Junior Universe Mechatronic Pilot (J.U.M.P.)

Machines in Space!

This ***Spark! Discovery box*** has been developed to encourage children, aged **5 to 10** with their accompanying adult, to explore, create, and discover, and to be inspired. Use the equipment and resources inside to **learn and have fun**. Try out the micro-missions we've described or invent your own adventures!

Please take great care of all the items in the box and make sure you always have an adult assistant with you. Be mindful that all items from the box are to be returned as you found them for other mission teams to use.

Exploring and learning about science and technologies in space is fun! We hope you'll be as excited as our team at the Australian Space Agency.

What's in the Box:

- Roo-ver Jr. programmable robot
- LEGO-compatible components
- Solar panel & Voltmeter
- Weather station with remote sensor
- Remote control & Torch
- Genuine meteorite sample
- Mission Test Track
- Mission Guidebook

Adult supervision is required at all times. Small parts – not suitable for children under 3 years old.
Rechargeable batteries can get warm while charging – do not leave unattended. If unit becomes hot immediately remove from power source.

Developed by Children's Discovery | www.childrensdiscovery.org.au

Machines in Space!

The Australian Space Agency supports space science and technology which enhances our everyday lives.
The Agency works on things like emergency communication, weather forecasting, GPS, and the internet. Through these efforts, the Agency contributes to creating a safer and better world.

Mission Preparation

Mission Control
This is an area in your home, school or library that you will use to plan missions and do your science. If you need to organise times when you can use the space, make sure you carefully pack all items back in the box at the end.

Micro-missions
These are a series of science and engineering questions you may wish to answer using the resources in the box. You may also decide to use outside spaces for some micro-missions. Make sure you have permission and supervision at Mission Control and for all micro-missions.

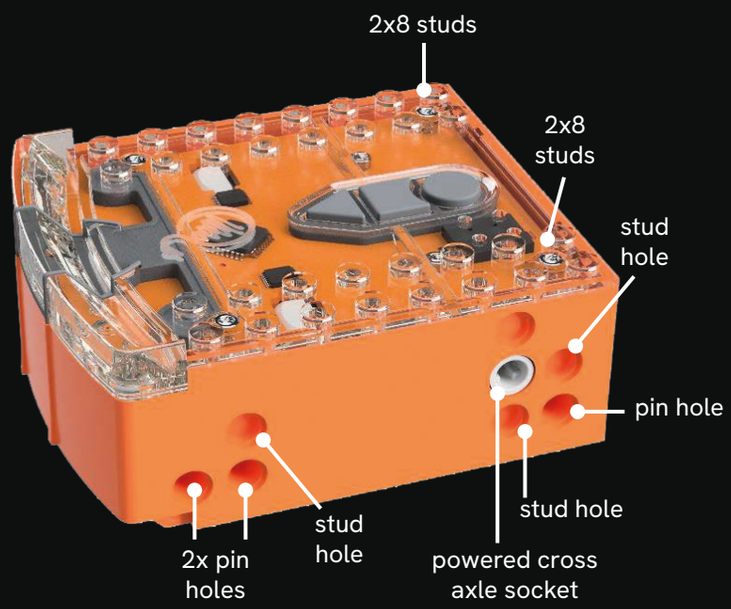
Design thinking
Behave like a scientist and engineer during each micro-mission:

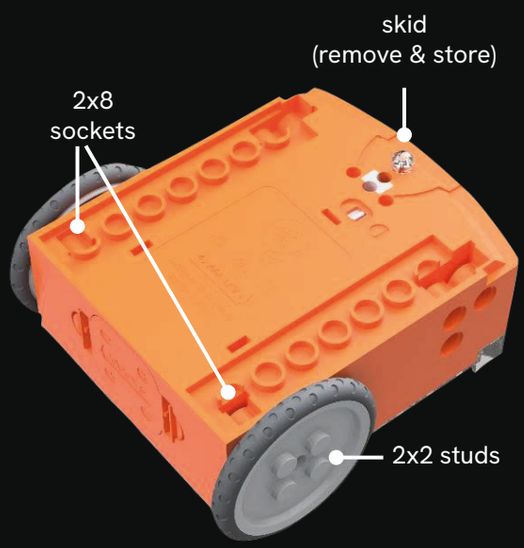
1. **Think** – what are you planning to learn or discover.
2. **Test** – do your experiment or try out your design.
3. **Change** – improve your experiment or design, go back to 1.

Equipment Set-up

Roo-ver Jr.

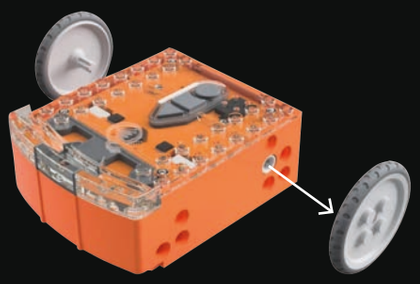
Roo-ver Jr. should come to you already with tracks instead of wheels. Follow the diagrams below to assemble the tracks if required. Roo-ver Jr. has a USB rechargeable battery which you can charge from any 5v USB port as required.





