Can We Get Humans to Mars?

STEM Professional Handbook

THE SCHOOLS' OBSERVATORY

FUNDED BY A PARTNERSHIP GRANT FROM THE ROYAL SOCIETY

PROUD TO BE PART OF LIVERPOOL JOHN MOORES UNIVERSITY

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 — all while supporting the Earth and Space topic in the national curriculum.

The overall Mars project consists of 6 mini-investigations. 4 of these will be delivered by STEM professionals, with the other 2 being teacher-led.

Information for the STEM professional-led investigations can be found in the relevant sections of this Handbook.

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Investigation 1

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 using scientific reasoning and evidence
- 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 Key Stage 2	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
	Earth and Space	Year 5	Describe the movement of the Earth, and other planets, relative to the Sun in the solar system
			Describe the movement of the Moon relative to the Earth
			Describe the Sun, Earth and Moon as approximately spherical bodies
			Use the idea of the Earth's rotation to explain day and night and the apparent movement of the Sun across the sky

Where Should We Build a Moon Base?

Subject	Topic	Year	Topic Elements
Science	Forces	Year 3	Compare how things move on different surfaces
		Year 5	Explain that unsupported objects fall towards the Earth because of the force of gravity acting between the Earth and the falling object
			Identify the effects of air resistance, water resistance and friction, that act between moving surfaces
	Light	Year 3	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
	Living things and their habitats	Year 4	Recognise that environments can change and that this can sometimes pose dangers to living things
Geography	Human and physical geography	Key Stage 1	Use basic geographical vocabulary to refer to key physical features
	Geographical skills and fieldwork		Use simple compass directions and locational and directional language to describe the location of features and routes on a map
			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

Where Should We Build a Moon Base?

Subject	Topic	Year	Topic Elements
Computing		Key Stage 1	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
		Key Stage 2	Use sequence, selection, and repetition in programs; work with variables and various forms of input and output
			Understand computer networks including the internet; how they can provide multiple services
			Select, use and combine a variety of software on a range of digital devices to design and create a range of programs, systems and content that accomplish given goals
English	Reading – comprehension	Years 5 and 6	Retrieve, record and present information from non-fiction. provide reasoned justifications for their views

Lesson Plan

Possible Student Misconceptions:

- The Moon has the same surface everywhere
- The Moon has an atmosphere like Earth
- It's possible to breathe on the Moon

Materials:

- Lesson PowerPoint presentation
- Student Workbooks
- Evaluation postcards
- Moon's features stickers
- Printed Moonsaic pieces
- 2 Moonsaic jigsaw puzzles
- Dot stickers
- Laptops/computers/tablets with internet access
- Optional: Teacher Handbook (see referenced pages for more information/guidance about the activity)

Duration	Activity	Pages	Materials
3 minutes	Hand out the student evaluation postcards for students to fill in. Collect these in when complete and return to Stacey.	Handbook: 10	Evaluation postcards
10 minutes	Introduce the overall Mars project, discussing as a class why we should go to Mars, the challenges involved, and the steps and skills required to reach the planet. Give an overview of the current investigation and how it links to the overall Mars project.	Handbook: 10 – 16	Lesson PowerPoint presentation
8 minutes	Show students the example images that detail the 4 key features on the Moon's surface that they'll be identifying.	Handbook: 16 – 18	Lesson PowerPoint presentation

Where Should We Build a Moon Base?

Duration	Activity	Pages	Materials
6 minutes	Explain why telescopes can only image parts of the Moon. Give each student a printed Moonsaic piece and stickers corresponding to the key features. Students complete the 'Explore the Moon's Surface' activity in their workbooks.	Handbook: 16 – 18 Student Workbook: 4	Lesson PowerPoint presentation Student Workbooks Printed Moonsaic pieces Moon's features stickers
6 minutes	Split the class into 2 groups and give each group a Moonsaic jigsaw puzzle. Students complete the Moonsaic jigsaw puzzle in their group. Discuss with students the similarities and differences they can see across the Moon's entire surface. (Note: this activity can be skipped if time is running out)	Handbook: 19 Student Workbook: 5	Lesson PowerPoint presentation 2 Moonsaic jigsaw puzzles
5 minutes	Have a class discussion about what makes a good site for Moon Base. Students complete the 'Choose a Moon Base Site' activity in their workbooks.	Handbook: 20 Student Workbook: 7	Lesson PowerPoint presentation Student Workbooks Dot stickers
23 minutes	Students complete the 'Taking a Moon Observation' activity in their workbooks. It will be useful to demonstrate each step to the class.	Handbook: 22 – 27 Student Workbook: 7 – 8	Lesson PowerPoint presentation Student Workbooks Laptops/computers/ tablets with internet access Dot stickers
2 minutes	Give students a brief insight to the next investigation and how it links to the current investigation and overall Mars project.	Handbook: 28	Lesson PowerPoint presentation

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 investigation starts with a project introduction and explores the reasons for going to Mars. Students will then think about the history of space exploration – both human and robotic – to the Moon and Mars, and the challenges involved.

Once pupils understand why we're visiting the Moon first, they'll learn about key features on its surface and identify these. They will consider what makes a good Moon Base location and choose their site.

Afterwards, they'll use The Schools' Observatory's website to submit an observation request for their chosen location.

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

Evaluation Postcards

Hand out the evaluation postcards to students. Once complete, collect these back in. Please keep them safe and hand in to Stacey (room 2.22) as soon as you're back in the office.

Starter Activity: Welcome to the Mission

Show students the image of the Martian surface from the PowerPoint presentation (on slide 1). Ask them to guess which planet it is.

You should encourage pupils to not shout out. Give them some thinking time before selecting a few to share their answers.

Confirm that the answer is Mars and ask the class what they already know about the planet. Some will probably say that it's the fourth planet from the Sun. Others may know it's called the 'Red Planet'. This is because there's iron oxide (rust) in its soil.

Why Go to Mars?

Show this question in the PowerPoint presentation (on slide 3). Again, give students thinking time and encourage no shouting out.

Select some to share their ideas before showing the class the answers on the board.

You could add some of the following information:

Mars is the most Earth-like planet nearby
It has days (a Martian day, known as a Sol, is only 36 minutes longer than on Earth), seasons, and polar ice caps.

We want to search for signs of life
Liquid water is vital for life on Earth, so we consider it when looking for life elsewhere – scientists believe Mars once had lots of liquid water on the surface in lakes, rivers, and possibly oceans.

However, this was probably billions of years ago when the Martian atmosphere was thicker and able to 'trap' more heat.

Help us in protecting our planet
Living on Mars could teach us how to survive in extreme conditions, which is especially important when considering the effects of climate change.

Also, if humans can recycle air, water, and grow food on Mars, we can use the same innovations to live more sustainably on Earth.

Space missions inspire new inventions
Technology developed for space often helps Earth (e.g., water filters, solar panels, medical imaging). If we can survive in a place with no air, no water, and freezing temperatures — imagine what we can invent for people here at home.

Big missions also inspire new generations and global cooperation.

How Many People have been to Mars?
Show this question in the PowerPoint presentation (on slide 4).

Tell students you will read out the options, and they'll vote by raising their hands (e.g. 'Who thinks the answer is A? What about B? And C?').

The correct answer is A. 0 – no humans have gone there, but we've sent technology instead.

You could ask pupils why they think no human has ever been to Mars never happened. This might bring up ideas around distances in space, the cost involved, and the capability of our technology. If any student mentions the time it takes to get there, you can say you'll be asking them about this soon.

You could also discuss the difference between sending technology (robotic missions) and sending humans (crewed missions). Technology can better withstand the extreme conditions of space, and humans need resources to survive – this will be explored in Investigation 2.

Mars Missions So Far
Briefly detail some of the missions involving Mars. Examples are given in the PowerPoint presentation (on slide 5).

Students will find out more about these missions in Investigation 3.

By learning from these missions, we can make better decisions for future human explorers.

Other missions/extra information:

- Perseverance (2021–present): searching for signs of past life, storing samples for future return.
- InSight (2018–2022): measured marsquakes.
- Tianwen-1 (China, 2021): orbiter and rover.
- ExoMars (ESA mission – part delayed, but 2016 orbiter still active).

How long does it take to get to Mars?
Show this question in the PowerPoint presentation (on slide 6). Tell students you will read out the options, and they'll vote by raising their hands, as done previously.

The correct answer is C. 9 months – this is the average time because it depends on the position of Earth and Mars in their orbits.

Some pupils may have known this or at least understood that it takes a long time, and this might have been mentioned during discussions about humans travelling to Mars.

You can link the idea of distance and journey time.

How long does it take to get to the Moon?
Show this question in the PowerPoint presentation (on slide 7). Tell students you will read out the options, and they'll vote by raising their hands, as done previously.

The correct answer is B. 9 months.

You could add that A. 9 minutes (the only answer not covered by the questions so far) is how long it takes to get into space.

How Many People have been to the Moon?
Show this question in the PowerPoint presentation (on slide 8). Tell students you will read out the options, and they'll vote by raising their hands, as done previously.

The correct answer is C. 12.

Other information you could add:
- First: Neil Armstrong & Buzz Aldrin (1969).
- Last: Gene Cernan & Harrison Schmitt (1972).
- The Apollo 11 landing site was the Sea of Tranquillity.
- Astronauts brought back 382 kg of Moon rocks and soil.

Where Should We Build a Moon Base?

What's the Challenge?

Show slide 9 of the PowerPoint presentation. Explain that getting to Mars isn't just about building a rocket, pressing launch, and landing.

There are many steps involved. We must first learn to live off-Earth before we can safely go to Mars. The Moon will act as an important stepping stone in our journey.

You could discuss the following information with the class:

Reaching Mars would take months, and the environment of space – and Mars – is very different to Earth's. Humans haven't gone further than the International Space Station for many years. There could be unexpected issues if we suddenly sent people to Mars now.

We'd have to figure out how to travel to the planet with enough resources, how to stay healthy in extreme conditions, how to avoid hazards and land safely, and so much more.

We'd need to design and build safe living spaces, plan how to get food, water and energy, and find ways to explore the planet.

So, we must practice living away from Earth first – and the Moon is our best option! It's relatively close and we've been there previously.

Moon-Earth communication is quicker than Mars-Earth, resupplies would arrive in around 3 days, and people can easily be evacuated to Earth if anything goes wrong. We can test out equipment/techniques and make improvements before building further away on Mars.

We might also use the Moon as launch site towards Mars.

Meet the Crew

Show slide 10 of the PowerPoint presentation. Explain that reaching Mars requires different skills across many areas. Every successful space mission needs an amazing team — not just astronauts.

We need geologists to understand rocks and pick safe landing spots. Engineers to build things that survive space. Coders to program our robots and get them to where they need to go.

We'll need medics and trainers to keep astronauts healthy in low gravity. Astronomers to use telescopes and study the Moon and planets. And, of course, mathematicians — because without maths, we can't even launch a rocket.

Tell students they're going to play all these roles across the project.

The 6 Investigations

Show students the overview of investigations in the PowerPoint presentation (on slide 11).

