MISSION: MARS

Museum of Science

Engineering on the Red Planet

LESSON PLANS

About Mission: Mars

Mission: Mars is set on the surface of Mars. Players select a mission and then design a vehicle to meet the requirements of that mission. If the vehicle does not help them complete the mission successfully, they may improve their design and try again.

- Play on any device that supports Roblox. A Roblox account is required.
- Free to play. No in-game purchases.
- Audience: ages 9–14, grades 3–8

Mission: Mars, an experience on Roblox, was developed by the Museum of Science, Boston with support from Roblox.

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Engineering Lesson Plans

Mission: MARS

Offline Mission

Prep Lesson

Use this lesson plan to introduce students to the basics of engineering.

This lesson takes place offline with hands-on materials.

Prep Lesson: Welcome to Mars

Overview

Before students play the Roblox game *Mission: Mars*, introduce them to the basics of engineering with this offline, hands-on mission.

Grades: 3–8
Time: 40–50 minutes
NGSS Science Standards: 3-5-ETS1-2 Engineering Design 3-5-ETS1-3 Engineering Design MS-ETS1-2 Engineering Design MS-ETS1-3 Engineering Design **Crosscutting Concept:** Science Is a Human Endeavor

Objectives

Students will be able to

- generate design solutions that meet the criteria of a problem within given constraints.
- test and evaluate different solutions to the same problem.
- improve their designs using what they learned from testing.
- describe the steps of an Engineering Design Process.

Materials and Preparation

For this activity, the whole class will need

- 1 small object for testing (see note below)
- 1 ruler or tape measure (optional)
- 1 timing device

Each student group will need

- Handout: *Mars Lighthouse Mission*
- 2 Mission Materials Kits

Each student will need

- Handout: *The Engineering Design Process*

Mission Materials Kit
Place materials in a bag or envelope. Make two kits per student group.
• 6 paper clips • 4 sheets of paper • 6 stickers or mailing labels, or 1 roll of tape • 12 toothpicks • 4 unsharpened pencils

Before the activity, do the following:

- Assemble Mission Materials Kits. You may substitute similar materials as long as each kit has the same materials in the same quantities.
- Choose a small object to use as the "light" placed on top of student "lighthouses," such as a small ball, paperback book, or knickknack. Note: This object will fall to the floor.
- Print copies of handouts.

Mission Management Tips

- Enlist student help for assembling, distributing, and collecting Mission Materials Kits.
- Use alternative materials as needed:
  - Fasteners: stickers, tape, mailing labels, paper clips, rubber bands, clay
  - Long, thin objects: toothpicks, straws, coffee stirrers, pencils, fuzzy wire sticks
  - Flat surfaces: paper, newspaper, thin cardboard, paper plates
- Focus on asking questions instead of giving answers or suggesting solutions. Students develop stronger engineering practices when they engage directly with the challenge and with each other.
- Celebrate failures! Engineers understand that failure leads to improved designs.

Vocabulary

- **criteria**—what a successful design needs to do or have
- **constraints**—limits on a design
- **Engineering Design Process**—the steps engineers use to design something to solve a problem

Introduce the Activity

These steps offer support for introducing the *Mission: Mars Engineering Prep Lesson* and connecting it to the *Mission: Mars* Roblox game.

1. Tell students that, during another session, they will be playing an online game where they act as astronaut-engineers on Mars. Share this information:
   - Engineers design solutions to solve problems.
   - The solutions engineers come up with depend on the problem that needs to be solved and on the available materials.
   - Before students play the online game, they will practice by solving a problem offline using materials in the real world.
2. Explain the parts of an engineering problem.
   - The design challenge states what you need to do to solve the problem.
   - The criteria state what a successful solution need to do or have. (The word *criteria* is plural; the singular is *criterion*.)
   - The constraints are limits on the solution.
3. Tell students what to expect. First, they will design a solution to a challenge. Then their solutions will be tested. They will review the results and improve their solutions using what they learned from the tests. Finally, they will reflect on how they acted as engineers.

Mars Lighthouse Mission—Round 1

Activity

These steps offer support for leading students through the hands-on activity.

1. Read aloud *Mars Lighthouse Mission*.
2. Show students the small object that you are using as a "light." Explain that, during testing, their lighthouse must hold up the "light" for 5 seconds.
3. Give each group one Mission Materials Kit and one copy of *Mars Lighthouse Mission*. Tell students not to touch the materials until you say "Start."
4. Answer any questions. At this point, the best answer to most questions is, "What does the mission say?"

