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 (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 using scientific reasoning and evidence
- To request real astronomical observations and interpret the data to support scientific inquiry

Career Link: Geologist

Lesson Plan

Duration	Activity	Pages	Materials
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 • Pre-evaluation postcards • Moon's features stickers • Printed Moon sections • Laptops//tablets with internet access • Optional: STEM Handbook (see referenced pages for more information/guidance about the activity)			
Duration	**Activity**	**Pages**	**Materials**
10 minutes	Introduce yourself. Hand out the pre-evaluation postcards and explain how to complete them (approx. 3 mins). Pupils complete the postcards and you collect them in (approx. 7 mins).	Handbook: 7 – 8	Evaluation postcards Lesson PowerPoint presentation
10 minutes	Explain why should we go to Mars and what challenges might we face. Explain what are the 6 investigations, and how they will help the class work towards exploring Mars. Give an overview of Investigation 1 and how it fits into the wider Mars project.	Handbook: 8 – 12	Lesson PowerPoint presentation

Where Should We Build a Moon Base?

Duration	Activity	Pages	Materials
15 minutes	Give each pupil their printed Moon image/section and the feature stickers. (approx. 1 min). Briefly explain how to spot the 3 key features: seas (maria), mountains (mons), and craters (approx. 3 mins). Pupils work as "geologists" to find the best example of each feature and complete the workbook activity (approx. 8 mins). Briefly explain what these features are (approx. 3 mins).	Handbook: 12 – 13 Student Workbook: 4 – 5	Lesson PowerPoint presentation Student Workbooks Printed Moon sections Moon's features stickers
5 minutes	Brief class discussion: What makes a good place to build a Moon base? (approx. 2 mins). Pupils complete the workbook activity (approx. 3 mins).	Handbook: 15 Student Workbook: 6 – 7	Lesson PowerPoint presentation Student Workbooks
18 minutes	Support pupils to log in to The Schools' Observatory website. Guide them step-by-step to request an observation for their Moon section.	Handbook: 16 – 20 Student Workbook: 7 – 8	Lesson PowerPoint presentation Student Workbooks Laptops/computers/ tablets with internet access
2 minutes	Briefly introduce the next investigation and how it links to today's learning and the wider Mars project.	Handbook: 20	Lesson PowerPoint presentation

Where Should We Build a Moon Base?

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 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.

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

Introducing Yourself

At the start of the session, please introduce yourself and your role. You are welcome to use the optional "About me" slide in the PowerPoint presentation (Slide 1) and personalise it (e.g., add your name, a photo, what you do, and what you enjoy about your work).

You can then show Slide 2 to share the project title and explain that you are visiting to support pupils with an exciting real-world challenge: exploring how we might one day get humans to Mars.

Evaluation Postcards

Hand out the evaluation postcards to students. Explain that: "Before we start the 'Can we get humans to Mars?' project, we'd like to know how you feel about science and space. There are no right or wrong answers, just choose what is true for you."

Important: Some pupils may be opted out of evaluation by their parent/carer. The class teacher will have a list of these pupils. Please ensure those pupils do not complete a postcard.

Guide pupils through each question together (slides 3 – 4):

- Pupils fill in their name and today's date on the front.
- For the questions with different emotional faces, pupils colour the one that matches best how they feel.
- For the tick-box question, pupils tick one box only.
- For the thumbs' questions, pupils circle one picture (Yes / Not sure / No).

Once complete, collect the postcards and keep them safe. Please hand them directly to a member of the TSO team (Room 2.22) as soon as you are back in the office. These contain pupil information and must not be left unattended.

Starter Activity: Welcome to the Mission

Show students the image of the Martian surface from the PowerPoint presentation (on slide 5). 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?
Ask students the question 'Why Go to Mars?'. Give students thinking time and encourage no shouting out. Select some to share their ideas before showing the class the answers from the lesson PowerPoint (slide 6).

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 7).

Tell students you'll 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. You could explain that pupils will explore what it would take to send humans to Mars safely and the first humans to go could be children in schools today.

What's the Challenge?
Show slide 8. Explain that getting to Mars is not as simple as building a rocket, pressing launch, and landing. A journey to Mars would take months, and space (and Mars) is a very different environment to Earth.

Humans have not travelled beyond low Earth orbit for many years, so there would be many unknowns if we tried to send people to Mars right now.

Explain that there are several steps we need to solve first. Through this project, pupils will explore each step.

Explain that before we can safely go to Mars, we need to learn how humans can live somewhere other than Earth. There is a closer place we can visit to practise this.

Ask pupils to guess what it is (again, encourage thinking time and no shouting out). Confirm that it is the Moon and explain that it will be an important stepping stone on the journey to Mars. Today's investigation is about studying the Moon's surface and choosing a suitable landing/base site.

The 6 Investigations

Show slide 9. Briefly outline the 6 project steps (keep each one to a single sentence):

- Step 1: Study the Moon and choose a safe place to land and build.
- Step 2: Plan how humans could live on the Moon (shelter, food, water, energy).
- Step 3: Learn how to control robotic rovers using coding, to explore before humans arrive.
- Step 4: Explore how space affects the human body and how to stay healthy.
- Step 5: Investigate how far away Mars is and what that means for travel.
- Step 6: Plan the best launch window for a safe journey to Mars.

Conclude by explaining that across the 6 investigations, pupils will work through these steps to build up a realistic plan for getting humans to Mars.

Meet the Crew

Show slide 10. 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.

Investigation 1: Where should we build a Moon base?
Show the question on slide 12 in the PowerPoint presentation. Read out the options and have students vote by raising their hands.

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.

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.

Activity: Explore the Moon's Surface

This activity focuses on 3 key features on the Moon's surface: seas (maria), mountains (mons) and craters.

Show the example images of each feature and briefly explain how pupils can spot each feature. Keep descriptions simple and visual.

Hand out Moon sections and a set of feature stickers. Explain that the Moon is very close to Earth, so it appears large in the sky. Telescopes often take images of different sections of the Moon, and these can be combined later, rather than taking one full image in a single frame.

Ask pupils to then find the best example of each feature on their Moon section and place the matching sticker on the feature. This can then be ticked in their workbook. Afterwards, they'll write a short description of one feature using the prompt in the workbook.

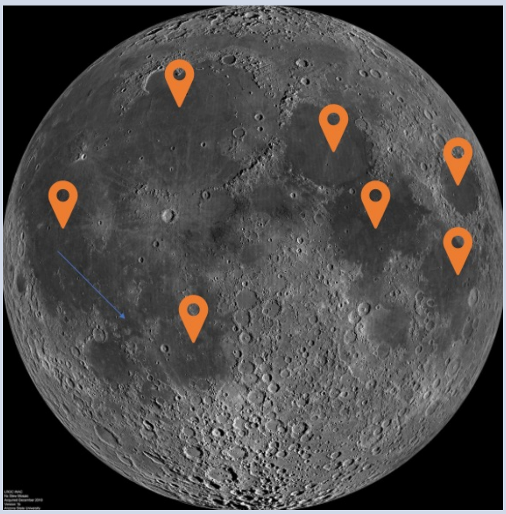
Pupils should keep their labelled Moon section safe on page 5 of their workbook. Ask the class teacher to support pupils with sticking the labelled Moon section into their workbooks after the investigation.

Where Should We Build a Moon Base?

After pupils complete the task, briefly explain what each feature is.

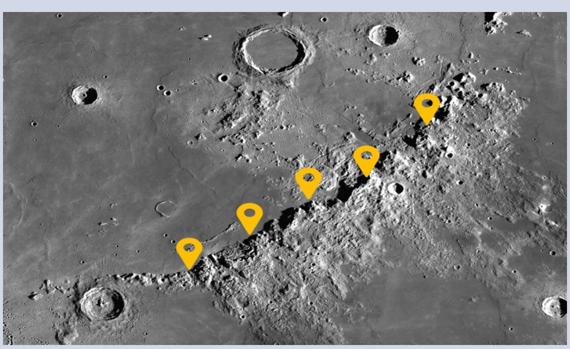
You could include some of the following information:

Sea/Mare



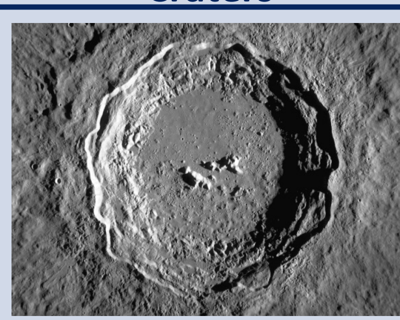
Key Facts:
- Large, dark plains made of basalt (lava rock).
- Formed by lava flooding giant impact basins billions of years ago.
- Ancient astronomers thought they were oceans; hence they called it "mare" (Latin: sea).
- Cover ~16% of the Moon's surface.

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.

Craters



Key Facts:
- Created by asteroid/comet impacts.
- Can be huge (hundreds of km).
- Bright rays sometimes spread from them – caused by ejected debris.
- With no atmosphere, craters remain unchanged for billions of years.

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 21).

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).

Ask students to use the Moon image in their workbook (page 6) to mark their chosen site. 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 (page 7) using the prompt words in the box.

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.

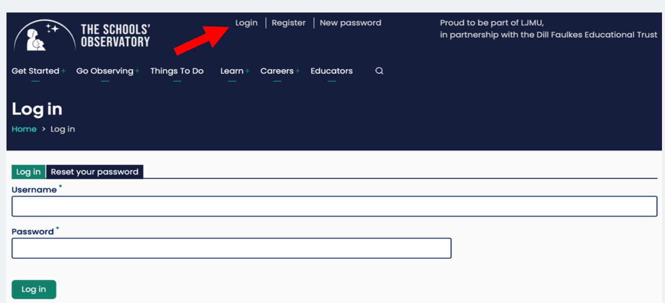
Ideally, demonstrate each step to the class so pupils can follow along. If you don't have an account, ask the class teacher to log on instead.

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.

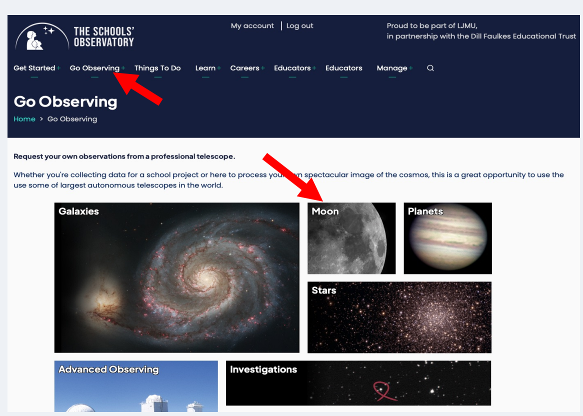
You should also ask if students need to leave the classroom to access any technology. Some schools may only have computers in certain classrooms.

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 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.



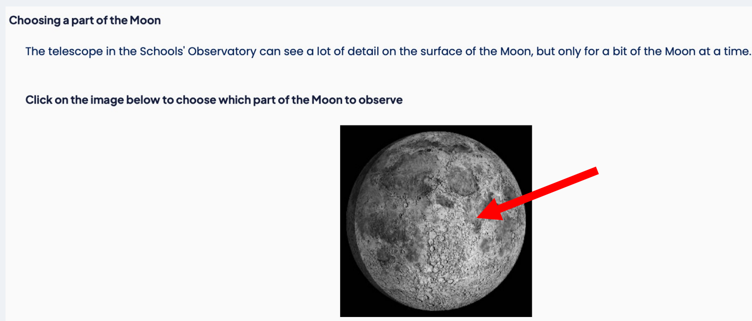
2) Click 'Go Observing' from the top menu and then select 'Moon' from the options.



Where Should We Build a Moon Base?

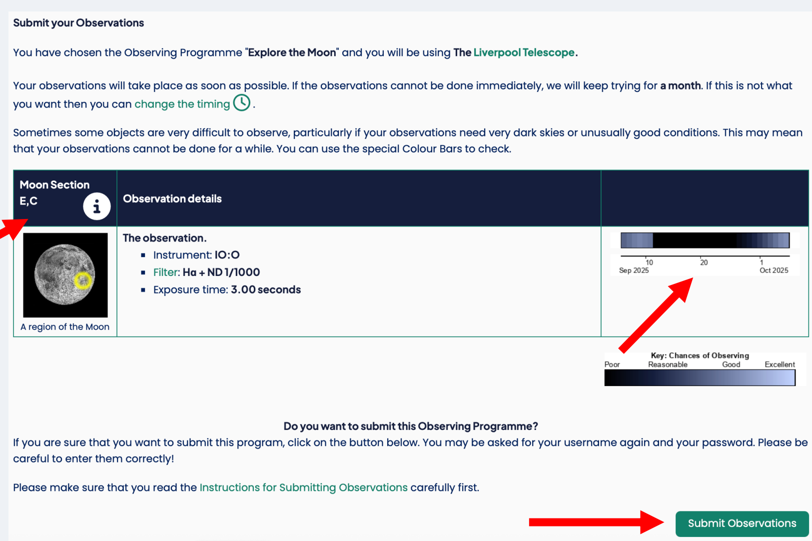
3) Select 'Observe The Moon'.