Explain that over the series of investigations, they'll take on the roles previously discussed, with each session progressing them towards the goal of launching to Mars and carrying out missions on the planet.

We'll start by choosing the best place to build a Moon base. Then we'll think about how humans can survive in space without Earth's resources.

We'll learn to control robotic rovers using code, test how space affects our health, explore how far away Mars really is and, finally, plan the perfect launch window for a safe journey.

Each mission builds on the one before it, so everything we do will help us prepare for the final goal: humans on Mars!

Mission Brief
Show slide 13 in the PowerPoint presentation.

Introduce the current investigation to the students – they are part of a team of geologists who will explore the Moon's surface, learn about its features, and decide where to build a Moon Base.

You could add some of the following information about how we've previously studied the Moon:

- Ancient times: observed by eye
- 1609: mapped by Galileo with telescope
- 1950s–1960s: robotic probes (Luna, Surveyor, Lunar Orbiter)
- 1969–1972: Apollo astronauts visited, returned samples
- Ongoing: Lunar Reconnaissance Orbiter, Chang'e missions (China), Artemis programme (NASA, 2020s)

Activity: Explore the Moon's Surface

There are 4 key features that this activity focuses on: sea/mare, mountain/mon, valley/vallis, and crater.

Show the example images in the PowerPoint presentation (on slides 16 to 24). After explaining the features to the class, give each student a printed Moonsaic piece and a set of key feature stickers.

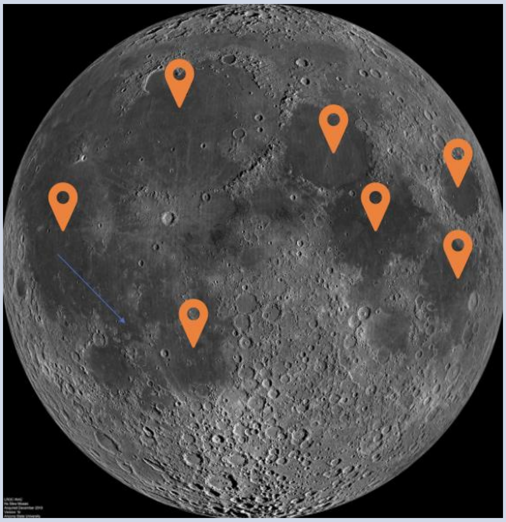
Explain that because the Moon is close to Earth, it is very large in the sky, so telescopes can't take a full picture. It doesn't into the frame of view. Instead, they image different sections and stitch them together.

Ask students to identify and label any features using the stickers. There is also an 'Unusual' option. Pupils then count the number of each and write the amounts into their workbooks, along with a short description of one feature.

The labelled Moonsaic piece can be placed inside the workbooks. Ask the class teacher to arrange sticking these in after the investigation.

Where Should We Build a Moon Base?

Sea/Mare



Key Facts:

- Large, dark plains made of basalt (lava rock).
- Formed by lava flooding giant impact basins billions of years ago.
- Ancient astronomers thought they were oceans, hence “mare” (Latin: sea).
- Cover ~16% of the Moon’s surface.

How to Spot:

- Dark, smooth patches compared to the brighter highlands.

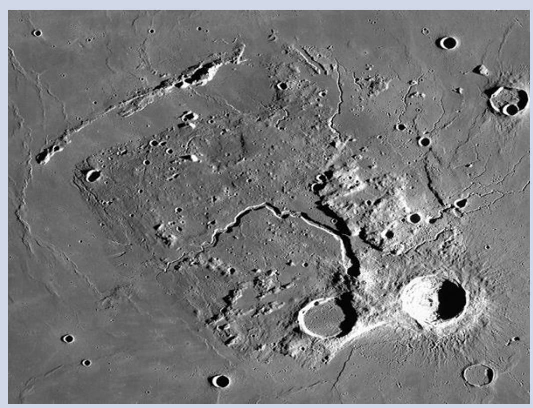
Valley/Vallis

Key Facts:

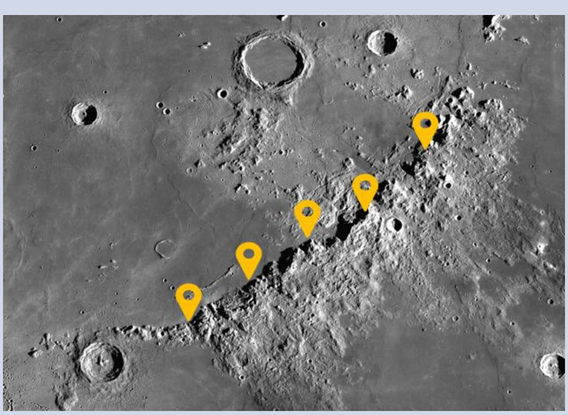
- Long, narrow channels up to hundreds of kilometres long.
- Formed by lava flows, collapsed lava tubes, or tectonic stretching (when plates or pulled apart and the crust becomes thinner).

How to Spot:

- Thin, dark lines or grooves cutting across plains.



Mountains/Mons



Key Facts:

- Bright, high areas often marking the rims of ancient impact basins.
- Some peaks are 3 – 4 km high.
- Older rock than the maria (seas); heavily cratered.

How to Spot:

- Bright patches near shadows, raised ridges.

Where Should We Build a Moon Base?

Craters

Key Facts:

- Created by asteroid/comet impacts.
- Can be huge (hundreds of km).
- Steep walls, flat floors, sometimes with central peaks (rebound rock).
- Bright rays sometimes spread from them – caused by ejected debris.
- With no atmosphere, craters remain unchanged for billions of years.

How to Spot:

- Thin, dark lines or grooves cutting across plains.

Extra Feature

Regolith

Key Facts:

- Layer of broken rock fragments and dust that covers the Moon's surface.
- Greek: rhegos (blanket), lithos (stone).
- Formed by constant bombardment of meteoroid impacts.
- 'Lunar soil' refers to grains with diameters of 1cm or less - 'lunar dust' is less than 1mm.

How to Spot:

- Makes the Moon look grey and dusty – but can only truly see it in lunar samples.

Because of the Moon's lack of atmosphere, there is no weathering or erosion by rain or wind like on Earth. This happens instead mainly through micrometeorite impacts – a slow process in comparison.

Therefore, features stay visible for a long time. The footprints of the astronauts will remain for millions of years.

Activity: Moon Jigsaw Puzzle

Split the class into 2 groups, each with a foam Moonsaic jigsaw puzzle. Each piece will have a letter and number written on the back e.g. 'B3'. This corresponds to the row and position of the piece along the row.

Tell the students to use the letters and numbers to assemble their jigsaw. Remind them to keep the letter and numbers the right way up, otherwise they may accidentally flip the pieces. If they get stuck, there is a reference image in their workbooks.

Usually, the tables in primary schools are clustered into bigger tables with e.g. 6 students around – those tables will be big enough for the Moonsaics, but all classrooms are set up differently, so discuss this with the class teacher.

Make sure to save a few minutes of activity time for a class discussion. Ideally, at least one group will have assembled the jigsaw at that point. But there is a full image in the PowerPoint presentation (on slide 27) that can be used instead.

Ask students about the similarities and differences students can see across the Moon's entire surface. Try to link these to the features they've learned about.

Example discussion points and answers:
Q: "Why does one side look darker?"
A: More seas/maria (lava plains) on the near side, while the far side is more mountainous.

Q: "Why do we only see one side of the Moon?"
A: The Moon is tidally locked — it takes the same time to rotate around its axis as it does to orbit Earth.

Activity: Choose a Moon Base Site

Ask students 'What make a good base site?'. Select some to share with the class before showing the answers in the PowerPoint presentation (on slide 29).

Prompts that students might consider:

- Whether there's sunlight or shadows (as solar power will be useful to power our Moon Base)
- Safety issues (e.g. avoid deep craters)
- How easy building and landing will be (flat land would be best)
- Access to resources (e.g. rocks, possible ice)
- The proximity of interesting places (e.g. craters, lave tubes – they might even hold water)

Good sites might include flat sea/mare areas near crater edges (solar energy + flat land + access to rocks).

Poor sites might include deep craters (hard to land + very cold + long shadows).

Hand out the dot stickers to students and tell them to mark their chosen site in their workbooks. Encourage them to balance pros and cons, rather than aiming for a perfect answer.

Ultimately, there is no wrong choice!

After selecting a site, students need to write a justification in their workbooks.

Tip: If some pupils are struggling to pick a location, you can show the image of the Apollo landing sites in the PowerPoint presentation (on slide 30).

Activity: Taking a Moon Observation

Now that students have selected a location, they can use The Schools' Observatory's website to request an observation of that area.

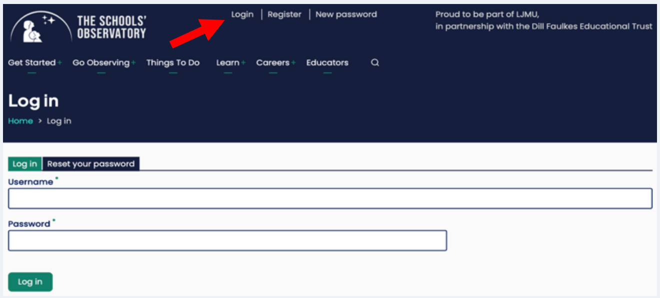
Ideally, demonstrate each step to the class so pupils can follow along. If you don't have an account, ask the class teacher to log on instead.

Tip: Speak to the class teacher prior to delivering the investigation and ask what resources students will be using (e.g. tablets, computers, laptops). If possible, the class teacher may be able to prep them during the previous activities – switching them on, loading the website, etc.

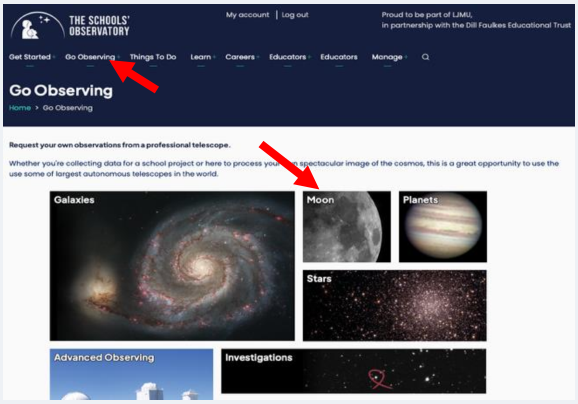
You should also ask if students need to leave the classroom to access any technology. Some schools may only have computers in certain classrooms.

The students should already have accounts on The Schools' Observatory's website, but you can confirm this with the class teacher prior to arriving at the school as well. There is space provided in their Teacher Handbooks (pages 54 and 55) for them to record details of the students' accounts.

1) Log on to The Schools' Observatory website – the class teacher will have details of the student accounts.