Hole Type	Description	Connects to
Pin hole	A full-depth hole for connecting pegs	
Stud hole	A hole of normal stud-depth which works with half pegs	
Cross axle socket	A powered socket which rotates	

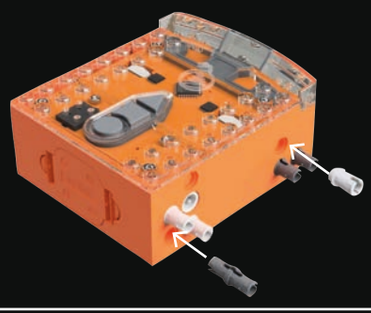
1



2

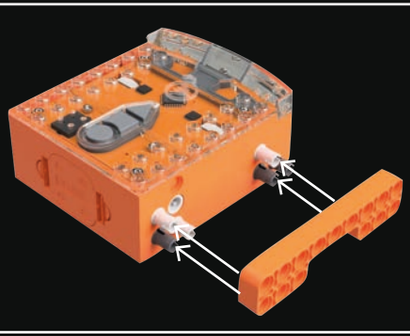
3x

3x



3

1x



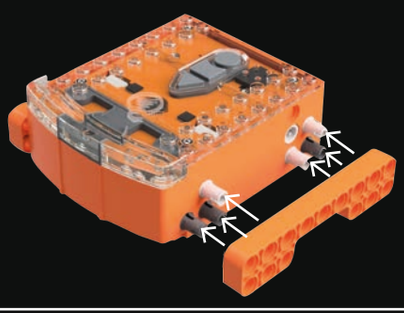
4

3x

3x

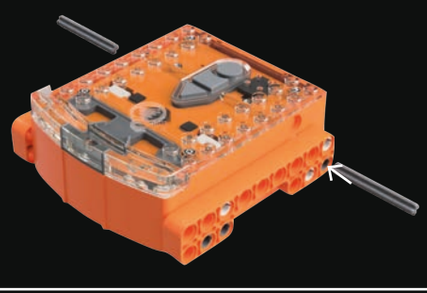
5

1x



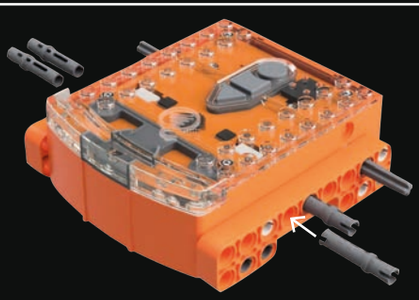
6

2x 3 cm



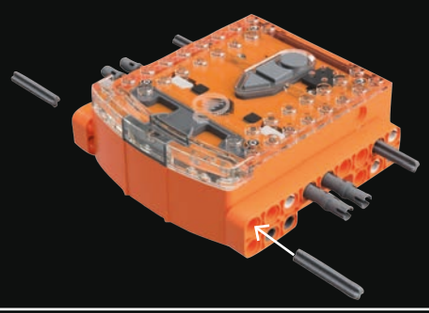
7

4x



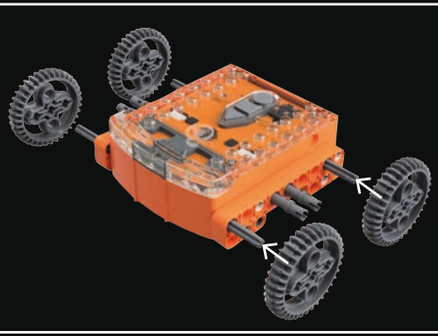
8

2x 2 cm



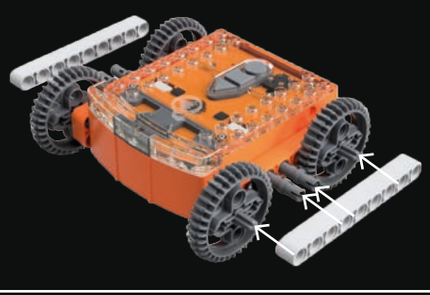
9

4x



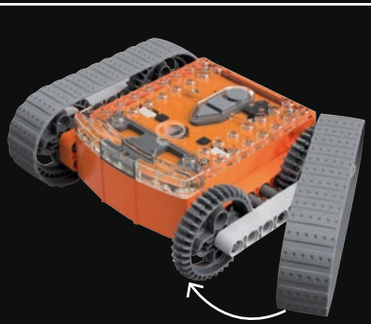
10

2x

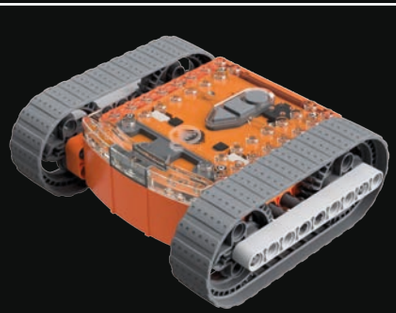


11

2x



12



Equipment Set-up

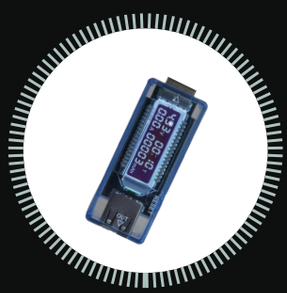
Roo-ver Jr. can be programmed to respond to commands from the **remote-control unit**. This unit requires 2 x AA batteries, which can be replaced when applicable. Please dispose of old batteries correctly in e-waste bins.

