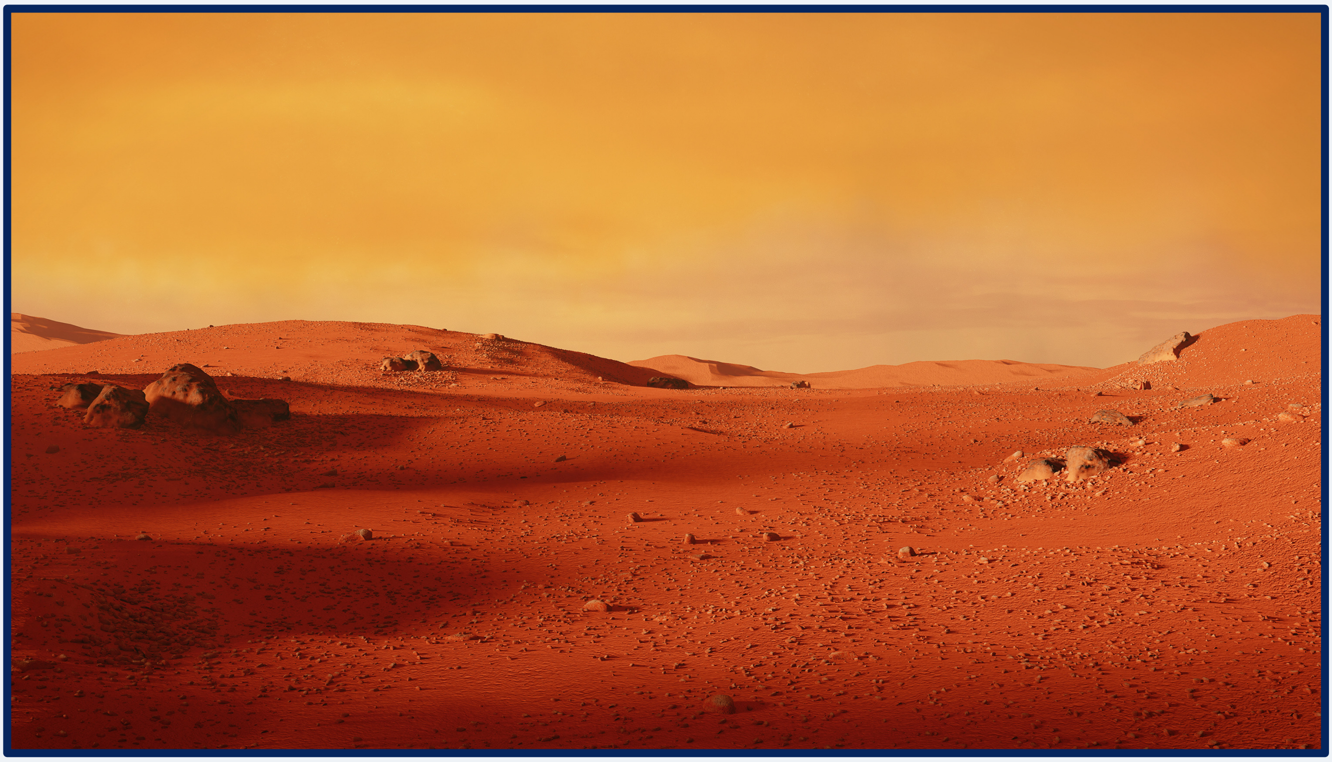
Can We Get Humans to Mars?



Teacher Handbook

THE SCHOOLS' OBSERVATORY

FUNDED BY A PARTNERSHIP GRANT FROM THE ROYAL SOCIETY

PROUD TO BE PART OF LIVERPOOL JOHN MOORES UNIVERSITY

Can We Get Humans to Mars?

Welcome

This free programme (funded by Liverpool John Moores University and the Royal Society) is designed to spark curiosity, build scientific skills, and give students a taste of real-world space exploration.

Information about the specific skills students will develop, and how the project links with Gatsby Benchmarks, is included in the appendices.

Project Overview

The overall Mars project consists of 6 mini-investigations.

Investigations 1, 3, 5 and 6 are delivered by STEM Professionals from Liverpool John Moores University. Prior to each one, please check the relevant information given in the specific sections of this handbook.

Investigations 2 and 4 are delivered by you as the class teacher. Information and guidance about these investigations can be found in the specific sections of this handbook.

Evaluation

To help us and the Royal Society evaluate this project, we ask for feedback from your students. This is done as pre- and post-evaluation postcards.

Please read the information provided in the specific section of this handbook and ensure everything is completed before Investigation 1.

We would also greatly appreciate it if you could facilitate your students completing any of the creative extension activities outlined in the information for Investigation 6.

Table of Contents

Pre- and Post-Evaluation Postcards for Students

Pre- and Post-Evaluation Postcards for Students

Postcards Overview

As part of the evaluation for this project, pupils will complete pre- and post-evaluation postcards. These quick, pupil-friendly questions will help us understand how their views and confidence in science change over the course of the project.

The postcards should only take a few minutes to complete with whole-class guidance from the STEM Professional.

Pre-evaluation: completed at the start of Investigation 1.
Post-evaluation: completed at the end of Investigation 6.

Postcards will be returned to The Schools' Observatory team and kept securely locked away. All data will be anonymised before evaluation.

Relevant Information for Teachers

Before Investigation 1

- Please send out the Parent/Carer Information Sheet (this explains the project and what data will be collected).
- Please send the opt-out consent form to parents/carers.
- Record any pupils whose parents/carers do not give consent for evaluation activities (see table opposite). These pupils can still take part in the investigations.

During Investigation 1 (pre-evaluation postcards)

The visiting STEM professional will bring the printed postcards and guide the class through how to complete them.

We would appreciate your support to:

- help hand out the postcards.
- support any pupils who need help following the instructions.
- ensure opted-out pupils do not complete a postcard.
- help collect the postcards at the end and hand back to the STEM professional who will return them to our team.

During Investigation 6 (post-evaluation postcards)

The same process will take place at the end of Investigation 6.

Pre- and Post-Evaluation Postcards for Students

Students who should not complete the evaluation postcards:

Student Name	Student Name

Investigation 1 (STEM Professional)

Where Should We Build a Moon Base?

Where Should We Build a Moon Base?

Learning Objectives

- To identify and describe key features of the Moon's surface
- To select and justify a suitable landing site for a Moon Base
- To request real astronomical observations and interpret the data to support scientific inquiry

Career Link: Geologist

Curriculum Links

Subject	Topic	Year	Topic Elements
Science	Working Scientifically	Lower KS2	Making systematic and careful observations and, where appropriate, taking accurate measurements using standard units, using a range of equipment, including thermometers and data loggers
			Gathering, recording, classifying and presenting data in a variety of ways to help in answering questions
			Recording findings using simple scientific language, drawings, labelled diagrams, keys, bar charts, and tables
			Reporting on findings from enquiries, including oral and written explanations, displays or presentations of results and conclusions
			Identifying differences, similarities or changes related to simple scientific ideas and processes
		Upper KS2	Recording data and results of increasing complexity using scientific diagrams and labels, classification keys, tables, scatter graphs, bar and line graphs
			Reporting and presenting findings from enquiries, including conclusions, causal relationships and explanations of and degree of trust in results, in oral and written forms such as displays and other presentations

Where Should We Build a Moon Base?

Subject	Topic	Year	Topic Elements
Science	Light	Y3	Recognise that they need light in order to see things and that dark is the absence of light
			Notice that light is reflected from surfaces
			Recognise that shadows are formed when the light from a light source is blocked by an opaque object
	Rocks		Compare and group together different kinds of rocks on the basis of their appearance and simple physical properties
	Earth and space	Y5	Describe the movement of the Moon relative to the Earth
			Describe the Sun, Earth and Moon as approximately spherical bodies
Geography	Human and physical geography	KS1	Use basic geographical vocabulary to refer to key physical features
		KS2	Describe and understand key aspects of physical geography
	Geographical skills and fieldwork	KS1	Use aerial photographs and plan perspectives to recognise landmarks and physical features; devise a simple map; and use and construct basic symbols in a key
Computing	KS1		Use technology purposefully to create, organise, store, manipulate and retrieve digital content
			Recognise common uses of information technology beyond school
			Use technology safely and respectfully, keeping personal information private
	KS2		Understand computer networks including the internet; how they can provide multiple services, such as the world wide web; and the opportunities they offer for communication and collaboration

Investigation Overview

This is the beginning of an exciting journey. Students will help plan one of the biggest missions in human history – getting people to Mars.

The project and the reasons for our mission is outlined to students. They'll consider space exploration history and the challenges involved, which justifies why we must first go to the Moon.

Pupils will learn about key features on the Moon's surface and how these are identified. They'll consider what makes a good Moon Base location and select a site.

Finally, students will use The Schools' Observatory's website to submit an observation request for their chosen location.

Relevant Information for Teachers

Before the Investigation

- Register as an educator on The Schools' Observatory website.
- Once registered, please create student accounts for your class (use the table on pages 19 and 20 to record the information).
- Students will be using The Schools' Observatory's website. Please arrange for devices (e.g. laptops, tablets) with internet access and installed web browsers to be available when the STEM Professional is delivering the investigation.
- Pupils will write their account username and password in their workbooks. Please ensure they have this information.
- Pupils will need sharp pencils and glue sticks for this investigation.

During the Investigation

- Pupils will be using The Schools' Observatory website to request an observation of a section of the Moon. The STEM Professional will guide the class through the steps for this. However, the instructions are provided for reference and/or supporting students.

After the Investigation

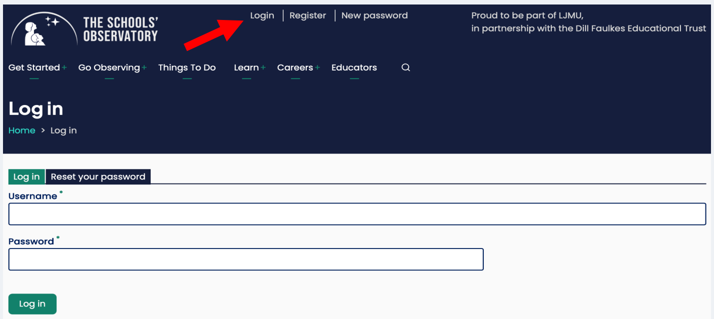
The final activity involves requesting a Moon observation from the Liverpool Telescope. This may take days or weeks to complete depending on weather conditions and moon phase.

- When a pupil's observation is ready, there will be an option to 'View Image' in 'My Observations' (see *Instructions: Taking a Moon Observation*). Please print a copy of this image (see *Instructions: Obtaining an Image*) for students to stick in their workbooks.
- Alternatively, if an observation is taking too long to complete, use the archive to find previous images of a specific moon section (see *Instructions: Using the Archive*).

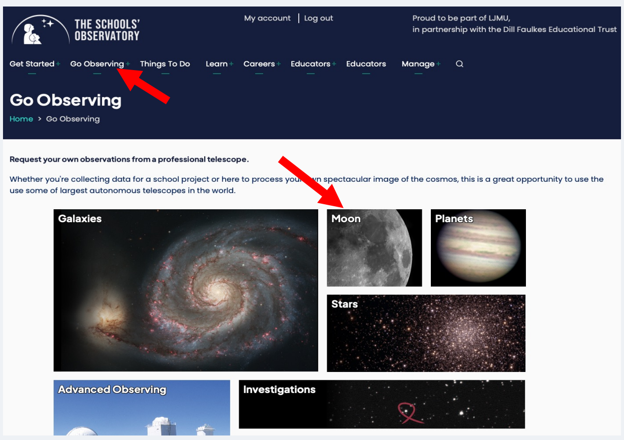
Instructions: Taking a Moon Observation

The STEM Professional will guide students through the following steps.

1) Log in to The Schools' Observatory website.



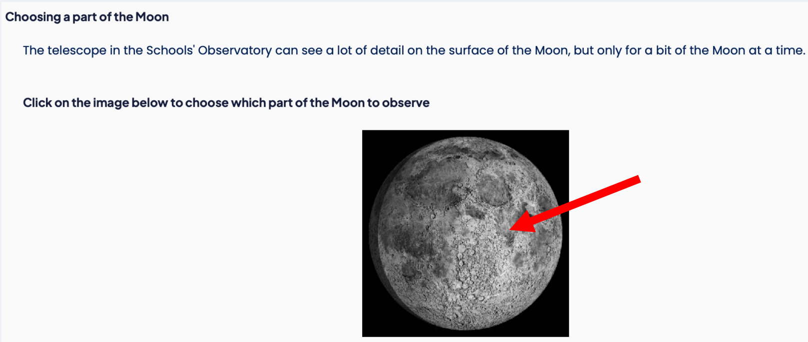
2) Click 'Go Observing' from the top menu and then select 'Moon' from the options.



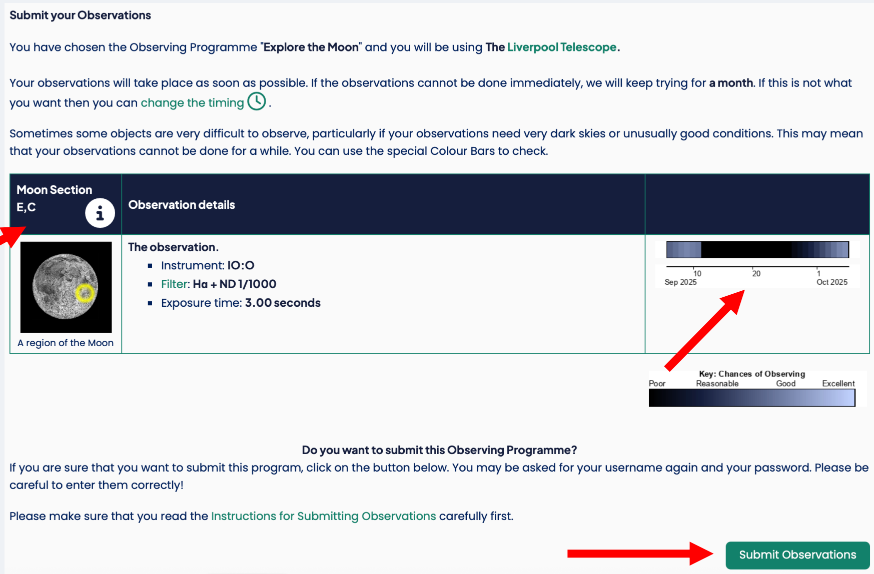
Where Should We Build a Moon Base?

3) Select 'Observe The Moon'.