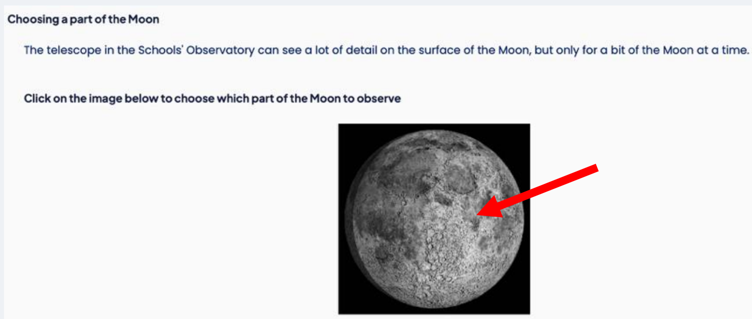
2) Click 'Go Observing' from the top menu and then select 'Moon' from the options.



Where Should We Build a Moon Base?

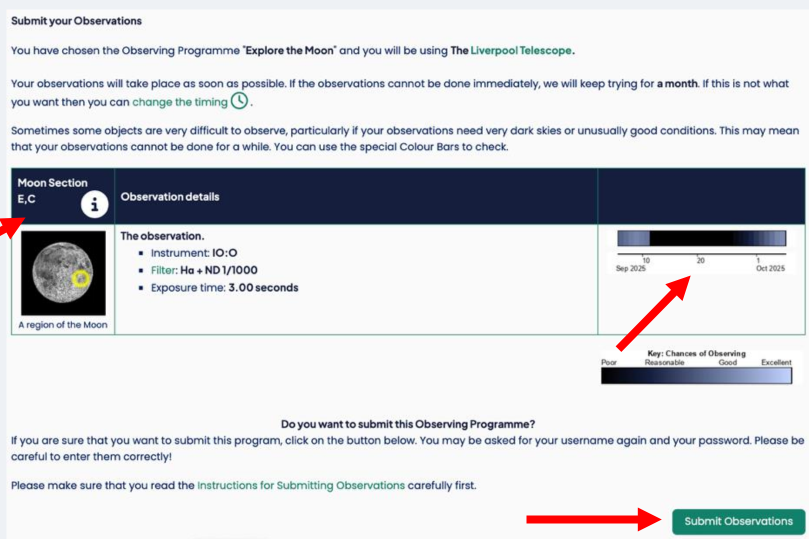
3) Select 'Observe The Moon'.

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



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

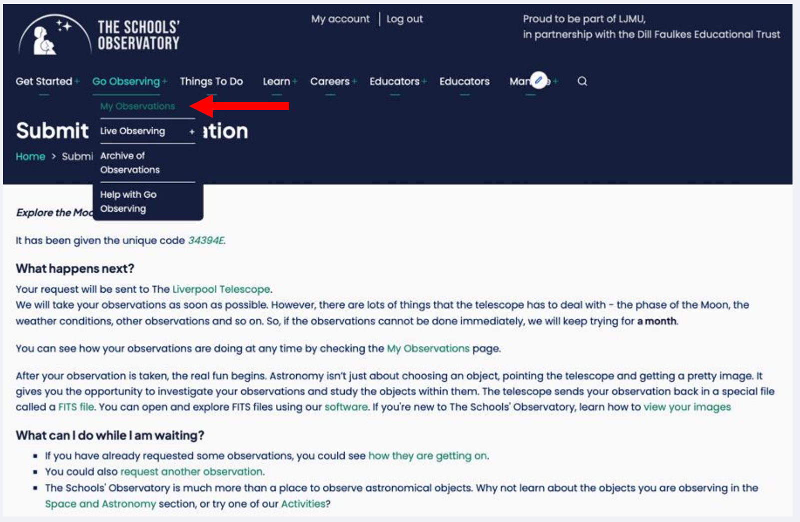
6) Explain the colours of the visibility bar – lighter means better chances of observing.



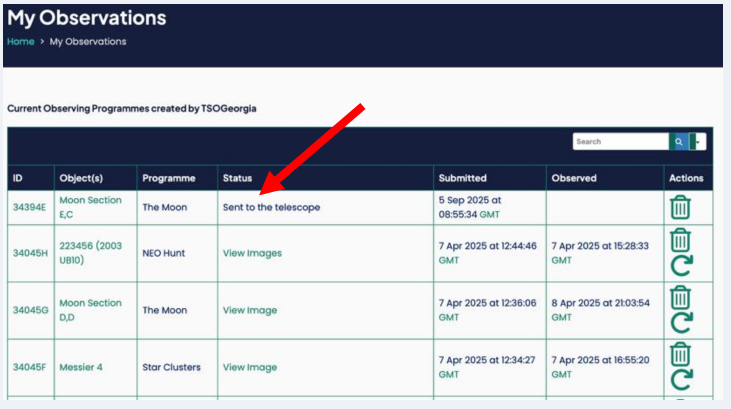
The chance of observing changes due to the Moon's phases – the amount of reflected sunlight we see depends on the position of the Moon its orbit.

7) Click 'Submit Observation'.

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

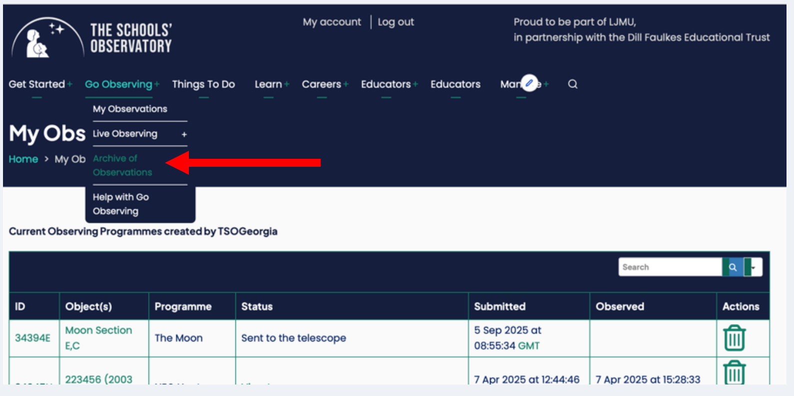


9) Tell students they can keep checking the status, but it might take days/weeks to complete, depending on the Moon’s phase.



10) Since we want an image sooner, we’ll search past observations.

Go to ‘Go Observing’ → ‘Archive of Observations’.

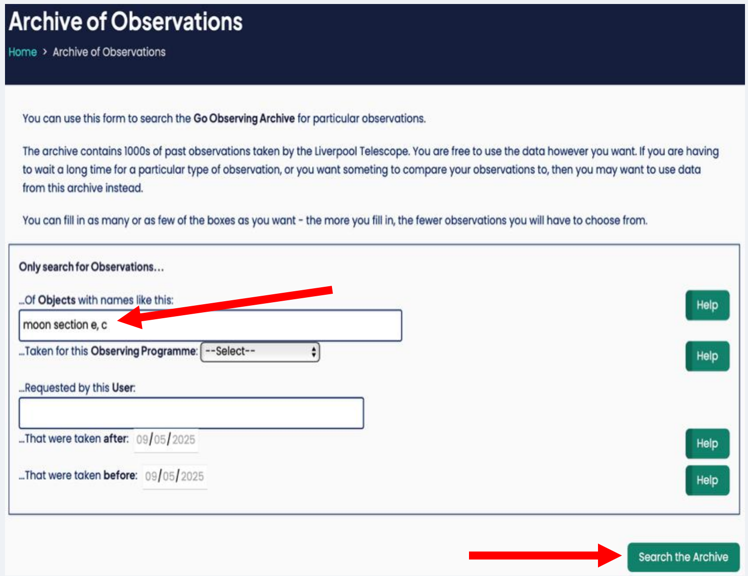


Where Should We Build a Moon Base?

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

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

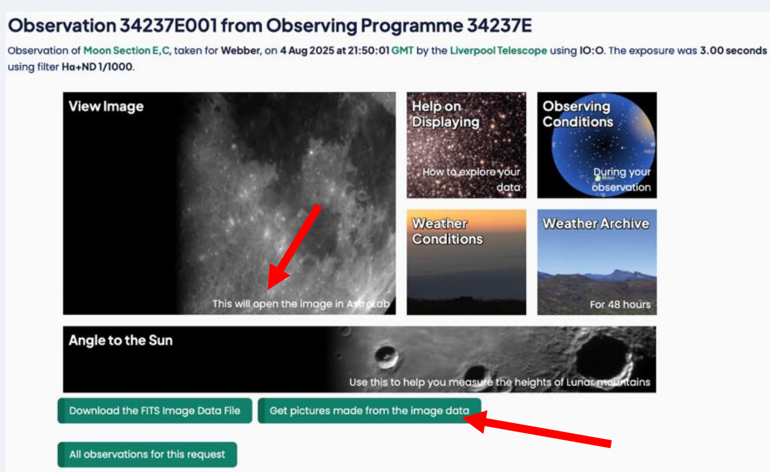
12) Click 'Search the Archive'.



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

14) There are two options for obtaining an image – A:Making a picture, or B: AstroLab

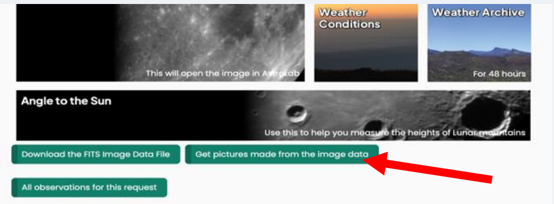
You can choose whichever method you prefer



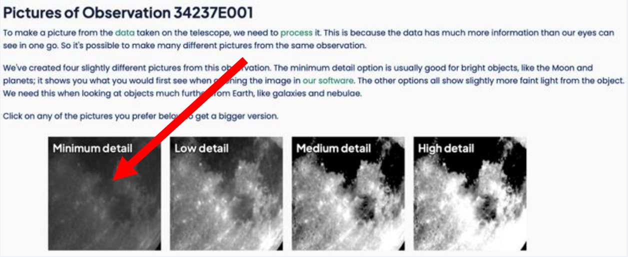
Follow either A or B in the following instructions for your method.

Option A: Making a Picture

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



16) a) Select 'Minimum detail'.

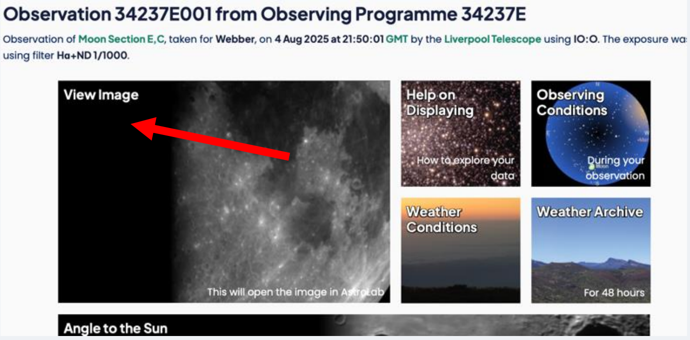


17) a) An image will appear in a new window. This can be saved by students for printing at a later time.

Ask the class teacher to arrange printing and sticking these into workbooks after the investigation.

