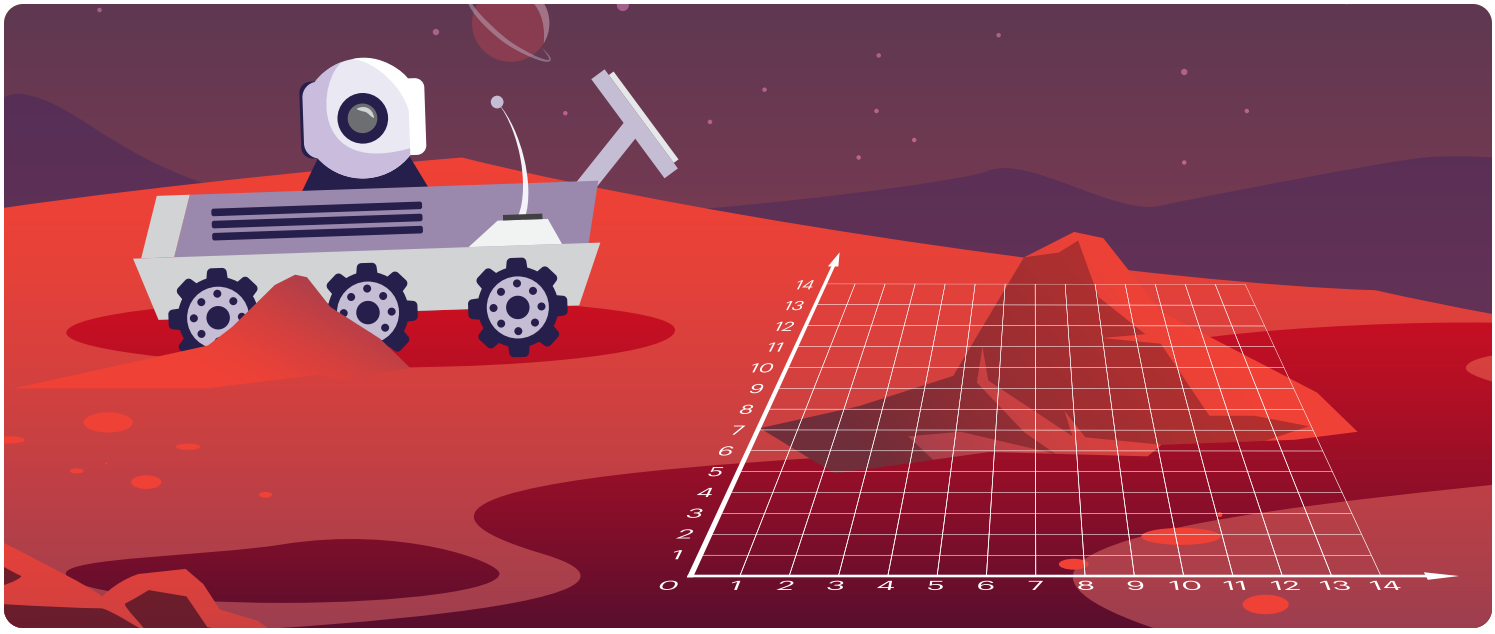
LESSON

Traverse the Terrain

The Tech Challenge 2017
Grade Levels: 6-8
Duration: 60 min

In this design challenge, learners will explore using coordinate planes to navigate a rover through uncharted territory on Mars. They will engage in communication and quality control best practices by mapping obstacles and checking other teams' instructions for accuracy.



Outline

Frame the Challenge	15 min total
Activate Prior Knowledge	10 min
Introduce the Challenge	5 min
Activity	**45 min total**
Build Model Terrains	10 min
Mapping Coordinates	15 min
Quality Control Inspection	15 min
Debrief	5 min

Grade Levels: 6-8

Duration: 60 min

Concepts/Skills
Coordinate planes, data collection

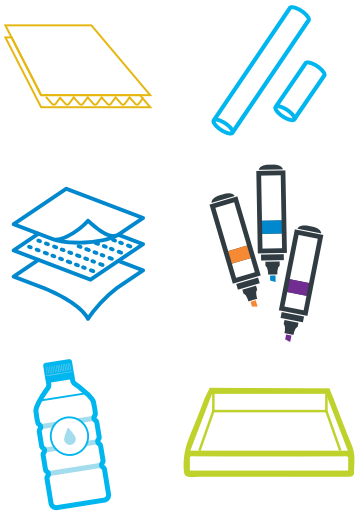
Objectives
Students will:
- Collaborate with their team to build a test model of the terrain of Mars with obstacles.
- Map the coordinates of the obstacles of a different team's model terrain.
- Practice quality control by creating and testing navigation instructions from another team's coordinates.

