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Make a Mission

Humans have been sending robotic explorers into space since the 1950's, starting with trips around our planet to expeditions all the way to the edge of the Solar System. Where would you explore if you could journey beyond Earth? In this activity, you'll design your own mission with a spacecraft, rocket, and plenty of imagination to answer questions you have about other worlds.

Materials

Planetary Explorer worksheets (pages 3–26)
Paper
Crayons or colored pencils
Solar System Mission Mysteries posters (Day 4)
Anatomy of a Rocket (Day 2) (Optional)
Anatomy of a Rover sheet (Day 3) (Optional)

Directions

1. **Choose** a moon or planet for your mission to explore. Look through the "Solar System Mission Mysteries" posters for some possible worlds and questions your mission could help answer.
2. **Fill out** the "Planetary Explorer" worksheet that matches your target world. For your mission to be successful you will need to:
    a. Decide the type of craft that will work best
    b. Choose the system that powers it
    c. Determine the kinds of scientific instruments it will use to explore the world and answer your mystery question
    d. Figure out how it will communicate with Earth
    e. Decide how it moves or propels itself
    f. Select how it will get to the surface of the world it is exploring (Entry, Descent, and Landing, or EDL)

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3. **Design** and **draw** your spacecraft once you've filled out the worksheet. Be sure to include each of the features:power system, scientific instruments, communication, propulsion, and EDL, and label each part. For inspiration, use the "Anatomy of a Rover" sheet from Day 3 or look up real-life missions from NASA.

4. **Design** and **draw** a rocket that would take your craft to your chosen planet or moon. For inspiration, use the "Anatomy of a Rocket" sheet from Day 2. Label the features you are including, like payload, fins, engine, stages, and boosters.

5. **Create** a mission overview. Now that you have a target world, a mission, and a spacecraft, it is time to do a mission overview. How will you tell the story of how your spacecraft will leave Earth, go to its target location, land, explore, and send information back home? Consider making a comic, writing a short story, making a movie, drawing a picture, or using any other method that will share this information with others.

6. **Spread the word!** Talk about your mission with friends and family.

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Planetary Explorer: Enceladus

Mission name:_____Mission chief (you):_____

Vital info: Enceladus is an icy moon of Saturn, much smaller than Earth's Moon. However, under its ice-crust, there is a warm and active liquid water ocean. As a small moon, Enceladus has little to no atmosphere, but has been observed spewing ice into space.

Explorer craft:
What kind of robotic explorer is the best fit for your mission? On Enceladus, there is little-to-no atmosphere but it has a rough, icy surface criss-crossed with broken icy structures caused by Saturn's tidal influence. Under the icy surface, huge amounts of liquid water exist. Circle the type craft you think will work to explore this world.

Orbiter	**Lander**	**Rover**	**Atmospheric probe**	**Submarine probe**
Goes around the target world high above the atmosphere.	Lands on the surface of the target world and remains in place.	Lands on the surface of the target world then uses limbs or wheels to move.	Travels by floating or flying through the world's atmosphere.	Swims in underwater areas. Requires liquid to move in.

Power source:
On Enceladus, the Sun is very distant, so it does not receive very much light or heat. Plus, the ice on its surface is thick enough to block sunlight from reaching its underground ocean. Circle the power source you think will work to explore this unusual moon.

Solar panels (photovoltaic cells)	**Electrochemical cells (batteries)**	**Nuclear power (radiothermal generator, or RTG)**
Solar cells get power from the Sun and don't require heavy power sources. Can only be used in places that get a lot of sunlight.	Reliable and cheap but often very heavy and do not have a long life without a way to recharge. Great for short or one-way missions.	A small amount of radioactive material like plutonium will make heat as it decays. RTGs capture that heat and turn it into electricity. Medium weight, long life but expensive and rare.

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Scientific instruments:
What tools and instruments will your craft use to explore Enceladus? Think about features Enceladus has, what specific questions you want to answer, and what tools will help collect the information you need. Circle the scientific instruments you will include on your craft.

Spectrometer	**Camera**	**Magnetometer**
Tool for analyzing substances to find out what they are made of.	For taking pictures and/or video of what the craft sees.	Instrument for analyzing magnetic fields.

Arms	**Lab**	**Other**
Can hold and use a variety of tools and pick things up.	Big and heavy tools for in-depth exploration without having to return samples to Earth.	What else might your craft use to explore?