4) Click an area of the Moon – for students, this will be their chosen site (marked in their workbooks).



5) Ask students to write down the letter of their section e.g. 'Moon Section E, C'.

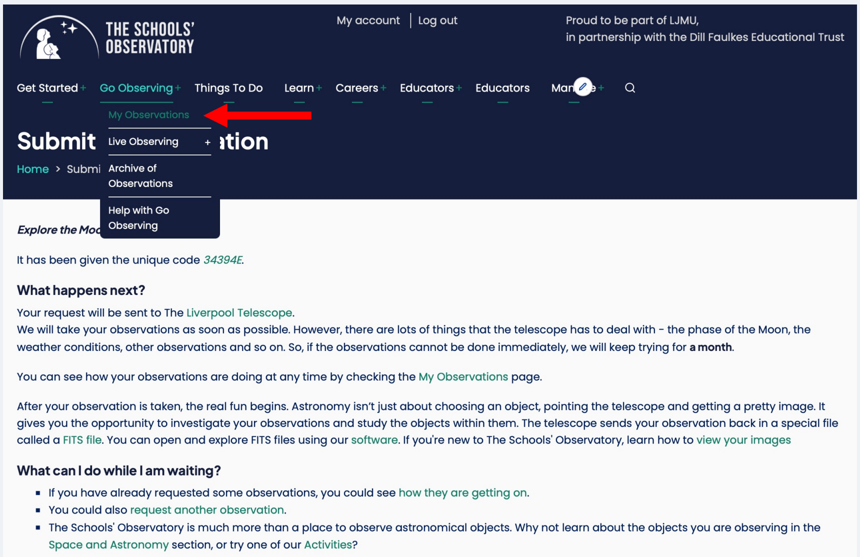


6) Explain the colours of the visibility bar – lighter means better chances of observing.

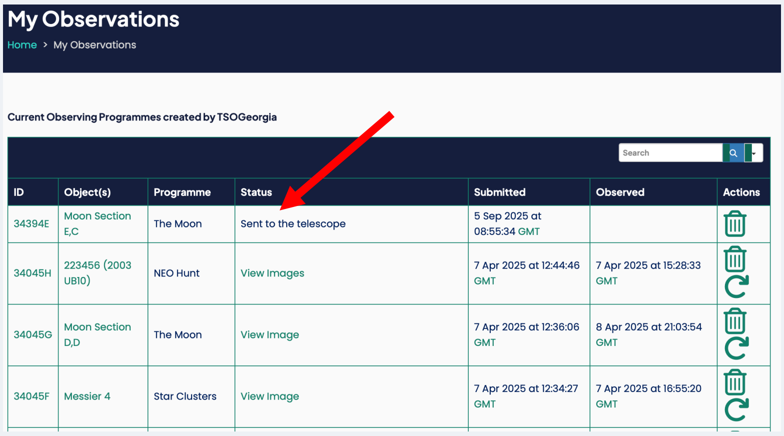
The chance of observing changes due to the Moon's phases – the amount of reflected sunlight we see depends on the position of the Moon in its orbit.

7) Click 'Submit Observation'.

8) To review the status of the observation, go to 'Go Observing' → 'My Observations'.



9) Tell students they can keep checking the status, but it might take days/weeks to complete, depending on the Moon's phase.



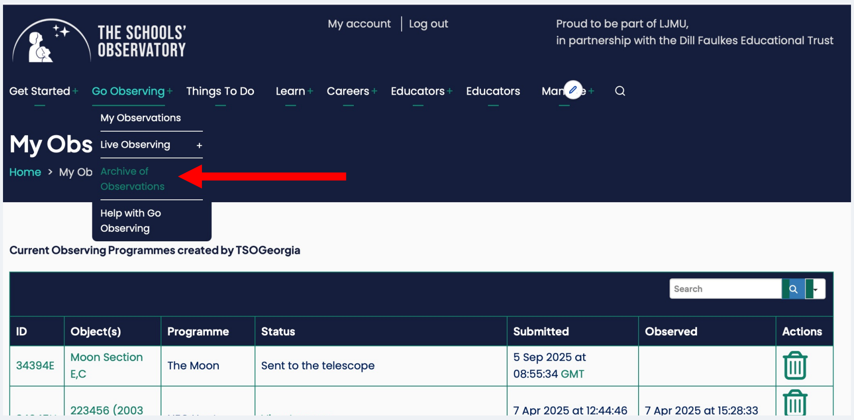
When an observation is ready, the student will see 'View Image' in the 'Status' column. Click this and follow the steps in *Instructions: Obtaining an Image* to get a picture.

Please print these and have students stick them in their workbooks.

Instructions: Using the Archive

If you want your students to have images of their Moon sections quicker, you can find previous data in the archive.

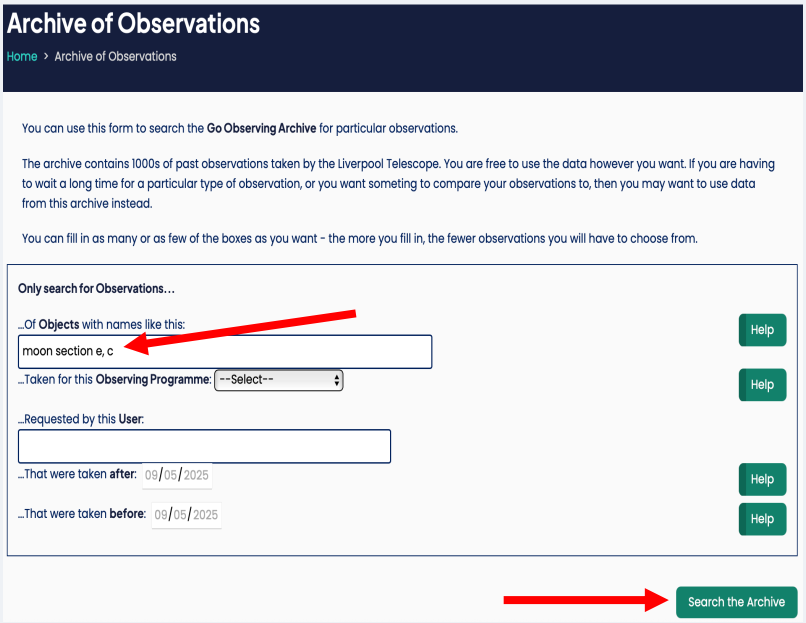
1) Go to 'Go Observing' → 'Archive of Observations'.



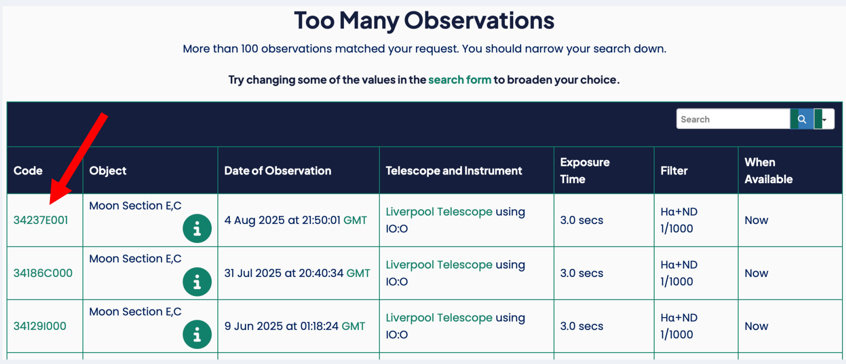
2) Type in the name e.g. 'Moon Section E, C'.

Typing in lowercase is fine, but students **must** include the comma between letters.

3) Click 'Search the Archive'.



4) Check the object name is correct, and then click on the code number.



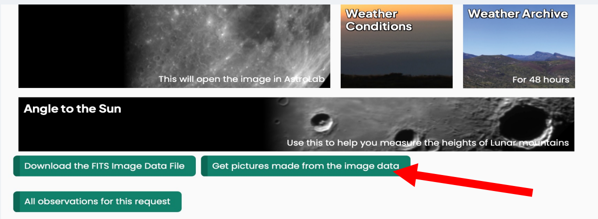
Instructions: Obtaining an Image

There are two options for obtaining an image – A: Making a picture, or B: AstroLab. You can choose whichever method you prefer.

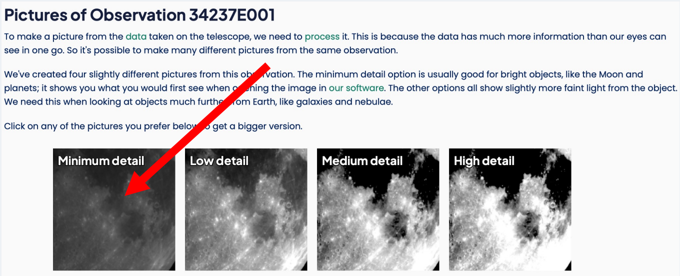
Follow the steps in either A or B for your method.

Option A: Making a Picture

1) a) Click 'Get pictures made from the image data'.



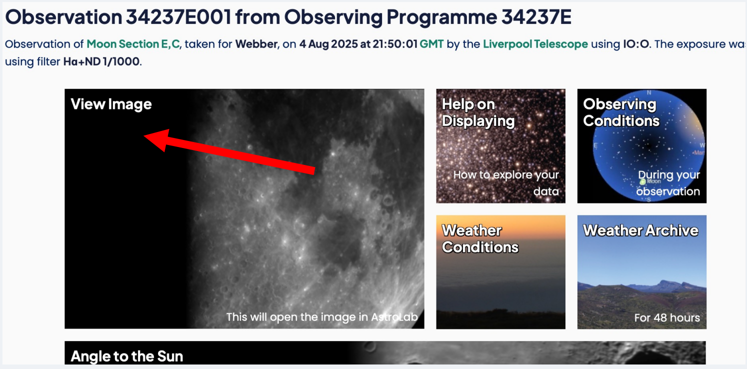
2) a) Select 'Minimum detail'.



3) a) An image will appear in a new window. This can be saved by students and then printed.

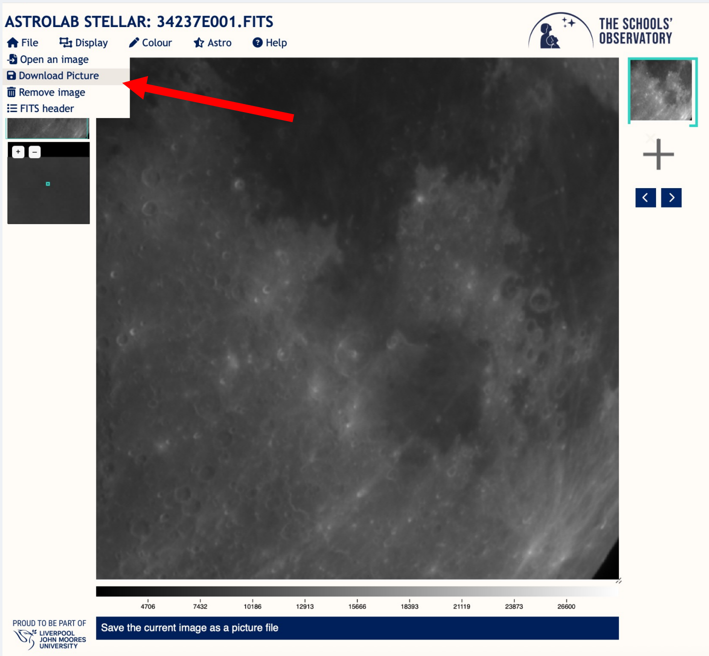
Option B: AstroLab

1) b) Click the 'View Image' panel.



2) b) AstroLab will appear in a new window. Go to 'File' → 'Download Picture'.

This saves the image in the downloads folder. Students can then print it.



Students may see 'AstroLab Nova' at the top instead of 'AstroLab Stellar'. This is just a different version of AstroLab for primary school students – step 2)b) can still be completed.

If you have time, you can explore other features in AstroLab like 'Colour' → 'False Colours' or 'Astro' → 'Measure Size' to find out the size of craters, a sea/mare, etc.

Extension Activities

If you wish to further explore the content from the STEM professional led investigation, please find the suggested ideas below:

- Use The Schools' Observatory's online tool to explore the Timeline of the Apollo Missions and understand how humans first reached the Moon and what was learned from these missions.
- Make Your Own Impact Crater by having students drop objects into flour/sand to see how craters form and investigate the factors affecting size and shape.
- Show students the video What Can We See on the Moon? to discover the many different features on its surface.
- Use The Schools' Observatory's online tool to explore Why Does the Moon Have Phases?
- Print the Moon Phases Poster from The Schools' Observatory's website and display it in your classroom.

Note: Underlined text is hyperlinked – please open the online version of this handbook to explore these in more detail.

Alternatively, you can search the name in the Things To Do! section of The Schools' Observatory's website.

Where should we build a Moon base?

Student Account Details

Student Name	Username	Password

Where should we build a Moon base?

Student Name	Username	Password

Investigation 2 (Teacher)

What Do Humans Need to Survive?

What Do Humans Need to Survive?

Learning Objectives

- To identify the basic resources for human survival on Earth and in space
- To reflect on Earth's sustainability and protecting our planet
- To design a Moon Base with essential life systems

Career Link: Engineer/Architect

Curriculum Links

Subject	Topic	Year	Topic Elements
Mathematics	Number - number and place value	Y3	Compare and order numbers up to 1000
		Y5	Interpret negative numbers in context, count forwards and backwards with positive and negative whole numbers, including through zero
	Number - fractions (including decimals)	Y4	Compare numbers with the same number of decimal places up to two decimal places
	Measurement	Y3	Measure, compare, add and subtract: lengths (m/cm/mm); mass (kg/g); volume/capacity (l/ml)
	Statistics	Y3	Interpret and present data using bar charts, pictograms and tables
		Y4	Solve comparison, sum and difference problems using information presented in bar charts, pictograms, tables and other graphs
		Y5	Complete, read and interpret information in tables, including timetables
	Ratio and proportion	Y6	Solve problems involving the calculation of percentages and the use of percentages for comparison

What Do Humans Need to Survive?