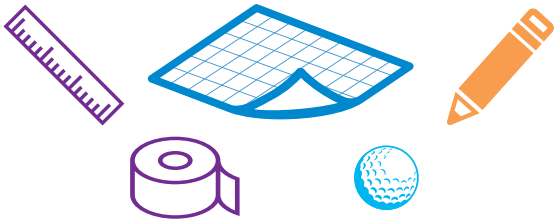
Materials and Preparation

Materials

Look for items that match the categories; see the suggestions below for ideas. Try to provide several different types of items for each category.

(per class of ~32 students)	*(1 per team)*
Obstacles *(25+)*	**Terrain**
• Cardboard • Cardboard tubes • Corks • Erasers • Foam • Markers • Takeout lids • Water bottles	• Traverse the Terrain Handout (1 per team) • 20 x 30 inch (51 x 76 cm) chart paper with grid – If unavailable, use plain chart paper and include a yardstick and marker for students to draw the grid, with lines approximately 1 cm apart. • *Optional:* Masking tape (to secure obstacles to chart paper) • Small test item to represent the rover (matchbox car, ping pong ball, etc.)



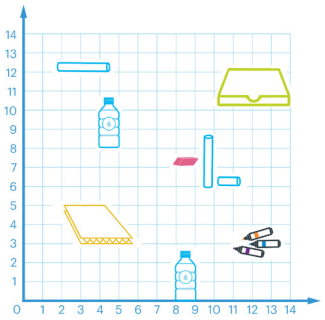


Testing Set-up

1. Set up the classroom so teams have space to build and test their model terrains.
   - Each team will need a flat surface (table or floor) on which to lay their chart paper.
   - Teams will be rotating from one model to another at least three times, so make sure there is enough space for students to move between models.

Preparation

1. Collect, organize, and set up obstacles materials.
2. Print out **Traverse the Terrain Handouts** double-sided (one per team).
3. Create an example terrain on chart paper by making the x and y axes and marking the units (we recommend two squares per unit). Set up obstacles on the terrain in an area of the classroom where it won't be disturbed.
4. Complete both the **Mapping Coordinates** and the **Navigation Instructions** on the **Traverse the Terrain Handout** based on the obstacles on your example terrain.



Sample Terrain

Frame the Challenge

Activate Prior Knowledge *(10 min)*

1. Begin by letting learners know that today they will be exploring how to guide a rover over uncharted terrain on Mars.
2. Asking **Guiding Questions** to explore what learners already know about **rovers** and the planet Mars:
   - *What is a rover? What are they designed to do?*
   - *Can you name one or more of the five rovers we have sent to Mars?*
   - *What kinds of things have we learned about the planet Mars from rovers?*
   - *What do you think the terrain of Mars is like?*
3. Introduce learners to the Perseverance rover, which has been navigating Mars and sending information to the National Aeronautics and Space Administration (NASA) since 2021.
   - If learners need more context, see **Additional Resources**.
   - *Optional:* Share the **Perseverance Explores the Jezero Crater Delta** video (3:19 min) of footage collected of the Jezero Crater Delta to help learners visualize the terrain of Mars.
4. Ask learners to consider how a rover like Perseverance navigates through the **obstacles** of the Martian terrain:
   - *How does a rover know which way to move?*
   - *Who controls the movement of the rover?*
5. Let learners know that they are going to be using a **coordinate plane** to create a test model of how to guide a rover through the hazardous terrain.

Career Connection: Mapping Specialist

Interested in what mapping Mars looks like in real life? Meet Fred Calef, PhD, a Mapping Specialist at NASA's Jet Propulsion Laboratory. He has worked on multiple rover missions to Mars, including the Opportunity, Curiosity, and Perseverance missions. In addition to keeping track of the rover position, his job involves providing mapping support for scientific observations and questions as the rovers collect data on Mars. When he is not mapping Martian terrain, Calef is exploring innovative ways of doing surface exploration over large distances.

