:

Early calendars were mainly based on the movements of the Moon because it was the most obvious regular change in the sky. In about 3000 B.C. the Egyptians developed the first calendar based on stars. Their year consisted of 36 weeks of 10 days

each – the start of each week was determined by the rise of a certain constellation.

Until Copernicus (1473-1543) set out the idea that the Sun is at the centre of the Solar System scholars believed that its centre was the Earth, with the Sun, Moon and stars circling our planet. The Copernican model is also called heliocentric, while the geocentric model is also referred to as the Ptolemaic model, after Greek astronomer Ptolemy.

Christmas cheer in space.

The calendar we use today is based on a calendar by Julius Caesar in which the year was divided into 365 days with an additional day every four years. This was slightly corrected by Pope Gregory in 1582 – the Gregorian calendar was born. Other cultures still use other systems; the Chinese calendar, for example, is based on the Moon and has a cycle of 60 years. The Jewish calendar starts on the day the world was created after Jewish belief (7 October 3761 B.C. after the Gregorian calendar) and has a year that either has 12 or 13 months.

Related topics:
Chapter 2.1 “The training of an astronaut”, Worksheet D “New symbols”.
Chapter 4.2 “Working on board the International Space Station”.

Websites:
http://www.calendarzone.com/
http://webexhibits.org/calendars/index.html
http://www.12x30.net/intro.html

4.2 Working on the International Space Station

Lesson – core elements:

Pupil's text:	Astronauts keep regular hours Work, relax, sleep Maintenance, reparation of the Space Station Scientific experiments Communicate with Earth
Worksheets:	Healthy environment (clean, tidy, proper waste system) Experiment: Crystal growth Experiment: Plant growth Time zones

Subjects represented:
Language
Science
Maths
Social Science

Working on an experiment module.

Background information:
Whenever possible, astronauts on board the ISS try to stick to a regular routine: an eight-hour working shift, followed by eight hours for relaxation and exercise, then eight hours sleep during the Station's 'night'. Saturday's work schedule is planned to fill only four hours, while Sunday is set aside as a rest day. But there is always essential maintenance to be done, and experiments to be checked and monitored: working hours tend to stretch and free time is often interrupted. There is no place aboard the space Station for anyone who wants a nine-to-five job!

The first duty of the astronauts is to the Station itself. Scheduled maintenance tasks – cleaning filters, for example, upgrading software or merely using a space-modified vacuum cleaner to suck dust and other debris from the air as well as module surfaces – take up a substantial part of their time. Only once the Station's safe running is assured can they devote themselves to their real work: supervising or monitoring the scores of scientific experiments that could be under way at any one time.

Many ISS experiments are designed to run hands-off, monitored from the ground by the Earth-bound scientists who prepared them. In such cases, all astronauts need to do is check occasionally that all is well, and be ready to

Roberto Vittori talking on the radio.

make adjustments if it is not. Other experiments require the astronauts' active participation: they might have to mix chemicals together inside a glovebox, for example, or manipulating delicate apparatus in a crystal-growing project. Earth observation experiments involve at least pointing cameras in the right direction, as well as the application of intelligent, highly-trained human eyeballs to the subject.

Perhaps the most exciting – and certainly the most exhausting – work takes place outside the station's pressurised modules. Experiments that require the vacuum of space or raw solar radiation are bolted on to various platforms on the station's exterior; to set them up, or bring them back for evaluation, astronauts have to don their spacesuits and – always working in pairs for safety reasons – step outside. They may well use the opportunity for a little external maintenance at the same time.

A fair proportion of ISS experiments use the astronauts themselves as subjects. Human physiology is greatly altered by weightlessness, with bone and muscle loss being the greatest – but by no means the only – problems. Medical experiments on board the ISS make accurate measurements and test possible remedies. Such research is essential if humans are to make long voyages out in the Solar System, but it has practical benefits much nearer home. Bone and muscle deteriora-tion are medical problems on Earth, too, especially among the elderly. Because the damage occurs much faster in weightlessness, and in controlled conditions, experiments that would take years to conduct on the ground can be squeezed into much shorter periods.

Frank De Winne.

There is one job that most astronauts soon learn to enjoy: communication. A few hours each week are usually set aside for broadcasts to schools and colleges on the ground, to phone-ins or, more usually these days, live Web appearances. Astronauts get a chance to share their strange environment with the 'groundlings', and to show ordinary people a few of its wonders.