Subject	Topic	Year	Topic Elements
Science	Working Scientifically	Lower KS2	Identifying differences, similarities or changes related to simple scientific ideas and processes
			Using straightforward scientific evidence to answer questions or to support their findings
	Animals, including humans	Y3	Identify that animals, including humans, need the right types and amount of nutrition, and that they cannot make their own food; they get nutrition from what they eat
		Y6	Recognise the impact of diet, exercise, drugs and lifestyle on the way their bodies function
	Living things and their habitats	Y4	Recognise that environments can change and that this can sometimes pose dangers to living things
	Electricity		Identify common appliances that run on electricity
	Forces	Y5	Explain that unsupported objects fall towards the Earth because of the force of gravity acting between the Earth and the falling object
Design and Technology	Design	KS2	Generate, develop, model and communicate their ideas through discussion, annotated sketches, cross-sectional and exploded diagrams, prototypes, pattern pieces and computer-aided design
	Cooking and nutrition		Understand and apply the principles of a healthy and varied diet
Geography	Human and physical geography	KS2	Describe and understand key aspects of Human geography, including: types of settlement and land use, economic activity including trade links, and the distribution of natural resources including energy, food, minerals and water

Lesson Plan

Possible Student Misconceptions:

- Only the Earth has gravity
- Gravity only acts on the planet's surface
- Plants breathe like humans

Materials:

- Lesson PowerPoint presentation
- Student Workbooks
- Pencils, coloured pencils, felt-tips, etc.
- Optional: Teacher Handbook (see referenced pages for more information/guidance about the activity)

Duration	Activity	Pages	Materials
2 minutes	Recap the last investigation and how it links to the current investigation and overall Mars project.	Teacher Handbook: 27	Lesson PowerPoint presentation
8 minutes	Students reflect on the question 'If we wanted to live elsewhere in space, what would we need to survive?'. Students complete the 'Resources for Survival' activity in their workbooks. Discuss answers as a class before students mark their work.	Teacher Handbook: 28 – 31 Student Workbook: 13	Lesson PowerPoint presentation Student Workbooks
5 minutes	Students reflect on the question 'What other resources would make astronauts feel happy, comfortable, and less homesick?'. Students complete the 'Essential or Extra?' activity in their workbooks. Show answers to class and have students mark their work.	Teacher Handbook: 31 – 34 Student Workbook: 13	Lesson PowerPoint presentation Student Workbooks
10 minutes	Show and discuss the comparison table for Earth, Moon, and Mars. Students use this to complete the 'Comparing the Earth, Moon, and Mars' activity in their workbooks. Show answers to class and have students mark their work.	Teacher Handbook: 35 – 36 Student Workbook: 14 – 16	Lesson PowerPoint presentation Student Workbooks

Duration	Activity	Pages	Materials
10 minutes	Explain to students the unique features of our planet. Show students the pictures of human activities that are damaging the planet and ask 'What's gone wrong?'. Select some students to share their ideas and discuss as a class. Show the video on slide 20. Students list ways of being more sustainable to complete the 'Caring for Planet Earth' activity in their workbooks. Discuss answers as a class before students mark their work.	Teacher Handbook: 37 – 39 Student Workbook: 16	Lesson PowerPoint presentation Student Workbooks
25 minutes	Guide students through the 'Moon Base Design' activity. There is information and guidance in the student workbooks. The PowerPoint presentation also contains some relevant videos that you can show, if needed.	Teacher Handbook: 40 – 45 Student Workbook: 17 – 25	Lesson PowerPoint presentation Student Workbooks Pencils, coloured pencils, felt-tips, etc.

Note: *Some videos in the PowerPoint presentation contain footage from the International Space Station. Its orbit around the Earth (being in constant freefall) means astronauts experience weightlessness.*

Emphasise to students that these are just examples of life in space – their bases on the Moon (and Mars, in the future) will experience gravity, though it'll be less than Earth's gravity.

The activity 'Comparing the Earth, Moon, and Mars' allows students to directly compare the strength of gravity.

How does it link to the Mars project?

In the previous investigation, students studied the Moon's surface and identified some observable features. They then choose a location for their Moon Base and requested an observation of this area.

In this investigation, students will act as engineers/architects to design their bases. They must consider the key resources needed for survival and make sure these are included in their plans.

A Moon Base could act as a launch site towards Mars. Yet, more importantly, it lets us model building and living in a base much closer to Earth. This is beneficial because Moon-Earth communication is quicker than Mars-Earth, resupplies can arrive in around 3 days, and people can easily be evacuated to Earth if anything goes wrong.

By testing equipment and techniques in a safer location (the Moon), the base can be improved before it is built much further away on Mars.

Investigation Overview

Students will think about the resources on Earth that are important for survival, how these are obtained, and the impact this has on the sustainability of our planet.

They will also compare environmental features of the Earth, Moon, and Mars – not only to shape the design of their Moon Base, but to reflect on the importance of living sustainably as well.

Using the template Moon Base design and provided prompts, students will draw and label the different items within their base and explain how these can help them to survive.

Further information and guidance is provided in the specific sections for each activity.

Activity: Resources for Survival

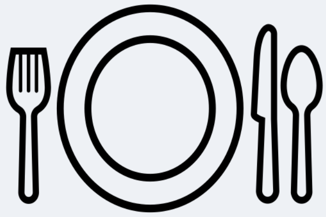
Show slide 4 of the PowerPoint presentation and ask students to think about the resources they'd need to survive in space. You could lead a class discussion or have students talk in pairs/group to generate ideas.

Pupils should write in their workbooks. As an extension task, they circle which resources are easier to get on Earth vs the Moon or Mars.

Show the answers on slide 6. The main resources that we've identified are food, water, oxygen, shelter, and electricity/power. Other resources mentioned by students may be more relevant to the next activity.

Food

Pupils may give this answer or use specific examples of food instead (e.g. cereal).



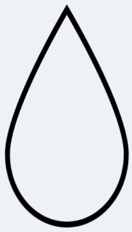
If an example is used, ask if it would be healthy to eat only that food all the time.

This highlights that different foods give us different nutrition, and that a healthy diet consists of a variety of foods eaten in the right amounts.

You may want to have students recall the different food groups, examples of foods within a group, and the role of each one for our bodies (e.g. meat or beans being a source of protein, and protein being used to build and repair tissues in the body).

The video on slide 6 of the PowerPoint presentation details how NASA tries to ensure their astronauts receive a balanced diet. It also explains why reducing the items mass is beneficial – less mass on board a rocket means less fuel is needed to transport it into space, which saves money and is also more sustainable.

Food on the International Space Station is usually heated and/or rehydrated with water before consumption. Spicy foods are popular. Due to the way scent travels onboard and the effects of microgravity on the body, many astronauts report senses like taste and smell being dulled, which can make food taste bland.



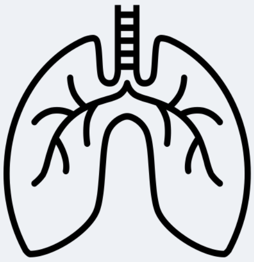
Water

Pupils may give this answer or state another type of drink or food with a high-water content (e.g. cucumber).

Whilst these other foods/drinks are beneficial in ways (e.g. vitamins in fruit juice), they may not contain the daily amount of water we need.

Water is important for our bodies. It keeps us cool by helping to regulate our temperature (the average body temperature is 37°C). It helps chemical reactions happen inside of us, too. An example is during digestion when larger food molecules are broken down into smaller ones, which are more easily absorbed into the blood.

Nutrients and waste dissolve in the water in our blood, which are then transported around the body when blood is circulated.



Oxygen

If any pupils say 'air', emphasise that humans (and most animals) need *oxygen* from the air to survive.

We breathe in oxygen. It's used in a chemical reaction in our cells (which releases energy) that is important for life processes (e.g. growth, repair, digestion). Carbon dioxide is produced as waste, and we breathe it out. Breathing requires the lungs.

Plants need carbon dioxide from the air for photosynthesis. They produce oxygen as waste, which moves out of the plant through tiny holes (known as pores) on the underside of leaves. As plants do not have lungs, this process is *not* called breathing.

Some pupils may say that plants are important for survival as we use them for food (directly – by eating, or indirectly – energy flow in food chains/webs); therefore, carbon dioxide is needed in the air for plants.

This is true, and you can discuss the role of plants as producers in food chains/webs. However, still emphasise that humans need oxygen from the air and that our bodies don't use carbon dioxide for any processes.

Shelter
Students may give this answer, a specific example, or say ‘protection’ or ‘safety’.

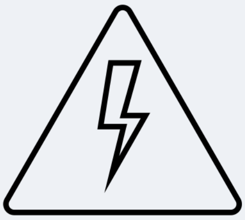
Others may refer to sleep or having somewhere warm, dry and/or protected from the weather, which links to shelter.

Almost all living things need shelter. Ask students about what shelter provides. It protects us from the environment and gives a safe place to sleep, which is important for our bodies to grow and heal properly.

You could discuss examples of shelter in different habitats. For example, houses in the UK have lots of insulation, but those built in warmer climates don’t. They might even be painted white/light-coloured to reflect heat.

In space, shelter protects us against risks of extreme temperatures, high radiation levels, and micrometeoroids (tiny bits of rock and metal).

Electricity/Power
Pupils may give this answer or an example of a device which requires electricity.



Electricity makes it easier to access the resources we need. You could ask students how they use electricity, making links to the previous answers.

For example, we use electricity to cook food, produce food packaging/containers, and build the transportation for moving food between locations. Electricity powers pumps that transport water from different sources to houses. It also powers the water treatment plants that make water safe for use.

In space, electricity would be used in the spacecraft/basecamp where humans live to run the systems that keep them alive (e.g. air pumps, water recycling).

Extension Task – Answer

All the resources are easier to get on Earth. Because the conditions (e.g. temperature, atmospheric composition and density) of the Moon and Mars are so different, we'd have to bring resources from Earth.

Whilst there is frozen water on the Moon and Mars, it would need to be extracted, transported to base, and made safe for use.

Electricity could be generated off-Earth (e.g. with solar panels). However, this – along with extracting frozen water – would require bringing equipment with us.

If you've not already done so, show students the video on slide 6 of the PowerPoint presentation. Along with the information given earlier (in the food section), you can emphasise that resources need to be brought into space with us. This requires fuel which is expensive.

Therefore, we must analyse the pros and cons of each item on board our spacecraft and only take those that are truly needed.

Activity: Essential or Extra

Ask students 'What other resources would make astronauts feel happy, comfortable, and less homesick?'. You can lead a class discussion or use mini-whiteboards and select some students to share their answers.

The following prompt images are included in the PowerPoint presentation (on slide 8). You may wish to discuss some of the following information with your class.

Image: NASA

Some pupils may give a specific example of something they find fun (e.g. playing video games).

Spending time on fun activities can be good for our health.

It reduces stress and improves our mood, which helps our physical health too.

It can boost creativity and imagination, which might help us in other ways (e.g. finding a creative way to solve a problem when we get stuck).

Some pupils might give answers such as 'family' and/or 'friends', or ways in which we can speak to them (e.g. phones, computers).

You might discuss how being able to talk with others can help us feel supported; it can reduce stress and improve our mood, which helps our physical health too.

You could also highlight the importance of communication in other areas, such as working together as a team and learning from each other.

For example, ground crews on Earth have regular contact with astronauts to get updates on how the mission is going and to help solve any problems that arise.

What Do Humans Need to Survive?

Exercise helps us stay healthy and live longer.

It strengthens bones and muscles; for the heart muscle, it improves blood circulation (cardiovascular health).

Our energy levels increase. Regular exercise is even good for our mental health and can help us sleep better.


Image: NASA

You could discuss how different types of exercise affect the body e.g. running improves cardiovascular health and stamina, lifting weights strengthens muscles.

You might ask students how exercise can be targeted based on age, career, or specific circumstances. For example, recovering from a broken bone requires not moving that part of the body while it heals, and since this will weaken muscles, a person might have physical therapy afterwards to build muscle strength.

Investigation 4 ‘How do we Stay Healthy in Space?’ will explore some types of exercises and training that astronauts complete.

After the class discussion, ask students to complete the table in their workbook. They must tick the listed resources as ‘essential’ or ‘extra’.

There are 2 blank spaces in the table that students can fill in with their own resources as an extension task. Ask them to explain why the resources are ‘essential’ or ‘extra’.

The table on the following page has information you could discuss with your class.

Answers are provided on slide 10 of the Powerpoint presentation.

What Do Humans Need to Survive?

Resource	Answer	Information
Oxygen	Essential	Oxygen is used by our body's cells for life processes. On the International Space Station, oxygen is generated from water (which contains hydrogen and oxygen atoms joined together). Splitting it apart with electricity provides oxygen for the astronauts to breathe.
Pizza	Essential/ Extra	Humans cannot produce their own food like plants do. That's why we must eat food to get the nutrients we need. But pizza isn't particularly healthy. And sending things into space costs a lot of money. We should prioritise bringing food with the most nutritional value.
Pets	Extra	Many people don't have pets. But they can provide companionship and reduce loneliness and stress, which boosts physical and mental health.
Music	Extra	Whilst not essential, listening to music or playing an instrument is a form of entertainment, the benefits of which have been previously discussed.
Beds	Essential/ Extra	Sleeping in a comfortable bed lets us rest better, which is good for recovery and health. However, a bed isn't necessary for sleep (e.g. a sleeping bag when camping). But we still need something to sleep in/with that keeps us warm. This is especially important in colder climates.
Hot Showers	Extra	Most people prefer the comfort of hot showers, but we can survive without them. There are different health benefits for both hot and cold showers.
Plants	Essential/ Extra	As producers, plants are an essential resource on Earth. But we don't need to take them into space – we can bring packaged food instead (though, ultimately, the food packs exist because of plants on Earth). Plants also give out oxygen – another essential resource. But in space, life systems provide oxygen (e.g. generating oxygen from water on the International Space Station).
Video Games	Extra	Whilst not essential, video games are a form of entertainment, the benefits of which have been previously discussed.

Activity: Comparing the Earth, Moon, and Mars

Comparing some key features of the Earth, Moon and Mars will help students understand the resources available and plan their Moon Base.

Show the comparison table from the PowerPoint presentation (on slide 12). It is also provided for students in their workbooks. They can complete the activity using this table.

Before starting the activity, you could discuss the data as a class using the following information.

Average Temperature (°C)

The unit of measurement is degrees Celsius. Temperature varies depending on location – the data has accounted for this. For Earth and Mars, the average accounts for day and night temperatures as well.

Mars is colder than Earth as it's further from the Sun. It also has a thinner atmosphere, so heat is reflected back into space. Earth's thicker atmosphere acts like a blanket to limit reflections into space. It 'traps' heat and keeps the surface warm.

The Moon has virtually no atmosphere. Its temperature differences are more extreme. Atmospheres protect against the Sun's intense radiation by scattering heat and limiting the amount that reaches the surface in the first place. Without this protection, the Moon's surface scorches when facing the Sun and plummets in temperature when turned away.