Check out Calef's talk on **Mapping Mars for Rovers** to hear about how it takes a big team to create the most accurate maps possible, and visit **his profile** on NASA Science's Mars Exploration site to learn more about his career path and why he values diversity in STEM.

Additional Resources: Perseverance Rover

Perseverance (nicknamed Percy by the engineers at the NASA Jet Propulsion Laboratory) is a Mars rover that was designed to explore the Jezero crater as part of NASA's Mars 2020 mission. Perseverance has several science goals, including looking for past signs of microbial life, collecting geological samples, and testing technologies that could potentially help humans live on Mars in the future.

Check out the resources from NASA Science Mars website below to learn more about Perseverance, other Mars rovers, and the search for signs of ancient life on Mars.

- "Overview and 3D Model of Perseverance," NASA website.
- "Meet the People Behind NASA's Perseverance Rover," NASA website.
- "Mars 2020 Mission Overview," NASA website.
- "Explore with Perseverance," NASA website.
- "NASA Science Space Place: The Mars Rovers," NASA website.

Image Credit: NASA/JPL-Caltech

Introduce the Challenge *(5 min)*

1. Introduce the design scenario:

NASA is getting ready to land a rover on an unchartered territory of Mars. You and your team of NASA engineers have been tasked with designing a test model of the Martian terrain. Since accuracy is pivotal for the success of the mission, teams will be checking each other's work by mapping the coordinates as well as creating and testing a set of written navigation instructions for another team's terrains.

2. Introduce the design problem, criteria, and constraints.

Design Problem	Build an accurate test model and written instructions to navigate the rover.	
Criteria	• Model terrain must: – be built on a coordinate plane (x and y axes) with the axes and values correctly labeled. – include at least seven obstacles. • Written instructions must: – navigate the rover safely from the origin (0,0) to a designated point. – include at least five coordinates.	
Constraints	• Use only the materials available to represent the obstacles. • There's a time limit for each section!	

Tip:

The idea of coordinate plane mapping can be applied to a variety of contexts. If the Mars rover design scenario is not the right fit for your class, consider other design scenarios, such as directing a person out of a maze or telling a robot how to move through a room.

Build Model Terrains *(10 min)*

1. Divide learners into teams of three to four.
2. Pass out one sheet of gridded chart paper to each team. Have teams start by creating their Mars terrain by adding:
   - the x- and y-axis.
   - the values.
   - a destination point for the rover.
     - Ask them to mark the destination point with a star so it will be clear on all the maps.
     - They can choose where they want to place the destination point, but it will need to be a place where the rover can navigate.
3. Once teams have completed their coordinate plane on the chart paper, they can pick up their obstacle materials.
4. Teams will spend a few minutes placing their obstacles on their coordinate plane.
   - Remind teams that their model of the Mars terrain will need to include at least seven obstacles.
   - Obstacles can be taped down to prevent them from moving accidentally.
5. Ask teams to indicate when their terrain is finished by raising their hands.

Mapping Coordinates *(15 min)*

1. Once all teams have completed placing their obstacles on the terrain, bring the class back together.
2. Let them know that their next job is to map out the location of each of the obstacles. Ask the class how they might communicate where the obstacles are to someone controlling the Mars rover.
3. Show learners your premade example of coordinates mapped using your Mapping Coordinates page of the **Traverse the Terrain Handout.**
   - Ask **Guiding Questions**:
     - *What do you notice?*
     - *What information would you need if you were moving the rover through the terrain?*
   - Learners should recognize that in most cases, they will need to record multiple coordinates around the perimeter of the obstacles so the rover will know all the places where it might hit an obstacle.
     - *Example*: If the obstacle is boxed-shaped, they will want to write down the coordinates at each corner.
   - Remind them that they will also want to mark the places where the rover starts (0,0) and ends (the destination point).
4. Remind learners that since accuracy is extremely important, a different team should map out the obstacles that were placed, ensuring quality control.
5. Have teams rotate to the station on their right. Pass out one **Traverse the Terrain Handout** to each team. Have them turn to the **Mapping Coordinates** page of the handout to get started.