Roo-ver Jr. can be programmed to respond to **torch** light. This torch has a USB rechargeable battery which you can charge from any 5v USB port as required.

As Roo-ver Jr. is LEGO compatible, you are welcome to use your own LEGO pieces in your designs (remember to take back all your pieces).

Solar panel & Voltmeter

The **solar panel** can be connected to the voltmeter. You can read the data on the voltmeter screen which tells you how much electrical energy is being generated by the solar panel.



Roo-ver Jr. can then be connected to the **voltmeter** which can tell you how much electrical energy is going into the Roo-ver Jr. battery.

A **LEGO riser** with hinge is provided so that you can engineer a way of connecting the solar panel onto Roo-ver Jr.

Weather station

The weather station should arrive to you already set to local time and date. **No other action is required** (a separate manual is provided if needed). This unit requires AA batteries, which can be replaced when applicable.

Place the **base station** at your Mission Control and the smaller **sensor unit** outside or wherever you are testing. You can even try mounting the unit on Roo-ver Jr.

The unit provides data on temperature and humidity. Does this data help you predict how much solar energy is available to charge Roo-ver Jr.'s batteries?

Meteorite

This is a genuine piece of '**space rock**', classified as nickel-ion coarse octahedrite, that was recovered after crashing to Earth about 6000 years ago in Argentina. Mapping and tracking meteorites in space helps keep our space technologies safe. Examine and be inspired, but please do not remove from the protective box.

Test Track

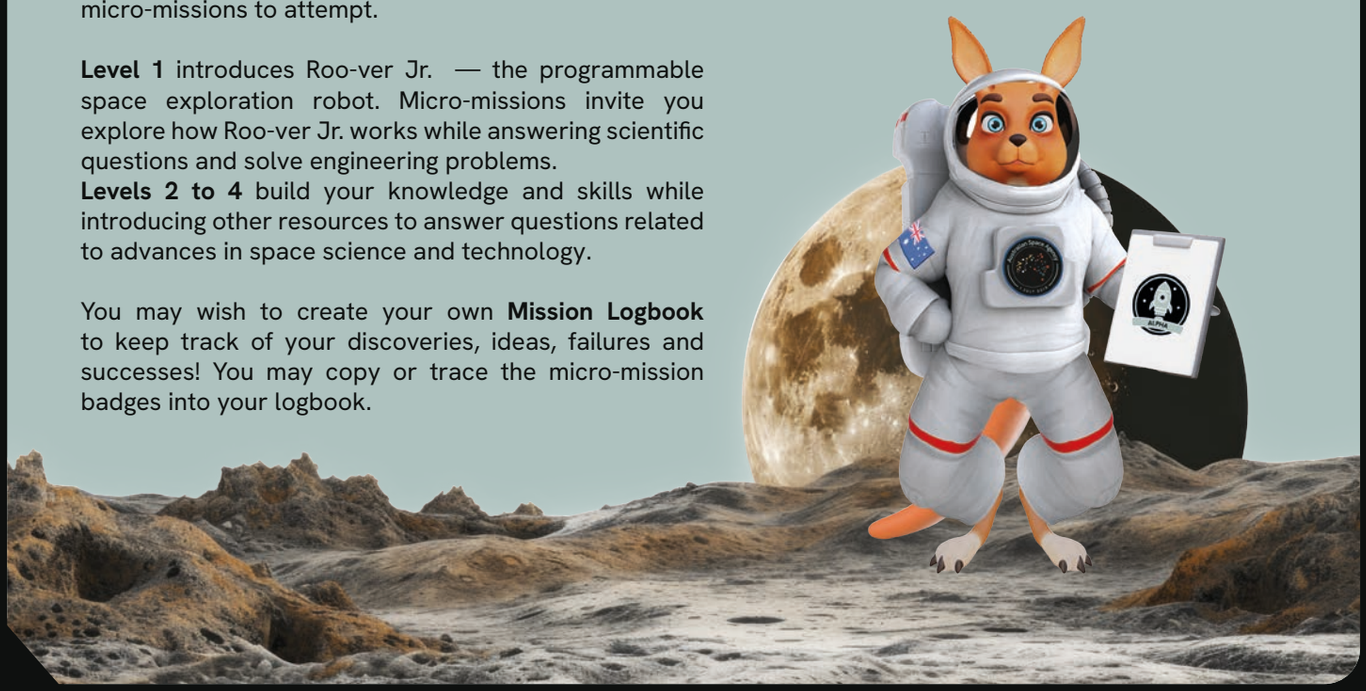
The Test Track is provided to test Roo-ver Jr. **programming**. It should be carefully unfolded and placed flat for testing, and then carefully folded to fit back in the box. Take care not to damage the Test Track while in use.