Strength of Gravity (g)

The unit of measurement is g or g-force. 1g is the force a stationary object (e.g. a person standing still) on Earth experiences.

The strength of gravity depends on the mass of an object. Mars is less massive than Earth, so has around 40% of Earth's gravity. The Moon is the least massive and has around 16% of Earth's gravity.

In weaker gravity environments, our bodies aren't working as hard to overcome gravity's pull, so bones and muscles lose density and strength. Astronauts living in space regularly exercise to combat this.

Mass of Atmosphere (kg)
The unit of measurement is kilograms. Most of an atmosphere's mass is concentrated towards the surface. It becomes thinner as altitude (vertical height) increases. On Earth, less air means less oxygen, which can impact breathing.

Atmospheres protect against space hazards such as UV radiation from the Sun and meteoroids (which burn up due to the heat generated by the frictional force of air resistance). Earth has the thickest atmosphere, so offers us more protection than Mars or the Moon.

If greenhouse gases are present in the atmosphere, like on Earth, then heat from the Sun can be retained. It essentially acts as a blanket and stops the temperature from dropping too low during nighttime. You can refer back to the average temperature data to illustrate this.

If students need help understanding the powers given in the data, you can relate it to squared (^{2}) and cubed (^{3}) numbers e.g., 2^3 is larger than 2^2. So, the larger the power, the larger the number. You could also write the numbers in full.

Gases in Atmosphere
The data shows the percentage of gases that exist in each atmosphere. When discussing similarities and differences, focus on the gases (e.g. nitrogen) as well as the amount (e.g. there is 78% nitrogen on Earth but only 2.5% on Mars).

However, consider the mass of each atmosphere as well. For example, argon makes up 21% of the Moon's atmosphere compared to 2% of the Martian atmosphere. But the Moon's atmosphere is much lower in mass and contains less particles – and, therefore, less argon. It's like comparing 21% of 10 to 2% of a million.

Once students have completed the activity, you can show the answers on slides 13 – 16 of the PowerPoint presentation.

Activity: Caring for Planet Earth

Life hasn't been discovered anywhere else in the Universe. This suggests Earth's unique conditions (e.g. temperature, atmosphere, physical geography) are best for supporting life as we know it.

But extracting Earth's resources can damage our planet and impact the conditions we rely upon. This is unsustainable, especially when our increasing human population puts more demand on resources.

Ask students to reflect on the ways we get resources. The following images are included in the PowerPoint presentation (on slide 19). You could discuss some of the given information with your class.

Humans produce a lot of waste that isn't always correctly disposed. Environmental harms of littering include microplastics in water, animals becoming sick/dying from ingestion, and damage to habitats.

Even correctly disposed waste may end up in landfills, with toxins potentially being absorbed into the ground.

Water is an essential resource. But man-made dams and reservoirs can stop water from reaching needed areas.

Crops/animals used for food and other resources require water too (e.g. it takes 10,000 litres of water to produce 1 kg of cotton for clothing). If water demand is too high, it may run out in a certain location.

Image Link – Factory

Industries emit greenhouse gases (like carbon dioxide). These limit reflection of heat from the planet's surface, making Earth warm and liveable. But having too much in the atmosphere 'traps' more heat. This increases the planet's temperature and affects the water cycle.

Climate change (caused by global warming) increases the frequency of extreme weather events such as droughts.

Factories mass-produce resources, but they can cause air, land, and/or water pollution from toxic substances or through greenhouse gas (e.g. carbon dioxide) emissions.

Factories also use large amounts of electricity. Currently, most electricity is generated by burning fossil fuels. This releases carbon dioxide into the atmosphere.

Ask students which every-day items are factory-produced. You could debate if the benefits (e.g. short production times, convenience) outweigh any damages.

Image Link – Water Scarcity
Industries emit greenhouse gases (like carbon dioxide). These limit reflection of heat from the planet's surface, making Earth warm and liveable. But having too much in the atmosphere 'traps' more heat. This increases the planet's temperature and affects the water cycle.

Climate change (caused by global warming) increases the frequency of extreme weather events such as droughts.

Image Link – Deforestation
Mass production puts a strain on resources. Trees may be cut down for resources (e.g. paper, furniture), or to clear space for infrastructures such as factories.

Image Link – Mining
Mass production puts a strain on resources. Resources like minerals and metals are mined from the earth. An increased demand leads to more mining activities.

Large areas of forests are levelled to raise cattle or grow crops. Some land may be used for infrastructure instead.

Deforestation massively impacts the ecosystem. A direct effect is species losing their habitats, which can decrease populations and put them at risk of extinction.

Indirectly, carbon dioxide increases in the atmosphere. Trees are carbon sinks, absorbing and storing more carbon dioxide than they release. When cut down (and especially if burnt), carbon dioxide is emitted back into the atmosphere.

Image Link – Factory
Trees may be cut down for resources (e.g. paper, furniture), or to clear space for infrastructures such as factories.

Image Link – Mining
A forest may be cleared to mine resources from the ground beneath it.

Overfishing affects all other living things in the ecosystem.

Fish prey populations increase drastically since less are being eaten.

Fish predators may suffer population decreases if alternative food sources are lacking. Or, if they do hunt other species, those populations will decrease instead.

You could discuss food chains/food webs with your students, asking them about the consequences of certain changes. In a balanced ecosystem, population numbers of species may change slightly at certain points, but they remain stable over a longer span of time. If there is a drastic change, however, this can have consequences. Ultimately, a food web may collapse if put under too much strain.

Fishing can also damage habits of marine life, further disrupting the ecosystem. Boats might cause pollution through fuel use and plastic.

Many resources are extracted from underground.

This includes minerals (e.g. limestone that is used for construction), metals (e.g. copper which is used in many electronics), fossil fuels (e.g. oil, which is burned to generate electricity), and gemstones (e.g. diamonds used in jewellery).

Mining increases energy demand; fuel to run vehicles, electricity to operate equipment. Therefore, more fossil fuels are burned, increasing carbon dioxide in the atmosphere. Depending on the resource being mined, it can also cause land and/or water pollution.

Mining now happens more frequently due to population growth and upgrades to infrastructure and technology.

Image Link – Factory
Resources like minerals and metals are mined from the earth. An increased demand leads to more mining activities.

Image Link – Deforestation
A forest may be cleared to mine resources from the ground beneath it.

What Do Humans Need to Survive?

Show students the video on slide 20 of the PowerPoint presentation. It details some ways that a primary school is acting sustainably.

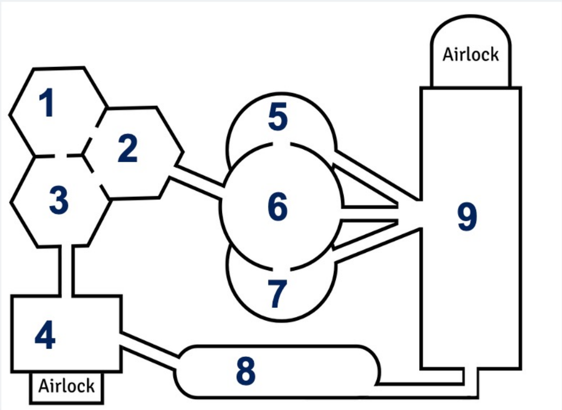
Ask students to write ideas about living more sustainably in their workbooks. Some answers are given on slide 21, but you or your students may have thought of many more.

You could discuss with pupils which ideas are the most feasible. For example, some regions do not have good public transport links. Other areas may have a limited diversity of wildlife to care for, or perhaps pupils don't have access to outdoor space at home.

Other factors to consider are the cost, effort, and the time expense involved, as well as individual abilities and circumstances.

Emphasise to students that no single person can do everything, but lots of people making small contributions can still make a big difference.

Activity: Moon Base Design



The student workbooks has this design template, which has 9 rooms/modules of varying shapes and sizes.

They must place the 9 types of rooms (see table on following pages) somewhere in their base and detail the items in them (by drawing, labelling, etc.).

They should consider how many people will live in the base and how this affects the facilities needed.

Pictures and item prompts are included in the student workbooks. The pictures are also in the PowerPoint presentation, along with videos that may be helpful if students get stuck on planning a particular room. You don't need to show all the videos, but you may wish to if time allows.

What Do Humans Need to Survive?

This table has information that you could discuss with your class.

Room	Information
Food Supply Room	Food must be nutritional and not perish easily/quickly. Student might consider food packaging and how to store food. Ask pupils if any of them have been camping and discuss the food they ate. Initially bringing food is vital, however long-term sustainability should be considered. Sending resupplies to the Moon would take around 3 days – for Mars, it could take months. This also uses a lot of fuel. Growing crops is an alternative. Ask students about plant requirements and how to recreate those conditions on the Moon and Mars.
	Item prompts in Student Workbook: Food that won't go mouldy or rot quickly, shelves or cupboards for storing items, crops/plants to eat, equipment to care for plants (like lighting or water sprinklers)
Communications Room	People at the Moon Base must be able to contact Earth. Ask students how they communicate with others when they're apart e.g. mobile phones, internet. Many communication systems (TV, radio, Wi-Fi, etc.) use radio waves to send and receive data, audio, and images/videos. The International Space Station (ISS) communicates with Earth via radio waves. A network of satellites transmits signals and data between the ISS and our planet.
	Item prompts in Student Workbook: Computers/Laptops, cameras, microphones, headsets/headphones, satellite dishes, radio antennas

Room	Information
Water and Air Filtration Room	Most of the water on the International Space Station is recycled from waste and cleaned to make it safe. You could make links to students' knowledge of separating techniques (if the topic content has been previously taught). Students should understand that the Moon's atmosphere is unsuitable for humans, so we'll need to recreate conditions like on Earth. This may include using oxygen generators or oxygen tanks. Fans can be added to move air throughout the base, and filters are needed to get rid of exhaled waste carbon dioxide Students could consider the proximity of specific rooms as well. A lot of water is used in the bathroom, so placing this room beside it means water can be returned and recycled quickly. If crops are grown, then placing this room and the food supply room together ensures the plants receive water quickly.
	Item prompts in Student Workbook: Water tanks, water filters (to clean the water), oxygen generators (to turn water into oxygen for breathing), air filters (to clean the air), fans, pipes for moving water and air to different places
Bathroom	Students could consider the number of facilities in the room and the location of the room in the base. For example, they might place the bathroom next to the water and air filtration room room so water can move quickly between them.
	Item prompts in Student Workbook: Toilets, showers, sinks

What Do Humans Need to Survive?

Room	Information
Bedroom	Students should consider what is needed for restful sleep and how many people will be living in their Moon Base. Astronauts on the International Space Station often have trouble sleeping. One reason is because the ISS orbits the Earth 16 times a day, so experiences 16 sunrises and sunsets. The Moon spins on its axis much slower than Earth. It takes 29.5 Earth days for the Moon to complete 1 full rotation (1 lunar day). There'll be periods of total darkness and total brightness. A Martian day, in comparison, is only 36 minutes longer than Earth's. However, astronauts work in shifts around the clock, so some may need to sleep whilst it's still bright outside regardless of being on the Moon or Mars. To help with this, students might have artificial lighting in their base and put shutters on any windows they want to add. Another reason for lack of sleep is the loud equipment – especially air fans on the International Space Station. Placing the bedroom away from noisier rooms could minimise this.
	Item prompts in Student Workbook: Sleeping bag/covers, mattress, pillows, bed frame, storage space (for clothes, personal items, and other things), sleeping masks and earplugs
Living Quarters with Kitchen	Students should include kitchen appliances and items for entertainment. Ask them how they relax or have fun and consider the feasibility of bringing certain items e.g. a drum kit compared to a handheld games console. Students could consider the location of the room. Placing it near the food supply room is the most convenient option.
	Item prompts in Student Workbook: Kitchen appliances (like an oven or microwave), kitchen items (like pans, utensils, cutlery, plates, or bowls), tables and chairs, items for entertainment (like TV screens and books)

Room	Information
Electricity/Power Supply Room	Most electricity on Earth is produced by making a turbine spin to power a generator. Heat from burning fossil fuels turns water into steam. This passes through a turbine and makes it spin. Similarly, wind turns the blades of wind turbines. Solar panels are a potential option. They absorb energy from the Sun, causing a current to flow. Batteries can store excess electricity for use when needed (such as during the nighttime period). Some students might have already considered using power packs or batteries in some way. More recently, the option of using nuclear energy is being explored. Rolls-Royce are hoping to develop a small nuclear reactor (around 1-metre x 3-metre in size) that could be used in space. This research is being funded by the UK Space Agency. Nuclear power relies on a process called nuclear fission – bigger (heavier) atoms splitting into smaller (more lightweight) atoms. Energy is released, and this is used to heat water into steam, which then spins a turbine and powers a generator.
	Item prompts in Student Workbook: Fuel cells/batteries (to store extra electricity), electrical circuits with wires/cables (to transport electricity), solar panels (on the outside of the room), nuclear reactor
Medical Room with Gym	It isn't feasible to bring certain medical equipment/supplies. For example, an ultrasound scanner can be transported much easier than a big and heavy MRI machine. The limited available space also means only taking that which is most useful and needed. Ask students about what is included in a first aid kit to help prompt some ideas if needed. The gym should include equipment for maintaining muscle and bone strength, as this weakens in lower gravity environments. But other ways to stay healthy can be included as well.
	Item prompts in Student Workbook: Medical equipment (like an ultrasound scanner or X-ray machine), medical items (like bandages, gloves, needles, or thermometers), medicines (like painkillers or antibiotics), exercise equipment (like treadmills, weights, or rowing machines)

<table>
<tr><th>Room</th><th>Information</th></tr>
<tr><td rowspan="2">Science Lab</td><td>Ask students to think about science experiments they could carry out on the Moon or Mars and what equipment is needed.

You can make a link to ‘Investigation 3: How do you control a robot rover?’, which involves using a rover to explore the Martian surface and find out more about the conditions there.

Some examples of experiments happening on the International Space Station (ISS) include:
• Understanding how our bodies change in low-gravity environments
• Exploring how microbes behave in space
• Exploring how plants grow in space
• Testing out water purification methods
• Monitoring Earth from a different perspective (e.g. looking at atmosphere, oceans, land, etc.)