Option B: AstroLab

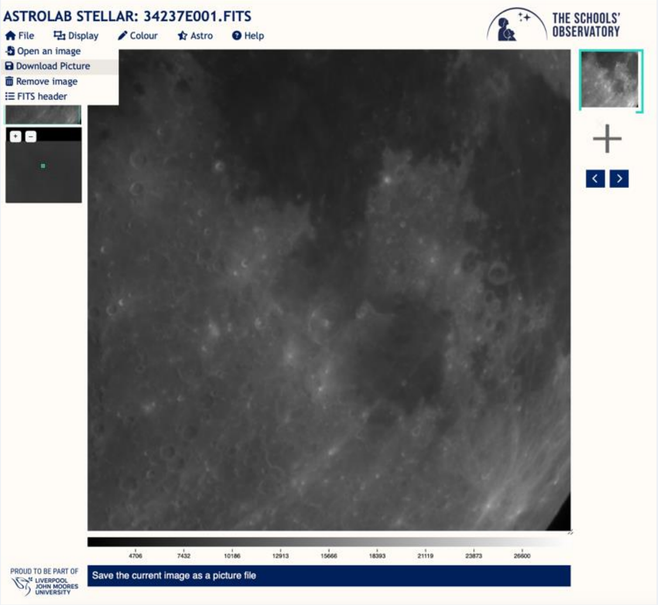
15) b) Click the 'View Image' panel.



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

This saves the image in the downloads folder.

Ask the class teacher to arrange printing and sticking these into workbooks after the investigation.



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 16)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.

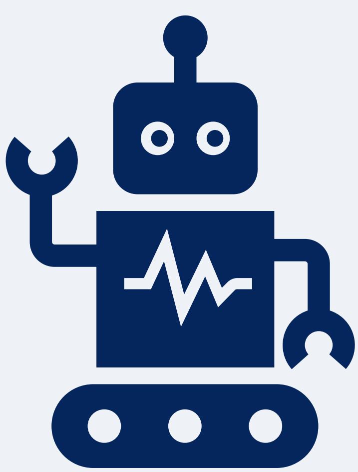
The Next Investigation

Tell students now that they have selected a site for their Moon Base, the next investigation will explore how to design it.

They'll learn about what resources humans need for survival and how we obtain these. This will help them understand what to include in the design of their Moon Base.

Investigation 3

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
Science	Working Scientifically	Lower Key Stage 2	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
	Rocks	Year 3	Compare and group together different kinds of rocks on the basis of their appearance and simple physical properties
	Living things and their habitats	Year 4	Recognise that environments can change and that this can sometimes pose dangers to living things
Geography	Geographical skills and fieldwork	Key Stage 1	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?

Subject	Topic	Year	Topic Elements
Computing	Online Safety	Key Stage 1	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
	Programming & Debugging	Key Stage 2	Use sequence, selection, and repetition in programs; work with variables and various forms of input and output
			Understand computer networks including the internet; how they can provide multiple services
			Select, use and combine a variety of software on a range of digital devices to design and create a range of programs, systems and content that accomplish given goals
		Key Stage 2	Design, write and debug programs that accomplish specific goals, including controlling or simulating physical systems.
			Solve problems by decomposing them into smaller parts.
	Digital Literacy & Collaboration	Key Stage 2	Select, use and combine a variety of software (including block-based programming in Scratch) on digital devices to design and create programs that accomplish given goals.

Lesson Plan

Possible Student Misconceptions:

- Humans have already landed on Mars.
- Robots on Mars are controlled in real time like remote-control cars.
- Mars has a thick atmosphere like Earth that makes landing easy.

Materials:

- Lesson PowerPoint presentation
- Student Workbooks
- 2 Mars canvases
- 8 Mission cards
- Models for communication, weather, temperature stations, and rocks
- 8 mbots
- Laptops/computers/tablets with internet access/google chrome browser
- Optional: Teacher Handbook (see referenced pages for more information/guidance about the activity)

Duration	Activity	Pages	Materials
15 minutes	Introduce the overall Mars project, reminding students about the Lunar Base Camp (Investigation 2). Explain why we need robotic rovers before humans can travel to Mars. Show slides on types of Mars missions and rovers. Link to the current investigation: students will take on the role of engineers and programmers, coding rovers to complete missions. → Ask: “Why do you think we send robots before people?” Show timeline of Mars missions and quiz: “How many rovers have landed?” Discuss the six rovers and their purpose. Show the Perseverance landing video. Ask students: “What challenges do you think spacecraft face when landing?” → Gather ideas.	Handbook: 36 – 39 Student Workbook: 22	Lesson PowerPoint presentation Student Workbooks

How Do You Control a Robot Rover?

Duration	Activity	Pages	Materials
8 minutes	Introduce programming with a quick "human coding" demo (volunteer follows instructions step-by-step). Explain what programming is. Introduce rover parts (wheels, sensors, motors, computer) and Scratch coding blocks (events, actions, show, sensing, control). Short demo in makeblock.	Handbook: 40 – 42	Lesson PowerPoint presentation
25 minutes	Group activity: Split the class into 2 big teams, each with 4 smaller mission teams. Each mission team: • Decide rover name + mission title • Plan route on Mars grid • Write and test their code • Record readings in workbook	Handbook: 42 – 46 Student Workbook: 22 – 24	Student Workbooks 2 Mars canvases Models for communication, weather, temperature stations, and rocks 8 mbots 8 mission cards Laptops/computers/ tablets with internet access
10 minutes	Supervisor starts the test runs. Each team attempts all 4 missions. Winning team = fastest + most accurate.	Handbook: 47 – 48 Student Workbook: 25	(same as above)
2 minutes	Wrap-up and teaser: "This investigation showed us how robots help us explore Mars. Next time, we'll look at how astronauts can stay healthy in space!"	Handbook: 49	Lesson PowerPoint presentation

How Do You Control a Robot Rover?

How does it link to the Mars project?

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.

In this investigation, students move one step closer to Mars. Before sending humans, space agencies use robotic rovers to explore, collect data, and test technologies. Students will act as engineers and computer programmers, coding their own robotic rovers to complete scientific missions on a Mars surface model.

This is beneficial because:

- Robotic rovers allow us to test conditions and collect data before risking human lives.
- Rovers can travel to dangerous or distant areas that would be difficult for humans to reach.
- The information rovers collect helps scientists plan safer human missions in the future.

By simulating rover missions in the classroom, students experience the link between coding and real-world planetary exploration, seeing how robots are used to gather evidence and solve problems on Mars.

Investigation Overview

Students will learn about the history and purpose of Mars missions, including orbiters and rovers.

They will explore how coding and debugging are used to control robots, linking this to real rovers on Mars. They will work in teams to complete 4 scientific missions on a Mars canvas using programmable mBots.

Each mission reflects a real scientific challenge faced by Mars rovers:

- Restoring communications by adjusting a satellite dish.
- Collecting rock samples to look for evidence of water and minerals.
- Measuring surface temperatures under different conditions.
- Recording weather data, including wind speed and atmospheric gases.

How Do You Control a Robot Rover?

Starter Activity: Why Explore Mars with Rovers?

Show this question in the PowerPoint presentation (on slide 3). Give students time to think, then ask them to share ideas before showing the answers.

You could add some of the following information:

Mars is far away and too risky for humans right now

- It takes months to travel there, and we don't yet have the technology to keep humans safe for the whole trip.
- So, we send robots first to test the conditions.

Rovers act like scientists on wheels

- They can study rocks, soil, and weather.
- They collect data about the planet that we couldn't get otherwise.

Robots are safer and cheaper than sending people

- If a robot fails, we can build another.
- Humans need food, water, and oxygen – robots do not.

Exploring Mars prepares us for the future

- Each mission teaches us more, so we can plan for when humans might one day live there.

Though pupils might be enthusiastically sharing information, try not to spend too long on this part! Tell them there might be a chance to share again later.

Previous Mars Missions

Show this in the PowerPoint (on slide 4).

Explain to students:

- Different countries including America, Europe (including the UK), China, India, Japan, and the UAE have been sending spacecraft to Mars for nearly 60 years!
- There are different types of Mars missions:
  - Flybys – spacecraft zoom past Mars and take pictures.
  - Orbiters – spacecraft go around Mars to study it.
  - Rovers – robot cars that drive on Mars' surface.

Over 50 missions have tried. Many failed at first, but now more succeed. Even failures are important, because scientists and engineers learn from every attempt.

How Do You Control a Robot Rover?

How Many Rovers Have Landed on Mars?

Show this question in the PowerPoint (on slide 5). Give students three options to guess from.

Select some to share their ideas before showing the class the answers on the board.

The correct answer is: 6 rovers have landed safely on Mars. Only 2 are still active today.

Mars Rovers So Far

Use the PowerPoint (on slide 6) to introduce each rover:

Sojourner (1997): First rover on Mars.
Spirit (2004–2010): Explored rocks and soil.
Opportunity (2004–2018): Looked for water.
Curiosity (2012–today): Studies climate and geology.
Perseverance (2021–today): Collects samples for return.
Zhurong (2021–2022): Explored surface and weather.

Also add the following information:

- All rovers are controlled from Earth. Every signal takes time to reach to the rover (don't give the answer here as this will be a reading for 'Activate Communication' mission.
- Only Curiosity and Perseverance are still alive and working today.

Activity: Landing a Rover

Show the Perseverance landing video (PowerPoint, slide 7).

Ask the students: "What challenges do you think we face when sending and landing a rover on Mars?"

Encourage them to watch carefully and then write down their answers in their workbook. You can then discuss these as a class.

How Do You Control a Robot Rover?

Key Challenges (with extra notes):

Distance

- Mars is about 55–400 million km from Earth (depending on orbit).
- This makes the journey very long – between 6–9 months.
- Once launched, there's no turning back to fix mistakes!

Thin Atmosphere (hard to slow down!)

- Mars' atmosphere is only about 1% as thick as Earth's.
- Parachutes don't slow spacecraft enough, so rockets and special landing systems (like "sky cranes") are needed.

Dust Storms

- Mars has giant dust storms that can cover the whole planet for weeks.
- They can block sunlight (bad for solar panels) and make landing harder.

Bumpy Surface

- The ground is full of craters, cliffs, and rocks.
- Rovers must land in carefully chosen "safe zones" that are flat enough, but still interesting to study.

Remote Control & Communication

- It takes about some time for a signal to travel from Mars to Earth.
- Scientists can't "joystick" the rover in real time — it must follow pre-programmed instructions.
- This is why the rover's landing is called the "seven minutes of terror" — it lands by itself before we even get the message that it started!

Activity: Coding a Rover

Programming is like giving step-by-step instructions to a robot or computer. The robot will only ever do exactly what you tell it to do—nothing more, nothing less.

Ask for a volunteer to come to the front.
Give them simple instructions, such as:
"Take 3 steps forward."
"Turn one step to the right."
"If you are near the desk, turn left."

Point out how this is just like coding, we give rules in order, and the computer follows them one by one.

Tip: Highlight that robots and computers aren't "clever" on their own. They only follow the program we design.
Emphasise how important clear instructions are, if our code has mistakes, the robot will not behave as expected. This is called **debugging**.