Communications:
A critical part of science is sharing the information. How will your craft's data get back to Earth? Enceladus has little gravity, so launching a rocket from the surface is not too difficult. Antennas can send information back to Earth very easily, but since Enceladus orbits Saturn very quickly and Saturn orbits the Sun, the antenna would have to be carefully aimed to reach Earth. Circle the kind of communication you will include on your craft.

High-gain antenna	**Low-gain antenna**	**Physical return to Earth**	**Orbiter relay**
Powerful high-strength antenna good for sending and receiving data, but needs to be pointed toward Earth and the Deep Space Network.	Low-frequency antenna, better for receiving information, but does not need to be pointed toward Earth.	Difficult. Your mission will need some way to blast off from the surface either to another orbiting craft or straight back to Earth.	Sends information from the surface to an orbiter around the world and then to Earth. Difficult if the craft is in a crater or canyon or under ice.

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Propulsion:

If your spacecraft lands on the surface of Enceladus, how will it get around? There are many ways to move on different parts of Enceladus' surface. The same methods that allow for moving on top of the ice will not work inside the ice or under the ice in the liquid layer—so consider carefully! Circle the kind of propulsion you will include on your craft.

Wheels	**Feet**	**Wings**	**Balloon**
Great for rolling on hard, flat ground.	Good for climbing uneven terrain.	Good for gliding in thick atmosphere.	Low energy way to fly or float in the atmosphere.

Propellers	**Jets**	**Swimming fins**	**Other**
Good for steering in water or air.	Fast but high energy movement in water or air.	Slow and maneuverable through water.	How else might your craft move?

Entry/Descent/Landing (EDL):

A spacecraft that lands is only as good as its landing method! An orbiter does not need to go down to the surface of a world but most other spacecraft do. How can your spacecraft get safely to the surface of Enceladus? Circle the kind of EDL you will include on your craft.

Parachute	**Rocket**	**Heat shield**	**Airbags**	**Other**
Requires an atmosphere, challenging with larger crafts.	Good for landing in places without atmosphere, but extra fuel can be heavy.	Protects spacecraft from heat while entering an atmosphere.	Allows craft to safely bounce on the surface before the airbags deflate.	How else might your craft do EDL?

Draw or sketch what your craft might look like (as a whole or just the pieces of it):

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Planetary Explorer: Europa

Mission name:_____ Mission chief (you):_____

Vital info: Europa is an icy moon of Jupiter, about the same size as Earth's Moon. However, similar to Enceladus, there is a liquid water ocean under its ice-crust. As a small moon, Europa has little-to-no atmosphere.

Explorer craft:
What kind of robotic explorer is the best fit for your mission? On Europa, you can expect to find little-to-no atmosphere but a rough, icy surface criss-crossed with broken icy structures due to Jupiter's tidal influence. Under the icy surface, huge amounts of liquid water exist. Circle the type craft you think will work to explore this world.

Orbiter	**Lander**	**Rover**	**Atmospheric probe**	**Submarine probe**
Goes around the target world high above the atmosphere.	Lands on the surface of the target world and remains in place.	Lands on the surface of the target world then uses limbs or wheels to move.	Travels by floating or flying through the world's atmosphere.	Swims in underwater areas. Requires liquid to move in.

Power source:
The Sun is very far from Europa so it does not receive much light or heat. Europa's ice is thick enough to block sunlight from the underground ocean. Circle the power source you think will work to explore it.

Solar panels (photovoltaic cells)	**Electrochemical cells (batteries)**	**Nuclear power (radiothermal generator, or RTG)**
Solar cells get power from the Sun and don't require heavy power sources. Can only be used in places that get a lot of sunlight.	Reliable and cheap but often very heavy and do not have a long life without a way to recharge. Great for short or one-way missions.	A small amount of radioactive material like plutonium will make heat as it decays. RTGs capture that heat and turn it into electricity. Medium weight, long life but expensive and rare.

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Scientific instruments:
What tools and instruments will your craft use to explore Europa? Think about features Europa has, what specific questions you want to answer, and what tools will help collect the information you need. Circle the scientific instruments you will include on your craft.

Spectrometer	**Camera**	**Magnetometer**
Tool for analyzing substances to find out what they are made of.	For taking pictures and/or video of what the craft sees.	Instrument for analyzing magnetic fields.

Arms	**Lab**	**Other**
Can hold and use a variety of tools and pick things up.	Big and heavy tools for in-depth exploration without having to return samples to Earth.	What else might your craft use to explore?

Communications:
A critical part of science is sharing the information. How will your craft's data get back to Earth? Europa is a relatively large moon, but launching a rocket from the surface is not too difficult. Antennas can send information back to Earth very easily, but since Europa orbits Jupiter very quickly as Jupiter orbits the Sun, the antenna would have to be carefully aimed to reach Earth. Circle the kind of communication you will include on your craft.