Another idea is studying rocks and other samples from the surface of the Moon or Mars. This could be to better understand the formation of these bodies, to look for signs of water, etc.</td></tr>
<tr><td>Item prompts in Student Workbook: Microscope, glassware (like beakers, flasks, and test tubes), glass slides (for looking at samples under a microscope), measuring cylinders, funnels, Bunsen burner, safety goggles and gloves, tweezers or forceps, droppers or pipettes, mixing rods, thermometers, stopwatches or timers, scales for measuring mass, notebooks for recording information/data</td></tr>
</table>

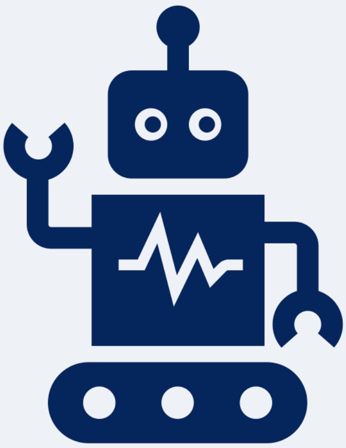
Extension Ideas

If you wish to explore the content from this investigation further, we have a list of suggested ideas below:

- Give students a range of materials to create a model of their base
- Grow different plants on the classroom windowsills to test which conditions support the best growth
- Have students write a diary entry about daily life in their Moon Base and describe the rooms and equipment
- Discuss how to make the classroom or school more sustainable and choose actions to take (students could design posters, speak in assemblies, etc.)

Investigation 3 (STEM Professional)

How Do You Control a Robot Rover?



How Do You Control a Robot Rover?

Learning Objectives

- To understand the role of robotic rovers in planetary exploration
- To develop basic programming and debugging skills using a block-based coding environment to control a rover
- To collaborate in teams to complete a Mars rover mission by applying logical thinking and problem-solving

Career Link: Engineer/Computer programmer

Curriculum Links

Subject	Topic	Year	Topic Elements
Computing		KS1	Understand what algorithms are; how they are implemented as programs on digital devices; and that programs execute by following precise and unambiguous instructions
			Create and debug simple programs
			Recognise common uses of information technology beyond school
		KS2	Design, write and debug programs that accomplish specific goals, including controlling or simulating physical systems; solve problems by decomposing them into smaller parts
			Use sequence, selection, and repetition in programs; work with variables and various forms of input and output
			Use logical reasoning to explain how some simple algorithms work and to detect and correct errors in algorithms and programs
			Select, use and combine a variety of software (including internet services) on a range of digital devices to design and create a range of programs, systems and content that accomplish given goals, including collecting, analysing, evaluating and presenting data and information

How Do You Control a Robot Rover?

Subject	Topic	Year	Topic Elements
Science	Working Scientifically	Lower KS2	Gathering, recording, classifying and presenting data in a variety of ways to help in answering questions
			Reporting on findings from enquiries, including oral and written explanations, displays or presentations of results and conclusions
			Using results to draw simple conclusions, make predictions for new values, suggest improvements and raise further questions
			Identifying differences, similarities or changes related to simple scientific ideas and processes
Mathematics	Geometry – position and direction	Y4	Describe positions on a 2-D grid as coordinates in the first quadrant
Geography	Geographical skills and fieldwork	KS1	Use simple compass directions and locational and directional language to describe the location of features and routes on a map

How Do You Control a Robot Rover?

Investigation Overview

In the previous investigation, students designed their own Moon Base. This helped them understand what humans would need to survive beyond Earth, and why practising on the Moon is important.

Before sending humans, space agencies use robotic rovers to explore, collect data, and test technologies.

In this investigation, students will act as engineers and computer programmers. They will explore how coding and debugging are used to control robots, linking this to real rovers on Mars.

Pupils will work in teams to complete 4 scientific missions on a Mars canvas using programmable rovers called ‘mBots’. Each mission reflects a real scientific challenge they may be faced with on Mars.

Relevant Information for Teachers

Before the Investigation

- This investigation requires a large, indoor space. Please book a school hall or similar venue if possible. Pupils will be controlling robot rovers (mBots) around a Mars canvas (A0 size) on the floor. There will be 4 canvases per class.
- Pupils will be working in 8 teams. You may wish to contact the STEM Professional and discuss student groupings ahead of time.
- Students will use a software called MakeBlock. Please arrange for 8 devices (e.g. laptops, tablets) with internet access and Bluetooth to be available during the investigation.
- Please see the set-up instructions for your device type (iPads and Android Tablets or Laptops (Windows, macOS, Chromebooks)) and ensure any required steps are complete.
- Please co-ordinate an early arrival for STEM Professionals and give access to devices so mBots can be connected.

How Do You Control a Robot Rover?

Set-up Instructions: iPads and Android Tablets

- Download the mBlock app by scanning the provided QR code for your device. On iPads, you can also search ‘mBlock’ in the App Store.

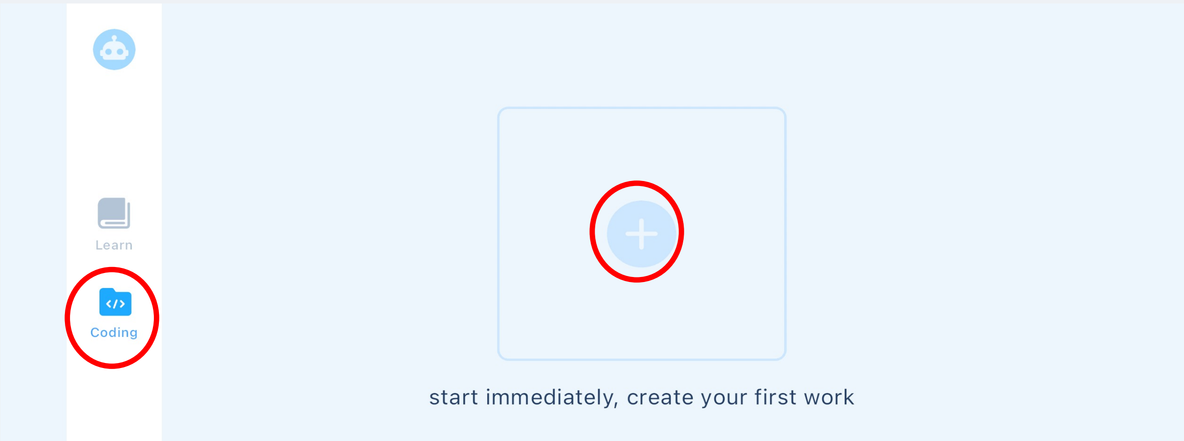
iOS

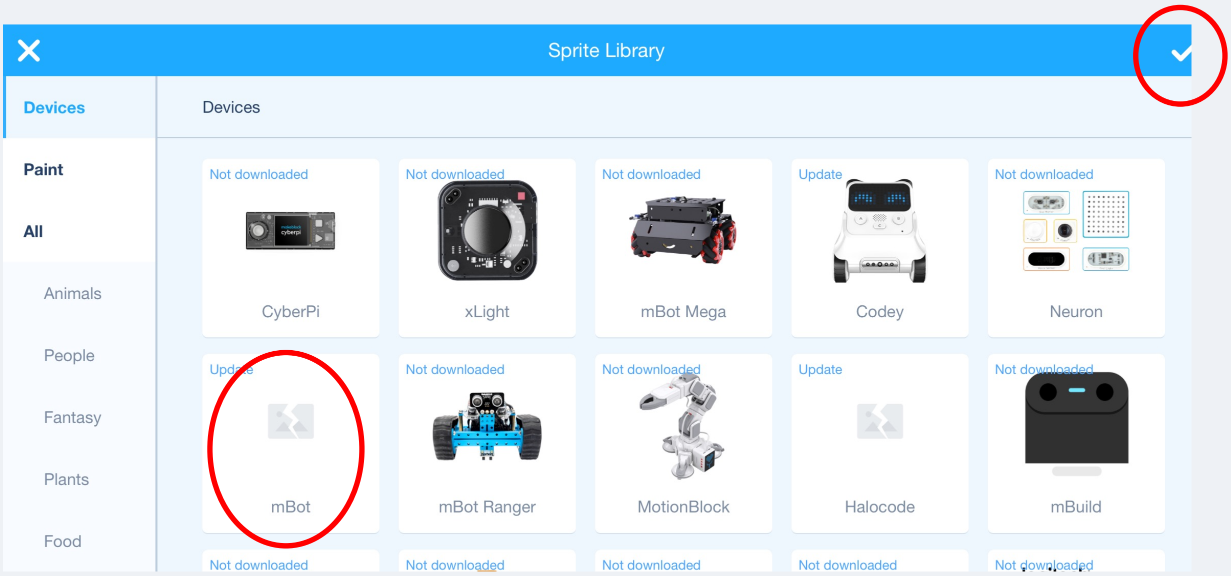
iOS 10.0 +

Android

Android 6.0 + (ARM-based devices only. X86 Android not supported)

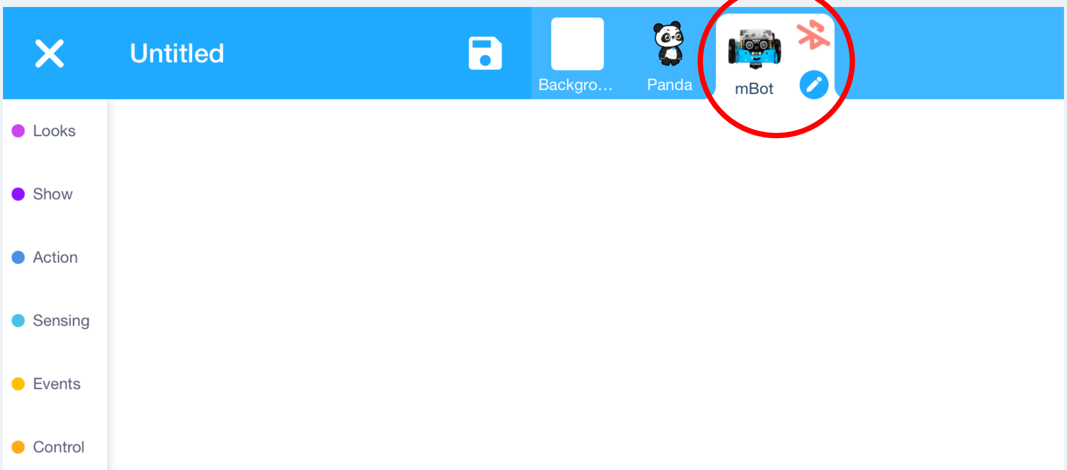
- Open mBlock and select ‘Coding’.
- Tap the ‘+’ button and choose ‘mBot’. Tap ‘update’ then the tick mark.

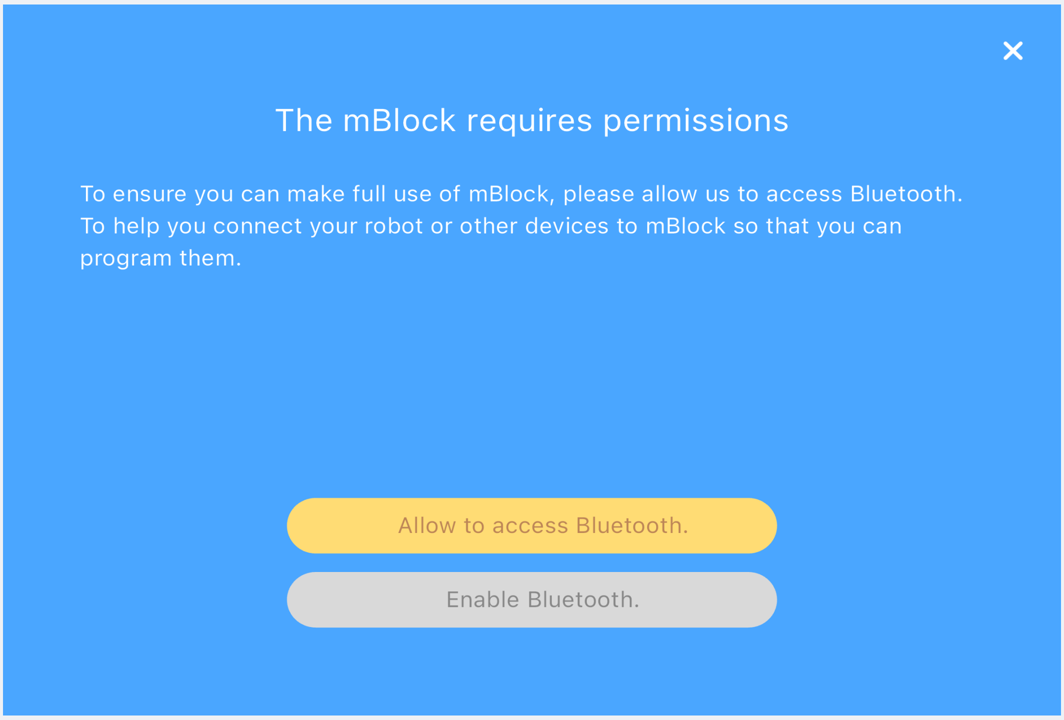




How Do You Control a Robot Rover?

- Tap the robot icon with the Bluetooth symbol and allow Bluetooth permissions.



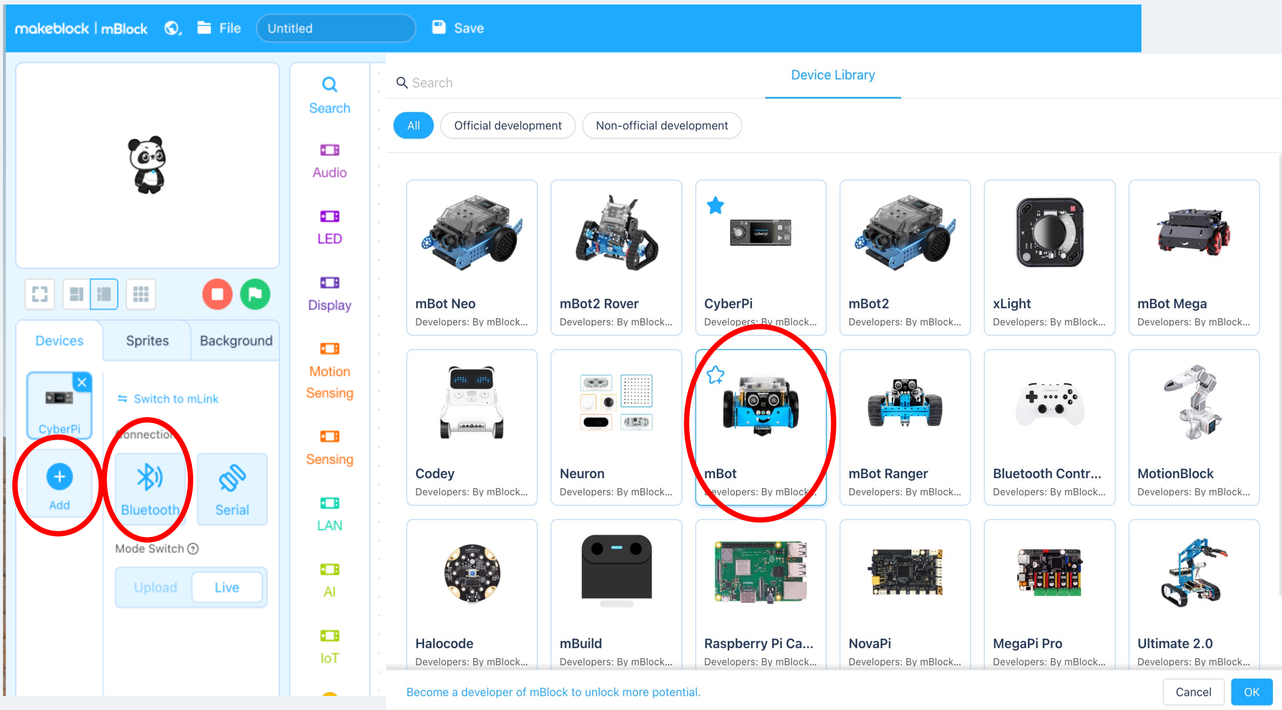


- If Bluetooth permissions are blocked, please contact your IT technician to enable them.