   Engineering Tips (Wait to share until Discussion or later.)

   - Solutions do not have to use all materials.
   - Wide bases are more stable than narrow bases.
   - Flimsy materials like paper are stronger when rolled or folded.
   - The structure cannot be attached to the table but it can be taped to a base or to itself.
5. Set a timer for 10 minutes and give the instruction to "Start."
6. When the timer goes off, tell students to "Stop." Tell students to step away from the lighthouses they built.
7. Go to each group's lighthouse in turn. Invite the group to describe their design to the class. Measure the height of the lighthouse (optional). Then place the "light" on top and test whether the lighthouse can hold up the "light" for 5 seconds.

Discussion

Lead a class discussion of student experiences during the activity.

1. Discuss these questions as a class. (Possible responses are in italics.)

   Q: What was the problem that the mission asked you to solve? *A: Design a lighthouse to help guide explorers back to base after nightfall.*

   Q: What criteria did the lighthouse design have to meet? *A: It had to be as tall as possible, stand up by itself, and hold the light for 5 seconds.*

   Q: Which designs met the criteria? *A: Responses will vary. Designs may have met all criteria, some criteria, or no criteria.*

   Q: Were all the designs the same? If not, what were the differences? *A: It is likely that different groups using the same materials came up with different designs.*

   Q: Were some designs more successful than others? What do those designs have in common? *A: Guide students to focus on observable design features, such as "It was built on a wide base" rather than opinions such as "That group always wins."*

   Q: How well did you work as a team? Did everyone know what the goal was? Did everyone know what to do? *A: Responses will vary.*

2. Tell students that engineers rarely design and build a successful solution on the first try. Even if they do, there is always room for improvement.

   Give students a moment to turn and talk in their groups to discuss the next two questions, then come together as a class to discuss their ideas.

   Q: Where do engineers get ideas for improving designs? *A: Accept all responses. If no one mentions, "From the results of their tests," or "From the results of other people's tests," then prompt students until someone does.*

   Q: How could you improve your process for designing and building as a team? *A: Responses will vary.*

Mars Lighthouse Mission—Round 2

Activity

These steps offer support for leading students through an activity to improve their designs from Round 1.

1. Set aside materials from Round 1. Groups should keep the *Mars Lighthouse Mission* handouts.
2. Tell students that they will repeat the mission, but this time two things will be different:
   - They can improve their designs using what they learned from Round 1.
   - The first 5 minutes will be for group planning only—they cannot touch anything. At the end of 5 minutes, they will have 5 minutes to create their improved lighthouses.
3. Answer any questions, set a timer for 5 minutes, and tell students to "Plan."
4. When the timer goes off, reset the timer for 5 minutes and tell students to "Create."
5. When the timer goes off again, tell students to step away from their lighthouses.
6. Go to each group's lighthouse in turn. Ask the group to describe their improvements. Measure the height of the lighthouse (optional). Then place the "light" on top and "test" whether the lighthouse can hold up the "light" for 5 seconds.

Discussion

Lead a class discussion about improving designs.

1. When all designs have been tested, discuss results.

   Q: Did more designs meet the criteria this time? *A: Accept all responses.*

   Q: How did you use the test results to improve your designs? *A: Accept all responses.*

   Q: How was your process for designing the lighthouse different this time? *A: Possible responses: We took time to plan before building. We had to talk about what we'd do before we touched anything.*

Connect to the Engineering Design Process

This section may be completed outside of class if time is running short. Be sure to complete the **Wrap-Up & Reflection** section below before playing the *Mission: Mars* Roblox game.

1. Collect and set aside mission materials.
2. Tell students that when they designed their lighthouses, they were following a process. The Engineering Design Process describes the steps engineers use to design something that solves a problem.
3. Distribute *The Engineering Design Process* handout to each student. Explain that they will work together to identify when their group used each step as they solved the *Mars Lighthouse Mission*.
4. Have students work in their groups to discuss and complete the handout.

Wrap-Up & Reflection

These steps offer support for discussing the *Engineering Design Process* handout in a large group and connecting this activity to the *Mission: Mars* Roblox game.