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



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.

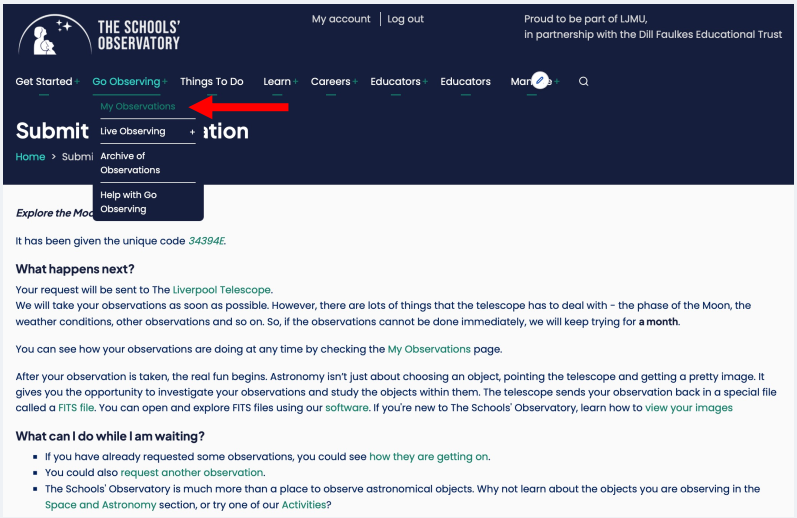


The chance of observing changes due to the Moon's phases – the amount of reflected sunlight we see depends on the position of the Moon its orbit.

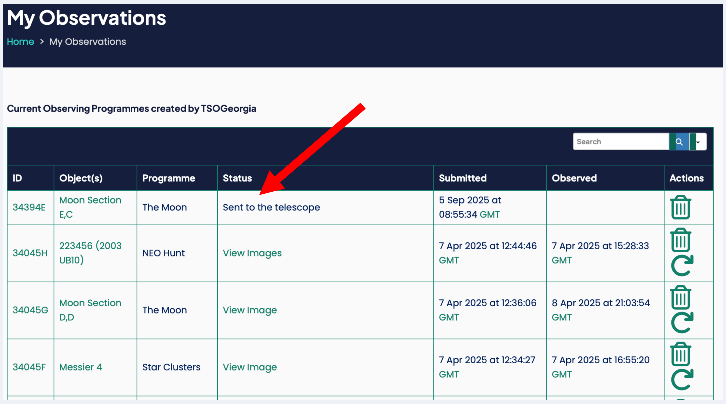
7) Click 'Submit Observation'.

Where Should We Build a Moon Base?

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.



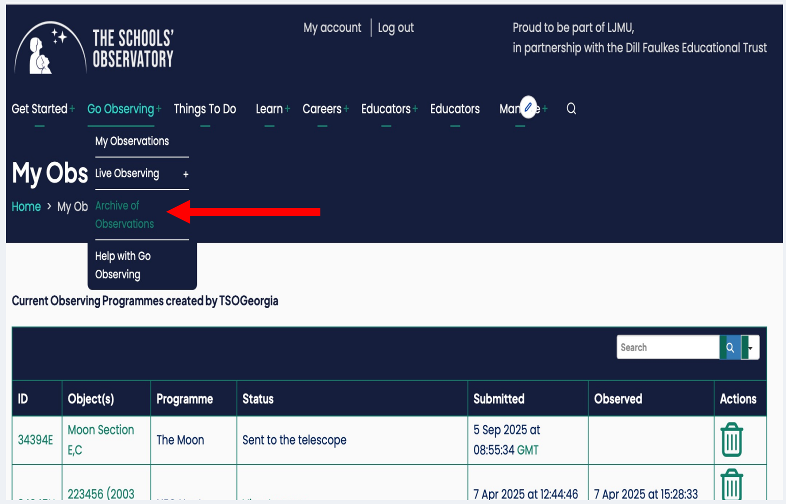
When an observation is ready, the student will see ‘View Image’ in the ‘Status’ column.

If you still have time remaining in the investigation, you could show students previous data of their moon section taken with the telescope.

Use the following instructions to guide students.

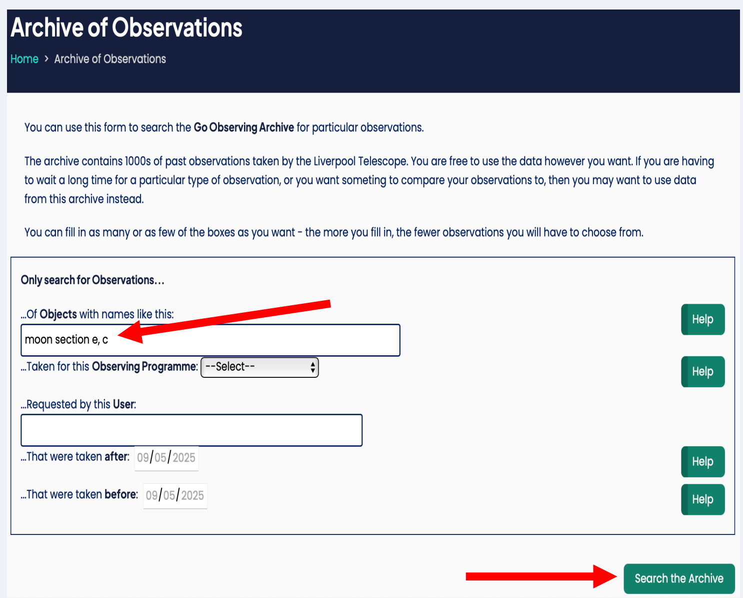
Instructions: Using the Archive

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



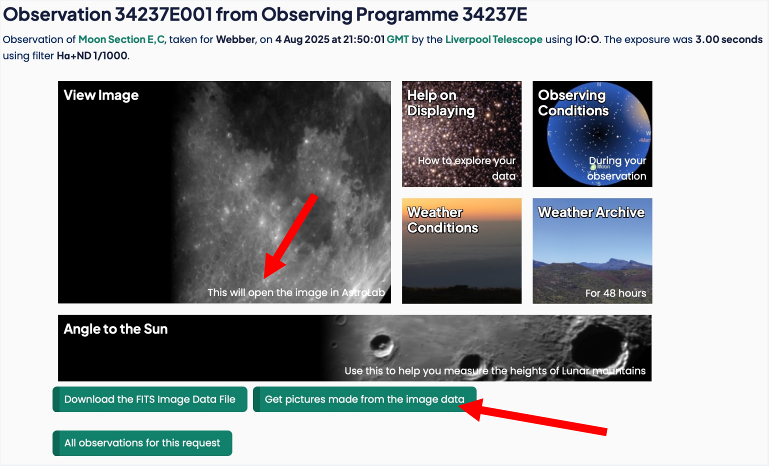
2) Type in the name e.g. 'Moon Section E, C'.

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



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

5) There are two options for seeing the image.



Either click the 'View Image' panel to open the image in our AstroLab software.

Or click 'Get pictures made from the image data' and select 'Minimum detail'. An image will appear in a new window. This can be saved by students for printing at a later time.

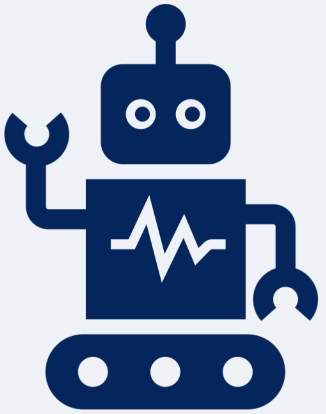
The Next Investigation

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 (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

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
- 4 Mars canvases
- 8 Mission cards
- 4 Models for rocks and 16 magnetic blocks
- 2 Rock/mineral stickers
- 8 mbots (we will add an extra 2 as a back up)
- Laptops/computers/tablets with internet access/google chrome browser (provided by the school)
- Optional: STEM Handbook (see referenced pages for more information/guidance about the activity)

Duration	Activity	Pages	Materials
2 minutes	Briefly recap the previous investigation and explain how it links to today's session and the overall Mars project.	Handbook: 27	Lesson PowerPoint presentation
3 minutes	Ask: "Why do we send robots before people?" Take 2–3 quick answers. Reveal the answer and keep the explanation short. Then ask them: "How many rovers they think have landed on Mars?"	Handbook: 28 – 29	Lesson PowerPoint presentation

How Do You Control a Robot Rover?

Duration	Activity	Pages	Materials
7 minutes	Introduce programming with a quick "human coding" demo (volunteer follows instructions step-by-step). Split pupils into teams and get each team set up with: • one device (logged in and ready with the coding page) • one mBot • one Mars canvas area Show pupils one key coding block and how to stop the rover safely if something goes wrong.	Handbook: 29 – 36	Lesson PowerPoint presentation 4 Mars canvases 4 Models for rocks and 16 magnetic blocks. 8 mbots Laptops/computers/ tablets with internet access
10 minutes	Pupils complete the Quick Rover Tests in their workbooks (support and troubleshoot as needed): • Move forward one square • Turn 90° left or right • Trigger a sound or light signal Remind teams to tick each test once completed.	Handbook: 38 – 39 Student Workbook: 28-29	(Same as above) + Student Workbooks
5 minutes	Briefly explain the four missions (plotting, coding, testing, and recording) then hand out one mission card per team. Pupils choose a rover name and note the mission title and information in their workbook.	Handbook: 40 Student Workbook: 30	Lesson PowerPoint presentation 8 mission cards Student workbooks
30 minutes	Pupils work through their mission and once a team completes their mission, give them the reading/value to record in their workbook. Circulate to support debugging and keep rovers moving safely on the floor.	Handbook: 40 – 42 Student Workbook: 31	(All the above) + Rock/mineral stickers
3 minutes	Discuss the readings with the class and link to the next investigation.	Handbook: 42	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.

We can use rovers to test conditions and collect data before risking human lives. Rovers can also 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

Pupils will learn how robots follow precise instructions, and how coding and debugging can be used to control a rover.

Pupils will work in teams to complete four missions on a Mars canvas using programmable rovers called mBots.

Each mission follows the same core pattern:

- plan a route on a grid
- use code to move forwards and turn in 90° steps
- trigger a light or sound signal to collect a “reading”
- record results and explain what the reading might represent

By the end of the session, pupils will understand that robotic exploration is a vital part of preparing for human missions and that coding is one of the tools we use to explore other worlds.

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.

How Many Rovers Have Landed on Mars?

Show this question in the PowerPoint (on slide 4). Give students three options to guess from.

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

You could add the following information:
Over 50 missions have tried from different countries for nearly 60 years. 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?

The information in this box is for your reference only. You do not need to share it with the class unless pupils ask about real Mars rovers, or if you have time at the end.

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.

Only Curiosity and Perseverance are still alive and working today.

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**.

How Do You Control a Robot Rover?

mBot and Makeblock Coding Blocks

Introduce the mBot rover. Explain that it is a small programmable robot that will represent a Mars rover in today's missions.

Next, introduce the Makeblock (mBlock) coding platform. Pupils will control the rover using coding blocks. This software is similar to Scratch, which students likely have used before. (You could show slide 7 on the PowerPoint presentation).

Demonstrate each step to the class, with pupils following along. (Instruction on how to connect mBot to mBlock coding platform and how to start programming are on the following pages).

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.

How to stop the rover

- Pupils start the program by clicking on the code block, so it's useful to keep a "stop moving" block that can be clicked if something goes wrong. They can also use the stop button in the software.

Finally, if the rover is not responding, show pupils the on/off switch to reset it and then help them to reconnect it to the software.

Connecting mBot to devices (before the session)

To connect mBot to the coding software (mBlock), the following are required:

- Bluetooth connection (for mBot pairing)
- Wi-Fi connection
- mBlock installed on tablets, or Google Chrome installed on laptops/Chromebooks

Teachers have been advised to check in advance that Wi-Fi and Bluetooth work on their devices and that the required software is installed. It is strongly recommended that you contact the class teacher as early as possible to confirm what devices the school will use and whether the set-up has been tested.

If there are any issues with Wi-Fi/Bluetooth permissions (for example, settings locked by school IT), and you are unsure how to resolve them, please contact the TSO team as early as possible. We can help troubleshoot and, where possible, discuss alternatives (e.g., using TSO tablets). Please note that alternative devices will still require access to the school's Wi-Fi, so early notice is essential.

