Exploring Space Through ALGEBRA

STUDENT EDITION

Algebra I
and Geometry

Lunar Rover

Background

Exploration provides the foundation of our knowledge, technology, resources, and inspiration. It seeks answers to fundamental questions about our existence, responds to recent discoveries and puts in place revolutionary techniques and capabilities to inspire our nation, the world, and the next generation. Through NASA, we touch the unknown, we learn and we understand. As we take our first steps toward sustaining a human presence in the solar system, we can look forward to far-off visions of the past becoming realities of the future.

The vision for space exploration includes returning the space shuttle safely to flight, completing the International Space Station, developing a new exploration vehicle and all the systems needed for embarking on extended missions to the Moon, Mars, and beyond.

In 1971 the Apollo 15 mission was the first to carry a lunar roving vehicle (LRV). This LRV (Figure 1) allowed astronauts to travel farther from their landing sites than in previous missions. This enabled them to explore and sample a much wider variety of lunar materials.

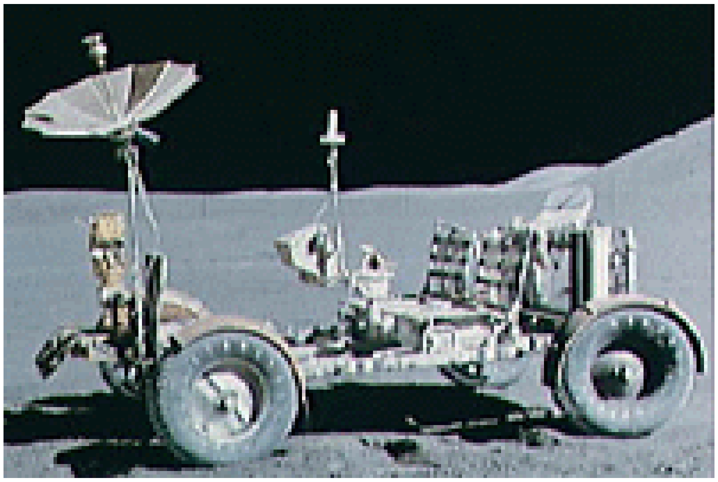


Figure 1: Apollo 15 Lunar Roving Vehicle taken on the Moon (NASA)

Because the vehicle was unpressurized, its longest single trip was 12.5 kilometers (7.8 miles). Its maximum range from the Lunar Module (LM) was 5.0 kilometers (3.1 miles). LRVs were also on Apollo 16 (1972) and Apollo 17(1972).

If the LRV should happen to fail at any time during the extravehicular activity (EVA), the astronauts must have sufficient life support consumables to be able to walk back to the LM. This distance is called the “walkback limit”, and it was approximately 10 kilometers (about 6 miles). Because of the reliability of the LRV and of the spacesuits, this restriction was relaxed on Apollo 17 for the longest traverse from the landing site, about 20 km (about 12 miles).

When NASA returns to the Moon, it will once again take LRVs to extend the distance astronauts may travel over the Moon's surface. Modern unpressurized rovers (Figure 2) will look similar to those of the Apollo years and steer like a car. These vehicles will be limited to local travels of 10 to 20 kilometers (about 6 to12 miles) from the outpost site during short periods of time that are less than 10 hours. Astronauts will still need to wear space suits while traveling in these unpressurized LRVs.

Figure 2: Unpressurized Rovers (NASA concept)

A second type of LRV will be pressurized and will have about 200 km as its starting point. Pressurized rovers (Figure 3) will give astronauts the ability to travel long distances and perform extended science missions away from their habitat. These pressurized surface vehicles will provide a comfortable indoor environment from which the crew can drive the rover and control a variety of sensing and manipulation tools. This allows exploration and science to be performed without the need to exit the vehicle. Vehicle concepts also include docking ports for the crew to directly enter the rovers from habitats and an airlock to allow EVA*.* The versatility of the vehicle, its power system, and its life support system will allow the astronauts to spend multiple Earth days away from their habitat performing work.

Figure 3: Pressurized Rovers (Artist concepts)

For more information about lunar roving vehicles and the U.S. Space Exploration Policy, visit www.nasa.gov.

Instructional Objectives

- You will create a scale drawing to model a real life problem.
- You will apply the Pythagorean Theorem and distance/rate formula ($d = rt$).
- You will analyze data to find a solution.

Problem

You are on the mission planning team that will determine the best route for the crew to use on the first trip using the new pressurized LRV (Rover 1). This exploration mission will include gathering rock samples from around the Moon's deGerlache crater.

Rover 1 is at habitat A on the map near Shackleton crater. Its mission for the day is to drive to the rim of deGerlache crater to collect rock samples. Rocks can be collected at any point along the edge of the crater (along segment $\overline{PQ}$ on the map). Before Rover 1 and the crew return to the habitat they must also stop at location B on the map in order to reset a seismic sensor that has been gathering data about the interior of the Moon. All distances are denoted on the problem diagram (Figure 4).