1. Review **criteria**, **constraints**, and the steps of the **Engineering Design Process**.
2. Ask a few students to share how the Engineering Design Process might help to design a vehicle to drive on Mars. As needed, prompt student thinking with questions like the following:

   Q: What would be important to know so you could Plan and Create a Mars vehicle? A: *Sample response: Knowing what the vehicle needs to do (criteria) and what it cannot do (constraints) is important for planning. Knowing what materials are available is important for creating*.

   Q: What are some questions you could ask before Planning and Creating a vehicle for Mars? *A: Sample response: Does Mars have air? What is its gravity like? Can you get fuel for a car on Mars? If you can, will the fuel burn? What is the surface like? What does the vehicle need to do—is it important for it to go fast, or to go far? Does it need to collect anything from the surface?*

3. Tell students that in the *Mission: Mars* Roblox game, they will be accepting missions on the surface of Mars and designing vehicles to meet the criteria for those missions. They will be able to improve the design of their vehicles so they are better able to succeed at the missions.

Name: ______________________________ Date: ____________

Mars Lighthouse Mission

Like Earth, Mars has days, nights, and seasons. Unlike Earth, Mars does not have streetlights—or even streets! Design a lighthouse to help guide explorers back to base after nightfall.

Directions: Design and build your lighthouse when you are told to “Start.” Stop when you are told to “Stop.” The lighthouse will be tested after 10 minutes.

Criteria—The lighthouse must…	**Constraints**—The lighthouse must…
• be as tall as possible. • stand up by itself. (It cannot be taped down to the table or be leaning against anything.) • hold up the “light” for at least 5 seconds.	• be built from materials in the materials list. • be completed as a group. • be completed in 10 minutes. **Materials** • 6 paper clips • 4 sheets of paper • 6 stickers • 12 toothpicks • 4 unsharpened pencils

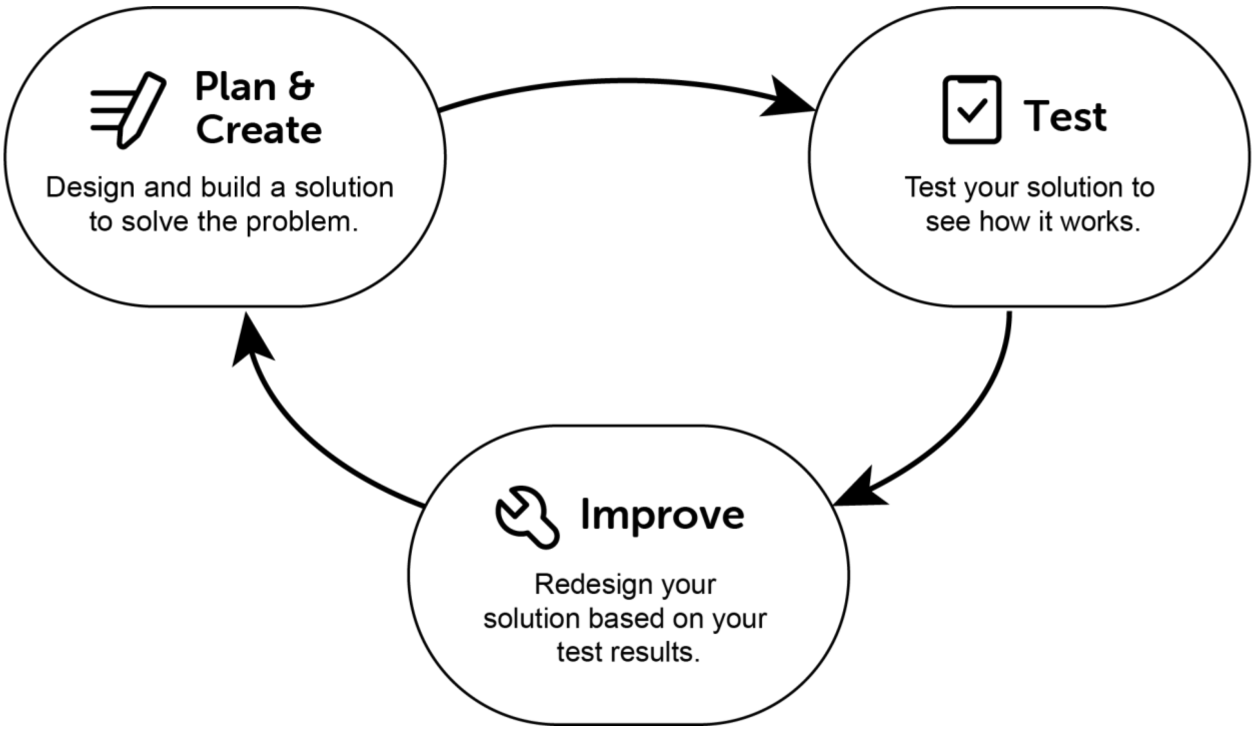
Test Results

Lighthouse	How tall was it? (add units: in. or cm)	Did it stand up by itself?	How many seconds did it hold up the “light”?
Design 1			
Design 2			