- If you have any issues with installation, Wi-Fi, or Bluetooth permissions, please inform your STEM professional as soon as possible (at least a few days before the investigation). We can help troubleshoot and/or provide an alternative solution.

Set-up Instructions: Laptops (Windows, macOS, Chromebooks)

- Make sure Google Chrome browser is installed and up to date.
- Check that Bluetooth is enabled on the device.
- Open Google Chrome browser and Go to: https://ide.mblock.cc
- Then click on the '+' add button and choose 'mBot' then tap 'OK'.



- Check whether the Bluetooth button is available (not greyed out).
- If it is greyed out or cannot be enabled, please contact your IT technician to adjust permissions/settings.
- If you have any issues with installation, Wi-Fi, or Bluetooth permissions, please inform your STEM professional as soon as possible (at least a few days before the investigation). We can help troubleshoot and/or provide an alternative solution.

Extension Activities

If you wish to further explore the content from the STEM professional led investigation, please find the suggested ideas below:

- Have pupils draw a design of their own Mars rover. Encourage them to think about the tools it would need (e.g., a drill, camera, weather sensor).
- Ask students to write a short diary entry as if they are a rover on Mars, describing what they see, what they measure, and how they "feel" as a robot.
- Provide images of the Martian surface (e.g., from NASA or The Schools' Observatory). Pupils can identify features such as craters, valleys, and volcanoes, and plot possible rover routes on a map.
- Give pupils simple Mars datasets (e.g., daily temperatures, dust storm speeds). Ask them to plot graphs or compare averages. This ties into maths and science skills.

THE SCHOOLS' OBSERVATORY

PROUD TO BE PART OF LIVERPOOL JOHN MOORES UNIVERSITY

Investigation 4 (Teacher)

How Do We Stay Healthy in Space?

Learning Objectives

- To know some of the dangers of human space exploration
- To practice and develop key physical skills
- To evaluate performance and recognise success

Career Link: Medic/Nutritionist/Physical Trainer

Curriculum Links

Subject	Topic	Year	Topic Elements
Mathematics	Measurement	Y3	Measure, compare, add and subtract: lengths (m/cm/mm); mass (kg/g); volume/capacity (l/ml)
			Record and compare time in terms of seconds, minutes and hours
			Compare durations of events
		Y4	Convert between different units of measure
			Estimate, compare and calculate different measures, including money in pounds and pence
		Y5	Convert between different units of metric measure (for example, kilometre and metre; centimetre and metre; centimetre and millimetre; gram and kilogram; litre and millilitre)
			Solve problems involving the calculation and conversion of units of measure, using decimal notation up to three decimal places where appropriate
		Y6	Use, read, write and convert between standard units, converting measurements of length, mass, volume and time from a smaller unit of measure to a larger unit, and vice versa, using decimal notation to up to three decimal places

Subject	Topic	Year	Topic Elements
Mathematics	Statistics	Y3	Interpret and present data using bar charts, pictograms and tables
		Y4	Solve comparison, sum and difference problems using information presented in bar charts, pictograms, tables and other graphs
		Y5	Complete, read and interpret information in tables, including timetables
		Y6	Calculate and interpret the mean as an average
Science	Working Scientifically	Lower KS2	Making systematic and careful observations and, where appropriate, taking accurate measurements using standard units, using a range of equipment, including thermometers and data loggers
			Gathering, recording, classifying and presenting data in a variety of ways to help in answering questions
			Recording findings using simple scientific language, drawings, labelled diagrams, keys, bar charts, and tables
			Reporting on findings from enquiries, including oral and written explanations, displays or presentations of results and conclusions
			Using results to draw simple conclusions, make predictions for new values, suggest improvements and raise further questions
			Using straightforward scientific evidence to answer questions or to support their findings

How Do We Stay Healthy in Space?

Subject	Topic	Year	Topic Elements
Science	Working Scientifically	Upper KS2	Taking measurements, using a range of scientific equipment, with increasing accuracy and precision, taking repeat readings when appropriate
			Recording data and results of increasing complexity using scientific diagrams and labels, classification keys, tables, scatter graphs, bar and line graphs
			Reporting and presenting findings from enquiries, including conclusions, causal relationships and explanations of and degree of trust in results, in oral and written forms such as displays and other presentations
	Animals, including humans	Y6	Recognise the impact of diet, exercise, drugs and lifestyle on the way their bodies function
Physical Education	KS2		Use running, jumping, throwing and catching in isolation and in combination
			Develop flexibility, strength, technique, control and balance
			Compare their performances with previous ones and demonstrate improvement to achieve their personal best

Lesson Plan

Possible Student Misconceptions:

- There is no gravity in space
- Living in space doesn't affect the human body

Materials:

- Student Workbooks
- Pens/Pencils for students
- Resources for each chosen activity (see specific activity section for a list of equipment)
- Optional: Lesson PowerPoint presentation (for relevant videos you could show to the class before/after the investigation)
- Optional: Teacher Handbook (see referenced pages for more information/guidance)

Duration	Activity	Pages	Materials
10 minutes	Students change into PE kits and go to where the lesson will take place.		
5 minutes	Recap the last investigations and how this connects to the current investigation and overall Mars project. Read the information in the student workbooks (*Some Dangers of Human Space Exploration*) to contextualise why astronauts undergo training.	Teacher Handbook: 61 – 62 Student Workbook: 35	Student Workbooks
5 minutes	Perform a warm-up with students.		
30 minutes	Have students complete the chosen activities. This can be done in a circuit training style, or by splitting the class into pairs/groups and performing the activities together one after another.	Teacher Handbook: 63 – 78 Student Workbook: 36 – 51	Student Workbooks Pens/Pencils Resources for each chosen activity
10 minutes	Perform a cool-down with students before they change back into their school uniforms.		

How does it link to the Mars project?

In previous investigations, students learned how to establish bases beyond Earth and how we can use robot rovers to explore regions far away from bases or too dangerous for humans.

In this investigation, students will act as health professionals and explore how training is fundamental to a successful mission – not only to keep ourselves healthy, but to work efficiently as well.

We must understand the effects of alien environments on the human body and how to reduce any negative impacts. Astronaut training also incorporates drills to practice key aspects of the job role (e.g. exercises to improve reaction times, learning how to manoeuvre in spacesuits).

Investigation Overview

Students will learn about some of the risks associated with human space exploration and how astronauts prepare for these.

They will then perform activities that simulate different aspects of astronaut training. Some highlight different essential skills, and others focus on how astronauts deal with issues of the space environment.

These are from the '*Mission X – Train Like an Astronaut'* project, which is supported by the European Space Agency (ESA) and UK Space Agency (UKSA) and facilitated by European Space Education Resource Offices (ESEROs) and volunteer national organisers.

The Schools' Observatory have adapted them for duration length and to incorporate students recording measurements in their workbooks.

We have also included questions for pupils to reflect on their results and draw conclusions/make links to the wider world. These can be completed as students do the activity or afterwards in a classroom.

Further information and guidance is provided in the specific sections for each activity.

Creating Your Lesson

The Schools' Observatory have selected 8 activities to choose from that link best with the project. The student workbooks contains them all, but it's not expected that they complete everything!

Simply choose activities based on school resources and facilities, class size, individual pupil needs, etc. We recommend a lower number (e.g. 3). It could be useful if another staff member can help you facilitate.

The activities can be done in a circuit training style, with pupils moving from activity to activity in a carousel. Alternatively, split your class into pairs/groups and perform each activity together one after another.

The investigation is best completed in a gym/hall. However, some activities are suitable for the classroom, if needed.

Note: Check the information for each activity and ensure your class has the relevant skills/knowledge to complete it (e.g. the '*Jump For The Moon*' activity requires students locating their pulse and counting their heartbeat).

Information: Some Dangers of Human Space Exploration

Read the information given in the student workbooks with your class. Students can think about these dangers as they complete activities. At the end, ask how each activity relates to/reduces risks of the dangers.

For example, 'The Speed of Light' activity tests reaction time. This is important when travelling in a rocket (to perform manoeuvres at the right time) and when wearing spacesuits in the space environment (to complete tasks quickly in the limited time available).

The Lesson PowerPoint presentation contains some videos related to astronaut training. Though it isn't necessary to show these, you may wish to before or after the investigation. They might engage students prior to the investigation and help to contextualise the activities.

Activity: Mission Control

Physical Skills – balance, concentration, coordination, hand-eye coordination, reaction time, stability.

Equipment – tennis ball (or similar), stopwatch.

Student Workbook – pages 36 and 37.

Overview

Students balance on one leg, repeatedly throwing a ball at the wall. They record the time it takes until they lose balance or drop the ball. On their next turn, they swap legs and repeat the activity.

The results table includes 3 attempts on each leg; however, some can be left blank if time runs out. But students must have at least 1 result recorded for each leg to compare and reflect on their balance.

This activity may be easier in pairs, with one student performing the task and the other using the stopwatch.

Astronaut Training Context

Balance is affected by gravity. We don't notice this on Earth, as we've adapted to the conditions of our planet – such as its gravitational field. However, the strength of gravity depends on the mass of the object. The bigger the mass, the stronger its gravitational pull.

Both the Moon and Mars are less massive than Earth, so their gravitational fields are weaker. The smallest is the Moon, which has around a sixth (~16%) of the gravity we experience on Earth. Mars has around two fifths (~40%) of Earth's gravity.

With less force pulling us downwards, our sense of balance needs time to adjust. Astronaut training includes exercises that focus on balance and spatial awareness, which hopefully helps to reduce any initial disorientation and nausea from being in a lower-gravity environment.

Student Workbook Answers
Along with answers, the following information gives further detail and possible discussion points to share with your students.

Did you balance better on your left leg or right leg?
This will be different for each student. The leg may or may not be on the same side as their dominant hand.

How do your results show that you balanced better on that leg?
Students should find their times are longer for either the left or right leg. This is the side with better balance.

Why might your balance be better on that leg compared to the other?
When walking or standing, we can unconsciously put more weight on one leg, making the muscles stronger. This makes it easier for that leg to support us when balancing. A weaker leg may shake when we put our weight on it, making it difficult to balance.

The activities we do can also influence muscle strength. For example, when playing football, the dominant foot is used to control and kick the ball. The other leg is used as support, which can improve balance on that side over time.

Focus is important too. If we think we're worse at balancing on one side, we tend to concentrate more and so might do better compared to the opposite side.

As the students are performing the activity with others around, this could be distracting and cause them to lose balance quicker as well.

Activity: The Speed of Light

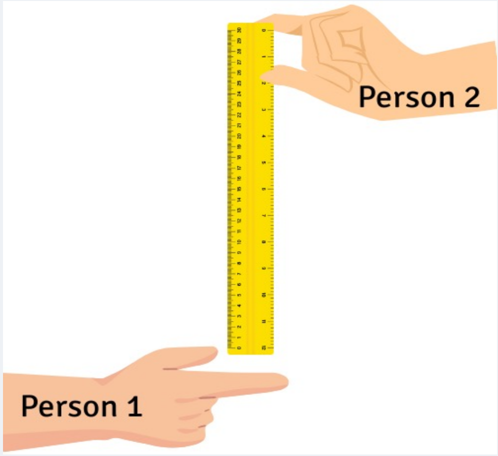
Physical Skills – concentration, fine-motor skills, hand-eye coordination, reaction time.

Equipment – 30cm ruler.

Student Workbook – pages 38 and 39.

Overview

Students work in pairs to measure their reaction time using a ruler-drop test.



One student holds out their dominant hand, and the other lines up the 0 cm mark on the ruler with the top of the thumb.

The ruler is dropped without warning, and the student catches it between their thumb and index finger.

The distance is recorded and then compared to the closest value in a Distance-Time chart, which gives a reaction time.

The results table includes 3 attempts; however, some can be left blank if time runs out.

Astronaut Training Context

Astronauts must be prepared for unexpected situations. They need to respond quickly to sudden changes and minimise the risk of dangers that arise. During training, they perform exercises to improve their hand-eye reaction time.

This not only prepares them for hazardous events, but it also helps them when operating the robotic arm on the International Space Station or completing spacewalks (Extra-Vehicular Activities/EVAs) outside the station.

Student Workbook Answers

Along with answers, the following information gives further detail and possible discussion points to share with your students.

The standard unit of distance is metres (m). 1 m = 100 cm.
Calculate your average distance in metres.

Divide the average distance by 100 to convert into metres.

The standard unit of time is seconds (s). 1 s = 1000 ms.
Calculate your average reaction time in seconds.

Divide the average reaction time by 1000 to convert into milliseconds.

What could have a bad effect on your reaction time and make it worse?

Some activities can help improve reaction time, but lifestyle factors also have an influence. Lack of sleep causes fatigue and slows down our reactions. Alcohol and certain drugs slow reaction time too.

Having better physical fitness has also been linked to faster reaction times, while dehydration can impair cognitive function and result in slower reactions.

As we get older, the number of neurons in the brain decreases, and this worsens our reaction time.

Reaction time also changes depending on which sense the stimulus is triggering. This is because the time taken for the stimulus to reach the brain is different for each sensory type. People tend to react quicker to sound than light, while reaction time to touch is the slowest.

Distractions in the environment, such as background noise, will increase reaction time as well.