Ideas and hints for the worksheet activities:

Worksheet A: Keeping it clean and tidy, page 130

The questions on the Worksheet are intended to let the pupils reflect on how they, themselves, would organise the classroom. The idea is that the pupils themselves should come up with ideas for the classroom and to reflect on who is responsible for the environment in the classroom. This could also include what rules they think are needed, e.g. on how they should treat each other, on discipline etc.

Pedro Duque.

As said in the introduction to the Worksheet, the astronauts have to be well organised. They also have to work closely with the people they have to live together with 24 hours a day in a confined space. This could lead to further discussions on the importance of working together and staying friends with people around us, as well as get an understanding for why, in particular in cases where we live and work with other people, it is important to have certain rules, be tidy and well organised. Let the pupils write down a plan for this work, or a draft for a plan that you work out together in full class, use a copy of the “Astronaut log”.

Worksheet B: Experiments in space – plant growth, page 131

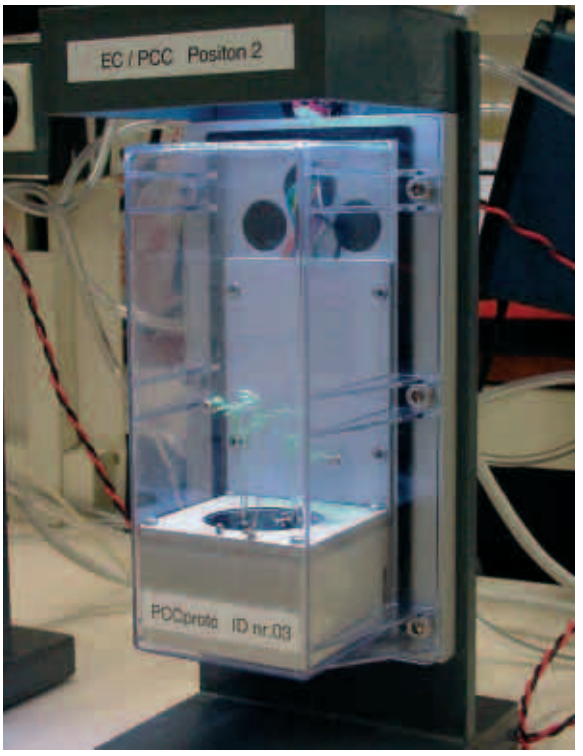
A wide variety of experiments are performed on board the Space Station, for example in material science, combustion science, biology and physiology. The main interest is to find out how things behave in a weightless environment. This can lead to insights into the properties of materials, plants and plant growth, the human body and how it works. All these findings can give us more information about what will be needed for long duration space missions, as well as information that can help us improve the conditions on Earth (e.g. with better shock absorbers for cars, new and better medicine, plants that give more efficient crops).

This Worksheet lets the pupils perform real scientific experiments which also can be related to experiments performed on board the Space Station.

Background information: plant experiments

Plants are vital to life on Earth, and may also become vital for future space missions. Space explorers going on longer missions possibly have to depend on plants to ensure their own survival. It will be hard to take all the food needed for a long-duration mission because storage space is limited onboard spacecraft. A solution could be that the astronauts grow their own food on the way. But before we can rely on plants as resource, we need to learn more about how they behave in weightless conditions.

Working on board the International Space Station



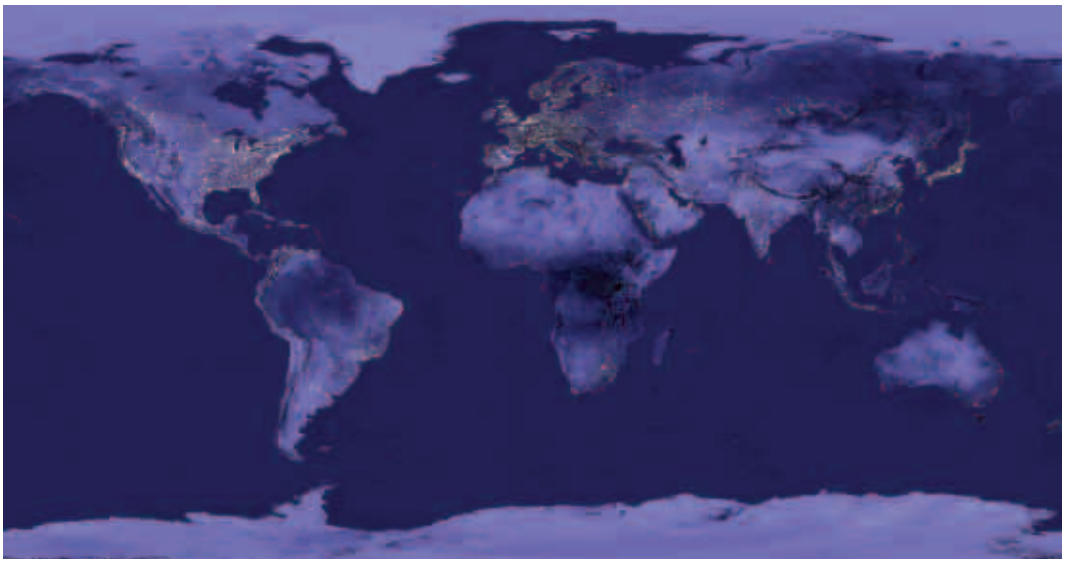
Plant container.