Name: ____ Date: ______________

Engineering Design Process

The **Engineering Design Process** is the steps engineers use to design something to solve a problem. Describe what your group did for each step of the Engineering Design Process as you designed and built your lighthouse.



PLAN & CREATE ____

____

____

TEST ____

____

IMPROVE ____

____

MISSION: MARS

In-Game Missions

General Lesson Plan

Use this lesson plan to turn any *Mission: Mars* engineering mission into a whole-class engineering activity.

See **Mission Resources** for mission-specific information, supports for players and educators, and mission-specific extensions.

General Lesson Plan for In-Game Missions

Overview

Use this lesson plan to turn any *Mission: Mars* engineering mission into a whole-class engineering activity.

See **Mission Resources** for mission-specific information, player and educator supports, and extensions.

Note: Before assigning an engineering mission, give students a brief session to explore the game environment and practice their vehicle crafting and driving skills in the *Free Play* area.

Grades: 3–8
Time: 40 minutes
NGSS Science Standards: 3-5-ETS1-2 Engineering Design 3-5-ETS1-3 Engineering Design MS-ETS1-2 Engineering Design MS-ETS1-3 Engineering Design See **Mission Resources** for additional mission-specific standards alignments.

Objectives

See **Mission Resources** for mission-specific objectives.

Materials and Preparation

For this activity, the whole class will need

- A way for students to view handouts in color, even if paper versions are in black and white.

Each student group will need

- Device with Roblox Player installed
- Handout: *Crafting Manual*
- Handout: *Mission Briefing* (from **Mission Resources**)

Each student will need

- Handout: *Mission Log*
- (Optional) Completed *Engineering Design Process* handout (from *Prep Lesson: Welcome to Mars*)
- (Optional) Handout: Mission Extension(s) (from **Mission Resources**)

Before the lesson:

- Prepare devices and confirm game access.
- Print copies of handouts.

Mission Management Tips

- Before assigning an engineering mission, give students a few minutes to explore the game environment.
- Most groups will need multiple attempts to complete a mission.
- During in-game play, monitor to make sure that students switch places between mission attempts so that each student has a chance to be the "driver."
- Group members who are not acting as the "driver" may offer polite suggestions to their teammates or remind the "driver" of the mission objective.

Vocabulary

See **Mission Resources** for mission-specific vocabulary.

Introduce the Activity

1. Tell students that today they will be going online to accept and complete a mission on Mars. Display the Mission Briefing and read the title and the mission description.
2. Explain to students that before they are transported to the surface, they need to understand the mission and plan a vehicle that will help them complete it.
3. Distribute the handouts. Each group receives 1 copy of the *Crafting Manual* and 1 copy of the *Mission Briefing* from **Mission Resources.**
4. Tell students what to expect. First, they will review the *Mission Briefing* and plan a vehicle design. Next, each group will launch the game online, select the mission, design their vehicle, and be transported to the Mars surface to attempt the mission. Then, they will use feedback from the mission to improve their vehicle and try again. Finally, they will reflect on how they acted as engineers.

Mission Planning (Offline)

1. Give student groups 10 minutes to review the information on the handouts and complete pages 1 and 2 of the *Mission Log*.
2. Circulate to answer questions from students. Guide students by asking questions like the following.
   - **Q: What is the mission asking you to do?**
   - **Q: Why did you choose to add these modules to your vehicle?**
   - **Q: Does anyone disagree with any of the choices?**
   - **Q: How is this mission different from others you have completed?** (Appropriate if students have played *Mission: Mars* before.)
3. Confirm that each group has a plan before students log in to the game.

Online Guided Play

1. Explain that each group should use only one Roblox account for group missions. Invite these accounts to a private server for the class.
2. Have each group log in to the game. As needed, talk students through selecting the mission from the Mission Board and then going to the Mission Play airlock.