High-gain antenna	**Low-gain antenna**	**Physical return to Earth**	**Orbiter relay**
Powerful high-strength antenna good for sending and receiving data, but needs to be pointed toward Earth and the Deep Space Network.	Low-frequency antenna, better for receiving information, but does not need to be pointed toward Earth.	Difficult. Your mission will need some way to blast off from the surface either to another orbiting craft or straight back to Earth.	Sends information from the surface to an orbiter around the world and then to Earth. Difficult if the craft is in a crater or canyon or under ice.

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Propulsion:

If your spacecraft lands on the surface of Europa, how will it get around? There are many ways to move on different parts of Europa's surface. The same methods that allow for moving on top of the ice will not work inside the ice or under the ice in the liquid layer—so consider carefully! Circle the kind of propulsion you will include on your craft.

Wheels	**Feet**	**Wings**	**Balloon**
Great for rolling on hard, flat ground.	Good for climbing uneven terrain.	Good for gliding in thick atmosphere.	Low energy way to fly or float in the atmosphere.

Propellers	**Jets**	**Swimming fins**	**Other**
Good for steering in water or air.	Fast but high energy movement in water or air.	Slow and maneuverable through water.	How else might your craft move?

Entry/Descent/Landing (EDL):

A spacecraft that lands is only as good as its landing method! An orbiter does not need to go down to the surface of a world but most other spacecraft do. How can your spacecraft get safely to the surface of Europa? Circle the kind of EDL you will include on your craft.

Parachute	**Rocket**	**Heat shield**	**Airbags**	**Other**
Requires an atmosphere, challenging with larger crafts.	Good for landing in places without atmosphere, but extra fuel can be heavy.	Protects spacecraft from heat while entering an atmosphere.	Allows craft to safely bounce on the surface before the airbags deflate.	How else might your craft do EDL?

Draw or sketch what your craft might look like (as a whole or just the pieces of it):

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Planetary Explorer: Mars

Mission name:_____ Mission chief (you):_____

Vital info: Mars is a small, rocky planet with a very thin atmosphere and less gravity than Earth. Famous for its reddish color, it is covered in mountains, valleys, and what seem to be ancient dried-up shorelines and flowsites from water that flowed on its surface a very long time ago.

Explorer craft:
What kind of robotic explorer is the best fit for your mission? Mars Is a small, rocky world with mountains and craters and a thin atmosphere. Some flying atmospheric craft will need a specialized design for flying on Mars. Circle the type craft you think will work to explore this world.

Orbiter	**Lander**	**Rover**	**Atmospheric probe**
Goes around the target world high above the atmosphere.	Lands on the surface of the target world and remains in place.	Lands on the surface of the target world then uses limbs or wheels to move.	Travels by floating or flying through the world's atmosphere.

Power source:
Different crafts doing different tasks will require different amounts of energy. For example, is it more important for your mission that your craft travel miles across the surface, or that it continues to explore for a long time? Circle the power source you think will work to explore it.

Solar panels (photovoltaic cells)	**Electrochemical cells (batteries)**	**Nuclear power (radiothermal generator, or RTG)**
Solar cells get power from the Sun and don't require heavy power sources. Can only be used in places that get a lot of sunlight.	Reliable and cheap but often very heavy and do not have a long life without a way to recharge. Great for short or one-way missions.	A small amount of radioactive material like plutonium will make heat as it decays. RTGs capture that heat and turn it into electricity. Medium weight, long life but expensive and rare.

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Scientific instruments:
What tools and instruments will your craft use to explore Mars? Think about the features Mars has, what specific questions you want to answer, and what tools will help collect the information you need. Circle the scientific instruments you will include on your craft.

Spectrometer	**Camera**	**Magnetometer**
Tool for analyzing substances to find out what they are made of.	For taking pictures and/or video of what the craft sees.	Instrument for analyzing magnetic fields.

Arms	**Lab**	**Other**
Can hold and use a variety of tools and pick things up.	Big and heavy tools for in-depth exploration without having to return samples to Earth.	What else might your craft use to explore?

Communications:
A critical part of science is sharing the information. How will your craft's data get back to Earth? Mars has some gravity, so launching a rocket from the surface may have some challenges. Antennas can send information back to Earth very easily, but would have to be carefully aimed and timed. Circle the kind of communication you will include on your craft.

