Exploring Space Through MATH
Applications in Algebra 1

STUDENT EDITION

Suit Yourself: Fitted for Space

Background

This problem is part of a series of problems that apply algebraic principles in NASA's human spaceflight.

The Space Shuttle Mission Control Center (MCC) and the International Space Station (ISS) Control Center use some of the most sophisticated technology and communication equipment in the world. Teams of highly qualified engineers, scientists, doctors, and technicians, known as flight controllers, monitor the systems and activities aboard the space shuttle and the ISS. They work together as a powerful team, spending many hours performing critical simulations as they prepare to support each mission and crew during normal operations and any unexpected events.

The Extra-Vehicular Activities (EVA) officer monitors all aspects of the spacewalks performed from the space shuttle and the ISS. The EVA officer monitors the technical operation of the spacesuits and the activities to be carried out prior to a spacewalk. The EVA officer also monitors the space walk from the MCC and evaluates the spacewalk afterward. The spacesuit is officially known as an Extra-vehicular Mobility Unit (EMU). Anytime a crew member has to step outside of a pressurized vehicle, such as the space shuttle or ISS, to work in the vacuum of space, an EMU must be worn.

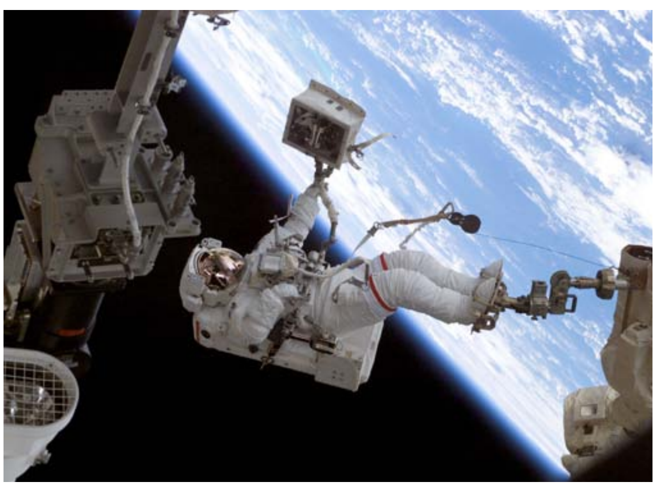

Figure 1: Astronaut on the mechanical arm.

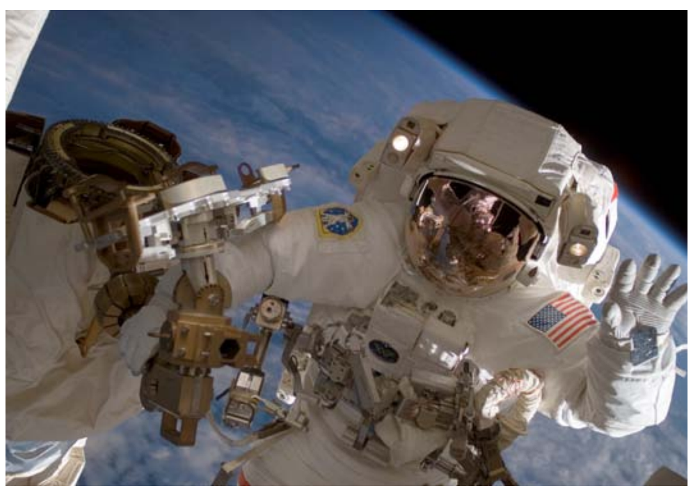

Figure 2: Astronaut on EVA.

Suppose an astronaut were to leave a pressurized vehicle without wearing an EMU. Because there is no oxygen, the astronaut would lose consciousness within 15 seconds. While in orbit the sun rises and sets every 90 minutes, which means the astronaut experiences sunlight for 45 minutes with temperatures possibly reaching 120^{o} C (248^{o} F) and darkness for 45 minutes with temperatures possibly dropping to -100^{o} C (-148^{o} F). A typical EVA may be up to 7 hours, which means the astronaut would change from hot to cold or cold to hot, about 9 times during the EVA. These extreme temperature changes and the lack of air pressure would cause the body fluids to boil or freeze. The astronaut would also be exposed to radiation and cosmic rays, and could even be hit by space debris, such as micrometeoroids, that move at high rates of speed.

The key features of the EMU that keep the astronauts alive and comfortable are habitable pressure, breathable air, heating and cooling control, and protection from the harsh space environment. It also provides the astronaut the ability to move around with a range of motion for arms and legs, good visibility, and communication with the crew and with the MCC. The EMU is its own controlled environment in which a crew member can perform scheduled activities and planned spacewalks for up to seven hours.