Missions

The following pages list a series of Mission Levels and micro-missions to attempt.

Level 1 introduces Roo-ver Jr. — the programmable space exploration robot. Micro-missions invite you explore how Roo-ver Jr. works while answering scientific questions and solve engineering problems.
Levels 2 to 4 build your knowledge and skills while introducing other resources to answer questions related to advances in space science and technology.

You may wish to create your own **Mission Logbook** to keep track of your discoveries, ideas, failures and successes! You may copy or trace the micro-mission badges into your logbook.



Level 1: Roo-ver Jr. + Test Track

Pre-mission set-up

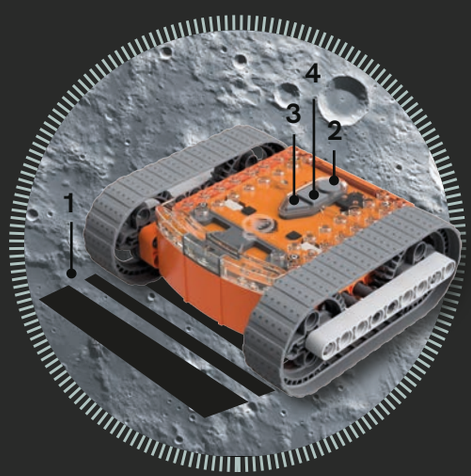
Build
Roo-ver Jr. will need to go into space ready to work. Check that your Roo-ver Jr. looks like the picture below. If required, follow the track wheel instructions.

Program
Roo-ver Jr. is a robot that needs instructions to know what to do. Some information is pre-programmed and activated by Roo-ver Jr. reading a barcode. More complex information can be programmed using **block code language**.

1. Place Roo-ver Jr. in front of any **barcode** as shown on the Test Track.
2. Press the '**record**' (round) button three (3) times. Roo-ver Jr. will drive forward over the barcode and 'read' the code using its light sensor and beep to indicate it is ready.
3. Press the '**play**' (triangle) button once. Roo-ver Jr. will perform the command.
4. Press the '**stop**' (square) button once to stop Roo-ver Jr.

Missions
Choose micro-missions to try. Go at your own pace and add your **creativity and imagination** to explore other questions and ideas.

Be mindful of working scientifically – that is being careful and thinking about what you are trying to do – always have an adult working alongside.



Level 1: Roo-ver Jr. + Test Track

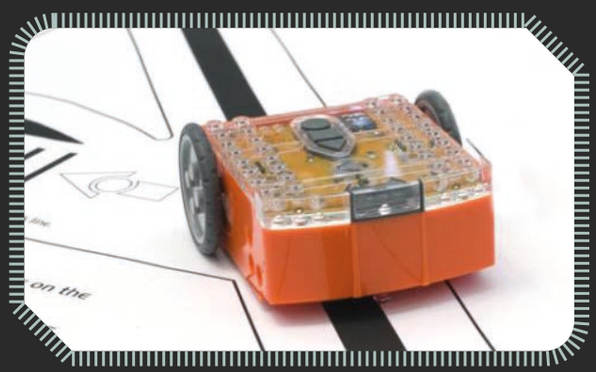
Micro-mission Murriyang

Roo-ver Jr. comes pre-programmed with the ability to respond to commands in the form of barcodes. These are *'read'* by Roo-ver Jr. while driving over them and using their light sensor to measure light bouncing back from the black and white lines of the barcode.

Q: Are you able to correctly program Roo-ver Jr. using the barcodes on the Test Track?

Q: Does Roo-ver Jr. always behave as expected?

Answer these questions by following the instructions on the Test Track. Test Roo-ver Jr.'s ability to: follow a line, bounce in borders and avoid obstacles, follow a line and make sounds. *What do you need to do or change if Roo-ver Jr. does not respond as expected?*



Claim your micro-credential and draw a copy of this badge in your logbook!

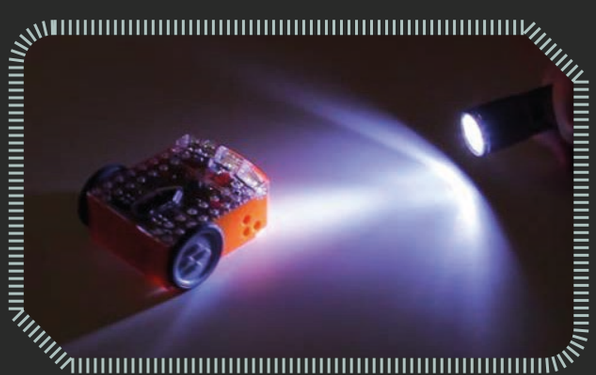
Micro-mission Weemala

Roo-ver Jr.'s sensors include the ability to *'see'* light, in the form of a **torch light**. This is useful if Roo-ver Jr. is to find its way home after a mission and can locate a light from a base station or to follow another Roo-ver Jr.