Because of the weightless conditions plant experiments are stored in sealed containers – otherwise soil and water would float around freely. Special containers have been developed especially for plant research in space. They also make sure that the plants are provided with the right level of gases, water, light and temperature. But how do plants know in which direction to grow in weightless conditions where there is no real up and down?

From experiments already performed on previous space missions, scientists have found out that plants grow in every direction. After a while though, the plants seem to adapt to the conditions and start to grow in a more stable direction. This is because they start to use other sources than gravity in order to orient themselves: the leaves use light as a reference, while the roots stretch towards water. The research has also lead to more insight about their balance system, but there is still more to discover about growth processes.


Growing in space.

The results from plant research in space can lead to an extended use of plants onboard spacecraft, for example to regulate the level of gases in the cabin air (plants absorb carbon dioxide and give off oxygen) and to recycle water (as they can be used to filter wastewater). The results can also give valuable knowledge that people on Earth can benefit from, for example on how to improve crops or develop new medicines.



Earth by night.

Worksheet C: Watching the Earth – Time zones, pages 133-136

Answers:

1. What's the time in Vienna when it is 14:00 in Moscow?
   It's 12:00 in Vienna.

2. What's the time in Lisbon when it is 21:00 in Helsinki?
   It's 19:00 in Lisbon.

3. What's the time in Sydney when it is 08:00 in Nairobi?
   It's 15:00 in Sydney.

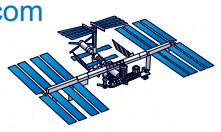
4. What's the time in Vancouver when it is 16:00 in Singapore?
   It's 00:00 in Vancouver - at least during winter. In summer, Vancouver is on "Pacific Daylight Time" – daylight saving time or summer time in Europe – and is only 13 hours behind Singapore, so it's 1:00.

5 What's the time in Lima when it is 24:00 in Tokyo?
   It's 10:00 in Lima.

If these numbers are too difficult for your pupils, one suggestion is to write up other times on the blackboard (times that don't include calculation over too many time zones).

Related topics:
Chapter 4.1 "Living on board the International Space Station". Worksheet D "Day and night" and Worksheet E "The year through".

Websites:
Timeanddate.com



4.3 Coming home

Lesson – core elements:

Pupil's text:	Spacecraft bring the astronauts back to Earth Parachutes deploy to slow down the spacecraft Astronauts feel gravity, they have to rest in bed for a few weeks Astronauts are sad to leave, though looking forward to meet friends and family They are eager to tell people on the ground about their adventures They will always dream about a new mission
Worksheets:	Friction Prepare an interview Summarise what you have learnt Memory card game

Subjects represented:
Science
Language
Arts


Leaving Earth.

Background information:
Sooner or later – an ISS crew's tour of duty lasts between three and six months – it is time to return to Earth. The replacement crew has been on board for a week or so while the old hands show them the ropes; the old hands have sympathised with the newcomers' space sickness and smiled at the clumsy way they regularly bang into walls and assorted pieces of equipment (even highly experienced astronauts need a little time to re-adapt when they return to space). The outgoing astronauts have probably been unable to resist showing off their own agility in zero-gravity, skills they have had months to learn.

There are two ways to return to Earth, just as there are two ways to reach the ISS: by Space Shuttle or by Soyuz. (For a time, after the loss of the Space Shuttle Columbia, travel was by Soyuz alone.) In either case, the astronauts must face the dangers of re-entry into the Earth's atmosphere. On board the Station, they are travelling at around 28 000 km/h: they must


Shuttle flying with open cargo bay.