Optional early test (recommended):

If you have time, you may take one mBot during your Investigation 1 visit to test connectivity after the session. If you would like to do this, please let the TSO team know in advance so this can be arranged.

Room check (important):

This investigation requires a large indoor space. Pupils must test and run their rovers on the floor (not on tables) to reduce the risk of damage and to allow enough room for the A0 Mars canvases. Teachers have been advised to book a hall or similar space, please confirm this with the teacher before the visit.

How Do You Control a Robot Rover?

Connecting mBot to devices (on the day)

It is highly recommended that you arrive early and work with the teacher to:

- connect all mBots to pupil devices before the session starts
- check Wi-Fi/Bluetooth are working
- lay out the 4 Mars canvases (A0) on the floor
- organise pupils into 8 groups (ask the teacher to support with groupings)

Arriving early will save a significant amount of time during the session. The Teacher Handbook also asks schools to coordinate early access to devices so mBots can be connected.

Set-up instructions: iPads and Android tablets

- Download the mBlock app: schools are provided with the following QR codes. On iPads, you can also search ‘mBlock’ in the App Store.

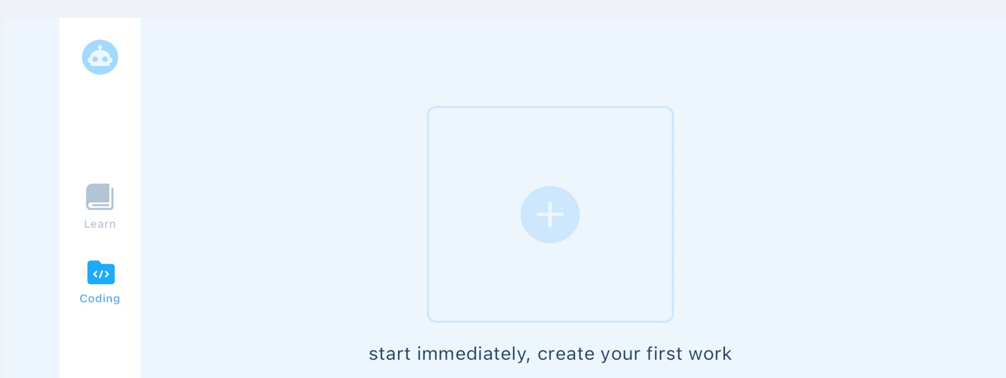
iOS

iOS 10.0 +

Android

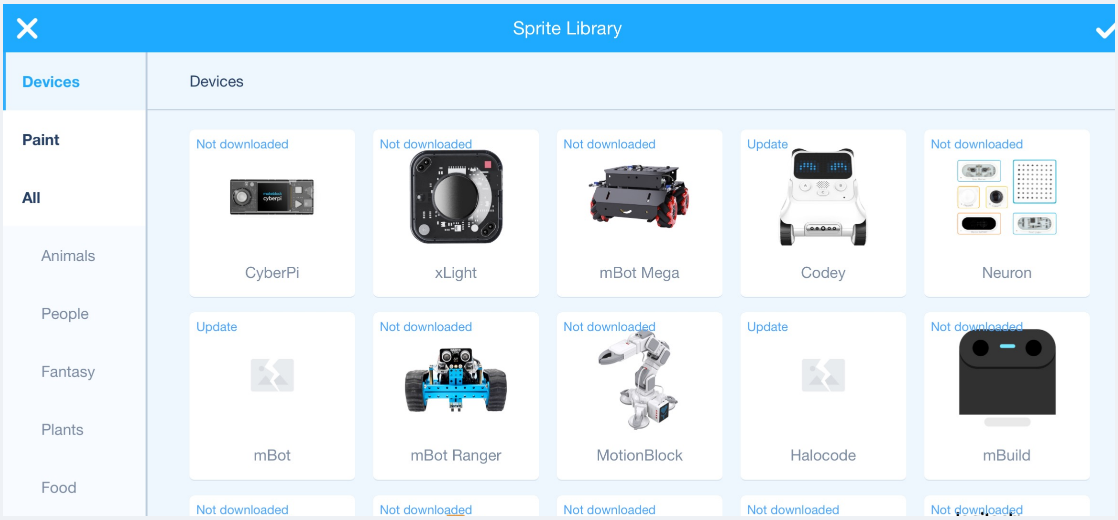
Android 6.0 +
(ARM-based devices only. X86 Android not supported)

- Open mBlock app and select ‘Coding’.
- Tap the ‘+’ button.

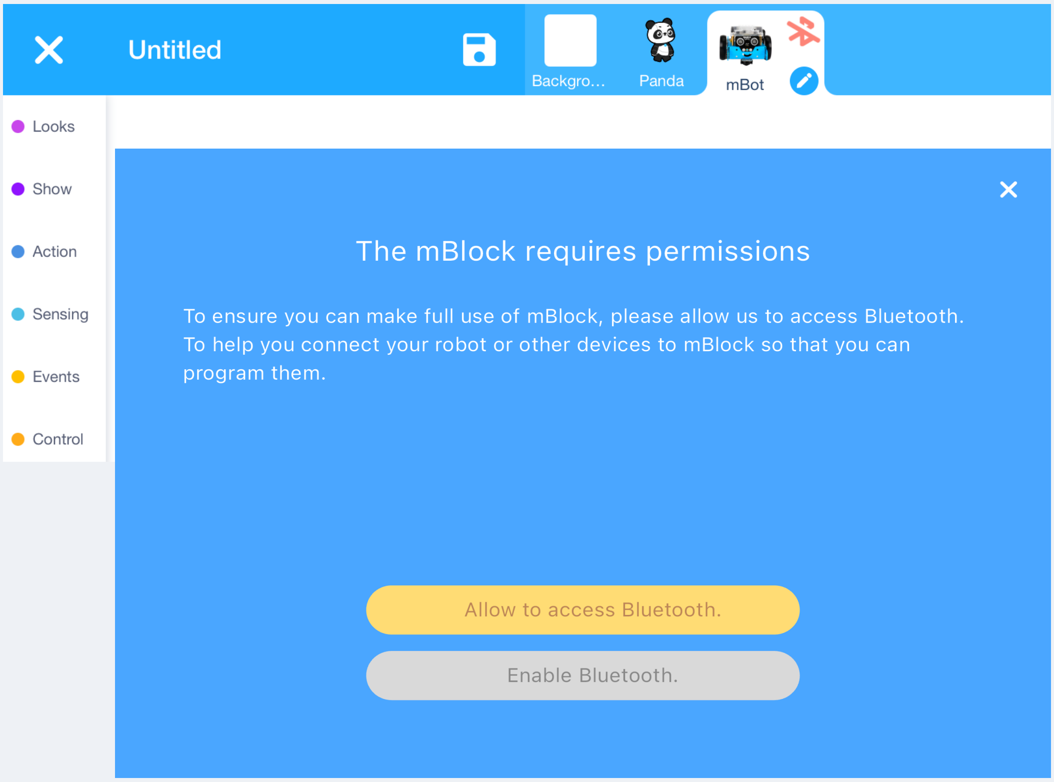


How Do You Control a Robot Rover?

- Choose mBot. Tap update, then the tick.



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

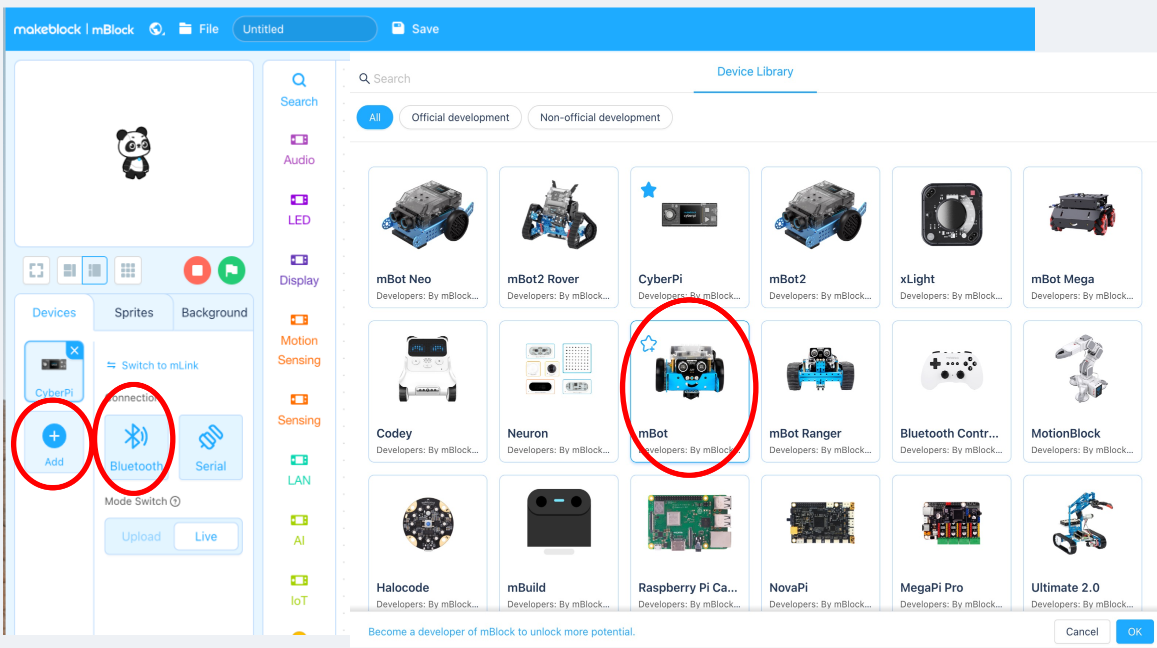


- Don't switch on all the mBots at once, turn them on and pair them one at a time to avoid confusion and connecting to the wrong rover.

How Do You Control a Robot Rover?

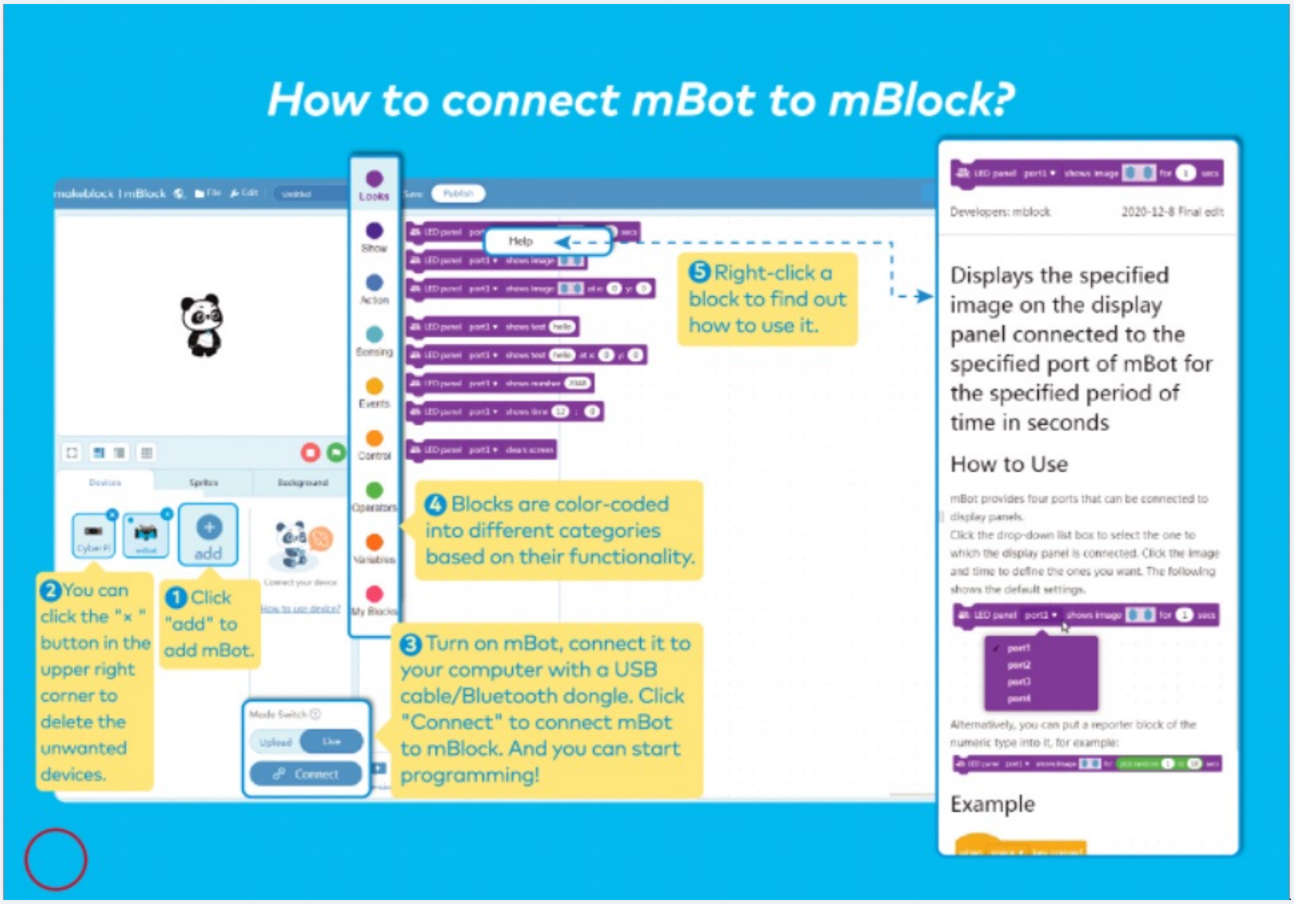
Set-up Instructions: Laptops (Windows, macOS, Chromebooks)