6. Let them know they have about 10 minutes to map out the obstacles. Ask them to again indicate when they are done by raising their hands.
7. Bring the class back together once all the teams have completed mapping the obstacles.

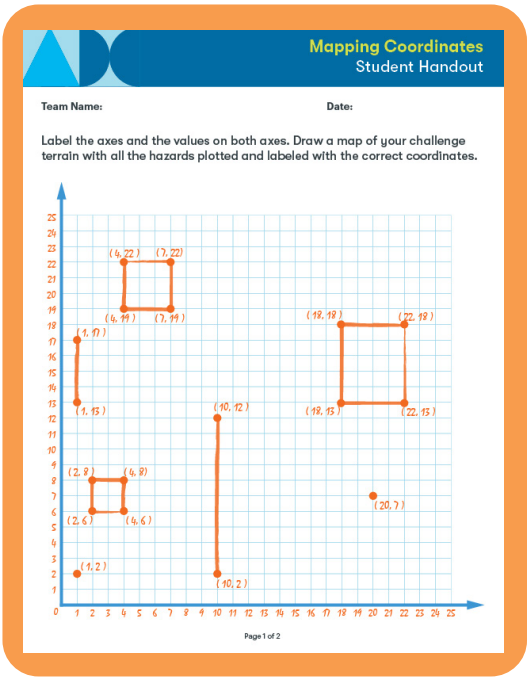
Computational Thinking:

Throughout this lesson, students are also using computational thinking.

Abstraction: Creating and reading maps is a great example of abstraction. Maps show only the important information (the stops, the general direction that you are heading) and leave out the finer details. This is similar to how computer programmers use generalization to focus on what is important.

Algorithms: Just as students are creating directions for the rover, algorithms provide a step-by-step instructions for a computer program. Similarly, programmers always do quality control, testing their algorithm and checking for errors.

To learn more about computational thinking go to thetech.org/ctlessons.


Mapping Coordinates
Student Handout

Team Name: Date:

Label the axes and the values on both axes. Draw a map of your challenge terrain with all the hazards plotted and labeled with the correct coordinates.

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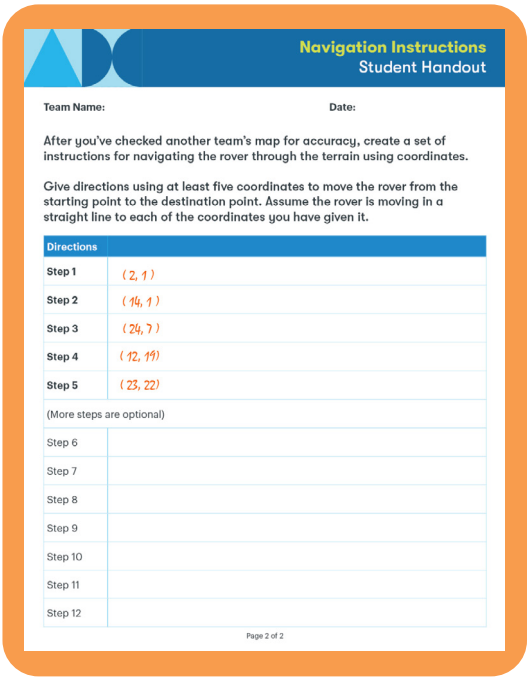
Sample Mapping Coordinates Handout

Quality Control Inspection *(15 min)*

1. Let learners know that their last step is to take on the role of quality control engineers. Their new job is to:
   - Do quality control on another team's map by checking the map for accuracy.
   - Create a set of instructions on how to navigate the rover through the terrain.
2. Show learners the back of your example Navigation Instructions.
   - Remind learners that they are telling the rover where to go to avoid hitting the obstacles, but they can decide as a team how to accomplish this.
     - Make sure they are aware that their last step should always be the destination point determined by the previous team.
   - Point out that they are directing the rover by giving it a set of step-by-step instructions like a recipe or algorithm, so the order that they write down the coordinates in the instructions matters.
   - Tell learners that they need to include a minimum of five steps for the rover to reach the destination point, but can include more if they would like.