High-gain antenna	**Low-gain antenna**	**Physical return to Earth**	**Orbiter relay**
Powerful high-strength antenna good for sending and receiving data, but needs to be pointed toward Earth and the Deep Space Network.	Low-frequency antenna, better for receiving information, but does not need to be pointed toward Earth.	Difficult. Your mission will need some way to blast off from the surface either to another orbiting craft or straight back to Earth.	Sends information from the surface to an orbiter around the world and then to Earth. Difficult if the craft is in a crater or canyon or under ice.

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Propulsion:
If your spacecraft lands on the surface of Mars, how will it move around on the rocky surface or through the thin atmosphere? Circle the kind of propulsion you will include on your craft.

Wheels	**Feet**	**Wings**	**Balloon**
Great for rolling on hard, flat ground.	Good for climbing uneven terrain.	Good for gliding in thick atmosphere.	Low energy way to fly or float in the atmosphere.

Propellers	**Jets**	**Other**
Good for steering in water or air.	Fast but high energy movement in water or air.	How else might your craft move?

Entry/Descent/Landing (EDL):
A spacecraft that lands is only as good as its landing method! An orbiter does not need to go down to the surface of a world but most other spacecraft do. How can your spacecraft get safely to the surface of Mars? Circle the kind of EDL you will include on your craft.

Parachute	**Rocket**	**Heat shield**	**Airbags**	**Other**
Requires an atmosphere, challenging with larger crafts.	Good for landing in places without atmosphere, but extra fuel can be heavy.	Protects spacecraft from heat while entering an atmosphere.	Allows craft to safely bounce on the surface before the airbags deflate.	How else might your craft do EDL?

Draw or sketch what your craft might look like (as a whole or just the pieces of it):

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Planetary Explorer: Mercury

Mission name:_____ Mission chief (you):_____

Vital Info: Mercury is the smallest planet in the Solar System and the closest to the Sun. It is rocky with almost no atmosphere and much less gravity than Earth. It is thought to have ice deposits hiding in the shadows of craters at the polar regions.

Explorer craft:
What kind of robotic explorer is the best fit for your mission? Since Mercury is so close to the Sun, any mission destined for the Mercurian surface needs to focus on specialised landing methods as well as ways of protecting itself from the Sun if it lands on the sunlit side to collect solar power. Even orbiters would need protection so close to the Sun. Circle the type craft you think will work to explore this world.

Orbiter	**Lander**	**Rover**
Goes around the target world high above the atmosphere.	Lands on the surface of the target world and remains in place.	Lands on the surface of the target world then uses limbs or wheels to move.

Power source:
Light from the Sun is abundant on one side of Mercury, but not the other. The intense light on one side also makes for a very hot, very dangerous environment for a spacecraft, so it will need extra protection. Circle the power source you think will work to explore it.

Solar panels (photovoltaic cells)	**Electrochemical cells (batteries)**	**Nuclear power (radiothermal generator, or RTG)**
Solar cells get power from the Sun and don't require heavy power sources. Can only be used in places that get a lot of sunlight.	Reliable and cheap but often very heavy and do not have a long life without a way to recharge. Great for short or one-way missions.	A small amount of radioactive material like plutonium will make heat as it decays. RTGs capture that heat and turn it into electricity. Medium weight, long life but expensive and rare.

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Scientific instruments:
What tools and instruments will your craft use to explore Mercury? Think about the features Mercury has, what specific questions you want to answer, and what tools will help collect the information you need. Circle the scientific instruments you will include on your craft.

Spectrometer	**Camera**	**Magnetometer**
Tool for analyzing substances to find out what they are made of.	For taking pictures and/or video of what the craft sees.	Instrument for analyzing magnetic fields.

Arms	**Lab**	**Other**
Can hold and use a variety of tools and pick things up.	Big and heavy tools for in-depth exploration without having to return samples to Earth.	What else might your craft use to explore?

Communications:
A critical part of science is sharing the information. How will your craft's data get back to Earth? From Earth's perspective, Mercury is sometimes on the opposite side of the Sun or very close to the Sun, so antennas would have to be carefully aimed and timed to reach Earth. However, Mercury has little gravity, so launching a rocket from the surface is not too difficult. Circle the kind of communication you will include on your craft.

High-gain antenna	**Low-gain antenna**	**Physical return to Earth**	**Orbiter relay**
Powerful high-strength antenna good for sending and receiving data, but needs to be pointed toward Earth and the Deep Space Network.	Low-frequency antenna, better for receiving information, but does not need to be pointed toward Earth.	Difficult. Your mission will need some way to blast off from the surface either to another orbiting craft or straight back to Earth.	Sends information from the surface to an orbiter around the world and then to Earth. Difficult if the craft is in a crater or canyon or under ice.