Q: Can you use the correct barcode to program Roo-ver Jr. to follow a torch?
Q: What can you learn from how Roo-ver Jr. follows your torch? Best in daylight or in the dark? How spread out can the light beam go before tracking stops.

Answer these questions by correctly programming Roo-ver Jr. to follow the torch provided. Run the test in a dark space and in a bright space. Bring the torch closer to or further away from Roo-ver Jr.

Note: the torch contains a USB rechargeable battery. It can be recharged using home USB charging ports and **must be supervised at all times**.



Claim your micro-credential and draw a copy of this badge in your logbook!

Micro-mission Ballima

Future missions may involve Roo-ver Jr. following lines pre-placed by earlier missions.

Q: What materials make the best tracks? You could try black pens, paint or tape.

Q: What do we need to know if tracks are to cross each other, before becoming too confusing for Roo-ver Jr. to follow?

Use materials you have (pens, paints, tapes) and create tracks on paper, card, or other materials – be sure you have permission and supervision and avoid staining Roo-ver Jr. or floors. DO NOT DRAW ON THE TEST TRACK. You might be able to send Roo-ver Jr. on a very long mission and return to base.

Claim your micro-credential and draw a copy of this badge in your logbook!

Micro-mission Endeavour

Roo-ver Jr. will need to move across the **surface** of the moons and other planetary surfaces.

Q: What kind of ground is Roo-ver Jr. best suited for?

Q: Which is better – tracks or wheels, or maybe skids?

Answer these questions by driving Roo-ver Jr. over different types of floors; such as carpet, tiles or timber. *Can Roo-ver Jr. drive up or down slopes or avoid obstacles?*

You can also try Roo-ver Jr. on footpaths and sand. Be sure to **clean Roo-ver Jr. after each experiment**.

Claim your micro-credential and draw a copy of this badge in your logbook!

Level 2: Roo-ver Jr. + Solar Panel

Micro-mission Australis

Roo-ver Jr. operates using rechargeable batteries which you can recharge when needed. This must be done under adult supervision using any suitable 5v USB power supply. **Solar panels** generate electrical power from sunlight, and possibly other light sources.

Voltmeters measure electrical energy (electrical 'push' or 'pressure') in **Volts** (V) and electrical current (rate of flow of electrical current) in **Amps** (A) and are useful for comparing how much energy is being produced by the solar panel at any time. Roo-ver Jr. will need to have its batteries recharged while on mission. We need to test if we can recharge Roo-ver Jr.'s batteries using solar energy or other light sources.

Q: Will a solar panel provide electrical energy that could be used to recharge batteries in Roo-ver Jr.?
Q: What is the best time or location for using solar panels to help recharge Roo-ver Jr.'s batteries?

Answer these questions by experimenting with the in-line voltmeter and solar panel. Gently connect the voltmeter into the USB socket of the solar panel. The voltmeter will measure how much electrical power it is receiving. Generally, this will be 0 volts when there is little or no sunlight.

Experiment by moving your solar panel, connected to the voltmeter, in and out of sunlight. *Do you find the voltage number changes?* In bright light, you might observe **4 to 5 volts** and in shadow this may drop to less than 2 volts. Roo-ver Jr. requires close to 5 volts of charge, which means the solar panel in full sunlight might just be able to provide this energy. The Amps will remain at 0 as there is no flow of electrical energy into a battery (or other device) - *see Mission Mirrabooka*.

You can next experiment with the best time of day and the best locations for recharging a Roo-ver Jr.'s battery. Take your solar panel, connected to the voltmeter, at different times and to different locations outside. You may like to keep a written record of your data. *When and where does the voltmeter show the solar panel is producing the most electrical energy?* This might be in an unshaded space in the middle of the day (remember to be **Sun Safe**!). *How does this location compare to other locations with shade or at other times of the day? Does cloud cover have any effect on solar energy production?*

Claim your micro-credential and draw a copy of this badge in your logbook!

Micro-mission Mirrabooka

If we are generating enough electrical energy from sunlight we should be able to recharge Roo-ver Jr.'s batteries.

Q: How well does the solar panel generate electrical energy to recharge Roo-ver Jr.'s batteries?
Q: How does solar charging Roo-ver Jr.'s batteries compare to recharging at Mission Control (from a 5v power point)?

You can answer these questions with some experiments using materials from the box. With the solar panel connected to the voltmeter, plug Roo-ver Jr. into the other side - take care not to twist the cables too much. You are now able to measure the **amount of electrical energy** going to charge the batteries in Amps.

Repeat the experiments from *Micro-mission Australis*, but this time ensure Roo-ver Jr. is connected to the voltmeter that is also connected to the solar panel. Roo-ver Jr. is programmed to indicate when the batteries are being charged (*beep beep* red **LEDs flash together**). Watch the voltmeter and observe when Roo-ver Jr.'s LEDs flash together.