André Kuipers is helped out of the Soyuz capsule.

somehow lose that speed in order to make a safe landing on the ground. It is impossible to carry enough rocket fuel for such a colossal deceleration. Instead, their spacecraft will use the last of its fuel to drop just below orbital speed. It will fall into the atmosphere, and use air friction as a brake to kill its speed.

Friction means heat: parts of the spacecraft will reach temperatures of more than 2000 degrees Celsius. The Shuttle has heat-resistant tiles to protect it, and the Soyuz is equipped with a heat shield. But re-entry is a dangerous procedure as the astronauts are well aware: some of their comrades have died during it.

There is a brief ceremony at the docking hatch; the hatch is closed; and the spacecraft breaks free. At a safe distance from the Station, the rockets fire. With apparent slowness, the craft begins to fall. On board, the astronauts feel the first faint tugs of deceleration as their spaceship meets the thin air of the upper atmosphere. It is the first time for months that they have felt any weight at all. The deceleration increases: the heat shield better be working properly, for the air around the craft is so hot that it glows. Radio messages cannot penetrate the hot cloud: the crew, for a few minutes, are utterly alone.

Roberto Vittori is checked by the doctor.

By now, though, most of the speed has gone. The air – and the heat shield – cool. On board, the returning astronauts feel the full force of Earth's gravity: it seems unbelievably strong. They can barely lift their arms against it, and even breathing is difficult. On board the Shuttle, the pilot – who brought up the other crew – steers the craft to a safe landing. On the Soyuz, a parachute automatically deploys, and as the capsule nears the ground, rockets fire to slow it still further: it touches down with scarcely a bump.

Claudie Haignieré waves to the press.

In each case, colleagues and medical teams await to help the astronauts out. None can really walk, although most are determined to try. They will need weeks of care and bed rest before they have even partly re-adapted to what they still feel is Earth's crushing gravity. But recover they will. They look up at the sky, where the Station is orbiting out of their sight. They'll be back, they promise themselves.

Ideas and hints for the worksheet activities:

Worksheet A: A spacecraft returning to Earth, pages 139, 140

This activity is about friction and can be used to explain why a spacecraft returning to Earth needs a heat shield. Upon re-entry into the atmosphere a spacecraft encounters particles that cause friction and thus heat on its outside. Manned spacecraft have to return their crew safely to Earth and thus need a good shield. Let the pupils think about situations in their daily lives in which they experience friction (e.g. when they ride their bike and need to brake, slowing down naturally on the bike, skiing, skating etc.)

Worksheet B: Prepare an interview with an astronaut, page 141

Astronauts give a lot of interviews before they go to and after they return from space. The public is curious about their experience on board the Space Station. Talk about what an interview is and how to conduct and write an interview. Explain that interviews are edited and the text that is printed is often shorter than the interview itself. To prepare the interviews the pupils could gather information from the astronaut biographies and from their mission websites (links see below). There are also examples of interviews.

Worksheet C: Make your own memory game, pages 142 – 146

This last worksheet is intended to summarise in a playful way what the pupils have learned. The pictures represent a chapter each. Talk about what you see in the pictures and check how much the pupils remember and what they have learnt. They can also design their own playing cards.

Additional Activity:

Subscribe to the news pages of ESA website.
Write a press release about a successful mission.
Compile a newspaper with the interviews you have conducted, or produce a TV news programme.

Related topics:

Chapter 2.1, Worksheet A, “Apply to become an astronaut”
Chapter 3.3, “Getting things there and back”
Chapter 4.1, Worksheet C, “An astronaut’s day and your day”

Websites:

Interviews, see astronaut biographies for more background information to prepare the interview http://www.esa.int/esaHS/astronauts.html
Friction, http://www.fearofphysics.com/Friction/frintro.html
http://www.bbc.co.uk/schools/scienceclips/ages/8_9/friction.shtml

Mission websites

Delta Mission, http://www.esa.int/Delta
Cervantes http://www.esa.int/Cervantes
Eneide, http://www.esa.int/Eneide/
Odissea http://www.esa.int/Odissea

Future missions, http://www.esa.int/esaHS/future.html
Aurora Exploration Programme, http://www.esa.int/SPECIALS/Aurora/index.html
ATV: http://www.esa.int/SPECIALS/ATV/index.html