Instructional Objectives

- You will identify slope and the effects of a change in slope, and determine what slope means in a problem situation;
- You will find the *x*-intercept, *y*-intercept, and determine what they represent in a problem situation;
- You will create linear equations given *y*-intercept and slope;
- You will solve linear equations and systems of linear equations using the substitution method and the graphing calculator; and
- You will work in cooperative learning groups to communicate mathematical ideas in a team environment.

Suit Yourself: Fitted for Space

Directions: Read the problem. Answer questions 1 – 6 in your group and be sure to include units. Discuss answers to be sure everyone understands and agrees on the solutions.

Problem

Two crew members are preparing for a spacewalk to install solar panels on the International Space Station (ISS). The spacewalk will last about seven hours. As they put on their Extra-vehicular Mobility Units (EMU), a series of system checks are taking place. One system of concern is the primary life support subsystem which supplies oxygen. The oxygen tank pressure is checked to ensure that the starting pressure is suitable to complete the spacewalk and that there are no leaks. The oxygen tank pressure is used to measure oxygen usage throughout the spacewalk and is measured in pounds per square inch (psi).

The starting pressure of the oxygen tank for Astronaut 1 is 906 psi. This astronaut will be performing the most work intensive portion of the spacewalk. It is estimated that his oxygen usage rate will be approximately 110 psi/hour.

The starting pressure of the oxygen tank for Astronaut 2 is 859 psi. This crew member will not be working as strenuously as Astronaut 1. Therefore, his oxygen usage rate is lower and estimated to be approximately 85 psi/hour.

1. Since the estimated rate at which an astronaut uses oxygen is constant, this scenario can be represented by two linear equations. What part of the first equation would the 906 psi starting pressure for Astronaut 1 represent?

2. What would the 110 psi/hr oxygen usage rate represent in the first equation?

3. Write a linear equation that describes the oxygen pressure, *p,* of the tank of Astronaut 1 at any given time, *t*.

4. What is the *y*-intercept for Astronaut 2?

5. What is the slope for Astronaut 2?

6. Write a linear equation that would show oxygen usage of Astronaut 2. Use *p* for oxygen pressure in psi and *t* for time in hours.

Directions: Answer questions 7 – 10 in your group and be sure to include units. Discuss answers to be sure everyone understands and agrees on the solutions.

7. The Extra-Vehicular Activities (EVA) officer needs to ensure that each astronaut can complete the seven hour spacewalk before their oxygen is depleted. Use the equations written in questions 3 and 6 to show if each of the astronauts will be able to complete the seven hour spacewalk before running out of oxygen.

8. Use the equations from questions 3 and 6 to find the time it would take for each of the astronauts to deplete all of their oxygen. Round to the nearest hundredth.

9. State your answers to question eight in hours and minutes. Round your answer to the nearest minute.

10. Write the two points that were found in questions 8 as coordinates (t, p). What would each point represent on a graph and why?

Directions: Answer questions 11 – 15 independently. Include units.

11. Using a graphing calculator and the equation for Astronaut 1 that you used in question 8, find the *x*-intercept and write it as an ordered pair. Round to the nearest hundredth. How does this result compare with the ordered pair that you found in question 10?

12. At some point during the spacewalk both astronauts will have the same oxygen pressure. Use the substitution method to solve the system of equations, to find the time, *t,* in hours, that the astronauts will have the same oxygen pressure. Express the time in hours and minutes. Then, find the pressure, *p,* in psi rounded to the nearest tenth that corresponds to that time. Explain your answer.

13. Use a graphing calculator to solve the system in question 12, and write your answer as an ordered pair. Round to the nearest hundredth. How does this result compare with the answers that you found in question 11?

14. Three hours into the spacewalk, Astronaut 1 has become exhausted. The Extra-Vehicular Activities (EVA) officer recommends that the two astronauts switch duties.

    a. How much oxygen pressure does each astronaut have left at this point?

    b. Write two new equations to represent the oxygen pressure for each astronaut after switching roles. Since Astronaut 1 now has a lighter work load and Astronaut 2 has a more strenuous workload, their rates of oxygen use will be reversed. Use p to represent oxygen pressure in psi and t to represent time in hours.

15. The EVA officer has recommended that the spacewalk be aborted if either astronaut reaches an oxygen pressure of 150 psi before the mission is complete. If 4 more hours are required to complete the EVA, will the astronauts be able to finish the spacewalk?