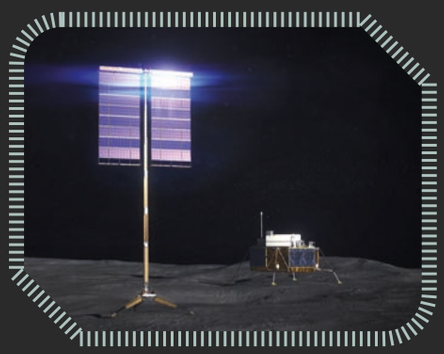
Earlier experiments observed electrical current of **0.03 Amps**, which is less than half the flow of power from a home plug. This would mean recharging would take at least twice as long.

Important: Roo-ver Jr. must be supervised at all times while connected to any recharging port in the home (Mission Control) or the solar panel (on mission). As this is a scientific study, we advise that Roo-ver Jr. not be connected to the solar charger for more than **15 minutes**.

Claim your micro-credential and draw a copy of this badge in your logbook!

Micro-mission Trailblazer

What happens if Roo-ver Jr.'s batteries need charging during the **night**?



Q: Do other sources of light allow solar panels to generate electrical energy?
Q: Does reflected sunlight allow solar panels to generate electrical energy?

You can answer these questions with some experiments using materials from the box and items from Mission Control. Shine light from other **light sources** onto the solar panel when it is connected to the voltmeter and Roo-ver Jr. This might be the torch from the box, a larger torch or desk light from Mission Control. *Does a room light work? How does a LED globe compare to a fluorescent or incandescent (rare to find) bulb?*

Could sunlight be reflected onto solar panels using a mirror or other shiny material? Find a suitable **mirror**, a shiny metal tray or lid and try to angle sunlight directly onto the solar panel - connected to the voltmeter, which you have placed in a dark place. If this works, *would a large mirror in space help charge batteries during the 'night'?*

Image credits: NASA

Claim your micro-credential and draw a copy of this badge in your logbook!

Micro-mission Kanyini

This mission is an **engineering challenge**. Make use of the included **LEGO blocks** and hinge to mount the solar panel onto Roo-ver Jr. The solar panel has a LEGO plate underneath - take care not to remove. You will need to test if your build still allows access to the buttons and there is no interference with Roo-ver Jr.'s sensors.

Try placing Roo-ver Jr. in a good location for collecting solar energy. Use the hinge to change the angle the panel faces the sun. Connect the voltmeter to the solar panel to measure electrical energy production at different angles. *What do you observe?*

You are welcome to use other materials from your Mission Control as long as you ensure all items from this box are returned in good order.

Claim your micro-credential and draw a copy of this badge in your logbook!

Level 3: Roo-ver Jr. + Weather Station

Micro-mission Kookaburra

Solar panels require direct sunlight to charge Roo-ver Jr.'s batteries, so being able to predict the best location for solar charging is important for planning future missions. Mission Control **weather stations** are used to measure temperature and humidity.

Q: How do we find the best location for solar charging?
Q: Does low temperature and low humidity create more solar charge?

Answer these questions by placing the weather base unit at your Mission Control and the small monitoring unit in different locations outside (not more than 20m from the Mission Control). Check the temperature and humidity readings on the base unit. Compare measurements at two or more locations.

Temperature is a measure of hotness or coldness as measured by a thermometer in units of *Celsius (C)* or *Fahrenheit (F)*. Temperature affects solar panel voltage and current. As temperature increases, the amount of energy a panel produces decreases. This is because higher temperatures create electrical resistance which reduces the flow of electrical power. **Humidity** is a measure of how much water vapour is in the air. Humidity affects solar panel voltage and current. As humidity increases, the amount of energy a panel produces decreases. This is because water vapour can collect as tiny water drops on solar panels (like beads of sweat) and reflect or refract sunlight away.

Attach the solar panel and voltmeter to Roo-ver Jr. and compare voltage and current outputs at different locations. Compare this data to that of the weather station sensor. *How confident are you to plan the best locations for recharging Roo-ver Jr. with solar panels?*

Claim your micro-credential and draw a copy of this badge in your logbook!

Micro-mission Cockatoo

Locating possible **sources of water** will greatly improve future human space missions. High humidity is an indicator of water availability, and possible signs of life.

Q: Using the weather station, can you locate areas of high humidity in your garden, park or home?

Q: Is it humid in areas where there's living material? Compare the humidity over grass versus concrete.

Answer these questions by using the **weather sensor unit** to measure temperature and humidity in various locations both inside and outside. Observe what you notice in these areas, in particular those with low temperature and low humidity - for example, *is there more or less plant life?*

You might like to create a way of connecting the weather sensing unit to your Roo-ver Jr. and drive out to a location to measure temperature and humidity. This might include a cupboard or space in your home. Areas of low temperature and humidity can indicate areas at risk of mould and other damage.

Claim your micro-credential and draw a copy of this badge in your logbook!