Online Student-Led Play

1. Tell students that they will make multiple attempts to complete the mission.
   - At the end of their first mission attempt, they need to review the in-game feedback and plan how to improve their vehicle design by completing pages 3 and 4 of the *Mission Log*.
   - Students should switch “drivers” for each attempt so that everyone has a turn with the game.
   - (Optional) Provide additional copies of *Mission Log* pages 3 and 4.
2. Give student groups 15 minutes to attempt the mission. (Provide more time if available.) Stop play with 5–10 minutes remaining in the session.

Wrap-Up

1. Have one student from each group briefly describe their experience with the mission.
2. Discuss the mission experience as a class. Prompt reflection with questions like the following.

   Q: Did you succeed?

   Q: Which vehicle modules improved the chance of success?

   Q: Did any vehicle modules reduce the chance of success?

   Q: How did you use the in-game mission feedback to improve your vehicle between attempts?

   Q: Would you know whether you succeeded if the game did not tell you? If so, how? *A: We knew we succeeded because we knew what the mission criteria were and what success would look like.*

   Q: How are the vehicles you designed for this mission different from the ones you designed for other missions? Why are they different? (Appropriate if students have played other *Mission: Mars* missions.) *A: Answers will vary but should include that the missions have different criteria.*

   Q: How did you use the Engineering Design Process (Plan and Create, Test, Improve) while attempting this mission?

Extension Ideas (for Any Mission)

Engage expert players who are ready for additional challenges with these suggestions.

1. Appoint expert players as “Tech Support” for their peers. When helping classmates, Tech Supporters are allowed only to ask other players questions rather than telling them what to do. For example, “Which mission did you take from the Mission Board?” “Did you enter the Mission Play airlock?” “What modules did you choose for your vehicle?”
2. Challenge expert players to improve their vehicles for a higher score.
3. Challenge expert players to see how badly they can engineer a non-solution. What is the lowest number of experience points they can accumulate from a mission attempt?

Name: ____ Date: ______________

Crafting Manual

Vehicle Modules

Choose from these modules to design and create a vehicle to meet the mission criteria.

Module Type	Options
Body: The body is the frame of your rover. All bodies act the same, even though they look different. Your vehicle may have only one body.	The **Viper** is a standard rover with extra headlights.
	The **Beetle** is a large, round rover with plenty of headroom.
	The **Mole** is a sleek, compact rover with panoramic windows.
Wheel Sets: Wheels allow your rover to cross different surfaces. Your vehicle may have only one set of wheels.	**Standard Aluminum Wheels** are lightweight and have little traction.
	Nickel-Titanium Mesh Wheels are medium weight and have some traction.
	Titanium Chevron Tread Wheels are heavy weight with added traction.
Motor: A motor is needed to turn your rover's wheels. Your vehicle may have only one motor.	A **large** (high power) motor is heavier and allows you to reach higher top speeds. A **medium** (medium power) motor is in between a small motor and a large motor in terms of weight and top speeds. A **small** (lower power) motor is lighter and reaches lower top speeds.
Battery: Batteries power everything on your vehicle. Your vehicle may have more than one battery.	Choose one, two, or three batteries. More batteries increase power available to the motor but also increase the weight of the vehicle.
Oxygen: You need oxygen to breathe while in your rover. You may carry more than one tank.	Choose one, two, or three tanks. More tanks increase your range but also drain the battery more quickly.
Drill: Drill devices break up the Mars surface to collect physical samples. Your vehicle may have more than one drill.	A multi-use **drill** can break up materials and gather small, powdered samples from below the surface.
	A **coring device** gathers a large sample from below the surface and keeps the layers in place.
Signal: Signaling devices send signals from the rover. Your vehicle may have more than one signal.	The **audio** signal device emits sounds and records sounds.
	The **light** signal device emits visible light.
	The **electronic** signal device emits radio waves.
Gather: Devices that help collect data and samples or that help recover large objects. Your vehicle may have more than one device.	A digital **camera** can be used to take photos.
	A multi-use **sampling arm** has a scoop on the end and can collect a sample from the surface.
	A **towing arm** drags an object behind your rover.

Name: ____ Date: ______________

Crafting Manual

Mars Regions

Missions take place in specific regions on Mars.

