# Exploring Space Through ALGEBRA

STUDENT EDITION

Algebra I

## Weightless Wonder – Reduced Gravity Flight

### 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 our quest to explore, humans will have to adapt to functioning in a variety of gravitational environments. Earth, Moon, Mars and space all have different gravitational characteristics. Earth's gravitational force is referred to as one Earth gravity, or 1g. Since the Moon has less mass than the Earth, its gravitational force is only one sixth that of Earth, or 0.17g. The gravitational force on Mars is equivalent to about 38% of Earth's gravity, or 0.38g. The gravitational force in space is called microgravity and is very close to zero-g.

*Figure 1: C-9 jet going into a parabolic maneuver.*

*Figure 2: Astronaut crew training onboard the C-9 aircraft in preparation for the Microgravity Science Laboratory missions flown on the Space Shuttle Columbia in April and July of 1997.*

When astronauts are in orbit, either in the space shuttle or on the International Space Station (ISS), Earth's gravitational force is still working on them. However, astronauts maintain a feeling of weightlessness, since both the vehicle and crew members are in a constant state of free-fall. Even though they are falling towards the Earth, they are traveling fast enough around the Earth to stay in orbit. During orbit, the gravitational force on the astronauts relative to the vehicle is close to zero-g.

The C-9 jet is one of the tools utilized by NASA to simulate the gravity, or reduced gravity, astronauts feel once they leave Earth (Figure 1). The C-9 jet flies a special parabolic pattern that creates several brief periods of reduced gravity. A typical NASA C-9 flight goes out over the Gulf of Mexico, lasts about two hours, and completes between 40 and 60 parabolas. These reduced gravity flights are performed so astronauts, as well as researchers and their experiments, can experience the gravitational forces of the Moon and Mars and the microgravity of space.

By using the C-9 jet as a reduced gravity research laboratory, astronauts can simulate different stages of spaceflight. This can allow crew members to practice what might occur during a real mission. These reduced gravity flights provide the capability for the development and verification of space hardware, scientific experiments, and other types of research (Figure 2). NASA scientists can also use these flights for crew training, including exercising in reduced gravity, administering medical care, performing experiments, and many other aspects of spaceflight that will be necessary for an exploration mission. A flight on the C-9 jet is the next best thing to blasting into orbit!

For more information on NASA's Weightless Wonder and reduced gravity research, see the 13 minute video at http://microgravityuniversity.jsc.nasa.gov/video/RGSFOP_video.mpg. For more information about the Vision for Space Exploration, visit www.nasa.gov.

## Instructional Objectives

- You will analyze data to derive a solution to a real-world problem.
- You will solve and evaluate quadratic functions.
- You will find the maximum of a quadratic function.

## Problem

To prepare for an upcoming mission, an astronaut participated in a C-9 flight simulating microgravity, or close to zero-g. The pilot flew out over the Gulf of Mexico, dove down to increase to a maximum speed then climbed up until the nose was at a 45° angle with the ground. To go into a parabolic maneuver, the pilot then cut the thrust of the engine letting the nose of the plane continue to rise then come back down at a - 45° angle with the ground. Ending the maneuver, the pilot throttled the engine back up and began another dive to prepare for the next parabola. The pilot completed 50 parabolas during the 2 hour flight.

Figure 3 shows the movement of the plane during a typical flight. The parabolic maneuver, where microgravity is felt, is highlighted. This is the part of the flight that you will focus on for the following questions.

The function $y = -4.9t^2 + 87.21t + 9144$ describes the altitude ($y$), in meters (m), of the plane in relation to the time ($t$), in seconds (s), after it started the parabolic maneuver. You will use this function to analyze the parabolic flight of the C-9.

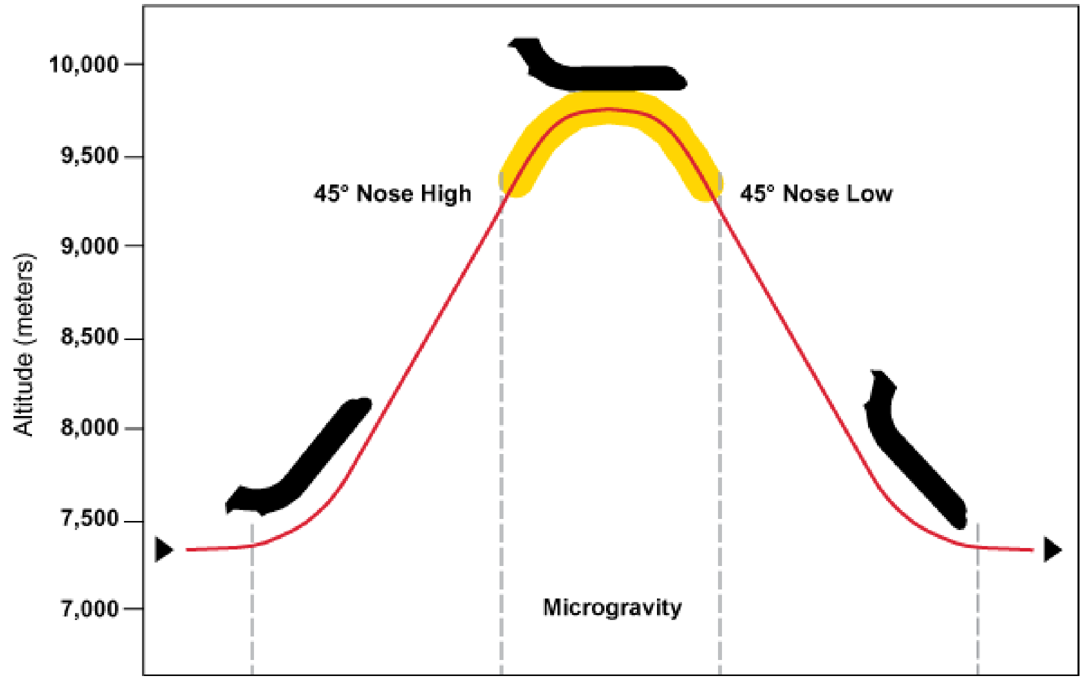


*Figure 3: A typical microgravity maneuver.*

1. Using the defined function, at what altitude did the astronaut start to feel microgravity?

2. Calculate the length of time the astronaut experienced micro-gravity during one parabolic maneuver.

3. Find the maximum altitude of the plane during one parabolic maneuver.

4. What percent of the astronaut's total flight was spent in microgravity?

5. How many parabolas would the pilot need to complete for the astronaut to have experienced at least 15% of his flight in microgravity?