Micro-mission Lorikeet

Weather satellites are an important observational tool for forecasting weather on Earth. Satellite data from space works alongside ground-based systems to improve long-range weather predication.

Q: Is there a difference in temperature or humidity from the ground compared to off the ground?
Q: What are the best locations for placing weather sensors around your location?

Use the weather sensor and base station to answer these questions. We understand that the higher you go, the lower the humidity - this is because air at higher altitude contains less water vapour due to a lower air pressure. *Do your measurements show this pattern?* Even at the top floor of an apartment we might not see much difference.

DO NOT CLIMB ON ANYTHING HIGH - always ask for adult assistance.

Claim your micro-credential and draw a copy of this badge in your logbook!

Micro-mission Corella

There are two types of weather satellites: polar orbiting and geostationary. **Polar orbiting** satellites provide imagery and atmospheric soundings of temperature and moisture data over the entire Earth. **Geostationary** satellites constantly focus on the same area.

Q: Is there a difference in temperature or humidity from your weather sensor that is covering your entire area compared to staying in one place?
Q: Which system would be best to work out suitable locations for solar charging?

You can answer these questions with experiments involving the two weather sensors - the base and remote sensor. The base can be your '*geostationary*' unit - leave it in one location, while the remote sensor can be your '*polar*' unit that you move around your entire area.

You might walk it around, or use Roo-ver Jr. to drive it. The base station shows measurement for both units, so it is quite easy to compare data. Describe what conclusions you make from using the two systems.

Claim your micro-credential and draw a copy of this badge in your logbook!

Level 4: Roo-ver Jr. + Advanced

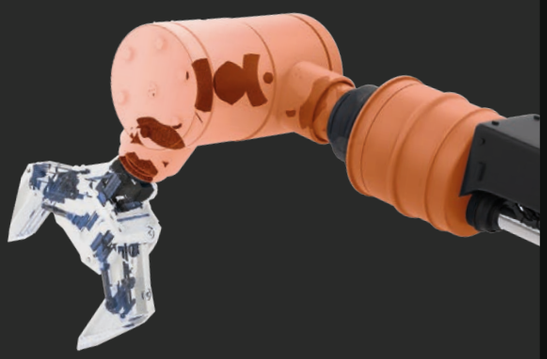
Micro-mission Musca

The **collection of material** from the surface helps scientists make more detailed analysis. Many Roo-ver Jr. missions will involve the ability to collect and transport materials from the surface or from below the surface.

Q: Can you create a way for Roo-ver Jr. to collect materials, possibly using a scoop or robotic arm?

Q: Can you combine the scoop/arm with remote control of Roo-ver Jr. to bring the materials back to base?

You may need to use additional materials from Mission Control to answer these questions. These could be items such as spoons, elastic bands or paddle-pop sticks, or a remote control robotic arm (you might be able to borrow). **Robotic arms** are also useful on orbiting missions, to help fix problems or to load materials from one station to another.



Claim your micro-credential and draw a copy of this badge in your logbook!

Micro-mission Lupus

Roo-ver Jr. could be damaged by **dust storms** or **rainstorms**. This is a real problem with many machines on or just above the surface of a planet.

Q: Can you create a way to protect Roo-ver Jr. from a dust storm?

Q: Does Roo-ver Jr. continue to respond to remote control commands while covered in protective materials?

To answer these questions you may need to find and experiment with materials from Mission Control, such as plastic or cardboard boxes, aluminium or plastic wrap and other types of covers. With each material, test that Roo-ver Jr. is responding to commands, and possibly continues to be able to function in other ways, such as using its robotic scoop/arm.

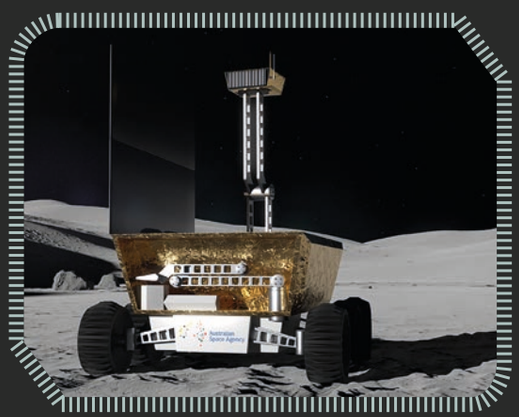
Claim your micro-credential and draw a copy of this badge in your logbook!

Micro-mission Dorado

For Roo-ver Jr. to become more independent, it could be engineered to carry a mobile phone* and use the phone camera to send **live video** feeds back to a second mobile phone at Mission Control. Mission Control can use this live feed to remotely steer Roo-ver Jr.

Q: Can you create a caddy that will hold a mobile phone on Roo-ver Jr.?
Q: Can you remotely control Roo-ver Jr. when out of sight from Mission Control?

You will need to find two phones and some materials to build the **caddy** for holding one phone on Roo-ver Jr. Once installed, Mission Control will see what Roo-ver Jr. is looking at, and be able to steer Roo-ver Jr. to various locations. Mission Control could also communicate with other stations via the phone mounted on the Roo-ver Jr.