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Propulsion:

If your spacecraft lands on the surface of Mercury, how will it get around? Since Mercury has no atmosphere, some features like wings and parachutes won't work, but the planet's hard and rocky surface would work well for ground-based movement. Circle the kind of propulsion you will include on your craft.

Wheels	**Feet**	**Roll**	**Other**
Great for rolling on hard, flat ground.	Good for climbing uneven terrain.	The entire craft rolls across flat ground.	How else might your craft move?

Entry/Descent/Landing (EDL):

A spacecraft that lands is only as good as its landing method! An orbiter does not need to go down to the surface of a world but most other spacecraft do. To land on Mercury, you will need to use rockets or airbags,, since parachutes and wings are useless without an atmosphere. Luckily, gravity is much lower closer to the surface of Mercury, so landings are a little easier. Circle the kind of EDL you will include on your craft.

Parachute	**Rocket**	**Heat shield**	**Airbags**	**Other**
Requires an atmosphere, challenging with larger crafts.	Good for landing in places without atmosphere, but extra fuel can be heavy.	Protects spacecraft from heat while entering an atmosphere.	Allows craft to safely bounce on the surface before the airbags deflate.	How else might your craft do EDL?

Draw or sketch what your craft might look like (as a whole or just the pieces of it):

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Planetary Explorer: Miranda

Mission name:_____ Mission chief (you):_____

Vital info: Miranda is one of Uranus' moons. It is so small that it is not a perfect sphere, and has very little gravitational pull and no atmosphere. Miranda is made of a mix of water ice and rock and appears to have amazingly varied surface terrains, with ridges, craters, and mountains seemingly squished together.

Explorer craft:
What kind of robotic explorer is the best fit for your mission? Miranda has a rocky and icy surface, but no atmosphere. Circle the type craft you think will work to explore this world.

Orbiter	**Lander**	**Rover**
Goes around the target world high above the atmosphere.	Lands on the surface of the target world and remains in place.	Lands on the surface of the target world then uses limbs or wheels to move.

Power source:
Orbiting Uranus, Miranda is extremely far from the Sun and receives very little light and heat. Circle the power source you think will work to explore it.

Solar panels (photovoltaic cells)	**Electrochemical cells (batteries)**	**Nuclear power (radiothermal generator, or RTG)**
Solar cells get power from the Sun and don't require heavy power sources. Can only be used in places that get a lot of sunlight.	Reliable and cheap but often very heavy and do not have a long life without a way to recharge. Great for short or one-way missions.	A small amount of radioactive material like plutonium will make heat as it decays. RTGs capture that heat and turn it into electricity. Medium weight, long life but expensive and rare.

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Scientific instruments:
What tools and instruments will your craft use to explore Miranda? Think about its features, what specific questions you want to answer, and what tools will help collect the information you need. Circle the scientific instruments you will include on your craft.

Spectrometer	**Camera**	**Magnetometer**
Tool for analyzing substances to find out what they are made of.	For taking pictures and/or video of what the craft sees.	Instrument for analyzing magnetic fields.

Arms	**Lab**	**Other**
Can hold and use a variety of tools and pick things up.	Big and heavy tools for in-depth exploration without having to return samples to Earth.	What else might your craft use to explore?

Communications:
A critical part of science is sharing the information. How will your craft's data get back to Earth? With such minimal gravity, launching a rocket from Miranda may not be too difficult. Antennas can send information back to Earth very easily, but since Miranda orbits Uranus very quickly and Uranus orbits the Sun, the antenna would have to be carefully aimed to reach Earth. Circle the kind of communication you will include on your craft.

High-gain antenna	**Low-gain antenna**	**Physical return to Earth**	**Orbiter relay**
Powerful high-strength antenna good for sending and receiving data, but needs to be pointed toward Earth and the Deep Space Network.	Low-frequency antenna, better for receiving information, but does not need to be pointed toward Earth.	Difficult. Your mission will need some way to blast off from the surface either to another orbiting craft or straight back to Earth.	Sends information from the surface to an orbiter around the world and then to Earth. Difficult if the craft is in a crater or canyon or under ice.

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Propulsion:

If your spacecraft lands on the surface of Miranda, how will it get around? There is no atmosphere to fly in and the surface of Miranda has many steep and jagged edges. Circle the kind of propulsion you will include on your craft.

Wheels	**Feet**	**Roll**	**Other**
Great for rolling on hard, flat ground.	Good for climbing uneven terrain.	The entire craft rolls across flat ground.	How else might your craft move?