Rover Parts

Before students begin coding their rovers, it's useful to understand the main parts that make them work. Use the slide to guide discussion:

Control System (Computer):

- The "brain" of the rover.
- Stores the program that students will write.
- Sends signals to other parts to make them move or sense.

Motors:

- The "muscles" of the rover.
- Control the wheels so it can move forwards, backwards, or turn.
- Some rovers use motors to move robotic arms or instruments.

How Do You Control a Robot Rover?

Wheels:
- Allow the rover to drive across the Martian surface.
- Different rovers have different wheels depending on the terrain (bumpy ground, sand, or rocks).

Sensors & Cameras:
- The "eyes and ears" of the rover.
- Cameras take pictures and videos of Mars' surface.
- Sensors detect things like light, distance, or obstacles.
- Scientists use data to learn about Mars' weather, rocks, and soil.

Tip:
- Link this back to real Mars rovers:
  NASA's Curiosity and Perseverance use cameras and sensors to study rocks and dust storms.
- Ask: What might happen if the rover didn't have sensors? (It could crash, get stuck, or miss important data.)
- Encourage students to think of the rover like a human explorer—brains, muscles, eyes, and legs all working together.

Makeblock Coding Blocks

Now that students know the different coding blocks, give them a short demo of how these blocks work in Makeblock. This software is similar to Scratch, which students likely have used before.

Ideally, demonstrate each step to the class so pupils can follow along

Drag and click each block
- Take one block (e.g., move forward).
- Drag it into the coding area, click on it, and show the robot reacting.
- Explain: "Every block is an instruction. When you click it, the robot listens."

Snap blocks together like LEGO
- Demonstrate how two blocks can be joined (e.g., when green flag clicked + move forward).
- Point out how the shapes only fit in certain places; this helps us know what works together.

Change variables

- Show how to change numbers in a block (e.g., "move forward for 1 second" → "move forward for 3 seconds").Ask: "What will happen if I change it to 5 seconds instead of 1?" Then test it.

Introduce "if…else" block (Control)

- Explain: "Sometimes the robot needs to make a choice. If this happens, do this. Otherwise, do that."
- Drag in an if…else block.

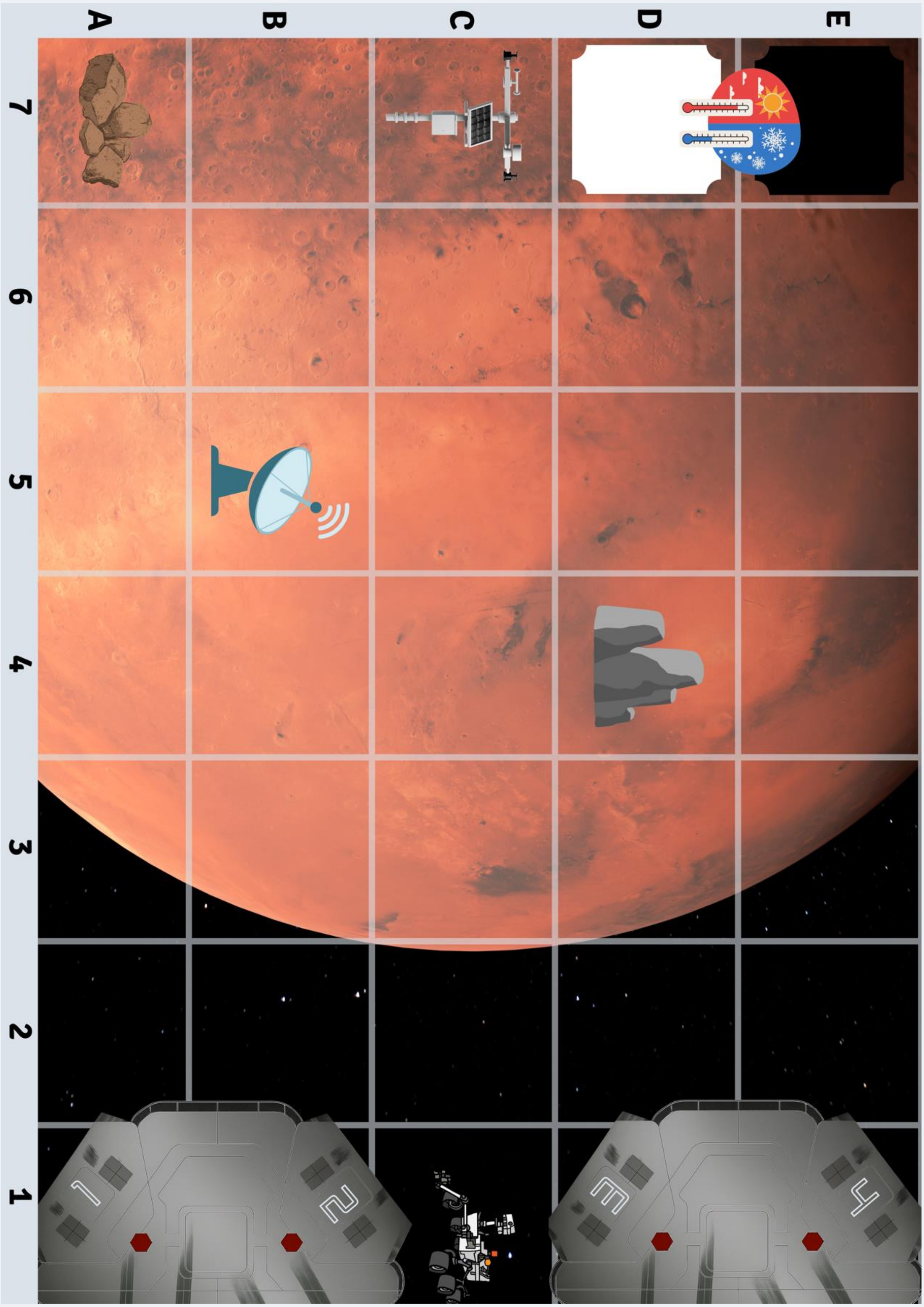
Add the line follower block (Sensing)

- Show the line follower sensor block (e.g., detects black).
- Demonstrate: "If the sensor sees black, the robot flashes a colour. If not, it beeps."

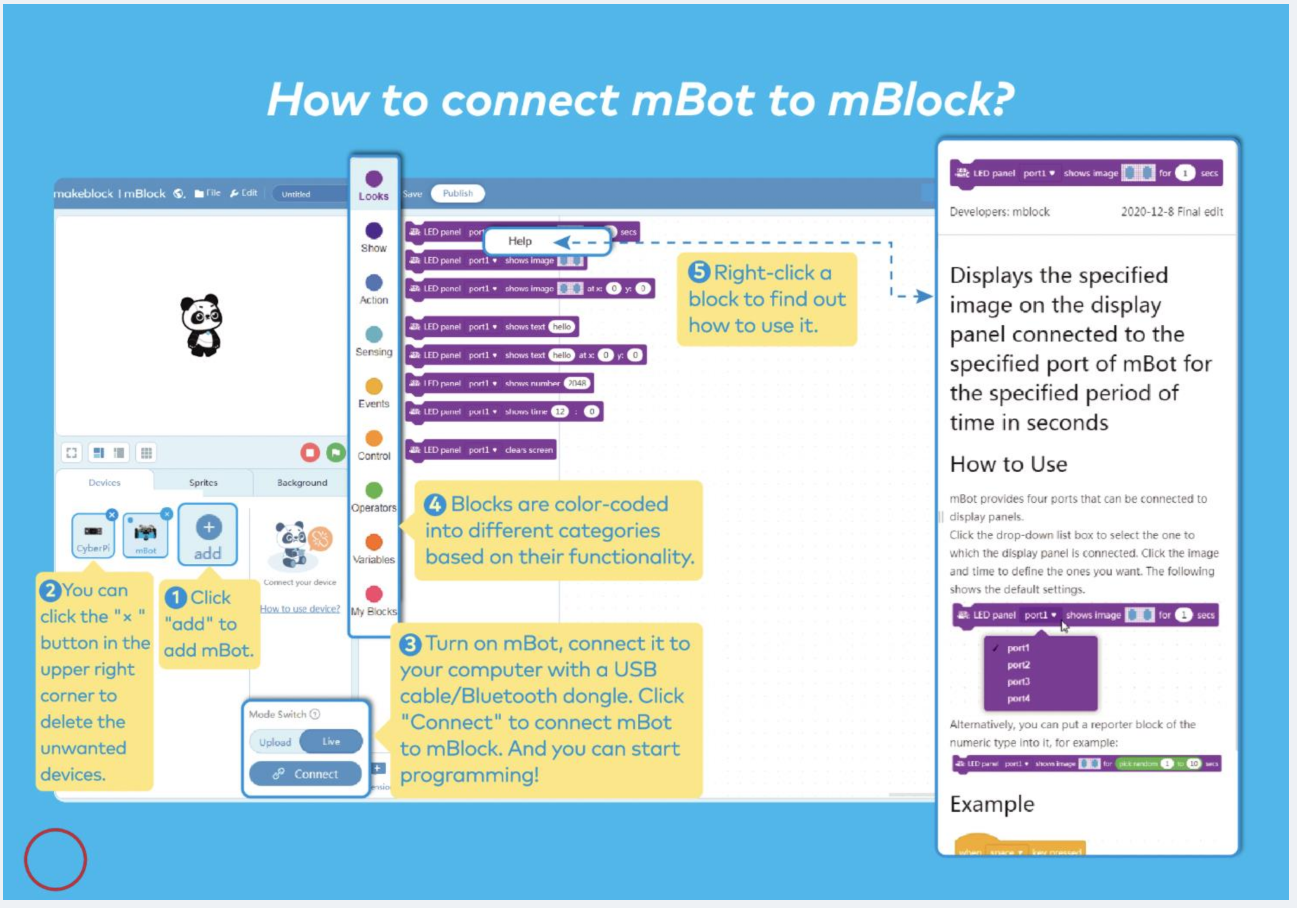
Tip:

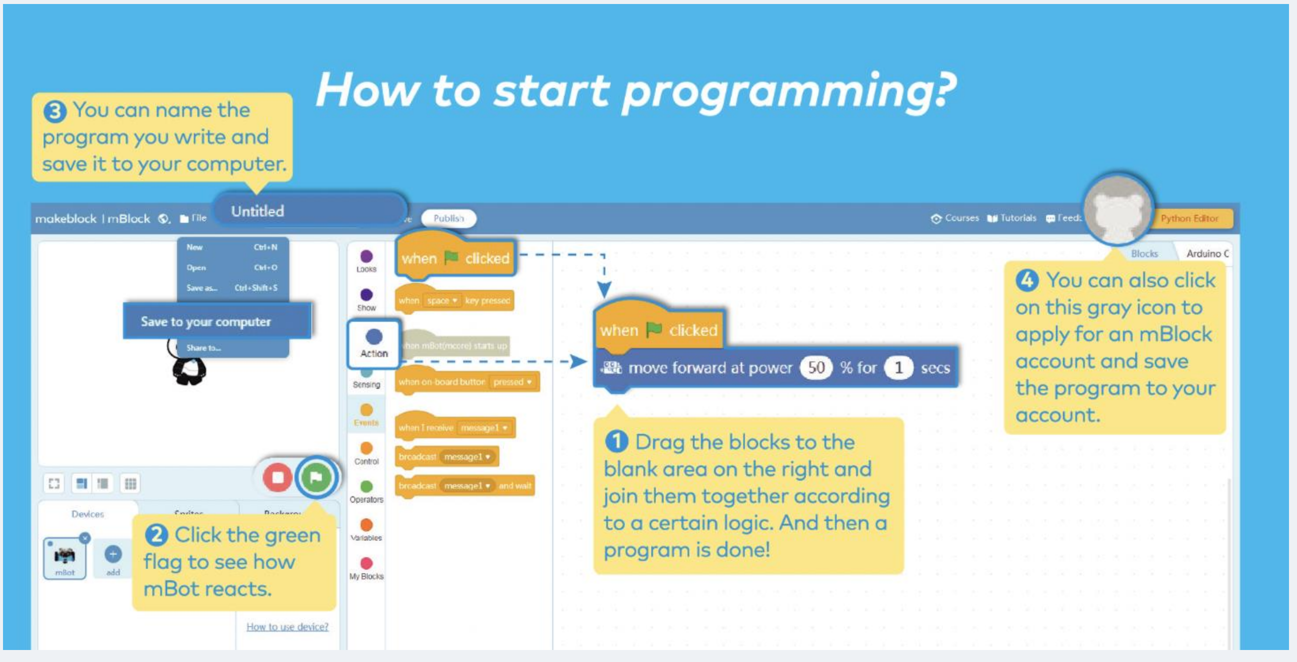
- Keep the demo short, students will learn most by trying it themselves.
- They might trigger the code by clicking anywhere on the code
- It is advisable to have 'stop moving' code ready to be clicked anytime if anything went wrong and you also have the stop button.
- It is highly recommended to arrive early on the day and arrange with the teacher to connect all the mbots to students' tablets/laptops before the session stars and to make sure everything is in order. This will save you plenty of time during the session.
- Remember to attach the magnets to the rovers doing 'Collect Rocks' mission.
- Also set up Mars canvas and place the models on it (check next page).
- For instructions how to connect mbot to laptop/tablet, please see the instructions in page (44). Please use 'Google Chrome' browser and visit this link https://ide.makeblock.com/

How Do You Control a Robot Rover?



How Do You Control a Robot Rover?





Mars Missions

Now that students have been introduced to Scratch and know how to use the different coding blocks.

Explain: Split the class into 2 large teams. Each large team is made up of 4 smaller mission teams (two per mission). Hand out the mission cards to each team.

Remind them that each team will:

- Plan their rover's path (plotting).
- Write their code (coding).
- Test it (debugging).
- Record their results (workbook).

Mention the time: ~20 minutes for all steps. Give reminders when it is 10min, 5min and 1min left. (You might need to come out of the presentation mode to start the countdown, then you can have it back).
Tip: Encourage teamwork: one student can plot, one code, one test, and one write.

Step 1 – Rover and Mission Details

- Ask students to agree on a rover name and write it in the workbook.
- They should also write down their mission title (from the mission card).

Tip: Emphasise collaboration: this step builds team identity and makes them feel like "real engineers."
You could prompt: "What would NASA or ESA name their rover? Can you come up with something inspiring or funny?"

Step 2 – Plotting & Planning

- Explain that plotting means drawing the rover's journey on the Mars grid before coding.
- Students should trace the safest path to their mission target.
- Remind them to think about obstacles (rocks, hills, stations).

Tip: Tell them to use arrows or step counts to map moves. This helps avoid errors later.
Connect to real science: engineers at NASA also plot rover paths carefully to avoid hazards.

Step 3 – Coding
Now, students turn their plotted path into code.

Remind them:
- Use the Scratch blocks introduced earlier.
- Each move or turn is a block.
- Sensors help the rover detect colours or obstacles.
- Encourage trial and error — mistakes are part of debugging.

Teacher Tip: Walk around and check that students are matching their planned path with their code.

Step 4 – Testing
- This is the debugging stage. Students test if their rover follows the plotted path.
- If it doesn't work the first time, that's fine! Encourage them to adjust the code and try again.
- Highlight that real missions also test multiple times before launch.

Ask: "What worked? What didn't? How can you improve it?"
Motivate them by saying even NASA engineers face failures before success.

Step 5 – Final Code
- Once their rover works, students copy their final code into the workbook.
- They can either draw the coding blocks or write them in order.

This step helps them reflect and makes their thinking visible.
Point out: "Your code is like the rover's recipe — without it, it wouldn't know what to do."

Step 6 – Readings
- Students record the rover's mission readings here.
- Each mission will give a "scientific result" (time delay, rocks collected, weather data, temperatures).
- They should also answer the question: "What does your reading represent?"

Testing time

Both teams will start the mission at the same time, and the winning team is the fastest team that completed all 4 missions and collected full data. (If any of the mbots touched the lines of any of the bases that should count as a success).

Wrap-Up & Supervisor Notes

Well done, teams! Both rovers made it through their missions. Let's look at the science data you've collected from Mars."

Mission 1 – Activate Communications

- 12.5 minutes → That's how long it takes a radio signal to travel between Mars and Earth (one way).
- This is why we can't control rovers in real time – there's always a delay.

Mission 2 – Collect Rocks

You found 4 key Martian rock types:

- Fe_2O_3 (Iron Oxide / Rust) → This is why Mars looks red.
- H_2O (Water minerals) → Signs that water once flowed on Mars.
- SiO_2 (Silica) → Found in rocks and dust, clues about past volcanic activity.
- Mg + Fe (Basaltic minerals) → Common in volcanic rocks, tells us Mars was geologically active.

Mission 3 – Record Weather

- 60 mph (97 km/h) → The average speed of dust storms on Mars.
- CO_2 → The Martian atmosphere is very thin and mostly carbon dioxide.
- This makes it hard for humans to breathe or stay safe without protection.

Mission 4 – Measure Temperature

- +35 °C (Summer high)
- -155 °C (Winter low)
- Mars has extreme temperature swings, much colder than Earth most of the time.

Example full code: Mission 4 – Measure Temperature Code

```
when [flag] clicked
move forward at power (50) % for (4.9) secs
if <line follower sensor [port1 ▾] detects [all ▾] being [black ▾] ?> then
    LED [all ▾] shows color ( ) for (1) secs
else
    play note [C4 ▾] for (0.25) beats
turn left at power (50) % for (0.45) secs
move forward at power (50) % for (0.5) secs
if <line follower sensor [port1 ▾] detects [all ▾] being [white ▾] ?> then
    LED [all ▾] shows color ( ) for (1) secs
else
    play note [C4 ▾] for (0.25) beats
move backward at power (50) % for (0.5) secs
turn right at power (50) % for (0.5) secs
move backward at power (50) % for (4.9) secs
LED [all ▾] shows color ( ) for (1) secs
stop moving
```

Next Investigation

So, now we know more about Mars — the rocks, the weather, the temperatures, and how far it is from Earth. But here's the big question: if we sent humans there, how could they stay healthy? That's what you'll explore in the next investigation!

Investigation 5

Why Does Mars Change Size?

Why Does Mars Change Size?

Learning Objectives

- To understand that the planets orbit around the Sun at set distances
- To understand that the distances between planets change as they orbit the Sun
- To accurately measure lengths and take averages, and to use these to plot graphs

Career Link: Astronomer

Curriculum Links

Subject	Topic	Year	Topic Elements
Science	Light	Year 3	Notice that light is reflected from surfaces
	Earth and Space	Year 5	Describe the movement of the Earth, and other planets relative to the Sun in the solar system
			Describe the movement of the Moon relative to the Earth
			Describe the Sun, Earth and Moon as approximately spherical bodies
	Working Scientifically	Lower Key Stage 2	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

Why Does Mars Change Size?

Subject	Topic	Year	Topic Elements
Science	Working Scientifically	Lower Key Stage 2	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
			Using straightforward scientific evidence to answer questions or to support their findings
		Upper Key Stage 2	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
			Identifying scientific evidence that has been used to support or refute ideas or arguments
Mathematics	Measurement	Year 3	Measure, compare, add and subtract lengths (m/cm/mm)
		Year 4	Convert between different units of measure [for example, kilometre to metre]
		Year 5	Convert between different units of metric measure (for example, kilometre and metre; centimetre and metre…)

Why Does Mars Change Size?

Subject	Topic	Year	Topic Elements
Mathematics	Measurement	Year 6	Solve problems involving the calculation and conversion of units of measure, using decimal notation up to three decimal places where appropriate
			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
			Convert between miles and kilometres
	Number – addition and subtraction	Year 4	Add and subtract numbers with up to 4 digits using the formal written methods of columnar addition and subtraction, where appropriate
	Fractions	Year 5	Solve problems that involve fractions
	Ratio and proportion	Year 6	Solve problems involving the calculation of percentages [for example, of measures, and such as 15% of 360] and the use of percentages for comparison
	Geometry	Year 6	illustrate and name parts of circles, including radius, diameter and circumference and know that the diameter is twice the radius
	Statistics	Year 6	Calculate and interpret the mean as an average

Lesson Plan

Possible Student Misconceptions:

- The planets orbit in a straight line
- The planets are spaced equally throughout the Solar System
- Planets move at the same speed
- Planets always look the same from Earth
- Mars is close to Earth

Materials:

- Lesson PowerPoint Presentation
- Student workbooks
- Till roll cut into strips – one for each student
- Planet stickers
- Rulers
- Pencils
- Optional: Calculators
- Optional: Teacher Handbook (see referenced pages for more information/guidance about the activity)

Duration	Activity	Pages	Materials
5 minutes	Recap what happened in the last investigation and how it links to the current investigation and overall Mars project. Ask students if they can name the planets and if they know the order of them. Show the correct order to the class and ask students to write it in their workbooks.	Handbook: 59 – 60 Student Workbook: 48	Lesson PowerPoint presentation Student Workbooks
15 minutes	Give each student a strip of till roll and carry out the 'Map the Solar System' activity, demonstrating each step at the front of the class. Explain that this is a scale model because distances in space are so vast. Have students write the scale size of the Solar System map in their workbooks	Handbook: 60 – 62 Student Workbook: 48	Lesson PowerPoint presentation Student Workbooks Till rolls Planet stickers

Why Does Mars Change Size?

Duration	Activity	Pages	Materials
15 minutes	Set the context for working out the distances between orbits. Students complete the 'Orbit Math's' activity in their workbooks. Show answers to class and students mark their work. Go through the information to put these figures in context.	Handbook: 63 – 64 Student Workbook: 49	Lesson PowerPoint presentation Student Workbooks Optional: Calculators
20 minutes	Explain the 'Measure Mars!' activity to students. Students measure their images and record the results in the table in their workbooks. Demonstrate how to plot the data on the graph provided in the workbooks. Ask students to complete the questions in their workbooks. Have a class discussion about why Mars appears to change size.	Handbook: 64 – 66 Student Workbook: 51 – 55	Lesson PowerPoint presentation Student Workbooks Rulers Pencils Optional: Calculators
5 minutes	Give students a brief insight to the next investigation and how it links to the current investigation and overall Mars project	Handbook: 67	Lesson PowerPoint presentation

Why Does Mars Change Size?