Perhaps one test mission might be to drive Roo-ver Jr. to Kitchen Station Alpha and request a snack, which can be collected and delivered to Mission Control!

*Other technology, such as GoPro could also be used.

Claim your micro-credential and draw a copy of this badge in your logbook!

Micro-mission Indus

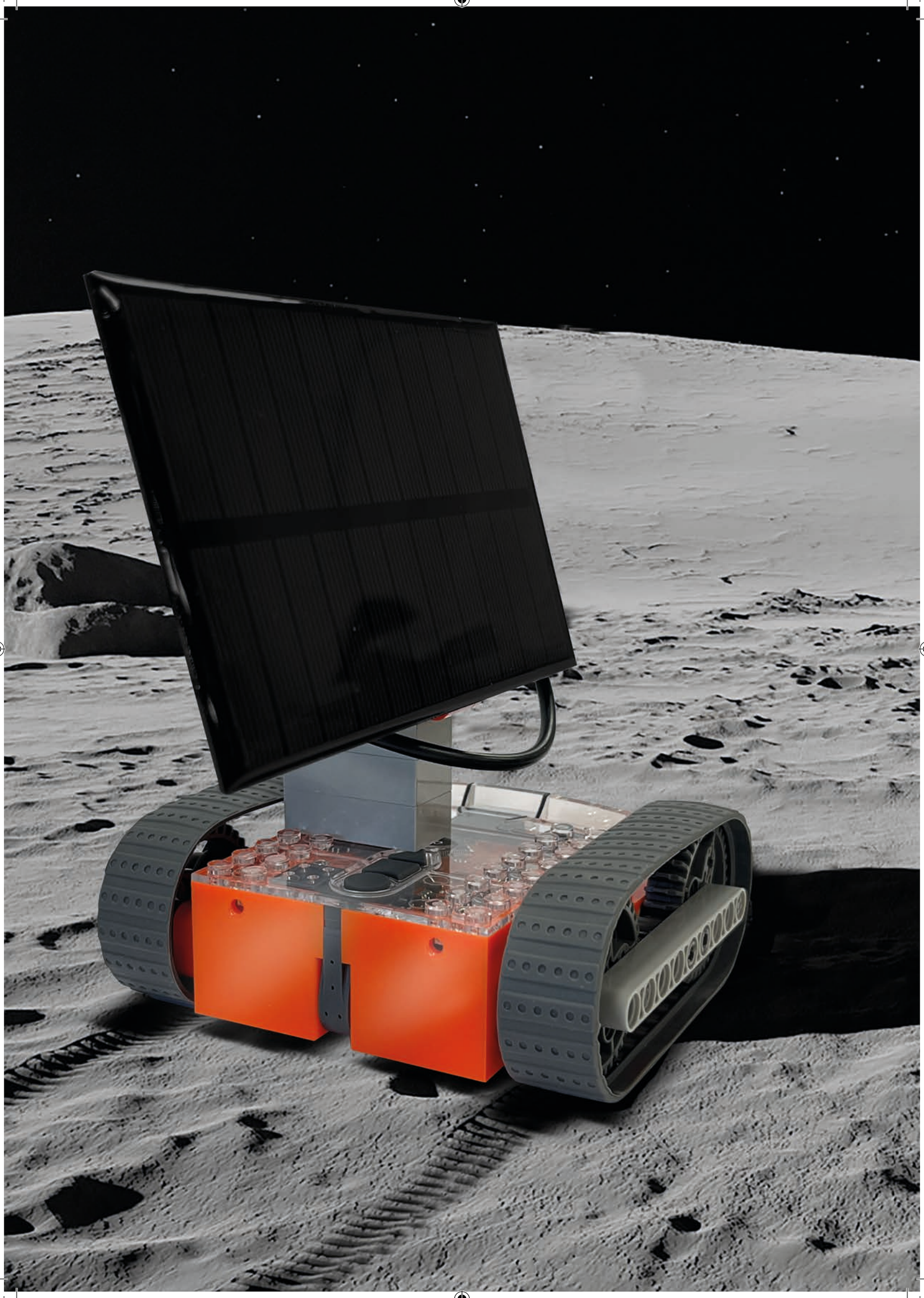
Roo-ver Jr. could be engineered to carry both a (phone) camera and weather unit and driven to various locations.

Q: Can you create a caddy that will hold both a camera and weather unit?
Q: Can you remotely control Roo-ver Jr. when out of sight from Mission Control and record temperature/ humidity at several locations?

These questions can be answered by using local materials to devise a way to carry both instruments.

You could also try to remotely drive Roo-ver Jr. to several locations outside or inside, perhaps across different terrains, to determine **best locations** for future solar charging. You could also attempt a design that allows Roo-ver Jr. to also carry the solar panel and voltmeter.

Claim your micro-credential and draw a copy of this badge in your logbook!



Australian Space Agency

This box was produced for the Australian Space Agency
by Children's Discovery Museum Limited
www.childrensdiscovery.org.au