Navigation Instructions
Student Handout

Team Name: Date:

After you've checked another team's map for accuracy, create a set of instructions for navigating the rover through the terrain using coordinates.

Give directions using at least five coordinates to move the rover from the starting point to the destination point. Assume the rover is moving in a straight line to each of the coordinates you have given it.

Directions	
Step 1	(2, 1)
Step 2	(14, 1)
Step 3	(24, 7)
Step 4	(12, 19)
Step 5	(23, 22)
(More steps are optional)	
Step 6	
Step 7	
Step 8	
Step 9	
Step 10	
Step 11	
Step 12	

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Sample Navigation Instructions Handout

3. Once they have completed their instructions, teams should:
   - find another team that is also done.
   - trade spots with that team.
   - test out the instructions they created to test for accuracy.
4. Let them know that they will have about 15 minutes to check the new map, create navigation instructions, and test out another team's instructions.
   - The class goal is for everyone's instructions to be tested by at least one other team before the time is up.
5. Once teams understand the directions have them turn to the **Navigation Instructions** page of their **Traverse the Terrain Handout** and begin.
6. Bring the class back together once every set of instructions have been tested.

Career Connection: Quality Control Inspector

Imagine a world where no one checked each other's work. Would you feel comfortable using products that have not been inspected for accuracy or safety? Quality control inspectors are in charge of making sure products are being developed to the highest quality possible. In addition to checking for accuracy, quality control inspectors are also in charge of safety, ensuring that the products being created are safe for the public to use.

Some of the tasks carried out by quality control inspectors include...

- testing raw materials.
- training employees on best practices.
- creating benchmarks for product quality.
- testing products at different stages of manufacturing to identify problems.
- conducting customer service evaluations and surveys.

Check out the U.S. Bureau of Labor Statistics website **Occupational Outlook Handbook** or **My Next Move** website to learn more about careers in quality control.

Debrief *(5 min)*

1. Lead a short debrief. Possible questions could include:
   - *How challenging was it to navigate through another team's terrain?*
   - *After working with the other team's terrains, would you make any changes to your team's terrain design if you could?*
   - *How do we give/use directions on Earth? How might that be different in outer space?*
   - *What are some situations in which a coordinate plane would be useful here on Earth?*
   - *What are ways we do quality control in our lives? (e.g., Having an adult check our homework.)*

Extension

- **Paper and pencil version:** If your class is in a smaller space, try having learners draw the obstacles and the coordinate plane on a blank chart.
- **Think big:** Want to try a large-scale, live action version? Work together as a class to create a giant coordinate plane outside using tape and bigger items as obstacles. Have volunteers act as the rover and move as directed around the obstacles.
- **Program It:** Apply your computational thinking skills and see if you can create an animation or game showing where the rover will move. **Scratch** and other computer coding platforms often use x and y coordinates to show the location of the character.

Dell presents The Tech CHALLENGE

ROCK THE RAVINE 2017

The Tech Challenge

This lesson was developed to prepare students for the 2017 Tech Challenge: Rock The Ravine, pesented by Dell.

Standards Connections

Next Generation Science Standards

Grades	Standard		Description
6-8	**Performance Expectation**	MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
Additional Standards		DCI ETS1.A	

Common Core State Standards

Grades	Standard	Description
6-8	CCSS.ELA-LITERACY.WHST.6-8.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
6	CCSS.MATH.CONTENT.6.NS.C.6.B	Understand signs of numbers in ordered pairs as indicating locations in quadrants of the coordinate plane; recognize that when two ordered pairs differ only by signs, the locations of the points are related by reflections across one or both axes.
6	CCSS.MATH.CONTENT.6.NS.C.8	Solve real-world and mathematical problems by graphing points in all four quadrants of the coordinate plane. Include use of coordinates and absolute value to find distances between points with the same first coordinate or the same second coordinate.