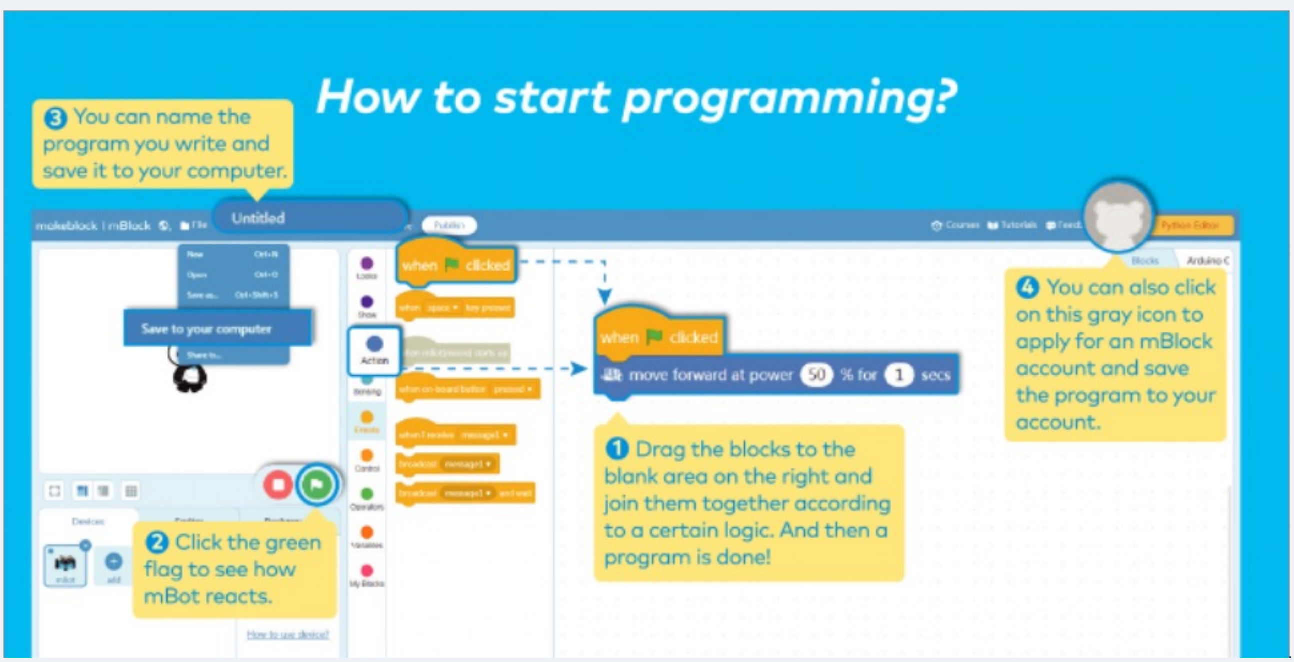
- Make sure Google Chrome browser is installed and up to date.
- Check that Bluetooth is enabled on the device.
- Open Google Chrome browser and Go to: https://ide.mblock.cc
- Then click on the '+' add button and choose 'mBot' then tap 'OK'.



- Check whether the Bluetooth button is available (not greyed out).
- Schools been advised that If the Bluetooth button is greyed out or cannot be enabled, They should contact the IT technician to adjust permissions/settings. As mentioned before please ensure with your school's teacher that this is not going to be an issue on the day.
- Don't switch on all the mBots at once, turn them on and pair them one at a time to avoid confusion and connecting to the wrong rover.

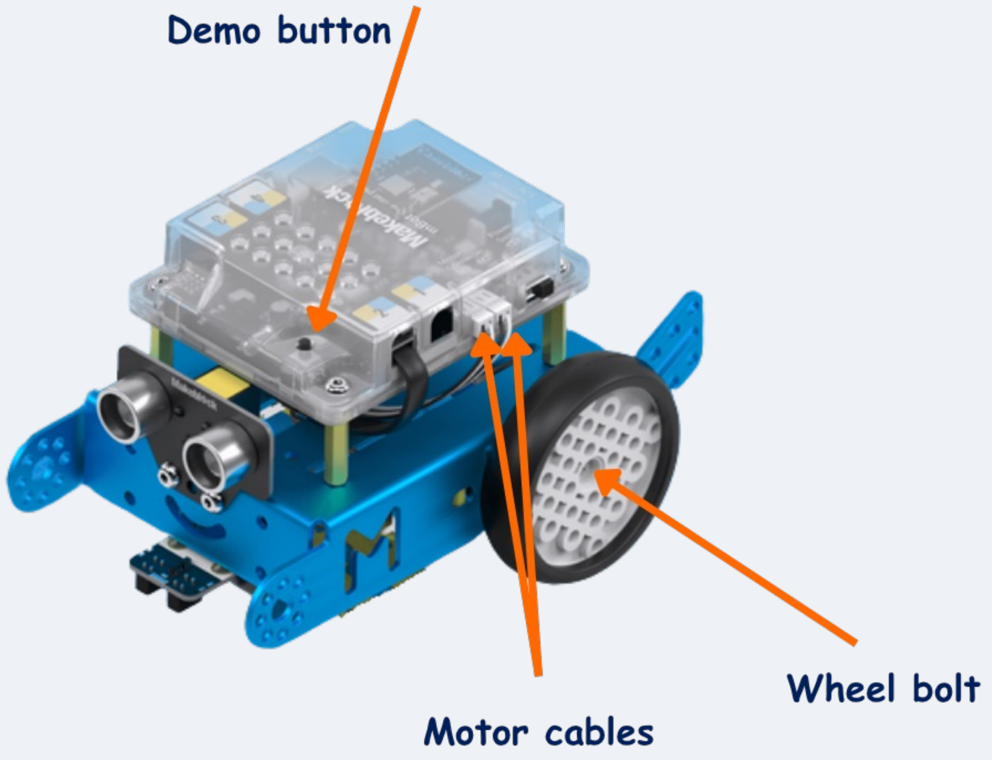
How to start programming (mBlock)





mBot notes (troubleshooting and care)

- If an mBot starts to behave strangely, try a quick reset first: switch it off and on, then reconnect to mBlock (the oldest trick in the IT book!). If the issue continues, use a spare mBot rather than losing time trying to fix it during the session.
- Please ask pupils not to press the "Demo" button on the mBot. If it is pressed and the rover starts moving on its own, use the stop button / "stop moving" block. If it still does not stop, switch the mBot off and on.
- Before the session: test each mBot's motors using a simple "move forward" program.
  - ➢ If the rover moves backwards, swap the white motor cables.
  - ➢ If the rover consistently moves at an angle, tighten the wheel bolts (see picture).
- You will have spare batteries and parts available — please use them if needed.
- At the end of the session, ask pupils to return the mBot carefully to its box (no dropping or throwing).
- Please let the TSO team know if anything goes wrong, so it can be repaired before the kit is used by the next STEM professional.



How Do You Control a Robot Rover?

Activity: Quick Rover Tests (mBlock)

Split the class into 8 groups and give each group one mBot. It is recommended to ask the class teacher to help with the grouping, as they know which pupils work well together.

If you have 16 pupils, 8 pairs works well. If you have fewer pupils than 16, reduce the number of groups and increase group size (e.g., 15 pupils could be 5 groups of 3).

Lay out the 4 Mars canvases on the floor (ideally before the session starts). Place the rock models on the canvases (1 rock model per canvas on A3 square) and add 4 magnetic blocks per canvas on C7 square (see the picture on the following page). Arrange 2 teams per canvas (1 team around A1 & B1 base and the other team around D1 & E1 base).

Before pupils begin, remind them to:

- handle the rovers carefully and not drop them from a height
- keep the rovers on the floor for coding and testing (not on tables)

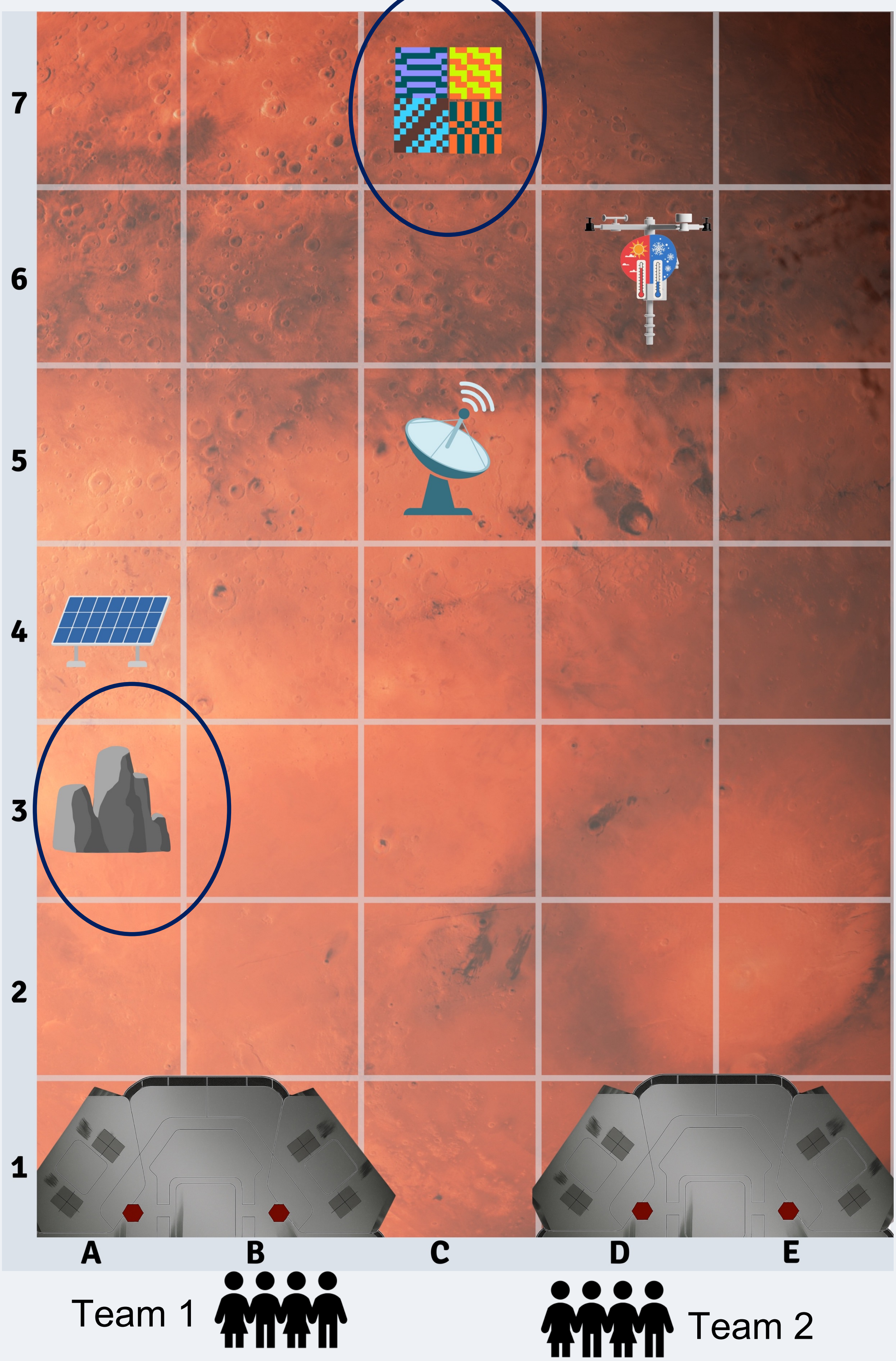
Give pupils time to complete the Quick Rover Tests. You can use the countdown timer on Slide 9 and adjust the time to fit your session.

Test 1: Move forward – make the rover move one square forward
Test 2: Turn 90° – make the rover turn 90° left or 90° right
Test 3: Sound or light signal – make the rover play a sound or show a light

Pupils should tick each test in their workbook (pages 28-29) as they complete it. Support any groups who are stuck and help them debug if the rover does not behave as expected.