Arsia Mons was chosen as the ideal location for the Social Hub. It's located in a large area of high elevation that is home to some of the tallest mountains in the solar system! These mountains were once volcanoes but are no longer active. The slopes are not very steep, and they have a variety of terrains in different areas.
Jezero Crater formed when a meteorite hit Mars. The crater is 28 miles, or 45 kilometers, wide. That must have been one big meteorite! The crater was probably a lake back when Mars was warm enough to have flowing water on its surface. That's why NASA chose Jezero as the landing site for the Perseverance Rover in 2021. The floor of the crater is mostly smooth and easy to drive over.
Arabia Terra was shaped by volcanic eruptions and is one of the oldest surfaces on Mars. It has a large number of impact craters, which have left the terrain extremely rough. Arabia Terra is home to some of the strangest terrains on Mars, including the brain terrain, which, from a distance, looks like the surface of the human brain.
Planum Boreum is a plain at the North Pole of Mars. It is home to the planet's northern ice cap. The ice cap is roughly 2 miles, or 3 kilometers, thick and has a large, deep canyon named Chasma Boreale. It also has high cliffs that are prone to avalanches. The ice cap is largely made up of water ice. When it's cold enough, the ice caps also gain layers of carbon dioxide ice.

Mission Log

(page 1)

Names of Mars Explorers: ____

Name of Mission: ____

What is this mission asking you to do?

Where does this mission take place?

What are the criteria? (What does the vehicle need to do? Does it need to collect something, send a signal, or something else?)

Discuss:
Which modules will help complete the mission? Which modules are not needed for this mission? (Refer to the *Crafting Manual* to read about the Vehicle Modules.)

Record your module choices on the design checklist for Vehicle Design 1. Explain why you chose each module.

Mission Log

(page 2)

Names of Mars Explorers: ____

Name of Mission: ____

Vehicle Design 1

Module Category	Category Options (Check off choices)	Reason for Choice
Body	☐ The Viper ☐ The Beetle ☐ The Mole	
Wheels	☐ Standard Aluminum ☐ Nickel-Titanium Mesh ☐ Titanium Chevron Tread	
Motor	☐ Low Power ☐ Medium Power ☐ High Power	
Battery	Number of Batteries ☐ ☐ ☐	
Oxygen	Number of Oxygen Tanks ☐ ☐ ☐	
Drill	☐ None ☐ Standard Drill ☐ Coring Drill	
Signal	☐ None ☐ Electronic (Radio) ☐ Light ☐ Audio	
Gather	☐ None ☐ Camera ☐ Sampling Arm	

Mission Log

(page 3)

Names of Mars Explorers: ____

Name of Mission: ____

Was your first attempt successful?

What feedback did you receive in the game?

What do you think were the main reasons for the outcome?

How can you improve the outcome on your next mission attempt? (Can you improve the vehicle design, do something different during the mission, or something else? Note: You may be able to improve your vehicle even after a successful outcome.)

Discuss:
Which modules will you choose for your next attempt?

Record your module choices on the design checklist for Vehicle Design 2.
Explain why you chose each module.

You can repeat the improvement step until you have a successful mission outcome.

Mission Log

(page 4)

Names of Mars Explorers: ____

Name of Mission: ____

Vehicle Design 2

Module Category	Category Options (Check off choices)	Reason for Choice
Body	☐ The Viper ☐ The Beetle ☐ The Mole	
Wheels	☐ Standard Aluminum ☐ Nickel-Titanium Mesh ☐ Titanium Chevron Tread	
Motor	☐ Low Power ☐ Medium Power ☐ High Power	
Battery	Number of Batteries ☐ ☐ ☐	
Oxygen	Number of Oxygen Tanks ☐ ☐ ☐	
Drill	☐ None ☐ Standard Drill ☐ Coring Drill	
Signal	☐ None ☐ Electronic (Radio) ☐ Light ☐ Audio	
Gather	☐ None ☐ Camera ☐ Sampling Arm	

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MISSION: MARS

In-Game Missions

Mission Resources

Use this information with the **General Lesson Plan** to support specific missions in *Mission: Mars*.

Mission Resources: Ramp Rescue

Mission Briefing

Make the leap—just make sure it's a good one. A research team on the other side of the canyon needs your help repairing their lab's oxygen tanks. Outfit your rover and choose a path to jump safely over the canyon or risk being the latest crew member to explore the canyon floor up close. Oof.

Mission Goal

Player chooses a combination of motor, battery, wheels, and ramp that makes the vehicle go fast enough to safely reach the other side of the canyon after driving off the ramp. Players must also carry enough oxygen to complete the mission by driving the repair kit to the lab after clearing the canyon.