How does it link to the Mars project?

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.

Now, they must understand how we'll reach the planet.

In this investigation, students will act as astronomers and explore our solar system, finding out why Mars appears to change size when we look at it from Earth.

Understanding why these changes happen is crucial to our mission – it could affect our plans of getting to the planet.

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 calculate the average distance between the orbits of Earth and Mars in both kilometres (km) and astronomical units (AU).

Once this value is put into context for them to understand, 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.

Students then plot a graph of their results to see these changes more clearly. They will use their graph to explain why Mars appears to change size in the Earth's night sky.

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

Activity: Map the Solar System

Ask the students if they know the names of the planets in the Solar System. Select some to give answers.

Next, ask students if they know the order of the planets. Again, choose a few to share their answers with the class.

Show the image of the planets from the PowerPoint presentation (on slide 3) and tell students to write the correct order in their workbooks.

You can mention that beyond Neptune there are also some dwarf planets, including Pluto.

There is also a dwarf planet (Ceres) in the asteroid belt – but only mention this if a student does. For the sake of the next activity, we will just have 'dwarf planets' listed at the orbit of Pluto.

Give each student a strip of till roll. Demonstrate the following instructions (reference image on next page) at the front of the class.

Step 1: Fold the paper in half, unfold, and write Uranus on the crease.

Step 2: Re-fold the half and then fold in half again. Write Saturn on the crease ¼ down the page, and Neptune ¾ down the page.

Step 3: Fold the paper from the Sun up to where Saturn lies and write Jupiter at this crease ($^1/_8$ down the page).

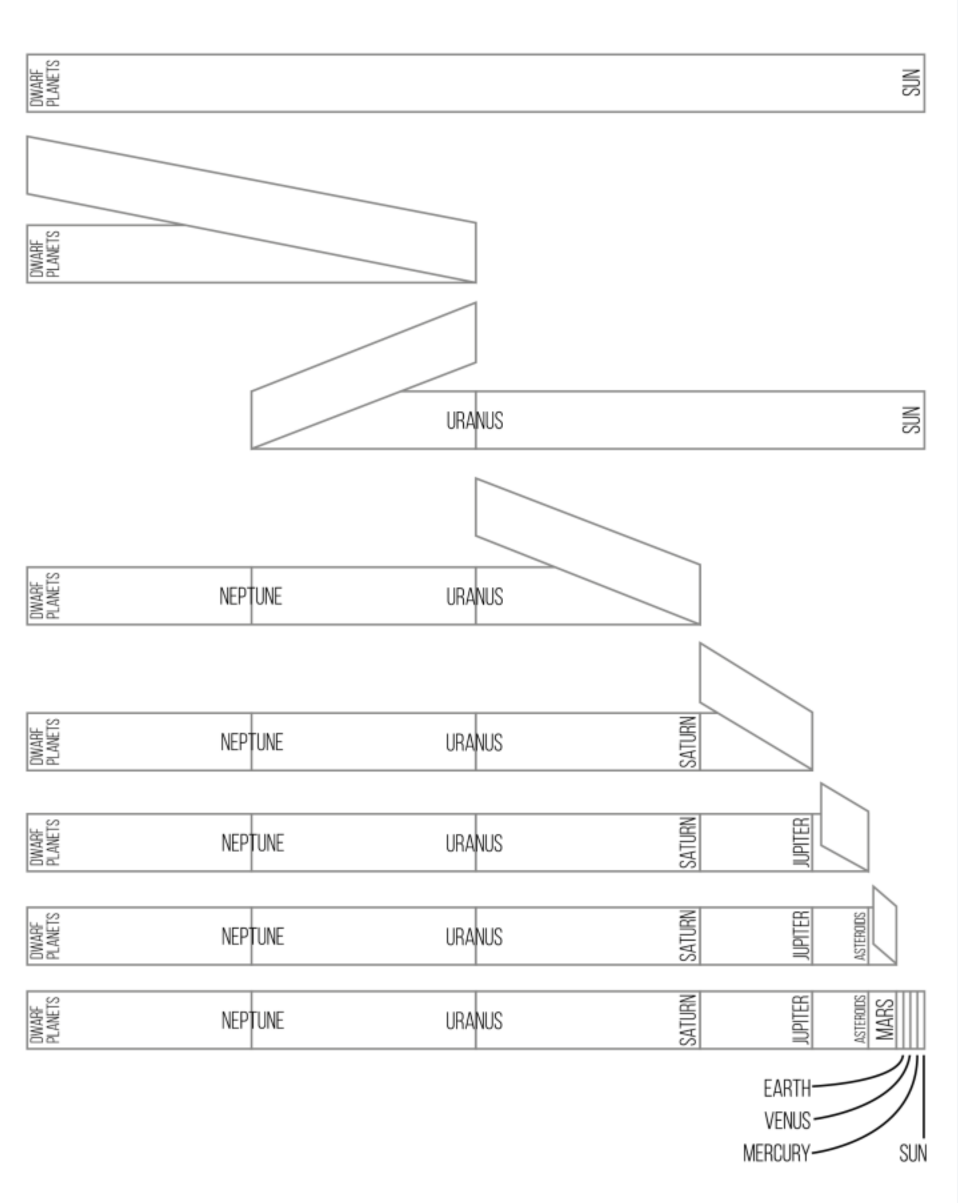
Step 4: Next, fold from the Sun up to Jupiter and write Asteroid Belt at this crease ($^1/_{16}$ down the page).

Step 5: Fold from the Sun up to the asteroid belt and write Mars at this crease ($^1/_{32}$ down the page).

Step 6: Write the remaining planets (Mercury, Venus, Earth – in this order) evenly in the space between the Sun and Mars, with Mercury closest to the Sun.

Why Does Mars Change Size?

The final till roll should look like this:



The maps can be placed inside the workbooks. Ask the class teacher to arrange sticking these in after the investigation.

Tip: If any students are struggling to spell the names of the planets, you can give them the planet stickers to use instead.

Why Does Mars Change Size?

Show slide 6 of the PowerPoint presentation. Explain that this is scale model because the distances in space are so vast. Ask students to write down the scale value in their workbooks.

Point out that even though many pictures of the solar system – and the maps we've created – show the planets in a straight line from the Sun, this isn't how things look in real life.

The planets all move around the Sun at different speeds and sit at different distances. That means that it's rare for the orbits of even 2 planets to line up at any one time – let alone 8 of them!

Play the video from the PowerPoint presentation (on slide 8). It shows how much the planets move over 4 years. The outer planets barely seem to move at all, whilst the inner planets make multiple orbits during the same period.

If this were sped up and extended for more time, the movement of the outer planets would be more obvious, but the inner ones would be moving so quickly that it would be hard to keep up!

Students will explore this more in the next investigation when they plan their launch date.

You could ask students why it takes so long for the outer planets to orbit the Sun compared to the inner planets.

You can discuss that:

- Planets further from the Sun need to cover a larger distance to complete 1 orbit, so this will take longer.
- The strength of gravity is weaker further away from the Sun, so the pull on the outer planets is less, and therefore so is their speed.

Activity: Orbit Math's!

To get to Mars, we need to know how far away it is. Because the planets are constantly moving, the distance between Earth and Mars is changing too. So, we are going to calculate the distance between their orbits instead.

You can compare it to cars on the road – we can measure the distance between lanes, but the cars could be close together or far away from each other.

Ask students to complete the calculations in their workbooks. The equations are given for them to use.

Tip: Speak to the class teacher before the investigation to discuss equipment such as calculators.

You can also inform them of the maths involved and ask if there are any students you/they should give extra support to. The teacher may also suggest pairing up certain pupils to help them further.

Once students have completed the activity, show the answers from the PowerPoint presentation (on slide 10).

Student Workbook Answers

Average distance between the orbits of Earth and Mars:

228 million – 150 million = **78 million km**

Distance from the Sun to the Earth in Astronomical Units (AU):

150 ÷ 150 = **1 AU**

Distance from the Sun to Mars in Astronomical Units (AU):

228 million ÷ 150 million = **1.52 AU**

Distance between the orbits of Earth and Mars in Astronomical Units (AU):

1.52 – 1 = **0.52 AU**

Highlight to students that they've worked out that 1 AU is the distance of the average orbit of Earth. This is how it was defined. Having different units makes the number less complex (rather than using millions and billions).

Emphasise again that these are averages. The orbits of planets are almost circular around the Sun (but not quite) – this isn't the distance between the planets all the time (because they move), but the distance between the orbits, or the paths that they take.

Ultimately, this activity is to demonstrate that the Earth and Mars are some of the closest planets in the Solar System – but the distance between us is still vast.

Show slide 11 from the PowerPoint presentation to put this into context for the students.

Activity: Measure Mars!

There are 8 images of Mars in the student workbooks. These were taken by the Liverpool Telescope – the same telescope pupils used to look at the Moon in Investigation 1.

The Liverpool Telescope lives on La Palma (one of the Canary Islands of Spain) and is completely robotic.

All 8 images are zoomed in to the same amount, so any differences in size are not to do with the images themselves.

Tell students they are going to investigate these differences. They will measure the size of Mars using a ruler and record the value in their results table.

The table includes columns for 3 measurements of each observation. You should briefly explain to students why repeat measurements are taken in science (e.g. reducing random errors by calculating an average, identifying anomalies, reliability).

Tip: Not at all students will be able to take 3 measurements and calculate an average in the time provided. Encourage them to do a measurement for each observation first and then repeat this for the second and third measurements if they have time.

You can also have students working in pairs and sharing results with each other to get measurements faster.

Tip: Students should measure the widest part of the planet, but they might struggle to know where the 'edge' is to take their measurement from.

This is often the case when measuring things in astronomy – just tell them that their best guess is okay, and it's why multiple measurements are important.

Tip: Students might not have come across averages before, or they may specifically know this as the mean average. You can support them in calculating these if needed.

Speak to the class teacher prior to the investigation and ask if they're okay with pupils using calculators for this step.

If calculators are used, the most common mistaken is dividing too early e.g. '52 + 51 + 53 ÷ 3' instead of '(52 + 51 + 53) ÷ 3' or '156 ÷ 3'.

Once students have their results, these are then plotted as a line graph (axes are provided in their workbooks). You should demonstrate/talk through plotting a few points whilst at the front of the class.

Make sure students are using pencils and ask them to plot using a cross (x) rather than a dot (•) – it's easier to see the centre of the cross, so results can be plotted precisely.

Why Does Mars Change Size?

When graphs are complete, students have questions to answer in their workbooks.

You can discuss the answers and results as a class. Ask them what is happening to the size of Mars and the reason for this.

The changes occur because the planets (both Earth and Mars) are moving. Mars appears larger as the planets move closer together and starts appearing smaller as the planets move further away.