If some groups finish early, you can offer an extension task from the Extension Activities section (page 43).

How Do You Control a Robot Rover?



Activity: Mission on Mars

Now that pupils know how to move, turn, and use lights/sound, they are ready to complete a Mars mission.

Hand out the mission cards to each team by canvas:

Canvas 1 and 2
Hand out the following mission cards, one per each team:

- Clean Solar Panels
- Activate Communications

Canvas 3 and 4
Hand out the following mission cards, one per each team:

- Check Weather
- Collect Rocks

Briefly explain that each team will follow a simple mission process. Use Slides 10–15 in the PowerPoint to guide the steps.

Step 1 – Rover and Mission Details (page 29 in the workbooks)

- 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).
- Pupils read the mission instructions on the back of the card and complete the sentences in their workbook.

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 (page 30 in the workbooks)

- Students should trace the safest path to their mission target.
- Remind them to think about obstacles (rocks and stations).

Tip: See pages 44 – 47 for some ideas on how to complete each mission. 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 same blocks they practised in the Quick Rover Tests.
- Each move or turn should be included as a block in their program. For example, if pupils need the rover to move several squares, they should change the value (or repeat the block), rather than repeatedly clicking a "move one square" block.
- Remind pupils that once the rover is placed on the launch base and they press start, they should not touch the code while it is running, the program should be complete before launch.

Tip: Walk around and check that teams' code matches their planned path.

Step 4 – Testing

- Pupils test their code on the floor and check whether the rover follows the planned route.
- If it doesn't work first time, reassure them that this is normal, they should adjust the code and try again.

Tip: 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 – Readings (page 31 in the workbooks)

- When a team completes their mission, they should let you know.
- Once they have successfully completed it, give them the relevant mission reading/value to record (as the mission controller).
- Pupils record the reading in their workbook and answer the question: "What does your reading represent?"

Allow around 30 minutes for the mission section in total (adjust as needed for your session). If teams finish early, you can offer an extension activity (see page 43).

How Do You Control a Robot Rover?

When all teams have finished, bring the class together to discuss their readings. Ask a few pupils to share their readings and ideas, then reveal the explanations using the slides (17-20). You could add some of the following information:

Mission 1 – Activate Communications
Reading to give pupils: 12.5 minutes
What it represents:
That's how long a radio message takes to travel from Mars to Earth (one way).
This is why we can't control Mars rovers in real time — there is always a delay.

Mission 2 – Collect Rocks
Reading to give pupils: Hand the stickers (four icons). Pupils should use the icons to identify and name the 4 rock/mineral types
What it represents:
The icons represent four key types of Martian rocks/minerals, which give us clues about Mars' past:
Rust (iron oxide) → explains why Mars looks red.
Water minerals → suggests water once existed or flowed on Mars.
Silica / sand → found in rocks and dust; can be linked to volcanic activity and past surface processes.
Volcanic rocks → shows Mars was geologically active in the past.

Mission 3 – Check Weather.
Reading to give pupils: 60 mph (97 km/h)
What it represents:
This is a typical speed for strong Martian dust storms. Dust storms can block sunlight and make it harder to power equipment.

Mission 4 – Clean Solar Panels
Reading to give pupils: 43%
What it represents: Mars gets about 43% of the sunlight that Earth receives, so solar panels on Mars produce less power than the same panels on Earth. Dust on the panels can reduce this even more — which is why cleaning them matters.

Next Investigation

So, now pupils know more about Mars, the rocks, the weather, the temperatures, and how far it is from Earth. In the next investigation, pupils would investigate with their teacher the question: if we sent humans there, how could they stay healthy?

Extension Activities

If any teams finish early, you can choose one or more of the following optional coding extension activities to keep pupils engaged and practising their programming skills.

Extension 1: Line sensor "Black or Not?" (if…else)

Goal: Use the line follower sensor to make a decision.

Task:

- Add an if…else block.
- If the sensor detects black, the rover flashes a colour.
- Else, the rover plays a short beep.

Put a black paper on the floor for the students to test their code.

Extension 2: "Traffic light rover" (sequence + timing)

Goal: Use lights to communicate a status.

Task: Program a 3-step signal:

- Green (ready) for 1 second
- Amber (moving) for 1 second
- Red (stop) for 1 second

Extension 3: Obstacle warning with ultrasound (if…else)

Goal: Use distance sensing to avoid crashing.

Task:

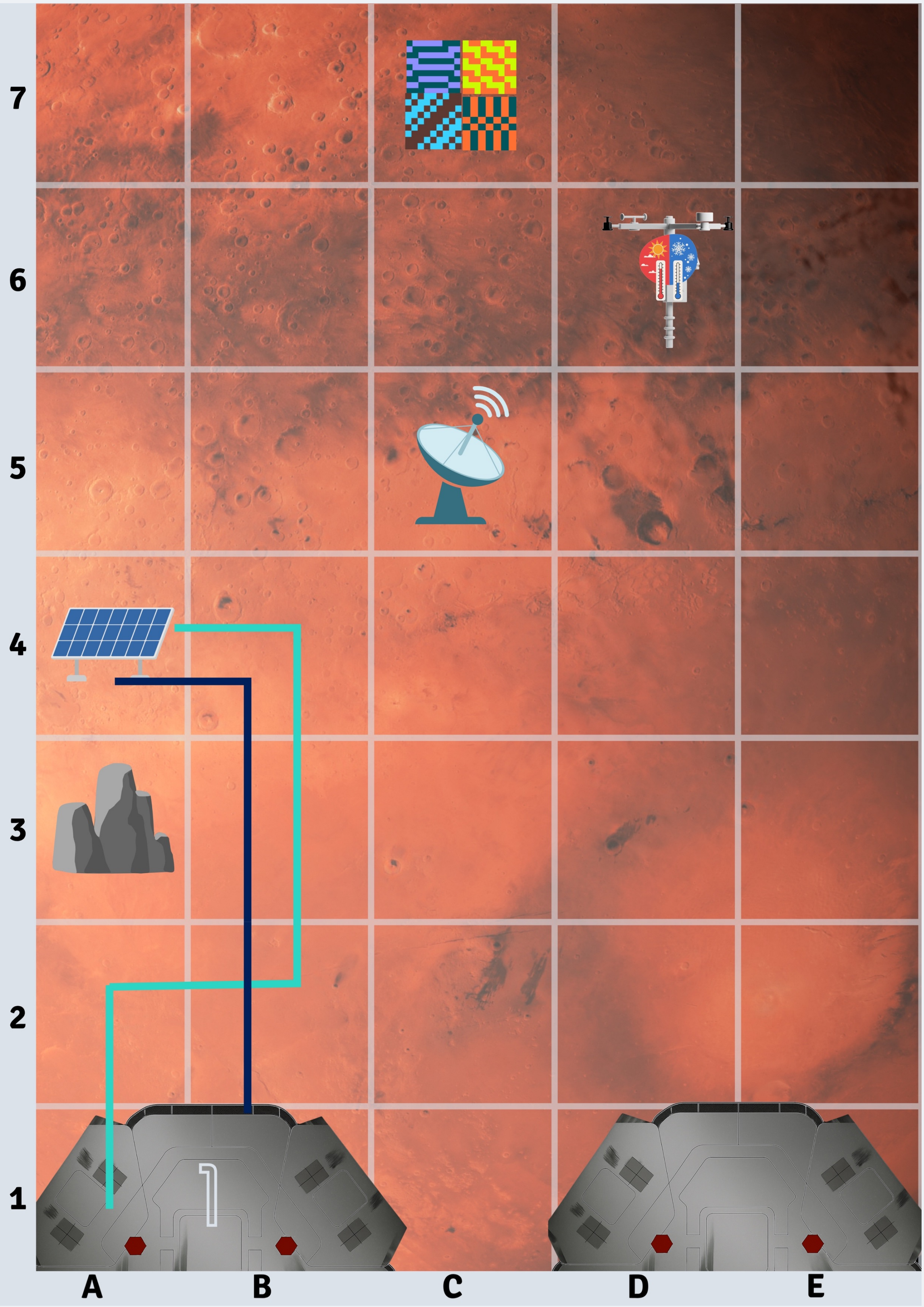
If distance < 15 cm → stop

Else → move forward

Students may use their hands as obstacles to test their code.

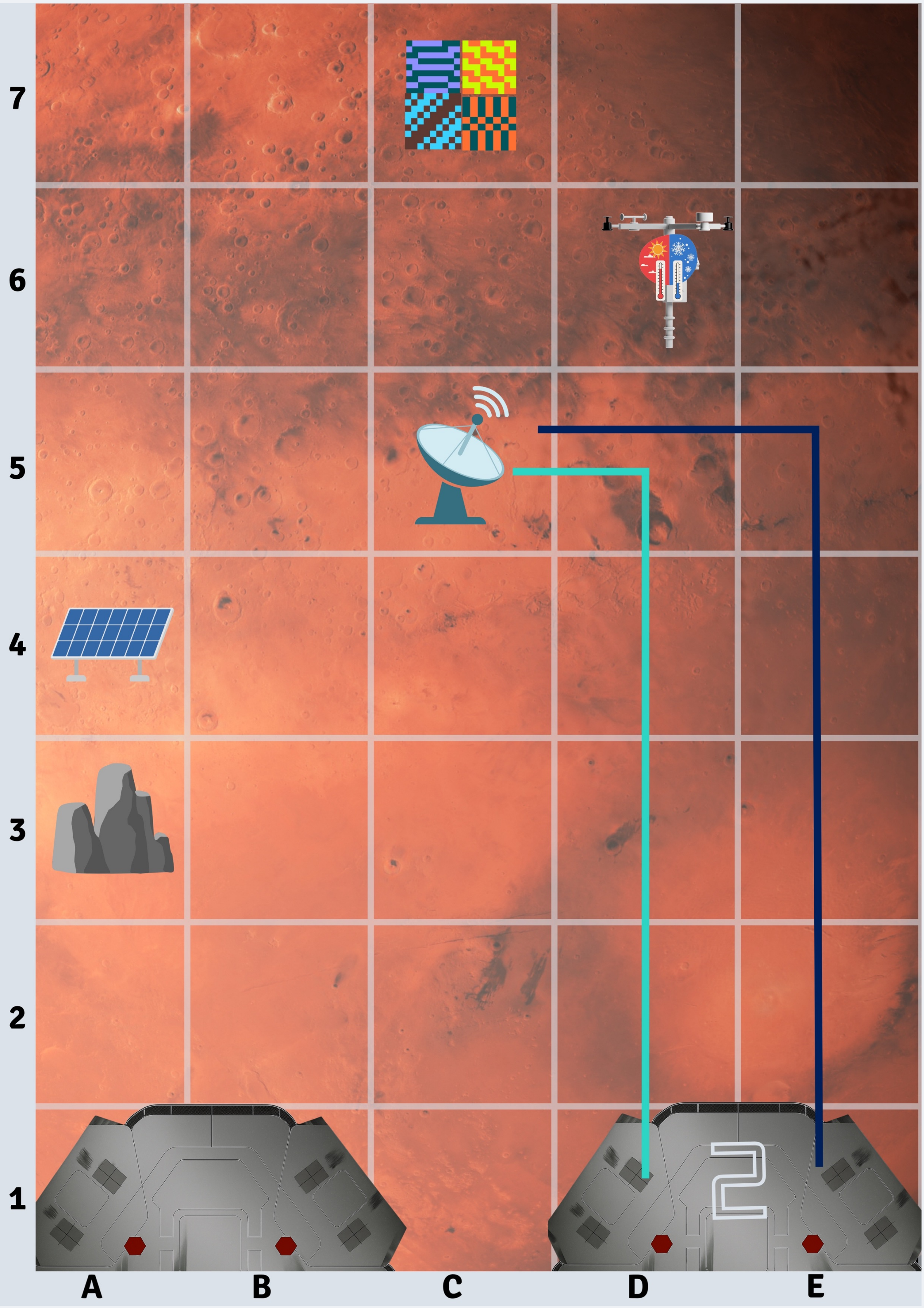
How Do You Control a Robot Rover?