In addition to the standards listed in the **General Lesson Plan**, this mission aligns with these standards.

NGSS Science Standards:
3-PS2-2 Motion and Stability: Forces and Interactions
DCI PS2.A: Forces and Motion
MS-PS2-2 Motion and Stability: Forces and Interactions
DCI PS2.A: Forces and Motion

Grades 3–5 Math Extension:
CCSS.5.NF
Grades 6–8 Math Extension:
CCSS.6.EE, CCSS.7.EE

Mission Tips

Share these tips with students.

- To **accelerate** means to move faster. A vehicle that is getting up to top speed is accelerating.
- When you add weight to a vehicle, it takes more force to accelerate it to top speed. Applying more force requires more energy from the battery.
- The angle of a ramp affects the angle that the vehicle rises and falls. This angle cannot be controlled after the vehicle leaves the ramp.
- The speed and direction of a vehicle cannot be changed between the time the vehicle leaves the ramp and when its wheels touch down again.
- As the slope of a ramp increases, the time a vehicle spends in the air after take-off increases.
- As vehicle speed increases, the distance the vehicle travels after take-off increases.
- Vehicles tilt while in the air because the front and back wheels take off from the ramp at different times. A speed that is too slow can make a vehicle tilt forward. A speed that is too fast can make it tilt backward.

Math Extensions

Grades 3–5

In this Extension activity, students find the weight of the Perseverance Rover on Mars. Students may need help choosing a strategy for solving this problem. Some may recognize this as a fraction multiplication problem while others may draw a model or picture to support their thinking.

Answers

Step 1: What is the weight in pounds of Perseverance on Mars?

Step 2: The weight on Earth, Mars gravity in relation to Earth's gravity

Step 3: Sample answer: Since gravity on Mars is 3/8 that of gravity on Earth, I can multiply the weight of Perseverance on Earth by 3/8.

Step 4: Sample answer: 3/8 × 2260 = 6780/8 = 847.5

Step 5: Perseverance weighs 847.5 pounds on Mars.

Grades 6–8

In this Extension activity, students find how much more force is required to accelerate a vehicle when it carries 3 oxygen tanks compared to when it carries 1 oxygen tank. Students may calculate the force required for both scenarios and then find the difference. They may also recognize that the difference in the masses for the two scenarios is 100 kg and calculate the force required to accelerate that mass.

Answers

Step 1: How much more force is needed to accelerate a vehicle when it carries 3 oxygen tanks instead of 1 tank. The answer is a force, so the units will be Newtons.

Step 2: Mass of vehicle, mass of 1 oxygen tank, acceleration

Step 3: Equation relating force, mass, and acceleration: F = ma

Step 4: Sample answer: (1) Find total mass of vehicle with 1 tank and calculate force to accelerate it, (2) Find total mass of vehicle with 3 tanks and calculate force to accelerate it, (3) Find the difference in the two forces

Step 5: Sample answer: (1) F = (1,000 kg + 50 kg) × 3 m/s^2 = 3150 N, (2) F = (1,000 kg + 150 kg) × 3 m/s^2 = 3450 N, (3) 3450 N – 3150 N = 300 N

Step 6: It would take 300 N more force to accelerate a vehicle carrying 3 oxygen tanks.

Name: ______________________________________ Date: ______________

Mission Briefing: Ramp Rescue

Mission Briefing

Make the leap—just make sure it's a good one. A research team on the other side of the canyon needs your help repairing their lab's oxygen tanks. Outfit your rover and choose a path to jump safely over the canyon or risk being the latest crew member to explore the canyon floor up close. Oof.

Mission Goal

Choose a combination of motor, battery, wheels, and ramp that makes the vehicle go fast enough to safely reach the other side of the canyon after driving off the ramp. Then drive the repair kit to the lab after clearing the canyon. Carry enough battery power and oxygen to complete the mission.

Mission Tips

- To **accelerate** means to move faster. A vehicle that is getting up to top speed is accelerating.
- When you add weight to a vehicle, it takes more force to accelerate it to top speed. Applying more force requires more energy from the battery.
- The angle of a ramp affects the angle that the vehicle rises and falls. This angle cannot be controlled after the vehicle leaves the ramp.
- The speed and direction of a vehicle cannot be changed between the time the vehicle leaves the ramp and when its wheels touch down again.
- As the slope of a ramp increases, the time a vehicle spends in the air after take-off increases.
- As vehicle speed increases, the distance the vehicle travels after take-off increases.
- Vehicles tilt while in the air because the front and back wheels take off from the ramp at different times. A speed that is too slow can make a vehicle tilt forward. A speed that is too fast can make it tilt backward.