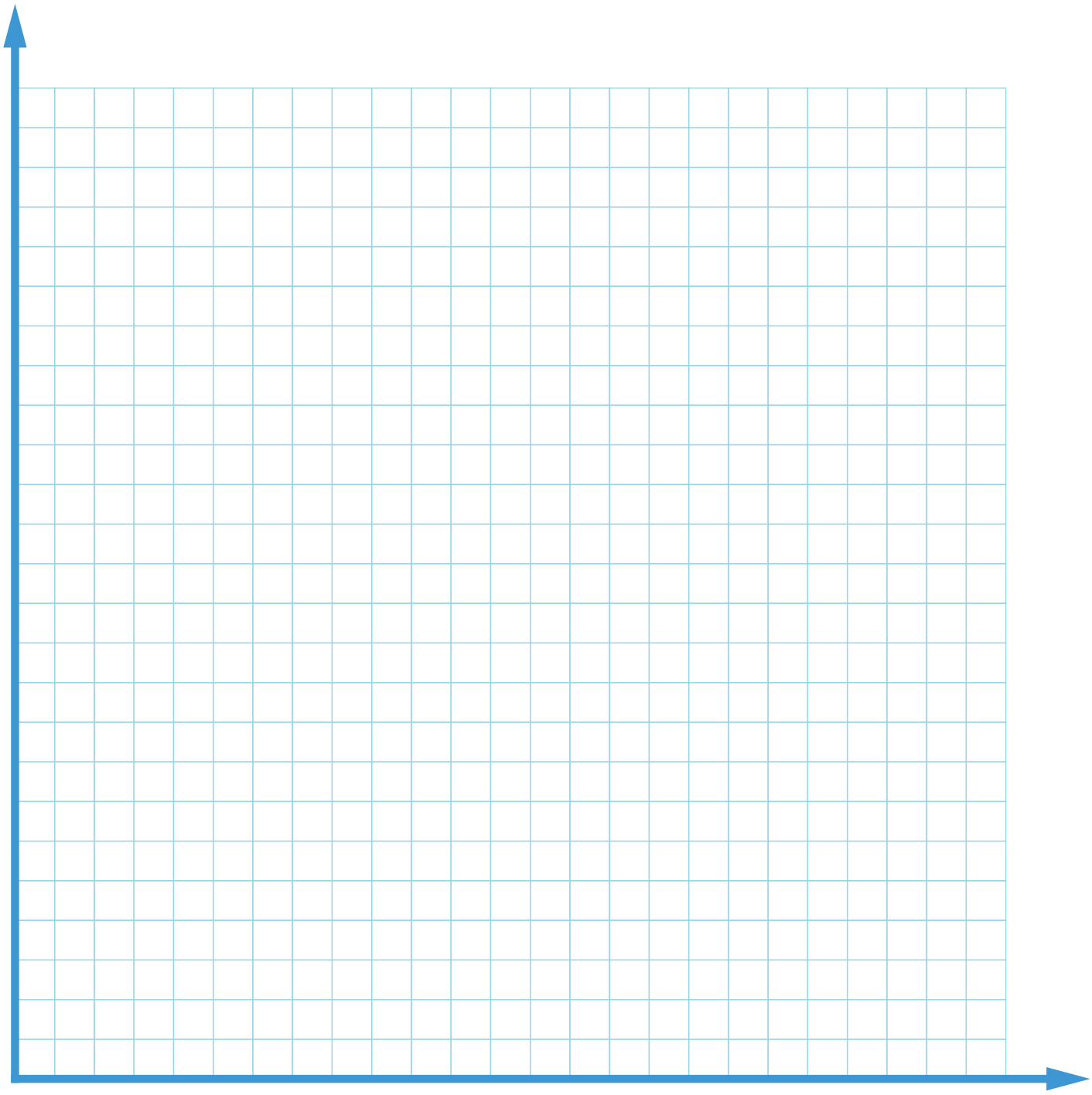
Vocabulary

- **Coordinate:** a set of values that show an exact position
- **Coordinate plane:** the plane containing the "x" axis and "y" axis
- **Obstacle:** something that blocks the way or prevents progress.
- **Rover:** a planetary surface exploration device designed to move across the solid surface on a planet
- **Terrain:** the physical features of a stretch of land

Traverse the Terrain Handout
Mapping Coordinates

Team Name: **Date:**

Label the axes and the values on both axes. Draw a map of your model terrain with all the obstacles plotted and labeled with the correct coordinates.



Traverse the Terrain Handout
Navigation Instructions

Team Name: **Date:**

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