Entry/Descent/Landing (EDL):

A spacecraft that lands is only as good as its landing method! An orbiter does not need to go down to the surface of a world but most other spacecraft do. How can your spacecraft get safely to the surface of Miranda? Circle the kind of EDL you will include on your craft.

Parachute	**Rocket**	**Heat shield**	**Airbags**	**Other**
Requires an atmosphere, challenging with larger crafts.	Good for landing in places without atmosphere, but extra fuel can be heavy.	Protects spacecraft from heat while entering an atmosphere.	Allows craft to safely bounce on the surface before the airbags deflate.	How else might your craft do EDL?

Draw or sketch what your craft might look like (as a whole or just the pieces of it):

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Planetary Explorer: the Moon

Mission name:_____ Mission chief (you):_____

Vital info: The Moon is a small, rocky world that orbits planet Earth. With no atmosphere and much less gravity than Earth, it is the only place beyond Earth that has been visited by human beings. It is covered in craters, mountains, and even ancient lava flows and is thought to have ice deposits below its dusty surface.

Explorer craft:
What kind of robotic explorer is the best fit for your mission? The Moon is a rocky and airless environment with much less gravitational pull than Earth. Circle the type craft you think will work to explore this world.

Orbiter	**Lander**	**Rover**
Goes around the target world high above the atmosphere.	Lands on the surface of the target world and remains in place.	Lands on the surface of the target world then uses limbs or wheels to move.

Power source:
Any one location on the surface of the Moon will have two weeks of light and heat followed by two weeks of darkness and cold. How will you power and keep your rover working under these conditions? Circle the power source you think will work to explore it.

Solar panels (photovoltaic cells)	**Electrochemical cells (batteries)**	**Nuclear power (radiothermal generator, or RTG)**
Solar cells get power from the Sun and don't require heavy power sources. Can only be used in places that get a lot of sunlight.	Reliable and cheap but often very heavy and do not have a long life without a way to recharge. Great for short or one-way missions.	A small amount of radioactive material like plutonium will make heat as it decays. RTGs capture that heat and turn it into electricity. Medium weight, long life but expensive and rare.

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Scientific instruments:
What tools and instruments will your craft use to explore the Moon? Think about the features the Moon has (rocks, craters, valleys, etc.), what specific questions you want to answer, and what tools will help collect the information you need. Circle the scientific instruments you will include on your craft.

Spectrometer	**Camera**	**Magnetometer**
Tool for analyzing substances to find out what they are made of.	For taking pictures and/or video of what the craft sees.	Instrument for analyzing magnetic fields.

Arms	**Lab**	**Other**
Can hold and use a variety of tools and pick things up.	Big and heavy tools for in-depth exploration without having to return samples to Earth.	What else might your craft use to explore?

Communications:
A critical part of science is sharing the information. How will your craft's data get back to Earth? Since the Moon orbits Earth quite closely, and the same side always faces Earth, communication can take a variety of forms. However, if your mission lands at the poles or the Far Side of the Moon, your spacecraft might need some assistance. Circle the kind of communication you will include on your craft.

High-gain antenna	**Low-gain antenna**	**Physical return to Earth**	**Orbiter relay**
Powerful high-strength antenna good for sending and receiving data, but needs to be pointed toward Earth and the Deep Space Network.	Low-frequency antenna, better for receiving information, but does not need to be pointed toward Earth.	Difficult. Your mission will need some way to blast off from the surface either to another orbiting craft or straight back to Earth.	Sends information from the surface to an orbiter around the world and then to Earth. Difficult if the craft is in a crater or canyon or under ice.

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Propulsion:

If your spacecraft lands on the surface of the Moon, how will it get around? Since the Moon is a rocky world, traveling along the surface can take a variety of forms—but without oceans or atmosphere, wings and jets might not be the best option. Circle the kind of propulsion you will include on your craft.

Wheels	**Feet**	**Roll**	**Other**
Great for rolling on hard, flat ground.	Good for climbing uneven terrain.	The entire craft rolls across flat ground.	How else might your craft move?

Entry/Descent/Landing (EDL):

A spacecraft that lands is only as good as its landing method! An orbiter does not need to go down to the surface of a world but most other spacecraft do. How can your spacecraft get safely to the surface of the Moon? Circle the kind of EDL you will include for your craft.

Parachute	**Rocket**	**Heat shield**	**Airbags**	**Other**
Requires an atmosphere, challenging with larger crafts.	Good for landing in places without atmosphere, but extra fuel can be heavy.	Protects spacecraft from heat while entering an atmosphere.	Allows craft to safely bounce on the surface before the airbags deflate.	How else might your craft do EDL?