If needed, you can prompt students by emphasising the dates – observations start in January and continue up to May. Ask what is happening to Mars in this time.

If pupils are still stuck, ask what happens to Earth between January and May. Students may talk about the seasons changing, and you can link this to our orbit around the Sun.

The Next Investigation

Now that students understand how the distance to Mars changes, tell them they'll need to use this knowledge in the next investigation.

They will use an online tool that shows movement of planets in our solar system. By analysing how the movement changes over time, pupils will plan when the best date is to launch to Mars.

Investigation 6

When Should We Launch to Mars?

When Should We Launch to Mars?

Learning Objectives

- To understand that the planets orbit the Sun at set distances
- To understand that the distances between planets change as they orbit the Sun
- To use data about the solar system to plan for a mission

Career Link: Mathematician

Curriculum Links

Subject	Topic	Year	Topic Elements
Science	Working Scientifically	Lower Key Stage 2	Asking relevant questions and using different types of scientific enquiries to answer them
			Setting up simple practical enquiries, comparative and fair tests
			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

When Should We Launch to Mars?

Subject	Topic	Year	Topic Elements
Science	Earth and Space	Year 5	Describe the movement of the Earth, and other planets relative to the Sun in the solar system
			Describe the movement of the Moon relative to the Earth
			Describe the Sun, Earth and Moon as approximately spherical bodies
Mathematics	Measurement	Year 3	Tell and write time from an analogue clock (12-hour and 24-hour clocks)
			Estimate and read time with increasing accuracy to the nearest minute; record and compare time in terms of seconds, minutes and hours; use vocabulary such as o'clock, a.m./p.m., morning, afternoon, noon and midnight
			Know the number of seconds in a minute and the number of days in each month, year and leap year
			Compare durations of events [for example, to calculate the time taken by particular events or tasks]
		Year 4	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
		Year 5	Solve problems involving converting between units of time
	Number – multiplication and division		Solve problems involving addition, subtraction, multiplication and division & a combination of these, including understanding the meaning of the equals sign

Subject	Topic	Year	Topic Elements
Mathematics	Number – addition, subtraction, multiplication and division	Year 6	Solve problems involving addition, subtraction, multiplication and division
			Use estimation to check answers to calculations and determine, in the context of a problem, an appropriate degree of accuracy
	Number - fractions		Solve problems which require answers to be rounded to specified degrees of accuracy

Lesson Plan

Possible Student Misconceptions:
- Mars and Earth are always close together
- The journey to Mars will be short
- There is no need to plan the launch date

Materials:
- Lesson PowerPoint presentation
- Student Workbooks
- Laptops/computers/tablets with internet access
- Evaluation postcards
- Optional: Calculators
- Optional: Teacher Handbook (see referenced pages for more information/guidance about the activity)

Duration	Activity	Pages	Materials
3 minutes	Recap what happened in the last investigation and how it links to the current investigation and overall Mars project.	Handbook: 76	Lesson PowerPoint presentation
10 minutes	Ask students to individually guess and write in their workbooks how long it will take to get to Mars. Select some students to share answers with the class. Show the correct answer to the class and have students write this in their workbooks. Students calculate this in approximate months and years in their workbooks.	Handbook: 77 Student Workbook 58	Lesson PowerPoint presentation Student Workbooks Calculators
17 minutes	Direct students to the electric orrery resource. Briefly explain what an orrery is. Students complete the 'Electric Orrery' activity in their workbooks.	Handbook: 78 – 79 Student Workbook: 59	Lesson PowerPoint presentation Student Workbooks Laptops/computers/ tablets with internet access

When Should We Launch to Mars?

Duration	Activity	Pages	Materials
13 minutes	Explain to students that they also need to consider the time it takes to get to Mars. Guide students through 'The Launch Date' activity.	Handbook: 80 – 81 Student Workbook: 60	Lesson PowerPoint presentation Student Workbooks Calculators
5 minutes	Briefly show the importance of the first words spoken on such an epic exploration – play the clip of Neil Armstrong and point out how most people still know these words today. Students complete the 'First Words' activity in their workbooks.	Handbook: 81 Student Workbook: 61	Lesson PowerPoint presentation Student Workbooks
5 minutes	Hand out the evaluation postcards for students to fill in. Collect at the end of the session and return to Stacey.	Handbook: 82	Lesson PowerPoint presentation Evaluation postcards
7 minutes	Take a little time to acknowledge that this is the end of the investigations and your last visit to the school. Show the video (on mute) about human exploration on Mars. Discuss these missions as a class and ask students if they've like to be involved in them.	Handbook: 82	Lesson PowerPoint presentation

When Should We Launch to Mars?

How does it link to the Mars project?

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.

Investigation Overview

Students will learn how long it takes to get to Mars and convert this from days into both months and years.

They will then use the Electric Orrery on The Schools' Observatory's website to analyse the motion of the planets and observe the distance between Mars and Earth at different points in time.

Once they know the date of the next closest approach, pupils will consider how long it takes to reach Mars and factor this into their calculation of a launch date. They will also pick a launch time and calculate how long it will be until they launch.

Finally, students will think about the importance of first words and reflect on Neil Armstrong's first words on the Moon. This will help them write what their own first words on Mars will be.

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

Activity: Travelling to Mars

Ask students to guess and write in their workbooks how long they think it will take (in either days, weeks, months, or years) to get to Mars.

Select a few students to share their answers. You could play the higher/lower game after each answer and have students raise their hands (e.g. 'Put your hand up if you think it will take longer').

Highlight that Mars is 56 million km away at closest approach– the same as going to the Moon and back more than 70 times. Even driving at over 100 km/h, it would take almost 65 years to cover this distance!

Show the answer from the PowerPoint presentation (on slide 5) and tell students to write this into their workbooks.

It takes roughly 250 days to get to Mars. Values typically span 210 to 270 days with the most fuel-efficient path and a good launch window.

The truth is, we don't have the technology for this right now, and these are best guesses based on the mathematics of the orbits and expected velocities of the vehicles.

In their workbooks, student's covert 250 days into both months and years. Tell them to round to 2 decimal places.

Show the answers on slide 6 of the PowerPoint presentation. Since we've assumed 30 days per month, the value won't be quite right, but it's an okay approximation.

Student Workbooks Answers

250 ÷ 30 = **8.33 months**

250 ÷ 365.25 = **0.68 years**

Note: It's okay if students haven't used the leap year – only the 3rd decimal place changes, and they're rounding to 2 decimal places.

Activity: Electric Orrery

Because it takes a long time to travel within the Solar System, we need to carefully plan the launch date to ensure the planet (or other object) is in the right position when we arrive!

We can plan using a tool called an orrery – a model of the Solar System that shows the planets in their correct positions relative to the Sun and each other. We can move the model forwards and backwards in time.

Tip: Speak to the class teacher prior to the investigation and ask what resources students will be using (e.g. tablets, computers, laptops).

If possible, the class teacher may be able to prep them during the previous activities – switching them on, loading the website, etc. If not, students can do this whilst you explain what an orrery is.

You should also ask if students need to leave the classroom to access any technology. Some schools may only have computers in certain classrooms.

Once students are on The Schools' Observatory's website (logging into an account is not needed), go through the following instructions.

Ideally, demonstrate this at the front using the teacher's computer.

1. Type '**orrery**' into the search box near the menu bar on The Schools' Observatory's website.
2. Click on the first search result: '**Electric Orrery**'.
3. Scroll to the bottom of the page: '**Start Exploring**!' section.
4. Click '**>**' from the top row of the '**Controls**' menu to play the orrery and observe the planets moving (each button along the menu is a different speed).
5. You can switch to 'Visible Solar System' (what we can see with our eyes) and 'Outer Solar System' in the '**Display**' options, but Mars and Earth are difficult to see.
6. Reset to '**Today**' and '**Inner Solar System**'.

7. Use the buttons on the **lower row** of 'Controls' (i.e. the arrows either side of the 'Today' button) to move forwards and backwards in time.
8. Reset to '**Today**'.
9. Tell students to work in pairs and start by using the '**>>**' button to move the orrery a month.
10. Ask all students to write the displayed **date** in the table in their workbook and circle '**Yes' or 'No**' to answer if Earth and Mars are close together. They can also write anything else they observe in the '**Notes**' column.
11. If time permits, get them to advance **day by day** at the end to find the exact date.

Students need to write what they think is the date of next closest approach in their workbooks.

The correct date is 19th February 2027. Hopefully, some students get close to this, but it's fine if they don't. The main focus of the activity was using the electric orrery.

When the planets are close together like this, it's called in opposition.

Activity: The Launch Date

We want to reach Mars on the date of closest approach – this will mean we've travelled the shortest distance to the planet.

But it takes time to reach Mars (remind students it's around 250 days). We must consider the journey time when planning a launch date.

To calculate their launch date, students need to start from the date of closest approach and subtract the number of days travel time. Students can use a calendar to do this or subtract the days month by month – the number of days in each month is given in the student workbook.

Tip: If students are really struggling, they can just use the internet to find the answer.

Student Workbook Answer

February 2027 – 19 days (to closest approach)
January 2027 – 31 days
December 2026 – 31 days
November 2026 – 30 days
October 2026 – 31 days
September 2026 – 30 days
August 2026 – 31 days
July 2026 – 31 days

Total: 234 days

There are 16 days left (250 – 234), so taking these away from the month of June gives a launch date of:

14th June 2026

Note: Answers from students may differ slightly depending upon whether they got to the exact closest approach date in the last activity.

Students then need to select a launch time. They should write it in their workbooks in both 12-hour and 24-hour clock format (e.g. 2:30pm and 14:30).

This is completely up to them – you can talk about how, in reality, it would depend upon the launch window of the orbit and the weather.

If you have time, select a few students to share their answers and ask them the reasons for choosing it.

Next, ask students to work out their countdown clock using their selected information about launch date and time.

Activity: First Words

Discuss briefly with the class the importance of the first words spoken from the Moon's surface. Neil Armstrong and NASA prepared these words long in advance of the flight.

Around 650 million people around the world watched live as the first steps were taken on the Moon – and most of us still know these words today.

Play the video from the PowerPoint presentation (on slide 14). Ask students to write in their workbooks what they would say as the first person to step on to Mars.

Students should do this independently and don't ask them to share – this can be personal to them.

Evaluation Postcards

Hand out the final student postcards for feedback and give them approximately 5 – 10 minutes to complete.

Collect these at the end of the session. Please keep them safe and hand in to Stacey (room 2.22) as soon as you're back in the office.

Final Thoughts

Play the video (on mute) from slide 16 of the PowerPoint presentation. Emphasise that this will happen in their lifetimes given current plans.

Future missions to Mars are being planned to launch as early as the 2030s, and advanced missions to land back on the Moon are planned for 2027.

Get the students to put their hands up if they'd like to be a part of a Mission to Mars – whether that's as an astronaut or part of the ground crew.

Finally, as this is your last visit to the school, wrap up with any words you'd like and express how you've found working with the class.

We hope you've enjoyed the project – thank you so much for being part of it!