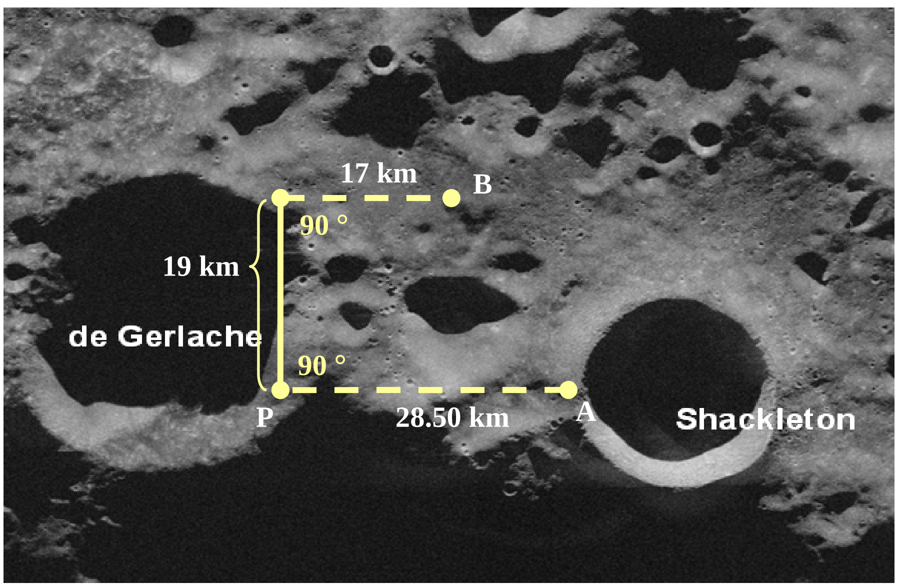


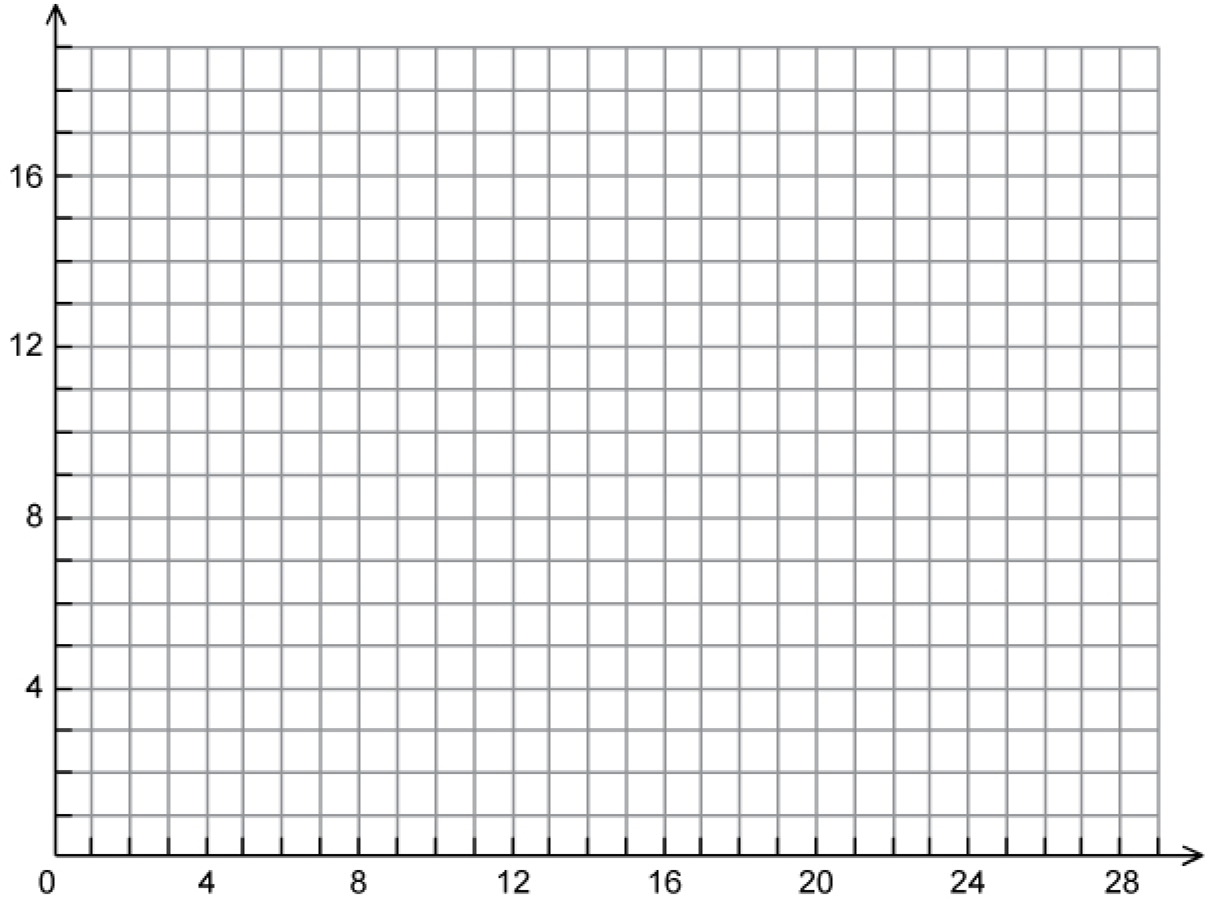
Figure 4: Problem diagram

1. **Minimal Path Problem**

   Your mission planning team must find the shortest total Path for the pressurized Rover 1 to travel for this exploration. The crew will start at habitat A and travel to a point along deGerlache crater (on segment $\overline{PQ}$) to collect rock samples. This point will be denoted as point C. Then, the crew will take Rover 1 from that point C to location B to reset the seismic sensor.

   a. Create a scale drawing of the mission on the graph provided (Graph 1). Point P is located at the origin, segment $\overline{AP}$ lies on the x-axis, and segment $\overline{PQ}$ lies on the y-axis. Chose a point on $\overline{PQ}$ along the deGerlache Crater that you think would give the shortest total distance. Label that point X.

Graph 1: Lunar Rover Mission Graph



b. Using a colored pencil and a straight edge, plot the point, C (0,3), on segment $\overline{PQ}$, along the deGerlache crater, where the crew will gather rock samples. Draw the path of Rover 1 from A to C, then to B. Label your points.

c. Find the total length AC + CB. You will need to make several calculations using the Pythagorean Theorem.

  1. Working with your mission planning team, plot 4 different locations from (0,1) to (0,19) for Point C (chose at lease one point with a fractional value for *y*) and draw the paths on your mission graph.
  2. Enter the corresponding data in the Minimal Path Table (Table 1) including a detailed process for finding each calculation. Round your answers to the nearest hundredth. The work for the given point, C(0,3) is already shown in the table. For the general point, (0, n), each entry in the last row will be a variable expression instead of a number. Use the process in the previous rows to draw conclusions about the entries in the last row.

Table 1: Minimal Path Table

C (0, *n*)	PC	CQ	AC	CB	AC+CB
(0, 3)	3	19 – 3 = 16	$\sqrt{28.50^2 + 3^2} = 28.66$	$\sqrt{17^2 + 16^2} = 23.35$	28.66 + 23.35 = 52.01
(0, *n*)					

d. Working with your mission planning team, analyze your table. According to your data, where is the best location for C so that the total distance Rover 1 travels is minimized? What is the distance traveled? Compare your results with those of 2 other teams. Does there seem to be one best location in order to minimize the path?