Activity: Planet You Go, Gravity You Find

Physical Skills – coordination, strength.

Equipment – 3 balls of varying masses (e.g. 0.5 kg, 1 kg, 1.5 kg) labelled A, B, and C; stopwatch.

Student Workbook – pages 40 and 41.

Overview

Students squat while holding a ball and jump forwards, lifting it above their head. They record the time taken to cover a set distance and repeat with the other balls. The different masses simulate different gravitational conditions.

You can measure out the distance covered (e.g. 3 metres) or mark out a start and end point (e.g. between 2 cones). But the distance must remain the same throughout the activity.

The results table includes 1 attempt for each ball. This activity may be easier in pairs, with one student performing the task and the other using the stopwatch.

Astronaut Training Context

Astronaut train in different simulated gravity environments (to prepare for these changes). On the International Space Station, they experience weightlessness due to the its orbit around the Earth; it's in constant freefall.

If we feel less gravity, it's because a smaller force is pulling us down, so our bodies don't work as hard to overcome it. This decreases muscle and bone density, which is why astronauts continue to exercise whilst in lower gravity environments.

They also feel different g-forces during rocket travel. 1-G is the force a stationary object on Earth feels. Up to 3-G can be experienced when taking off and re-entering Earth's atmosphere.

Student Workbook Answers

Along with answers, the following information gives further detail and possible discussion points to share with your students.

Which ball was the easiest to jump with?

The lightest mass ball is easiest to jump with. The correct letter depends on how you've labelled them.

How do your results show which ball was the easiest to jump with?

The time taken for this ball is the quickest.

Imagine you lifted the same object on Earth, on the Moon, and on Mars. Which ball matches what it would be like to lift the object in these places?

Earth: ball with largest mass, Moon: ball with smallest mass, Mars: ball with medium mass.

Explain your answers. Include data (the time) from your results table.

The Earth, Moon, and Mars have different gravitational field strengths because they are different masses. Therefore, the force needed to lift the same object on each of them is also different.

Earth is the most massive, so has the strongest gravitational pull. The largest mass ball modelled lifting the object on Earth. This should be their longest time.

The next most massive is Mars. Its strength of gravity is around two fifths (~40%) of Earth's. The medium mass ball modelled lifting the object on Mars. This should be their next longest time.

The least massive is the Moon. The strength of gravity is around a sixth (~16%) of Earth's. The smallest mass ball modelled lifting the object on the Moon. This should be their quickest time.

Activity: Crew Assembly Training

Physical Skills – communication, dexterity, hand-eye coordination, teamwork.

Equipment – 1 pair of boxing gloves per student. Alternatively, they can wear 2 pairs of other gloves (e.g. winter, fabric, disposable, rubber, football, etc.) or a combination instead; building pieces (e.g. blocks, stacking cups); stopwatches; optional: mats, hula hoops, etc.

Student Workbook – pages 42 and 43.

Overview

Students wear thick gloves to simulate wearing bulky spacesuits. They are split into at least 2 teams and record the time taken for them to build a structure (block tower or stack of cups).

Each teams forms a line at a starting area, referred to as 'Basecamp'. There is an 'Assembly Area' a small distance (e.g. 3 metres) away. Measuring the distance isn't necessary, but it must be the same for all teams. You could use mats/hula hoops/other objects to mark these areas for students.

The building blocks/stacking cups are placed at the back of the student line. Students pass along a piece until it reaches the person at the front. They take it to the Assembly Area and return to the back of the line at Basecamp. This process is repeated until the structure is built.

If the structure falls, one student is nominated by the team to go to the Assembly Area and fix it. Students note down if this happens and a 10 second penalty is awarded each time, with this added to their total at the end.

The results table includes space to record the completed time, the number of penalties (that students will tally mark), the penalty time, and the total time (both calculated by students).

Astronaut Training Context
Astronauts need good dexterity and hand-eye coordination to assemble devices and use objects during their missions. Some do spacewalks (extra-vehicular activities/EVAs), which requires manipulating tools while wearing spacesuits. They practice this in training, learning how to use tools wearing thick and bulky gloves.

Teamwork skills are also essential. Astronauts spend a lot of time together as a crew onboard small spacecrafts. To complete tasks efficiently, they must communicate and support each other. This is especially important during EVAs, as spacesuits can only be worn for up to 6 or 7 hours – working well together maximises performance output during the limited timeframe.

Student Workbook Answers
Along with answers, the following information gives further detail and possible discussion points to share with your students.

<u>Give one way your team worked well together and one way you could improve as a team.</u>
Use some of these prompt questions to help student reflection:
- Did you assess the strengths and weaknesses of everyone in your team? (e.g. a person might have been slower getting to the Assembly Area, but much better at stacking the blocks/cups).
- Did your team plan the order of people (i.e. who went first, second, etc.)?
- Would it have been helpful to have a team leader? Why? What could this person do to improve how your team works?
- How did your team communicate? Did anyone shout at others? Was everyone listened to when they spoke?
- If your structure fell, how did you respond as a team? Did you still put in the same effort afterwards, or did you not try as much?
- How did your team support each other? Did you cheer each other on? Did you say encouraging things if a team member had a set back?

Activity: Astro Agility Course

Physical Skills – agility, balance, coordination, spatial awareness.

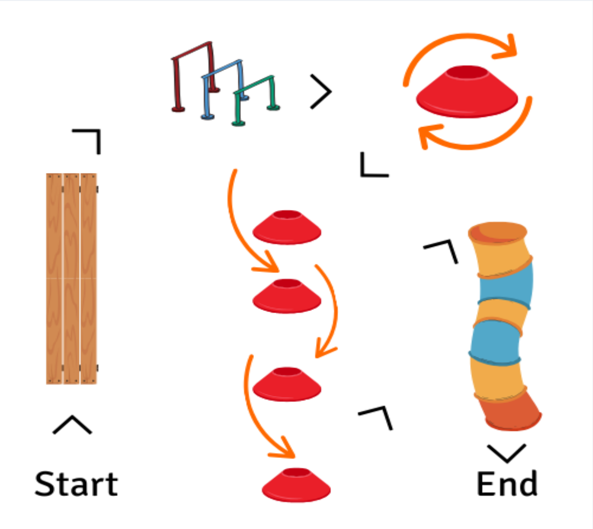
Equipment – cones, agility ladder, hula hoops, hurdles, tunnels, or other similar objects; stopwatch; optional: tape (to guide students around the course).

Student Workbook – pages 44 and 45.

Overview

Students complete an agility course that tests their balance and coordination, recording the time taken. If an object is knocked over/moved out of place, a 2 second penalty is awarded each time. This is added to their total at the end.

The example course (on the right) is set out as follows: students walk across a bench, jump over hurdles, run around a cone, weave between a series of cones, and then crawl through a tunnel.



The design and layout of the agility course can be modified to suit your class, location of the lesson, available resources, etc.

The results table includes 3 attempts; however, some can be left blank if time runs out.

This activity may be easier in pairs, with one student performing the task and the other using the stopwatch and keeping count of penalties.

Astronaut Training Context

Astronauts experience different forces of gravity. On the International Space Station, they experience weightlessness due to the its orbit around the Earth; it's in constant freefall.

They also feel different g-forces during rocket travel. 1-G is the force a stationary object on Earth feels. Up to 3-G can be experienced when taking off and re-entering Earth's atmosphere.

These different environments affect balance and body control, impacting how quickly astronauts react to situations and events. Agility is tested before and after missions so scientists can understand any changes and hopefully mitigate these in the future.

Student Workbook Answers

Along with answers, the following information gives further detail and possible discussion points to share with your students.

<u>What was the most challenging part of the Astro Agility Course? How could you improve your performance on this part?</u>

Challenges will depend on how you've built the Astro Agility Course and individual student ability.

However, certain exercises/drills can enhance agility overall. These involve quick changes in speed and direction (e.g. agility ladder, side shuffles/steps, shuttle runs, skipping rope exercises, and high knees).

Students should link their challenges to the relevant skills for improvement (e.g. exercises to strengthen leg muscles if they struggled to jump over hurdles, exercises to improve cardio if they became tired partway through the course, etc).

After each attempt, times may improve since the course is more familiar. But it could also increase because of fatigue.

Activity: Crew Strength Training

Physical Skills – balance, endurance, strength.

Equipment – stopwatch/timer.

Student Workbook – pages 46 and 47.

Overview

Students count the number of squats and push-ups they can complete in 30 seconds. Results are then compared to assess the difference between upper-body and lower-body muscle strength.

The results table includes 3 attempts for both squats and push-ups; however, some can be left blank if time runs out.

This activity may be easier in pairs, with one student performing the task and the other using the stopwatch.

Astronaut Training Context

The strength of gravity depends on the mass of the object. The bigger the mass, the stronger its gravitational pull.

Both the Moon and Mars are less massive than the Earth, so their gravitational fields are weaker. The smallest is the Moon, with around a sixth (~16%) of the gravity we experience on Earth. Mars has around two fifths (~40%) of Earth's gravity.

In weaker gravity, a smaller force is pulling down, so our bodies don't work as hard to overcome it. This decreases muscle and bone density.

Astronauts exercise before, during, and after spending time in lower gravity environments. This includes cardiovascular exercises and weight bearing activities to strengthen muscles and bones.

Student Workbook Answers
Along with answers, the following information gives further detail and possible discussion points to share with your students.

Do you have better upper-body or lower-body strength? Use your results to explain your answer.
If students performed more push-ups than squats in 30 seconds, this shows they have better upper-body strength.

If students performed more squats than push-ups in 30 seconds, this shows they have better lower-body strength.

What exercises would improve the strength in the weaker part of your body?
Exercises that improve upper-body strength include:

- Arm raises (front and side)
- Burpees
- Plank
- Pull-ups
- Lifting weights/dumbbells (e.g. bicep curls, overhead press)
- Rowing
- Wall press-ups

Exercises that improve lower-body strength include:

- Lunges (front and side)
- Glute bridge
- Step-ups
- Calf raises
- Leg lifts (front and side)

Activity: Jump For The Moon

Physical Skills – balance, coordination, endurance.

Equipment – stopwatch/timer, skipping rope.

Student Workbook – pages 48 and 49.

Overview

Students measure their heart rate and then skip with a rope for 1 minute. Their heart rate afterwards is also measured for comparison.

To measure heart rate, students count their heartbeat for 10 seconds and then multiply by 6.

The results table includes 3 attempts; however, some can be left blank if time runs out. This activity may be easier in pairs, with one student performing the task and the other using the stopwatch.

Astronaut Training Context

The strength of gravity depends on the mass of the object. The bigger the mass, the stronger its gravitational pull.

Both the Moon and Mars are less massive than the Earth, so their gravitational fields are weaker. The smallest is the Moon, with around a sixth (~16%) of the gravity we experience on Earth. Mars has around two fifths (~40%) of Earth's gravity.

In weaker gravity, a smaller force is pulling down, so our bodies don't work as hard to overcome it. This decreases muscle and bone density, and since the heart is a muscle, it can weaken.

Astronauts exercise before, during, and after spending time in lower gravity environments. This includes cardiovascular exercises and weight bearing activities to strengthen muscles and bones.

Student Workbook Answers
Along with answers, the following information gives further detail and possible discussion points to share with your students.

How did your heart rate change after skipping for 1 minute?
Students should find that their heart rates increase. The biggest increase might be after the first attempt, though this could depend on what activity they were doing previously (if it was more strenuous, their heart rate may still be recovering).

This is because they're at their most 'rested' before attempt 1. After skipping once, the rest period between attempts may not be sufficient to return their heart rate back to its resting rate, so the change will be lower for these subsequent attempts. However, it should still increase.

Why did this change happen?
A higher heart rate means the heart is beating more per minute. This happens during exercise because oxygen demand increases.

Muscles need more oxygen when we exert ourselves, and oxygen is delivered via the blood. The heart must beat faster to pump the required oxygenated blood to our muscles. Because blood is circulating faster, waste products like carbon dioxide can also be quickly removed.

Our breathing rate (and depth) increases too. This allows us to breathe in more oxygen per second and breathe out waste carbon dioxide.

Regular exercise makes the heart muscle stronger. A stronger heart can squeeze harder, pumping out more blood with each beat. This means the same amount of oxygenated blood can be circulated through the body in less heartbeats, which is more efficient.

So, for those who exercise often, their heart rate doesn't have to increase as much to fulfil the demand for oxygen.

Activity: Do a Spacewalk

Physical Skills – coordination, dexterity, flexibility, strength.

Equipment – tape measure (or alternative way to measure distance), object marker (e.g. cone).

Student Workbook – pages 50 and 51.

Overview

Students perform a crab walk (from sitting on the ground with knees bent, they put their arms and hands behind them and then lift up), travelling as far as they can before falling down. An object marker is placed on this end spot, and the distance is measured with a tape measure (or other piece of equipment).

If students reach the edge of the designated activity area, they need to turn around and travel back to the start, repeating as often as necessary.

The results table includes 3 attempts; however, some can be left blank if time runs out. This activity may be easier in pairs, with one student performing the task and the other placing the object marker down.

Astronaut Training Context

Astronauts may complete spacewalks (extra-vehicular activities/EVAs). They wear bulky spacesuits for up to 6 or 7 hours at a time, relying on their coordination and strength to move around. The spacesuits have large, thick gloves, so good dexterity is important.

To practice these strenuous movements, astronauts train underwater while wearing their spacesuits, performing the kinds of tasks they'll do on their mission.

Other parts of their training also focus on developing their muscle strength and coordination.

Student Workbook Answers

Along with answers, the following information gives further detail and possible discussion points to share with your students.

<u>What exercises might help you to improve and travel a further distance?</u>

Performing a crab walk uses lots of different muscles. Some of these include muscles in the shoulders and arms (e.g. triceps), the legs (e.g. calves, quadriceps, gluteal), and core muscles (e.g. abdominal).

Students' answers may focus on exercises to target these muscles. They might also give examples of exercises that improve balance and flexibility, especially in the hips, shoulders, wrists, and ankles.

Extension Ideas

If you wish to explore the content from this investigation further, we have a list of suggested ideas below:

- Try out some other activities from the *Mission X* project
- Collate the class data for one (or more) of the activities and have students display the data by drawing graphs
- Research the nutritional requirements for an astronaut and have students plan a 'Space Meal' to meet thee dietary needs

Investigation 5 (STEM Professional)

Why Does Mars Change Size?

Why Does Mars Change Size?