Name: ______________________________________ Date: _____________

Ramp Rescue Math Extension

(Grades 3–5)

Weight measures how much the force of gravity pulls down on an object. The force of gravity is different from planet to planet. So, the weight of an object changes when it is moved from one plant to another.

The Perseverance Rover landed on Mars in 2021. Scientists on Earth use it to explore the surface of Mars. Perseverance weighs 2,260 pounds on Earth. The force of gravity on Mars is 3/8 of the force of gravity on Earth.

How much does Perseverance weigh on Mars?

Step 1: What is the problem asking you to find?

Step 2: What information does the problem give you?

Step 3: What strategies or methods can you use to solve this problem? (Have you solved a problem like this before?)

Step 4: Solve the problem. Show your strategy or method.

Step 5: Write the answer. Remember to include the units.

Name: ____ Date: ______________

Ramp Rescue Math Extension

(Grades 6–8, page 1)

Newton's second law of motion states that the force needed to accelerate an object equals the mass of the object times the acceleration. In other words, the more mass an object has, the more force it takes to get it up to speed.

Newton's second law of motion:

Force = mass × acceleration

$$F = ma$$

mass – kilograms (kg)

acceleration – meters per second squared (m/s^2)

force – Newtons (N), $1\ N = 1\ kg \times 1\ m/s^2 = 1\ kg\ m/s^2$

Notice that when you multiply the units for mass by the units for acceleration, the result is Newtons.

The mass of a Mars vehicle is 1,000 kg. The mass of an oxygen tank is 50 kg.

How much more force is needed to accelerate the vehicle to 3 m/s^2 when it is carrying 3 oxygen tanks compared to when it is carrying 1 oxygen tank?

Step 1: What is the problem asking you to find? What units will the answer be in?

Step 2: What information does the problem give you?

Name: ____ Date: ______________

Ramp Rescue Math Extension

(Grades 6–8, page 2)

Step 3: What information do you need to solve the problem?

Step 4: How many steps do you need to find the answer? Write your plan.

Step 5: Set up and solve the problem. Show your strategy or method.

Step 6: Write the answer. Remember to include the units.

Mission Resources: Ice, Ice Maybe

Mission Briefing

Collect a sample of water ice from the North Pole of Mars and drop it off at the lab. Collect wisely! Not all ice is created equal, and lower temperatures could mean that carbon dioxide ice has formed. Good luck!

Mission Goal

Player chooses a combination of motor, battery, wheels, and instruments to take a sample of water ice. Players must also carry enough oxygen to complete the mission by depositing the sample at the lab.

In addition to the standards listed in the **General Lesson Plan**, this mission aligns with these NGSS Science and Engineering Practices.

NGSS Science and Engineering Practices:
Planning and Carrying Out Investigations
Analyzing and Interpreting Data

Mission Tips

Share these tips with students.

- The north polar ice cap of Mars has a seasonal layer of CO_2 ice that forms directly out of the atmosphere because of the extreme cold temperatures in Martian winter. Underneath this seasonal layer of CO_2 ice, there is a stable layer of water ice.
- Players need to choose scientific modules for their rover that will allow them to get a deep enough sample that is not contaminated by CO_2 ice.

Name: ____ Date: ______________

Mission Briefing: Ice, Ice, Maybe

Mission Briefing

Collect a sample of water ice from the North Pole of Mars and drop it off at the lab. Collect wisely! Not all ice is created equal, and lower temperatures could mean that carbon dioxide ice has formed. Good luck!

Mission Goal

Choose a combination of motor, battery, wheels, and instruments to take a sample of water ice. Carry enough battery power and oxygen to complete the mission by depositing the sample at the lab.

Mission Tips

- The north polar ice cap of Mars has a seasonal layer of CO2 ice that forms directly out of the atmosphere because of the extreme cold temperatures in Martian winter.
- Underneath this seasonal layer of CO2 ice, there is a stable layer of water ice.
- Players need to choose scientific modules for their rover that will allow them to get a deep enough sample that is not contaminated by CO2 ice.