e. Show your solution on your mission graph by highlighting Rover 1's path for the shortest distance traveled. How close was your prediction, X, for the shortest total distance to the actual value found?

2. Minimal Time Problem

The average speed of Rover 1 is 8.9 km/hr with an empty payload. With a full payload of rocks the average speed drops to 5.5 km/hr. Find the best location for point C so that you minimize the total travel time for the distance AC + CB. Recall that $d = rt$, *and* $t = d/r$.

a. Using the locations chosen in Problem 1 and the Minimal Time Table below (Table 2), find the time needed for each path. Include in the last column of the table a detailed process for finding each calculation.

Example: The time from A to C is 28.66 / 8.90, and the time from C to B is 23.35 / 5.50.
The total time is 28.66 / 8.90 + 23.35 / 5.50 = 7.47

Table 2: Minimal Time Table

C (0, *n*)	AC	CB	Total Time
(0, 3)	28.66	23.35	28.66 / 8.90 + 23.35 / 5.50 = 7.47
(0, *n*)			

b. According to your data, where is the best location for C so that the total time traveled is minimized? What is the minimum time for the mission?

c. Show your solution on your mission graph by highlighting Rover 1's path for the minimum travel time.

d. Based on your work so far, where do you think is the best place to collect rocks along the deGerlache Crater in order to minimize both distance and time? Explain.

3. Find the minimum using a graphing calculator.

a. Given any point C(0, n) along segment $\overline{PQ}$, write an expression in terms of n to represent the following quantities. Use your process from the Minimal Path table in Problem 1.

PC =

CQ =

AC =

CB =

Total Distance (AC + CB) =

b. Enter the equation for the total distance into y1 in your graphing calculator. Graph the equation and use the minimum function of the calculator to approximate the minimum distance. Does it match your solution?

Hint: To set the WINDOW values of the min and max of x, recall that x represents the distance, n, from P to C (first column). For the min and max values of y, recall that y represents the total distance, AC + CB (last column).

c. Using your Minimal Time table from Problem 2, write an equation to represent the total time.

d. Repeat Part b, above, for the equation for total time. Does it match your solution?

Hint: The WINDOW values for the min and max of x are the same as above. For the min and max values of y, recall that y represents the total time (last column).