Mission: Clean Solar Panels



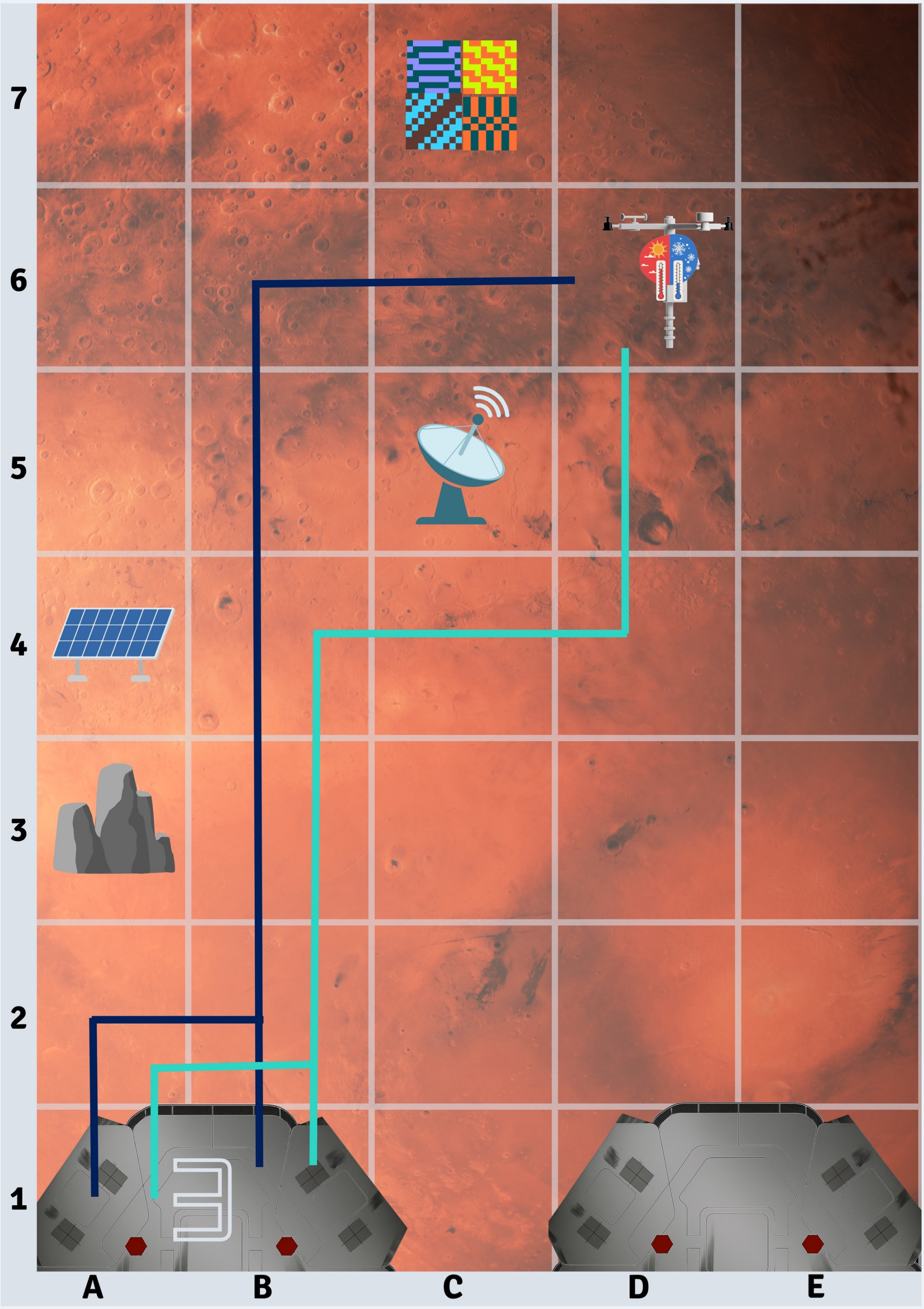
How Do You Control a Robot Rover?

Mission: Activate Communications



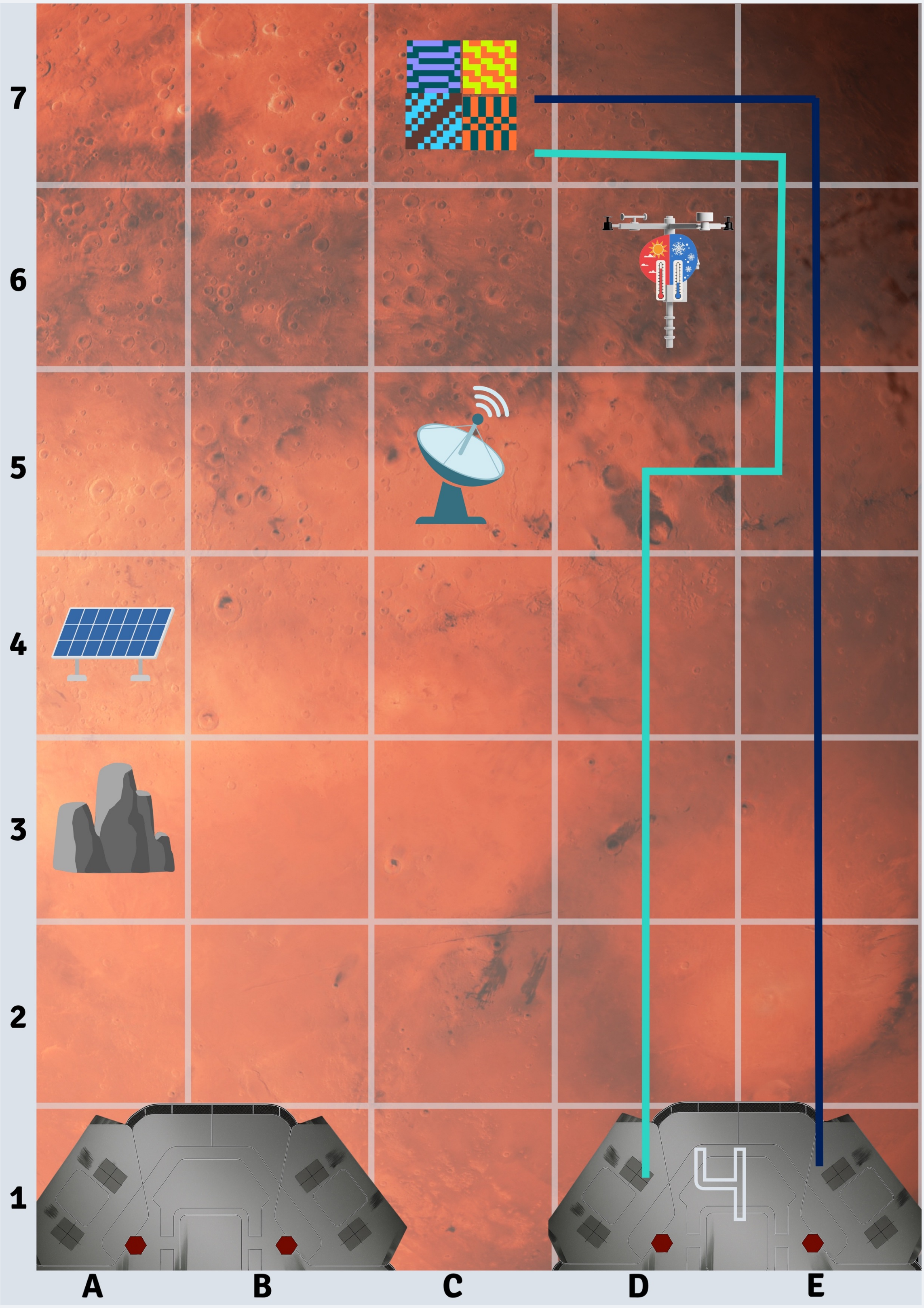
How Do You Control a Robot Rover?

Mission: Check Weather



How Do You Control a Robot Rover?

Mission: Collect Rocks



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

Lesson Plan

Possible Student Misconceptions:

- The planets orbit in a straight line
- The planets are spaced equally throughout the Solar System
- The planets all 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: 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.	Handbook: 52	Lesson PowerPoint presentation
5 minutes	Students complete the 'Order the Planets' activity. Show answers to class and have students mark their work.	Handbook: 53 Student Workbook: 54	Lesson PowerPoint presentation Student Workbooks

Why Does Mars Change Size?

Duration	Activity	Pages	Materials
15 minutes	Hand out till rolls and demonstrate each step of the 'Map the Solar System' activity. Students write the scale size of the Solar System map in their workbooks.	Handbook: 54 – 56 Student Workbook: 55	Lesson PowerPoint presentation Student Workbooks Till rolls Planet stickers
5 minutes	Explain how planets orbit the Sun and show the video that demonstrates this. Students complete the 'Planetary Motion' activity. Show answers to class and have students mark their work.	Handbook: 56 – 57 Student Workbook: 55	Lesson PowerPoint presentation Student Workbooks
10 minutes	Set the context for working out the distances between orbits. Students complete the 'Orbit Maths' activity in their workbooks. Show answers to class and students mark their work.	Handbook: 57 – 59 Student Workbook: 56 – 57	Lesson PowerPoint presentation Student Workbooks
20 minutes	Explain the 'Measure Mars' activity to students. Students measure their images and record the data. Demonstrate plotting some data on the graph provided in the workbooks. Students plot a graph and complete the questions in their workbooks. Show answers to class and have students mark their work.	Handbook: 69 – 61 Student Workbook: 59 – 64	Lesson PowerPoint presentation Student Workbooks Rulers Pencils
5 minutes	Give students a brief insight to the next investigation and how it links to the current investigation and overall Mars project.	Handbook: 61	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 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 analyse their results and 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: Order the Planets

Show slide 4 of the PowerPoint presentation. Go over the information with the class and then ask students if they know the names of any planets in the Solar System. Select some to share their answers.

If any students give the answer of Pluto, you can explain that while it was previously classed as a planet, we later discovered many similar objects in our Solar System. So, we decided how to define a planet.

There are 3 criteria: (1) orbit a Star, (2) massive enough that the force of gravity has made it a spherical shape, (3) cleared the area around its orbit of other similarly sized objects

Pluto meets the first 2 criteria, but not the third. It is surrounded by objects just like itself.

After naming the different planets, students then need to write them in the correct order in their workbooks. Their knowledge of this could be varied, depending on if/when the topic was covered in class.

If their knowledge of the Solar System seems limited, complete the activity with them. Either ask the students for answers or just tell them the correct order. Alternatively, give the first letter of each planet to help students complete the activity themselves. Write the letters on a whiteboard visible to the whole class if possible.

Show the answers on slide 4 by clicking through the animations. 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.

Slide 5 of the PowerPoint presentation shows the scaled size of the planets in comparison to each other. You could briefly go over this with the class, especially if some students have talked about which planets are larger than others.

Activity: Map the Solar System

Hand out the till rolls – 1 per student. Go through the instructions as a class. Demonstrate each step (reference image on next page) at the front of the class.

The steps are also given on slides 7 – 14 of the PowerPoint presentation along with reference images. Students might find these useful to refer to as they work through the activity.

If any students lack confidence with writing or spelling (ask your class teacher about this), give them the planet stickers to use instead.

Instructions

Step 1: Hold the paper out with the Dwarf Planets end on the left and the Sun on the right.

Step 2: Fold the paper in half and write Uranus on the crease.

Step 3: Fold the paper from Dwarf Planets up to Uranus. Write Neptune on the crease.

Step 4: Fold the paper from the Sun up to Uranus. Write Saturn on the crease.

Step 5: Fold the paper from the Sun up to Saturn. Write Jupiter on the crease.