Draw or sketch what your craft might look like (as a whole or just the pieces of it):

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Planetary Explorer: Titan

Mission name:_____ Mission chief (you):_____

Vital info: Titan is a large, rocky moon of Saturn. In many ways, it is the most Earth-like place in the Solar System. It has a thick atmosphere—the only moon that does—made of nitrogen (the same dominant gas as Earth's atmosphere), a solid surface with liquid oceans, and even clouds, rain, and liquid lakes. The big difference? Titan is so far from the Sun and so cold that its liquids are not made of water, but methane!

Explorer craft:
What kind of robotic explorer is the best fit for your mission? Titan is a large world with a thick atmosphere made of nitrogen (the same dominant gas as Earth's atmosphere) and a rocky surface with mountains, valleys, and liquid oceans. Circle the type craft you think will work to explore this world.

Orbiter	**Lander**	**Rover**	**Atmospheric probe**	**Submarine probe**
Goes around the target world high above the atmosphere.	Lands on the surface of the target world and remains in place.	Lands on the surface of the target world then uses limbs or wheels to move.	Travels by floating or flying through the world's atmosphere.	Swims in underwater areas. Requires liquid to move in.

Power source:
Powering a spacecraft on Titan poses an interesting challenge. Titan orbits Saturn, very far from the Sun, and its thick haze can block sunlight, making solar panels a difficult option. Circle the power source you think will work to explore it.

Solar panels (photovoltaic cells)	**Electrochemical cells (batteries)**	**Nuclear power (radiothermal generator, or RTG)**
Solar cells get power from the Sun and don't require heavy power sources. Can only be used in places that get a lot of sunlight.	Reliable and cheap but often very heavy and do not have a long life without a way to recharge. Great for short or one-way missions.	A small amount of radioactive material like plutonium will make heat as it decays. RTGs capture that heat and turn it into electricity. Medium weight, long life but expensive and rare.

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Scientific instruments:
What tools and instruments will your craft use to explore Titan? Think about the features Titan has, what part you want to explore, the specific questions you want to answer, and what tools will help collect the information you need. Circle the scientific instruments you will include on your craft.

Spectrometer	**Camera**	**Magnetometer**
Tool for analyzing substances to find out what they are made of.	For taking pictures and/or video of what the craft sees.	Instrument for analyzing magnetic fields.

Arms	**Lab**	**Other**
Can hold and use a variety of tools and pick things up.	Big and heavy tools for in-depth exploration without having to return samples to Earth.	What else might your craft use to explore?

Communications:
A critical part of science is sharing the information. How will your craft's data get back to Earth? Titan is a very large moon, but launching a rocket from the surface is not too difficult. Antennas can send information back to Earth very easily, but since Titan orbits Saturn and Saturn orbits the Sun, they will have to be very carefully amined and timed. Circle the kind of communication you will include on your craft.

High-gain antenna	**Low-gain antenna**	**Physical return to Earth**	**Orbiter relay**
Powerful high-strength antenna good for sending and receiving data, but needs to be pointed toward Earth and the Deep Space Network.	Low-frequency antenna, better for receiving information, but does not need to be pointed toward Earth.	Difficult. Your mission will need some way to blast off from the surface either to another orbiting craft or straight back to Earth.	Sends information from the surface to an orbiter around the world and then to Earth. Difficult if the craft is in a crater or canyon or under ice.

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Propulsion:
If your mission is designed to land on the surface or atmosphere of Titan, how will it move? Titan's thick atmosphere could provide a great opportunity for a flying spacecraft, and its cold oceans could provide options for liquid mobility methods as well. Circle the kind of propulsion you will include on your craft.

Wheels	**Feet**	**Wings**	**Balloon**
Great for rolling on hard, flat ground.	Good for climbing uneven terrain.	Good for gliding in thick atmosphere.	Low energy way to fly or float in the atmosphere.

Propellers	**Jets**	**Swimming fins**	**Other**
Good for steering in water or air.	Fast but high energy movement in water or air.	Slow and maneuverable through water.	How else might your craft move?

Entry/Descent/Landing (EDL):
A spacecraft that lands is only as good as its landing method! An orbiter does not need to go down to the surface of a world but most other spacecraft do. How can your spacecraft get safely to the surface or atmosphere of Titan? Circle the kind of EDL you will include on your craft.