Learning Objectives

- To know that the planets orbit around the Sun at set distances
- To understand how distances between planets change
- To accurately obtain data and plot a graph

Career Link: Astronomer

Curriculum Links

Subject	Topic	Year	Topic Elements
Science	Earth and space	Y5	Describe the movement of the Earth, and other planets, relative to the Sun in the solar system
			Describe the Sun, Earth and Moon as approximately spherical bodies
	Working Scientifically	Lower KS2	Making systematic and careful observations and, where appropriate, taking accurate measurements using standard units, using a range of equipment, including thermometers and data loggers
			Gathering, recording, classifying and presenting data in a variety of ways to help in answering questions
			Recording findings using simple scientific language, drawings, labelled diagrams, keys, bar charts, and tables
			Reporting on findings from enquiries, including oral and written explanations, displays or presentations of results and conclusions
			Using results to draw simple conclusions, make predictions for new values, suggest improvements and raise further questions
			Identifying differences, similarities or changes related to simple scientific ideas and processes

Why Does Mars Change Size?

Subject	Topic	Year	Topic Elements
Science	Working Scientifically	Upper KS2	Taking measurements, using a range of scientific equipment, with increasing accuracy and precision, taking repeat readings when appropriate
			Recording data and results of increasing complexity using scientific diagrams and labels, classification keys, tables, scatter graphs, bar and line graphs
			Reporting and presenting findings from enquiries, including conclusions, causal relationships and explanations of and degree of trust in results, in oral and written forms such as displays and other presentations
Mathematics	Number - addition and subtraction	Y3	Add and subtract numbers with up to three digits, using formal written methods of columnar addition and subtraction
	Number - multiplication and division	Y5	Solve problems involving multiplication and division including using their knowledge of factors and multiples, squares and cubes
			Solve problems involving addition, subtraction, multiplication and division and a combination of these, including understanding the meaning of the equals sign
	Number - addition, subtraction, multiplication and division	Y6	Divide numbers up to 4 digits by a two-digit whole number using the formal written method of long division, and interpret remainders as whole number remainders, fractions, or by rounding, as appropriate for the context
			Solve problems involving addition, subtraction, multiplication and division
	Number - fractions	Y3	Recognise and use fractions as numbers: unit fractions and non-unit fractions with small denominators

Why Does Mars Change Size?

Subject	Topic	Year	Topic Elements
Mathematics	Number - fractions (including decimals)	Y4	Round decimals with one decimal place to the nearest whole number
			Compare numbers with the same number of decimal places up to two decimal places
	Number - fractions (including decimals and percentages)	Y5	Read, write, order and compare numbers with up to three decimal places
			Solve problems which require knowing percentage and decimal equivalents of 1/2, 1/4, 1/5, 2/5, 4/5 and those fractions with a denominator of a multiple of 10 or 25
		Y6	Use written division methods in cases where the answer has up to two decimal places
			Solve problems which require answers to be rounded to specified degrees of accuracy
			Recall and use equivalences between simple fractions, decimals and percentages, including in different contexts
	Measurement	Y3	Measure, compare, add and subtract: lengths (m/cm/mm); mass (kg/g); volume/capacity (l/ml)
		Y4	Estimate, compare and calculate different measures, including money in pounds and pence
	Statistics	Y3	Interpret and present data using bar charts, pictograms and tables
		Y4	Interpret and present discrete and continuous data using appropriate graphical methods, including bar charts and time graphs
		Y6	Interpret and construct pie charts and line graphs and use these to solve problems
	Ratio and proportion	Y6	Solve problems involving the relative sizes of two quantities where missing values can be found by using integer multiplication and division facts

Why Does Mars Change Size?

Investigation Overview

Students will think about the order of planets in our Solar System and the distances between them, creating a scale map to represent this.

They will consider how planets orbit the Sun and how this effects the distances between planets. This will help them calculate the shortest and longest distance between Earth and Mars and make a comparison between them.

Next, students will analyse real images of Mars taken by the Liverpool Telescope and measure the planet's size in each picture. This will enable them to compare changes across different dates.

The recorded data will then be used to plot a graph to see these changes more clearly. The graph will help students analyses their results and explain why Mars appears to change size in the Earth's night sky.

Relevant Information for Teachers

Before the Investigation

- One of the activities involves students adding the names of the Planets to a scaled map. If any students lack confidence with writing and spelling, you may wish to contact the STEM Professional and discuss best practice for supporting everyone in class. The STEM Professional will have planets of the stickers available as an alternative option. However, please note that these will be limited in number.
- Some of the activities involve use of maths (see curriculum links for more information). If any students lack confidence with maths, you may wish to contact to the STEM Professional and discuss best practice for supporting everyone in class.
- Students will need sharp pencils and rulers during this investigation.

Extension Activities

If you wish to further explore the content from the STEM professional led investigation, please find the suggested ideas below:

- Students can covert their distances into miles
- Make a Play-doh Solar System showing the sizes of the planets to scale
- Use The Schools' Observatory's online software to Investigate the Size of a Planet
- Use The Schools' Observatory's online tool to Calculate the Speed of the Planets
- Have students research how our understanding of the Solar System has changed over time (you may want to use information from The Schools' Observatory's website)

Note: Underlined text is hyperlinked – please open the online version of this handbook to explore these in more detail.

Alternatively, you can search the name in the Things To Do! section of The Schools' Observatory's website.

Investigation 6 (STEM Professional)

When Should We Launch to Mars?

When Should We Launch to Mars?

Learning Objectives

- To apply knowledge about the movement of the planets
- To use online software to gather and record data
- To use data about the Solar System to plan for a mission

Career Link: Mathematician

Curriculum Links

Subject	Topic	Year	Topic Elements
	Working Scientifically	Lower KS2	Asking relevant questions and using different types of scientific enquiries to answer them
			Making systematic and careful observations and, where appropriate, taking accurate measurements using standard units, using a range of equipment, including thermometers and data loggers
			Gathering, recording, classifying and presenting data in a variety of ways to help in answering questions
			Recording findings using simple scientific language, drawings, labelled diagrams, keys, bar charts, and tables
			Reporting on findings from enquiries, including oral and written explanations, displays or presentations of results and conclusions
			Using results to draw simple conclusions, make predictions for new values, suggest improvements and raise further questions
		Upper KS2	Recording data and results of increasing complexity using scientific diagrams and labels, classification keys, tables, scatter graphs, bar and line graphs
			Reporting and presenting findings from enquiries, including conclusions, causal relationships and explanations of and degree of trust in results, in oral and written forms such as displays and other presentations

When Should We Launch to Mars?

Subject	Topic	Year	Topic Elements
Science	Earth and Space	Y5	Describe the movement of the Earth, and other planets relative to the Sun in the solar system
Mathematics	Number - multiplication and division	Y5	Multiply numbers up to 4 digits by a one- or two-digit number using a formal written method, including long multiplication for two-digit numbers
			Solve problems involving addition, subtraction, multiplication and division and a combination of these, including understanding the meaning of the equals sign
	Number - addition, subtraction, multiplication and division	Y6	Divide numbers up to 4 digits by a two-digit whole number using the formal written method of long division, and interpret remainders as whole number remainders, fractions, or by rounding, as appropriate for the context
			Solve problems involving addition, subtraction, multiplication and division
			Use written division methods in cases where the answer has up to two decimal places
			Solve problems which require answers to be rounded to specified degrees of accuracy
			Recall and use equivalences between simple fractions, decimals and percentages, including in different contexts
	Number - fractions	Y3	Recognise and use fractions as numbers: unit fractions and non-unit fractions with small denominators
	Number - fractions (including demicals)	Y4	Round decimals with one decimal place to the nearest whole number

When Should We Launch to Mars?

Subject	Topic	Year	Topic Elements
Mathematics	Number - fractions (including decimals and percentages)	Y5	Solve problems which require knowing percentage and decimal equivalents of 1/2, 1/4, 1/5, 2/5, 4/5 and those fractions with a denominator of a multiple of 10 or 25
		Y6	Use written division methods in cases where the answer has up to two decimal places
			Solve problems which require answers to be rounded to specified degrees of accuracy
			Recall and use equivalences between simple fractions, decimals and percentages, including in different contexts
	Measurement	Y3	Tell and write the time from an analogue clock, including using Roman numerals from I to XII, and 12-hour and 24-hour clocks
		Y4	Read, write and convert time between analogue and digital 12- and 24-hour clocks
			Solve problems involving converting from hours to minutes; minutes to seconds; years to months; weeks to days

Why Does Mars Change Size?

Investigation Overview
In previous investigations, students learned how to establish bases off-Earth, keep healthy in alien environments, and control robot rovers. This will enable them to live and work on the surface of Mars.

They also explored the Solar System in the last investigation and learned that the distance between Mars and Earth constantly changes as the planets move and orbit the Sun.

In this investigation, students will act as mathematicians to analyse the motion of the planets and calculate a launch date for their mission to Mars.

This final step of the project is crucial. It's important to time our journey just right when Mars and Earth are close together. Also, selecting the right launch window will make the travel time as short as possible, which ensures we'll have enough supplies to last the journey.

Relevant Information for Teachers
Before the Investigation
- Students will be using an online resource on The Schools' Observatory's website. Please arrange for devices (e.g. laptops, tablets) with internet access and installed web browsers to be available when the STEM Professional is delivering the investigation. Students will work in pairs, so only a smaller number of devices is needed.
- One of the activities involves some use of maths (see curriculum links for more information). If any students lack confidence with maths, you may wish to contact to the STEM Professional and discuss best practice for supporting everyone in class.
- One of the activities involves students working in pairs. You may wish to contact the STEM Professional and discuss student pairings ahead of time.

Extension Activities

If you wish to further explore the content from the STEM professional led investigation, please find the suggested ideas below:

- Have students design a mission patch. These are created for every space mission and usually have the crew's names along with some images which explain a little about what the mission is for.
- Ask the students to make a creative artwork (you can direct the medium and form) that shows themselves as an astronaut on the surface of Mars.
- Ask the students to create a creative writing piece (you can direct the medium and form) that brings their imagination to life. What would it be like to be the first human to set foot upon the Martian surface? What is it like? What can they see? How do they feel?

Evaluation

It would be helpful for the evaluation of this project if you were able to run any of the creative activities outlined above. These are designed to give students a sense of belonging about who STEM subjects are for, and to allow them to display some of the knowledge they have learnt.

We will ask to collect a random sample of the work from your class – these can be copies or photographs of the work and do not need to be the originals.

Appendix 1

Student Skills Audit

THE SCHOOLS' OBSERVATORY

PROUD TO BE PART OF LIVERPOOL JOHN MOORES UNIVERSITY

Appendix 1: Student Skills Audit

Skills Audit	Workshop							
	1	2	3	4	5	6	Evaluation Activities	
Reading with understanding	X	X	X	X		X		
Discussion and explanation from text	X	X						
Writing	X	X						X
Noticing and interpreting details, patterns, and changes	X	X	X	X	X	X		
Speaking and communication	X	X		X				X
Listening and responding	X	X	X	X	X			
Solving number problems					X	X		
Works with fractions, decimals, percentages		X			X			
Measuring accurately				X	X	X		
Interpreting data and critical thinking		X	X	X	X	X		
Appling maths to real-life problems						X		
Planning and conducting investigations	X		X		X	X		
Understanding key topics	X	X			X	X	X	X
Recording and interpreting results			X	X	X			
Using scientific vocabulary	X	X			X	X		
Writing and debugging simple code			X					
Understanding how networks work	X		X					
Using technology to create or research	X		X			X		
Understanding the position of objects in space and how they move	X		X	X	X	X		
Working independently	X	X		X	X		X	X
Solving problems			X			X		
Reflecting on learning	X	X	X				X	X
Managing time	X		X					
Learning about a variety of professions	X	X	X	X	X	X		
Team working	X	X		X		X		
Understanding civic responsibility		X						
Exploring ideas through art	X	X					X	
Participating in PE and sports				X				
Showing creativity and imagination		X					X	X
Understanding environmental issues and sustainability	X	X				X		
Understanding diversity and cultural differences	X		X					
Participating in decision-making	X		X			X		

Appendix 2

Gatsby Benchmarks

Gatsby Benchmarks – Good Career Guidance

The project aligns with the following benchmarks:

Benchmark	Criteria
3. Addressing the needs of each young person	A school's careers programme should actively seek to challenge misconceptions and stereotypical thinking, showcase a diverse range of role models and raise aspirations.
4. Linking curriculum learning to careers	Every year, in every subject, every pupil should have opportunities to learn how the knowledge and skills developed in that subject helps people to gain entry to, and be more effective workers within, a wide range of careers.
5. Encounters with employers and employees	Every year, from the age of 11, pupils should participate in at least one meaningful encounter with an employer.
7. Encounters with further and higher education	By the age of 16, every pupil should have had meaningful encounters with providers of the full range of learning opportunities, including sixth forms, colleges, universities and ITPs.

Gatsby and other organisations also developed the 'Skills Builder Universal Framework' which offers employers/employees/young people a common approach to develop and describe transferable essential skills.

These skills are listening and speaking (grouped as 'Communication'), problem solving and creativity (grouped as 'Creative Problem Solving'), adapting and planning (grouped as 'Self-Management'), and leadership and teamwork (grouped as 'Collaboration').

The skills also align well with those from our Student Skills Audit.

Gatsby Benchmarks – Good Practical Science

The project aligns with the following benchmarks:

Benchmark	Criteria
2. Purposeful Practical Science	Teachers should have a clear purpose for every practical activity and know how it relates to the rest of what they are teaching.
	Teachers should plan to their satisfaction how to introduce each practical and how to follow it up.
3. Expert Teachers	At pre-16 level, if teachers do not have a post-A level science qualification related to the subject they teach, they should have had sufficient additional training to give them the confidence, subject knowledge and skills to conduct effective practical work at that level.
4. Frequent and varied practical science	Practical activities can be short or long. There should be enough long science lessons (of at least 50 minutes) in the timetable to give teachers flexibility about when they do experiments.
	Practical activities should be varied and balanced in type.
5. Laboratory facilities and equipment	There should be sufficient equipment to make it possible for teachers to do standard practical activities expected in their specialist subject at that level.
7. Real experiments, virtual enhancements	Virtual environments and simulated experiments have a positive role to play in science education but should not be used to replace a good quality, hands-on practical.
	Digital technologies are rapidly evolving and teachers should have access to evidence about what works, and training in their use, before implementing them in their science lessons.
8. Investigative projects	There should be opportunities for students to do open-ended extended investigative projects in science.
10. Assessment fit for purpose	Teachers should regularly use practical activities as an opportunity to formatively assess students' understanding of science, where it is appropriate to do so.