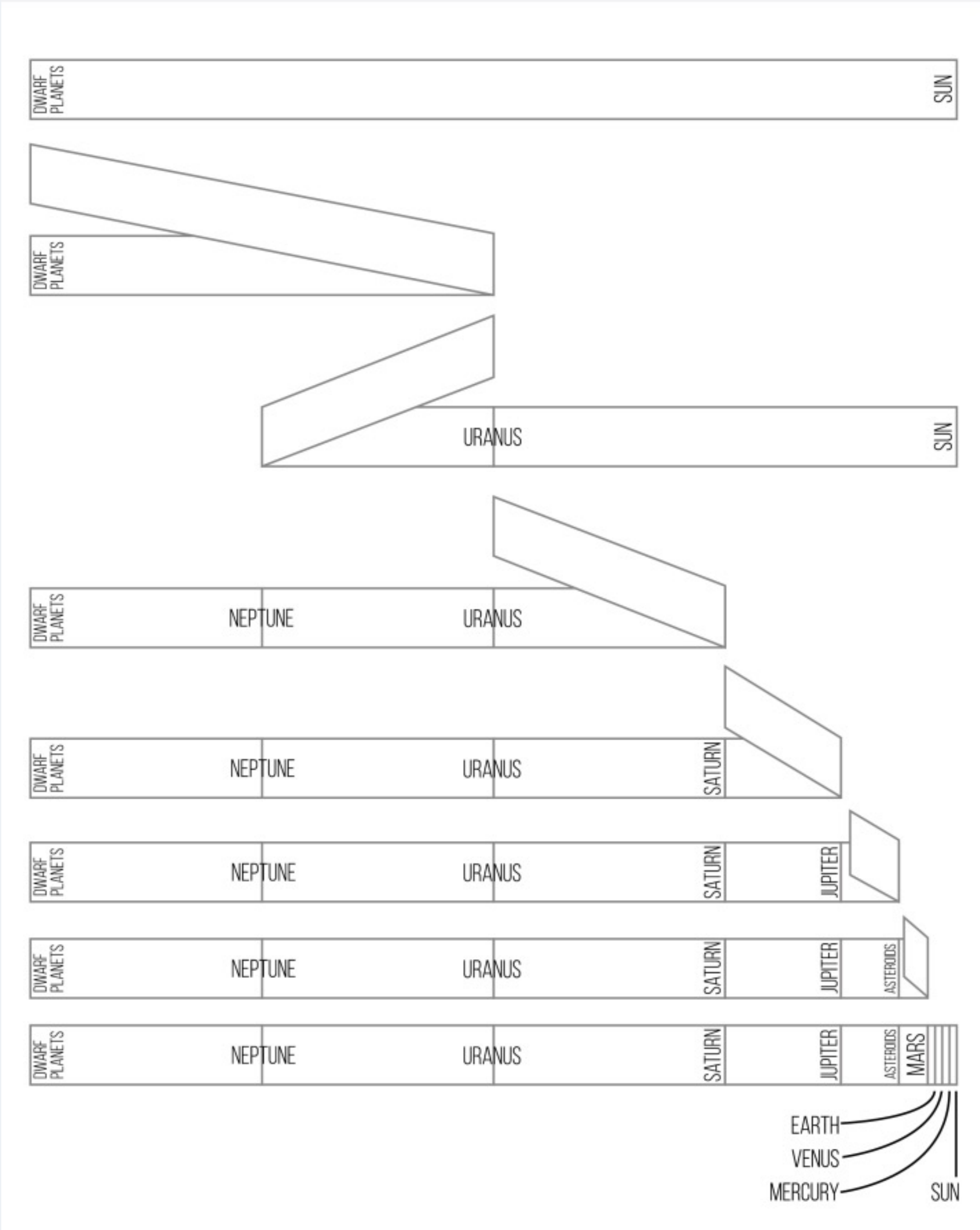
Step 6: Fold the paper from the Sun up to Jupiter. Write Asteroid Belt on the crease.

Step 7: Fold the paper from the Sun up to the Asteroid Belt. Write Mars on the crease.

Step 8: Write Mercury, Venus, and Earth evenly in the space between the Sun and Mars. Write them in the correct order 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 of workbooks. Ask the class teacher to arrange sticking these in after the investigation.

Why Does Mars Change Size?

Show slide 15 of the PowerPoint presentation. Explain that we use scales to represent real things that span large distances (e.g towns/cities in a country). This lets us see sizes, locations, and distances in a way we can understand.

Show the scale of our Solar System map for students to write in their workbooks. Because space is so vast, our scale is much bigger than other maps. This is also we are using millions of kilometres (km). Otherwise, the numbers would be too complex.

Activity: Planetary Motion

Show slide 17 of the PowerPoint presentation. Explain that while pictures of the Solar System - and the map we've created - show the planets in a straight line, this isn't how things look in real life.

Each planet moves around the Sun repeatedly in a path. This is called an orbit. As the planets orbit, they don't stay lined up.

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!

The video on slide 17 of the demonstrates this. It shows planetary motion over 4 years. The outer planets barely move at all, whilst the inner planets make multiple orbits during the same period.

You could discuss with students 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.

Point out that the orbits aren't perfect circles. They're stretched into. This means the distance between a planet and the Sun constantly changes during its orbit, though these differences may be smaller for some planets (with less oval shaped orbits) compared to others.

Why Does Mars Change Size?

Tell students to complete the activity (filling in the blank sentences) in their workbooks.

Show the answers on slide 19 of the PowerPoint presentation by clicking through the animations.

Slide 20 has information about Earth's orbit. Because it is much less oval shaped than Mars's orbit, the distance between the Sun and Earth's orbit doesn't change very much. This is why only 1 distance (149 million km) is given.

Slide 21 has information about Mars's orbit. It is much more oval shaped, so the distance between the Sun and Mars's orbit changes a lot. This is why 2 distances (204 million km and 247 million km) are given – the closest and furthest points of the orbit.

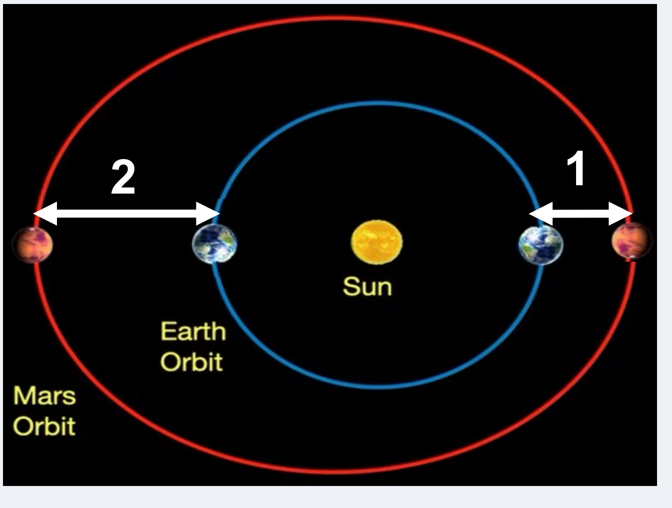
Note: The orbit distances have been chosen to simplify the calculations in the next activity. However, they're similar to the true values.

Discuss with students how the distance between Earth and Mars changes due to their orbits. The first image on slide 21 shows the planets on the same side of the Sun. They have lined up in their orbits and are close to each other.

Click to show the second image. At this point in their orbits, the planets are on opposite sides of the Sun, so are further away from each other.

However, even if Earth was on the same side as Mars, the distance between them (shown with arrow 2) is still larger than the distance in the previous example (shown with arrow 1).

This is due to the shape of Mars's orbit.



Activity: Orbit Maths

Show slide 23 of the PowerPoint presentation.

Ask students to complete the calculations in their workbooks. The equations they need are given to them.

Tip: Before the investigation, discuss with your class teacher how confident the students are with maths. They can let you know if there is anyone you/they should give extra support to.

If lots of students would benefit from extra support, you could do this activity together as a class, with you guiding them through each step. This is also useful if you're worried about how much time is left – the activity can be completed much quicker this way.

Show the answers on slides 24 – 26 of the PowerPoint presentation. They are included for reference below.

Student Workbook Answers

Calculate the shortest distance between Earth and Mars.

204 – 149 = <u>55 million km</u>

Calculate the longest distance between Earth and Mars.

247 + 149 = <u>396 million km</u>

Calculate how much further away Mars is at its longest distance from Earth compared to its shortest distance.

Give your answer as a decimal.

$$396 \div 55 = 7\frac{11}{55} = 7\frac{1}{5} = \underline{7.2}$$

Lastly, round your answer to the nearest whole number.

$$7.2 \rightarrow \underline{7}$$

Highlight to students the difference between the distances. It would take longer to reach Mars if it was further away from us. This is why we need to consider where each planet is in its orbit when planning our trip to Mars. Students will explore this further in the next investigation.

Remind students of the Solar System map they made earlier. Earth and Mars are some of the closest planets in the Solar System, but even at the closest point in their orbits, the distance (55 million km) is still vast.

Slide 28 of the PowerPoint presentation puts this value into context for the students.

Activity: Measure Mars

Students have 8 images of Mars in their workbooks. They are all zoomed in to the same amount, so any differences in size are not to do with the images themselves.

Students will investigate these differences in this activity.

Step 1: Record the Data

Ask students to measure the size of Mars in centimetres with a ruler. They can record the data (given to 1 decimal place) in the results table.

They will first measure Mars at its widest point (from left to right). If students complete this quickly, the results table also includes columns for measuring the size of Mars vertically (top to bottom) and diagonally.

Emphasise completing a full set of measurements in one direction before measuring in a different direction.

Students 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.

Slide 31 contains a list of useful information for the students that you can show as they complete this part of the task.

Step 2: Plot the Data
Once all students have obtained a first set of data (measuring from left to right across Mars), they can then use this to plot a graph. This will let them easily see the changes in size between the observation dates.

The graph in their workbooks shows each observation date on the x axis and the size (increasing in 0.1 cm's) on the y axis.

Slide 32 of the PowerPoint presentation demonstrates how to plot two data points on the graph. Go through this with the students.

When plotting, they should use a sharp pencil and 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.

Tip: Students will likely have varied experience and confidence in plotting graphs. Before the investigation, discuss this with your class teacher. They may offer advice or explain how students have done graph work previously.

Slide 33 contains a list of useful information for the students that you can show as they complete this part of the task.

Step 3: Analyse the Results
Ask students to complete the questions in their workbooks. They have a range of prompts and sentence starts to help them.

Show the answers on slides 35 and 36 of the of the PowerPoint presentation. They are included for reference on the following page.

Why Does Mars Change Size?

Student Workbook Answers

Describe how the apparent size of Mars changes over time.

At the start of the observations… Mars appears to get bigger in the night sky.

The date that Mars reaches its largest apparent size is 16/1/2025

*After this date, the size of Mars appears to…*get smaller in the night sky.

Explain why the size of Mars appears to change.

The planets orbit the Sun at different distances and speeds.

Earths orbits the Sun *faster* *than Mars.*

When Earth moves towards Mars, Mars appears to get bigger because… the planets are getting closer together (the distance between them decreases).

When Earth moves past Mars, Mars appears to get smaller because… the planets are getting closer together (the distance between them decreases).

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 the 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 (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

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: Handbook (see referenced pages for more information/guidance about the activity)

Duration	Activity	Pages	Materials
3 minutes	Recap the last investigation and how it links to the current investigation and overall Mars project.	Handbook: 66	Lesson PowerPoint presentation
10 minutes	Recap the distance to Mars and put this into context. Ask students to write in their workbooks how long they think it would take to get to Mars Select some students to share answers with the class. Tell students to real value and have them write it in their workbooks. Students finish 'Travelling to Mars' activity in their workbooks. Show answers to class and have students mark their work..	Handbook: 67 Student Workbook	Lesson PowerPoint presentation Student Workbooks

When Should We Launch to Mars?

Duration	Activity	Pages	Materials
15 minutes	Briefly explain what an orrery is. Show the electric orrery resource. Set the context for finding the date of closest approach. Students complete the 'Electric Orrery' activity in their workbooks.	Handbook: 68 – 71 Student Workbook:	Lesson PowerPoint presentation Student Workbooks Laptops/computers/ tablets with internet access
10 minutes	Explain why we need to launch earlier than the date of closest approach. Students complete 'The Launch Date' activity in their workbooks.	Handbook: 72 – 73 Student Workbook:	Lesson PowerPoint presentation Student Workbooks
5 minutes	Discuss the importance of words and impact they can have. Students complete the 'First Words' activity in their workbooks. Play the video of the first steps and words on the Moon.	Handbook: 73 Student Workbook:	Lesson PowerPoint presentation Student Workbooks
10 minutes	Hand out the evaluation postcards for students to fill in. Collect at the end of the session and return to TSO team.	Handbook: 74	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'd like to be involved in them.	Handbook: 74	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.

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. They will look at when date of the next closest approach is after 1st January 2035 – after we've had time to build rockets and train astronauts.

Once they know this date, 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.

Finally, students will think about the importance words and write their own first words for their first steps on Mars.

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

Activity: Travelling to Mars

Show slide 4 of the PowerPoint presentation and remind students that 55 million km is the shortest distance to Mars. This is the same as travelling to the Moon and back over 70 times!

Getting to Mars when the planets are close together reduces the journey time. Our spacecraft will carry important supplies (food, water, oxygen, etc.). A shorter journey means carrying less supplies, so less mass that might potentially impact how fast the spacecraft can travel.

Ask students to 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 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').

Show the real value (250 days) on slide 6. Students need to write this in 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.

But we don't have the technology right now. These are best guesses based on the mathematics of the orbits and expected vehicle velocities.

Students then need to complete the maths questions in their booklet.

Show the answers on slides 7 – 8 of the PowerPoint presentation. They are included for reference below.

Student Workbook Answers

Calculate this in months – assume 30 days in each month.
Give your answer to 1 decimal place.

$$250 \div 30 = 8\,\frac{10}{30} = 8\,\frac{1}{3} = 8.3$$

Lastly, round your answer to the nearest whole number.

$$8.3 \rightarrow \underline{8}$$

When Should We Launch to Mars?

Activity: Electric Orrery

To plan a launch date, we must first know when the planets are close together. We can do this using a tool called an orrery – a model of the Solar System showing where the planets are at any point in time, relative to the Sun and each other.

Define orrery for the students (slide 10 of the PowerPoint presentation). We will be using an electric orrery on The Schools' Observatory's website.