Parachute	**Rocket**	**Heat shield**	**Airbags**	**Other**
Requires an atmosphere, challenging with larger crafts.	Good for landing in places without atmosphere, but extra fuel can be heavy.	Protects spacecraft from heat while entering an atmosphere.	Allows craft to safely bounce on the surface before the airbags deflate.	How else might your craft do EDL?

Draw or sketch what your craft might look like (as a whole or just the pieces of it):

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Planetary Explorer: Venus

Mission name:_____ Mission chief (you):_____

Vital info: Venus is an Earth-sized, rocky planet with Earth-like gravity and a very thick atmosphere that blocks light from reaching the surface. Its atmosphere is made of gases poisonous to humans, creates high pressures, and traps so much heat that is hotter than Mercury even though it is farther from the Sun.

Explorer craft:
What kind of robotic explorer is the best fit for your mission? Venus has a rocky surface and a thick atmosphere, but that atmosphere can block many spacecrafts' views of the surface from orbit, and heat and pressure have crushed and melted past landers on the planet's surface. Circle the type craft you think will work to explore this world.

Orbiter	**Lander**	**Rover**	**Atmospheric probe**
Goes around the target world high above the atmosphere.	Lands on the surface of the target world and remains in place.	Lands on the surface of the target world then uses limbs or wheels to move.	Travels by floating or flying through the world's atmosphere.

Power source:
Sunlight can be scarce on the surface of Venus due to its thick, cloudy sky, but may work for orbiters or some atmospheric probes since Venus is close to the Sun. Circle the power source you think will work to explore it.

Solar panels (photovoltaic cells)	**Electrochemical cells (batteries)**	**Nuclear power (radiothermal generator, or RTG)**
Solar cells get power from the Sun and don't require heavy power sources. Can only be used in places that get a lot of sunlight.	Reliable and cheap but often very heavy and do not have a long life without a way to recharge. Great for short or one-way missions.	A small amount of radioactive material like plutonium will make heat as it decays. RTGs capture that heat and turn it into electricity. Medium weight, long life but expensive and rare.

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Scientific instruments:
What tools and instruments will your craft use to explore Venus? Think about Venus' features, what part of the planet your craft is exploring, what specific questions you want to answer, and what tools will help collect the information you need. Circle the scientific instruments you will include on your craft.

Spectrometer	**Camera**	**Magnetometer**
Tool for analyzing substances to find out what they are made of.	For taking pictures and/or video of what the craft sees.	Instrument for analyzing magnetic fields.

Arms	**Lab**	**Other**
Can hold and use a variety of tools and pick things up.	Big and heavy tools for in-depth exploration without having to return samples to Earth.	What else might your craft use to explore?

Communications:
A critical part of science is sharing the information. How will your craft's data get back to Earth? Venus' thick atmosphere poses a challenge to sending data back to Earth from the surface. Circle the kind of communication you will include on your craft.

High-gain antenna	**Low-gain antenna**	**Physical return to Earth**	**Orbiter relay**
Powerful high-strength antenna good for sending and receiving data, but needs to be pointed toward Earth and the Deep Space Network.	Low-frequency antenna, better for receiving information, but does not need to be pointed toward Earth.	Difficult. Your mission will need some way to blast off from the surface either to another orbiting craft or straight back to Earth.	Sends information from the surface to an orbiter around the world and then to Earth. Difficult if the craft is in a crater or canyon or under ice.

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Propulsion:
If your spacecraft lands on the surface or atmosphere of Venus, how will it move? Circle the kind of propulsion you will include on your craft.

Wheels	**Feet**	**Wings**	**Balloon**
Great for rolling on hard, flat ground.	Good for climbing uneven terrain.	Good for gliding in thick atmosphere.	Low energy way to fly or float in the atmosphere.

Propellers	**Jets**	**Swimming fins**	**Other**
Good for steering in water or air.	Fast but high energy movement in water or air.	Slow and maneuverable through water.	How else might your craft move?

Entry/Descent/Landing (EDL):
A spacecraft that lands is only as good as its landing method! An orbiter does not need to go down to the surface of a world but most other spacecraft do. Landing on the surface of Venus through its turbulent atmosphere is something that has only been accomplished a few times. How can you protect your spacecraft on its way down to the surface? Circle the kind of EDL you will include on your craft.

Parachute	**Rocket**	**Heat shield**	**Airbags**	**Other**
Requires an atmosphere, challenging with larger crafts.	Good for landing in places without atmosphere, but extra fuel can be heavy.	Protects spacecraft from heat while entering an atmosphere.	Allows craft to safely bounce on the surface before the airbags deflate.	How else might your craft do EDL?

Draw or sketch what your craft might look like (as a whole or just the pieces of it):