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

You should also ask if students need to switch rooms to access any technology. Some schools may only have computers in certain areas.

Since we currently lack the technology to reach Mars, we'll be finding the date of closest approach after 1/1/2035. Tell students this gives us enough time to build the rockets and train the astronauts. Mention that they'll be adults at this point too, so they could be part of the crew!

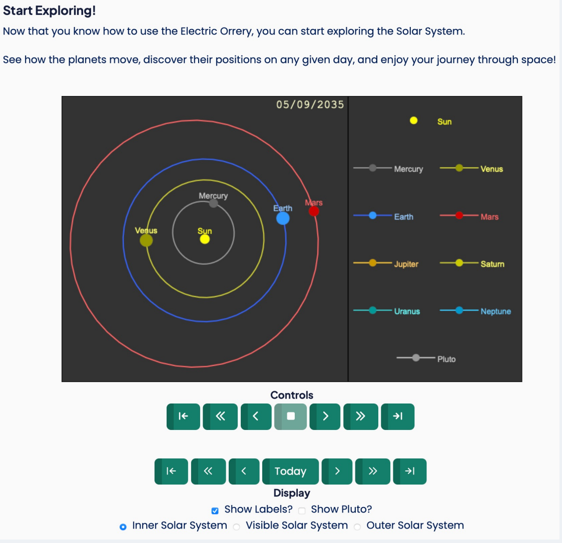
Show slide 11 of the PowerPoint presentation. Direct students to The Schools' Observatory's website (logging into an account is not needed) and then go through the following instructions with them.

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.

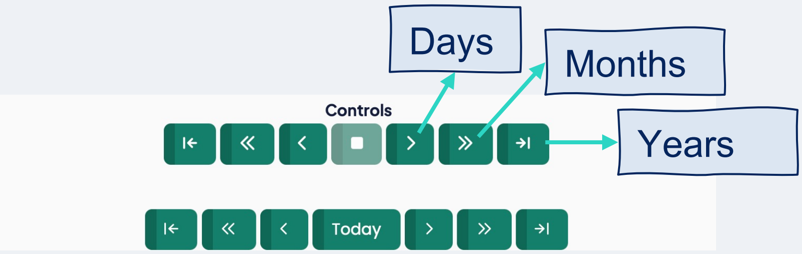
2. Click on the first search result: '**Electric Orrery**'.

3. Scroll to the bottom of the page: '**Start Exploring**!' section.

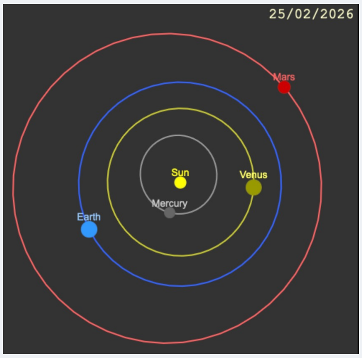


When Should We Launch to Mars?

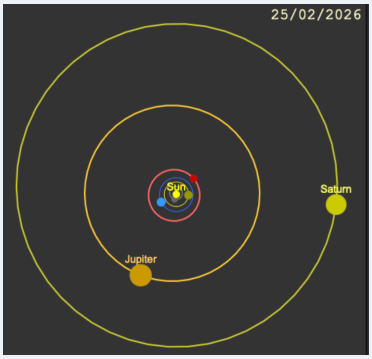
4. Click '**>**' from the top row of the '**Controls**' menu to play the orrery and observe the planets moving constantly through the days (each button in the menu fast forwards/backwards by a different speed)



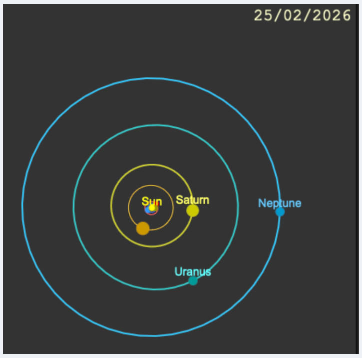
5. You can switch to 'Visible Solar System' (what we can see with our eyes) and 'Outer Solar System' in the '**Display**' options, but Mars and Earth are difficult to see.



Inner Solar System

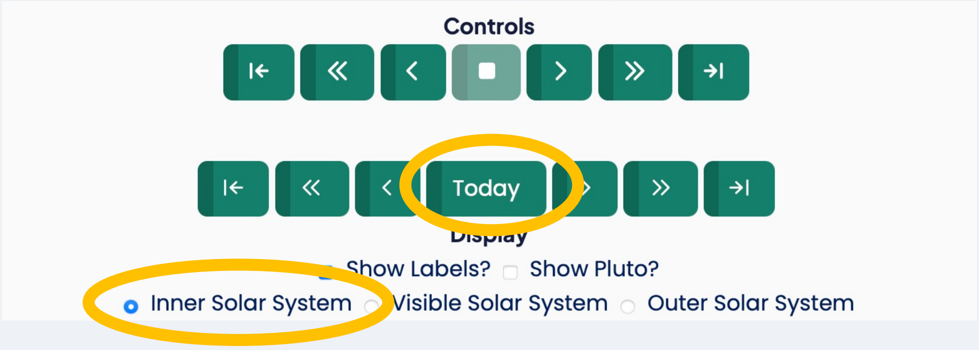


Visible Solar System

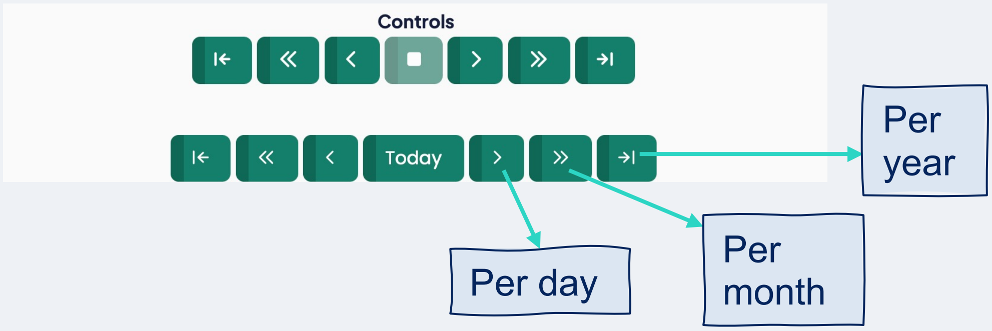


Outer Solar System

6. Reset to '**Today**' and '**Inner Solar System**'.

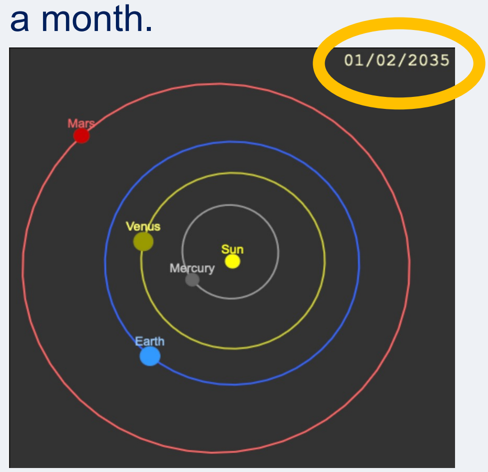


7. Use the buttons on the **lower row** of 'Controls' (i.e. the arrows either side of the 'Today' button) to move forwards and backwards in time by a set amount on each click.



8. Use the buttons to move forwards in time until 1/1/2035. Ask students to do the same.

For the activity, students can work in pairs. Tell them to start by using the '**>>**' button to move the orrery forwards a month.



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 add to the '**Notes**' column.

Slide 12 of the PowerPoint presentation has prompts of what students might add, along with a reminder of the instructions.

Once they have found the month when Earth and Mars appear closest together (this should be September 2035), ask students to go through the month **day by day** to find the exact date.

The month of closest approach is **September**. However, the planets appear close together in August as well, so some students may start going day by day here.

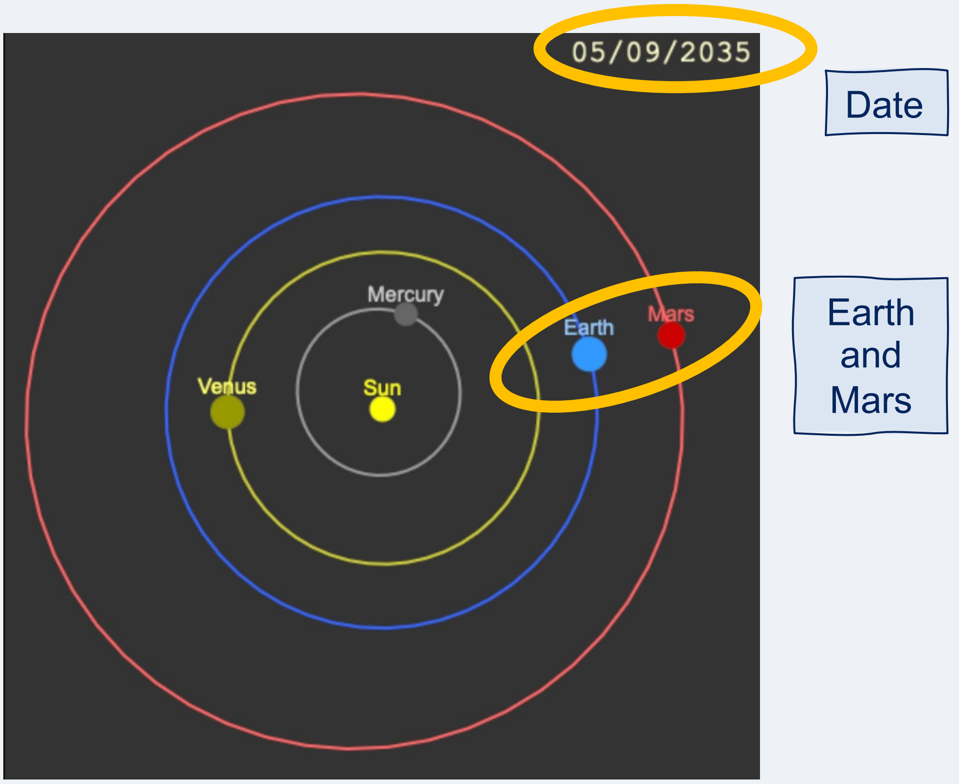
Encourage students to always check ahead in time when they think they've found a point of closest approach. This lets them compare the distance and check if they're right.

When Should We Launch to Mars?

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

This should be a date in early September e.g., 5/9/20235.

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 (because Mars and the Sun are on opposite sides of Earth).

Activity: The Launch Date

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!

Essentially, we need to leave Earth and travel towards where we know Mars will be on a specific date (e.g. the date of closest approach). And must factor travel time into our planning of the launch date.

Show slide 14 of the PowerPoint presentation. It shows the trajectory of a spacecraft leaving Earth and reaching Mars at a point when the planets are close together. Use this to help explain to students why we must leave earlier than the date they have just found.

Ask students to complete the questions in their workbooks.

For simplicity, they will use 8 months as the travel time to Mars (their rounded answer from the first activity). You may need to remind them of this answer if they seem to be struggling.

The workbooks contain this calendar row to help students count backwards and find their launch month.

Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**

From September, going back 8 months gives an answer of January.

Students can choose whichever day of the month to launch. Ideally, this would be before the day of month from their date of closest approach (e.g. before the 5th of the month if the closest approach was 5/9/2035).

But since students rounded down for their answer of 8 months, they won't get an accurate date anyway. The main focus of this activity is for students to understand why we must leave Earth earlier than the date of closest approach. It doesn't matter if their date is correct or not.

So, they're free to pick whichever day they want!

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.

Activity: First Words

Show slide 17 of the PowerPoint presentation. 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.

Around 650 million people watched live the Moon landing live. Even more people might watch the future Mars landing – the population is bigger, and more people have access to technology. The words spoken on Mars will be just as important as those said on the Moon.

Ask students to write in their workbooks what they would say as the first person to step on to Mars. Slide 18 contains some prompts for any students who be struggling.

Tell them that the words can be personal to them, so they don't have to share them with anyone else. But if some students are eager, you could allow them to say theirs if time allows.

Play the video from the PowerPoint presentation (on slide 19). Neil Armstrong's words were: 'That's one small step for [a] man, one giant leap for mankind' (the *a* was lost in the static noise).

You could discuss the meaning with your class. While that step from the spacecraft to the Moon's surface was small physically, it marked a massive achievement in human history, highlighting the technological and scientific advancements we'd made and hope to continue making in the future.

Evaluation Postcards

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

Guide students through the questions if necessary.

Collect these at the end of the session. Please keep them safe and hand in to a member of the TSO team (room 2.22) as soon as you're back in the office. These must be given to a person directly. They have student information on them, so cannot be left unattended.

Final Thoughts

Play the video (on mute) from slide 21 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!